SEMESTER-I

MBIO1C 001T: BIOCHEMISTRY

Credit: 4

Course Objective: To introduce the fundamental structures and molecular interactions of vital biomolecules that help in organization and functioning of living cells.

Course learning outcome: Students will be able to demonstrate advanced knowledge and understanding of aspects of physical, chemical and biological properties of biomolecules.

UNIT I: Biochemical basis of life

Review of basic concepts of solution chemistry- acid, base, ionic strength; Structure of atoms, molecules and principles of chemical bonding, Water and its physicochemical properties, Ionization of water, pH, buffers, acids and bases, Stabilizing interactions (*Van der Waals*, electrostatic, hydrogen bonding, hydrophobic interactions); Basic principles of Bioenergetics, equilibrium and concept of free energy, Entropy and Enthalpy

Unit II: Carbohydrates and Lipids

Occurrence, classification, properties and functions of mono, di, and polysaccharides with special reference to glycogen, amylase and cellulose, amino sugars; Lipids: Classification, properties and functions of important storage and membrane lipids, lipoproteins, Phospholipids, glycolipids, prostaglandins and cholesterol

UNIT III: Proteins, Enzymes and Nucleic acids

Structure, classification, physical and chemical properties of amino acids, Protein structure, Protein folding; Enzyme basics, Classification and Nomenclature, Factors affecting enzyme activity, Michaelis Menten Kinetics, Lineweaver-Burk equation, Enzyme inhibition, Coenzyme and Cofactors; Nucleic acids: Structure and functions, different forms of DNA and RNA

UNIT IV: Metabolism of Biomolecules

Metabolic regulation and control of glycolysis, gluconeogenesis, Tri carboxylic acid (TCA) Cycle, glyoxalate and pentose phosphate pathways; Cholesterol metabolism, metabolism of amino acids and their regulation, Nucleic acids biosynthesis-*de-novo* and salvage pathways, Associated metabolic disorders (Diabetes, Fatty liver disease, Lesch-Nyhan syndrome & Gout), Ketone bodies.

Lab: Practicals based on the theory content.

Reference Books and Suggested Readings: (Latest editions)

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

MBIO1C 002T: CELL AND MOLECULAR BIOLOGY

Credit: 4

Course Objective: Course Objective: The students will understand the Cellular organization, choromosomal structure and dynamics and other aspects of Cell and Molecular Biology.

Course Learning Outcomes: Student should be equipped to understand fundamental and advanced aspects in biological phenomenon at cellular and molecular level.

Unit I: Cell organization

Introduction to cell, cellular organization, cell structure and functions. Structure of cell membrane, facilitated diffusion, ion channels, active transport, membrane pumps.

Structural organization and functions of intracellular organelles; Cytoskeleton: Composition, organization and functions of Microfilaments, microtubules, intermediate filaments and associated proteins.

Chromosome and chromatin organization: level organization, heterochromatin and euchromatin, metaphase chromosomes, telomere and its maintenance, C-value paradox. Cell division and cell cycle regulation

Unit II: DNA replication and gene expression

DNA replication in prokaryotes and eukaryotes, DNA damage and repair mechanisms, homologous and site-specific recombination.

RNA synthesis and processing: RNA polymerases, transcription activator and repressor, RNA processing, RNA editing, splicing, and polyadenylation, control of prokaryotic and eukaryotic gene expression at transcription

Protein synthesis and processing; Ribosome, genetic code, translational inhibitors, post-translational modification of proteins. Control of gene expression at translation level in prokaryotic and eukaryotic genes.

Unit III: Cell signalling and communication

Hormones and their receptors, cell surface receptors, G protein coupled receptors, signal transduction pathways, regulation of signalling pathways, bacterial and plant two component systems, light signalling in plants, regulation of hematopoiesis, general principles of cell communication, cell adhesion and role of different adhesion molecules, gap junctions, extracellular matrix, integrins, neurotransmission and regulation

Unit IV: Cancer, stem cells and embryonic development

Development and cause of cancer: Proto-oncogenes, oncogenes and tumor suppressor genes, therapeutic interventions of uncontrolled cell growth, apoptosis.

Gametes and fertilization: early development, embryonic induction, cell lineages, pattern formation, committed cells and late development, stem cells- types and applications, ethical issues associated with stem cell research

Lab: Practicals based on the theory content.

Reference Books and Suggested Readings: (Latest editions)

1. Alberts, B., Johnson, A., Lewis, J., Raff, M., Roberts, K., & Walter, P. (2018). Molecular biology of the cell. New York: Garland Science.
2. Lodish, H. F. (2019). Molecular cell biology. New York: W.H. Freeman.
3. Krebs, J. E., Lewin, B., Kilpatrick, S. T., & Goldstein, E. S. (2015). Lewin's genes XI. Burlington, MA: Jones & Bartlett Learning.
4. Cooper, G. M., & Hausman, R. E. (2019). The cell: A molecular approach. Washington: ASM ; Sunderland.
5. Hardin, J., Bertoni, G., Kleinsmith, L. J., & Becker, W. M. (2019). Becker's world of the cell. Boston: Benjamin Cummings.
6. Watson, J. D. (2016). Molecular biology of the gene (7th ed.). Menlo Park, CA: Benjamin/Cummings.

MBIO1C 003T: MICROBIOLOGY

Credit: 4

Course Objective: To introduce the students to basics and advanced aspects of microbes and their importance in industry and ecosystem functioning.

Course learning outcome: Students will be able understand:

1. The historical aspects and scope of Microbiology vis-a-vis challenges ahead.
2. The culturing of microbes under Laboratory conditions.
3. Importance of microbes in industry and ecosystem dynamics.

Unit I: Microbial characteristics & Diversity

Introduction to microbiology and microbes, history and scope of Microbiology. Classification of microorganisms: Microbial diversity-Fungi, Bacteria (Eubacteria & Archaea), viruses, viroids, prions.

Culture media for microbes, Cultural methods for isolation & enumeration of microbes, Bacterial growth- Batch and continuous culture, bacterial growth kinetics

Unit II: Viruses

Structure and classification, RNA & DNA viruses, bacteriophages; viral replication and life cycle, Corona viruses- characteristics, structure, replication and spread, control strategies & challenges; AIDS- Human immunodeficiency virus (HIV)- structure, spread and control, Human papilloma virus (HPV), Avian flu virus, Tobacco mosaic virus

Unit III: Microbial communities in natural ecosystems

Microbial communities; plant-microbe interactions, endophytes; Microbial diversity and natural products, Microbial niche and habitat. Extremophiles- General account of Acidophiles, Alkalophiles, Halophiles, Psychrophiles, Thermophiles, Hyperthermophiles, Barophiles,

Unit IV: Applied aspects of microbes

Role of microbes in agriculture: nitrogen fixers, biocontrol agents, Biofertilizers, Industrial applications of microbes- enzymes, biofuel, bioplastics, food and antibiotics, diseases caused by microbes, role of microbes in environment.

Lab: Practicals based on the theory content.

Reference Books and Suggested Readings: (Latest editions)

1. Willey, J. M., Sherwood, L., Woolverton, C. J., Prescott, L. M., & Willey, J. M. (2011). Prescott's microbiology. New York: McGraw-Hill.
2. Matthai, W., Berg, C. Y., & Black, J. G. (1999). Microbiology, principles and explorations. Boston, MA: John Wiley & Sons.
3. Raina M. Maier, Ian L. Pepper and Charles P. Gerba, Environmental Microbiology

ANALYTICAL TECHNIQUES (UMBIO10002T)

Credit: 4

Course Objectives: The course is meant to reiterate the principal concepts of several analytical techniques employed in general and advanced research in life sciences. Also, it will the students in scientific understanding of various analytical techniques and they can plan, execute the experiments and interpret their results accordingly.

Course learning outcomes: The learner will have a clear understanding of the subject related concepts. They can plan an experiment based on the knowledge imparted by this course and also enable them to analyze the outcomes of the experiments.

Unit I: Microscopy

A brief history of microscopy, principles, working and applications of Microscopy. Light microscopy: Bright field, Darkfield, phase contrast, fluorescence, Confocal microscopy. Electron microscopy: principle, working and applications of electron microscopy, Transmission electron microscope (TEM), Scanning electron microscope (SEM), Scanning tunnelling electron Microscopy (STEM), Atomic force microscopy (AFM)

Unit II: Chromatography

Principle, types and applications of different types of chromatography: Planar, Column, Partition and Adsorption Chromatography, Ion-exchange, Affinity, Hydrophobic Gel permeation chromatography; High-Pressure Liquid Chromatography (HPLC)/Fast protein liquid chromatography (FPLC), Ultra-performance liquid chromatography (UPLC), Gas Chromatography (GC).

Unit III: Electrophoresis and blotting tcehniques

Principle and applications of electrophoresis, Agarose gel electrophoresis, Polyacrylamide gel electrophoresis. SDS-Polyacrylamide gel electrophoresis, Native gel electrophoresis, Isoelectric focusing, Capillary electrophoresis, Immuno-electrophoresis, 2D gel electrophoresis, Disc gel electrophoresis; Gradient electrophoresis, Pulsed-field gel electrophoresis. Molecular hybridization Techniques- Southern blotting, Northern blotting and Western blotting; DNA fingerprinting.

Unit IV: Centrifugation

Basic principles and applications of centrifugation (RCF, Sedimentation coefficient etc); Types of centrifuges; Microcentrifuge, High speed and Ultracentrifuges; Types of rotors; fixed-angle rotors, vertical tube rotors and swinging-bucket rotors; Care and maintenance of rotors; Analytical centrifugation, Preparative centrifugation; Differential and density gradient centrifugation.

Unit V: Spectroscopy and Radiotracer techniques

Electromagnetic radiation, Absorption and emission spectrum, Beer-Lambert law. Applications. Principle, instrumentation and application of Single, double beam spectrophotometer, Fluorescence Spectrophotometer, FTIR spectrometer, differential scanning calorimetry (DSC) and Overview of – CD, NMR, Mass Spectrometry (MS), MALDI-TOF

Radio-isotopic Techniques: Introduction to Radioisotopes and their biological applications, Radioactive Decay – Types and Measurement. Principles and applications of GM Counter, Solid and Liquid Scintillation Counter, Autoradiography.

Reference Books and Suggested Readings: (Latest editions)

1. Principles and Techniques of Biochemistry and Molecular Biology (2010) 7th Edition by Keith Wilson. Fundamentals of Immunology: Paul Williams
2. Biochemical methods of analysis: Theory and applications. Saroj Dua and Neera Garg, Alpha Science Intl Ltd; 1st Edition (2010)
3. Experimental Biochemistry - 3rd edition, Switzer, R.L. & Garrity, L. F. W. H. Freeman & Company.
4. Biochemistry Laboratory: Modern Theory and Techniques, Rodney F. Boyer, Pearson Prentice Hall; 2nd Edition (2010).
5. Foundations of Spectroscopy- Duckett, S. & Gilbert, B., Oxford University Press
6. Physical Biochemistry: Principles and Applications by David Sheehan 2nd Edition, John Wiley & Sons (2009)

PROTEIN ENGINEERING (UMBI010003T)

Credit: 2

Course Objectives: The aim of this course is to an overview and impart a conceptual understanding of protein structure, and protein folding pathways and to introduce techniques developed over recent years to study proteins. To create a deeper understanding of the significance of prediction, design of protein structures and strategies commonly used in protein engineering

Course learning outcome: It will give an understanding and explore protein structure and characteristics that lay the foundation to protein engineering studies. It will help students to acquire knowledge of protein folding mechanisms and use of bioanalytical techniques. It will provide an advanced understanding of the core principles and applications of various important techniques employed for protein structure conformation studies.

Unit I: Basics of protein structure and function

Proteins-basic building blocks, primary, secondary, tertiary and quaternary structure of protein, protein folding, classification of proteins based on their functions. Role of proteins in health and disease, food / feed, agriculture, industry, environment.

Unit II: Tools for protein engineering

Basics of gene cloning and Recombinant DNA technology, site-directed mutagenesis, PCR/RTPCR, Recombinant protein expression, Web based resources for Protein structure on the world wide web: different databases and their uses-PDB, SCOP, CATH. Applications of bio-analytical techniques to study proteins, Spectroscopic properties; Applications of UV-visible-Fluorimetry, CD, NMR, X-Ray diffraction to study protein conformations.

Unit III: Application of Protein engineering

Protein engineering applications: food, detergent, environmental, medical, industrial enzymes.
Case study: engineered chimeric antibodies. case study: engineered lipase for improved stability in methanol.

Reference Books and Suggested Readings: (Latest editions)

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

BASICS OF BIOSTATISTICS (UMBI0100047) Credit: 2

Course Objectives: This course is designed to make students familiar with the basic tools and techniques of biostatistics.

Course learning outcome: After completion of this courses, the student will know the importance of sampling and sampling techniques. How and where to collect the data and how to present it. What statistical measures are and why are they significant. What hypothesis testing means in biostatistics. How to perform different statistical tests.

Unit I: Biological data

Introduction to statistics and its biological application, function and limitation of statistics. Data structure- univariate, bivariate and multivariate data; data sources and data collection.

Data Presentation- Brief description and tabulation of data and its graphical representation. Data analysis tools, sampling techniques in Biostatistics and its significance.

Unit II: Statistical measurements and hypothesis

Measure of central tendency and description: arithmetic Mean, Mode, Median Measures of dispersion- Range, Standard deviation, Variance.

Types of errors and level of significance and hypothesis and statistical decision making

Unit III: Tests of significance

Tests of significance: T test, Chi-Square tests, ANNOVA, Correlation analysis- types, positive, negative, simple, partial, multiple, linear and non-linear correlation.

Regression analysis- Introduction, significance and applications, Kinds of regression analysis, simple and linear regression.

Reference Books and Suggested Readings: (Latest editions)

1. Bland, M. (2015). An introduction to medical statistics. Oxford University Press (UK).
2. Eason, G., Coles, C. W., &Gettinby, G. (1980). Mathematics and statistics for the bio-sciences. Ellis Horwood Ltd..
3. Douglas, C. M. (2001). Design and analysis of experiments.
4. Agresti, A. (2003). Categorical data analysis (Vol. 482). John Wiley & Sons.
5. Prem S. Mann; Introductory Statistics; 6th Edition; Wiley; 2006.

INTELLECTUAL PROPERTY RIGHTS, BIOSAFETY AND BIOETHICS (UMBI0100047) (2 Credits)

Course Objectives: This course is designed to make students familiar with the basic aspects of IPRs, biosafety and bioethics.

Course learning outcome: After completion of this courses, the student will know about IPRs, patent filing, patent laws. The students will know about bio safety regulators and bioethics.

Unit I: Introduction to Intellectual Property

Introduction and history of intellectual property system in India. Intellectual property; trade secrets, copyright, trademarks, choice of intellectual property protection GATT and TRIPS.

Patents: meaning of patent, types, laws, Indian Patent Act 1970 & recent amendments; rights of patent and other owners of patents, obligations of patentee, patent specifications. Patenting of biological material: International conventions and cooperation, Protection of GMOs IP as a factor in R&D Patents for higher plants and animals.

Unit II: Biosafety and risk assessment

Biosafety: Introduction; Introduction to Biological Safety Cabinets; Primary Containment for Biohazards; Biosafety Levels. Biosafety guidelines - Government of India; Roles of Institutional Biosafety Committee; RCGM; GEAC etc. for GMO applications in food and agriculture; Environmental release of GMOs.

Risk Analysis, Risk Assessment; Risk management and communication; Overview of National Regulations and relevant International Agreements including Cartegana Protocol. Issues and challenges- Cultural, ethical, social and economic issues

Unit III: Bioethics

Ethical conflicts in biological sciences - interference with nature, bioethics in health care - patient confidentiality, informed consent, euthanasia, artificial reproductive technologies, prenatal diagnosis, genetic screening, gene therapy, transplantation.

Bioethics in research – cloning and stem cell research, human and animal experimentation, animal rights/welfare, agricultural biotechnology - Genetically engineered food, environmental risk, labeling and public opinion. Ethical issues in patenting, publishing, procedure for registration, offences, penalties. ,

Reference Books and Suggested Readings: (Latest editions)

1. Ganguli, P. (2001). Intellectual property rights: Unleashing the knowledge economy. New Delhi: Tata McGraw-Hill Pub.
2. International Union for the Protection of New Varieties of Plants. http://www.upov.int
3. National Portal of India. http://www.archive.india.gov.in

SEMESTER-II

MBIOIC0004T **GENETICS** Credit: 4

Course Objectives : This course is designed to make students familiar with the field of basic and advanced genetics.

Course learning outcome: Provides students with an understanding to: 1 Know the organization of genome and the concept of genes. 2. Learn about cytogenetic and related techniques. 3. How the genetic information is inherited in living organisms. 4. Causes of variation in the genetic material and genetics of human diseases. 5. Use of nucleotide sequences in molecular phylogenetics.

Unit I: Basic concepts of genetics and genome organization

Mendelian genetics- laws of inheritance and exceptions, Genotypes and Phenotypes, Chromosomal inheritance, Cytoplasmic inheritance, Sex-linked inheritance, Sex limited and sex influenced characters, Quantitative inheritance, Incomplete dominance, Co-dominance, Genome imprinting, Pleiotropy.

Concept of genes, gene structure, gene loci, split gene pseudogenes, non-coding genes, and jumping genes, allele, pseudoallele, multiple alleles, lethal alleles, epistasis genes.

Organization of nuclear and organellar genomes, Molecular markers: RAPD, RFLP, AFLP, SSR, FISH, SNPS, Repetitive DNA-satellite DNA and interspersed repeated DNAs. Transposable elements, LINES, SINES, Alu family and their application in genome mapping.

Unit II: Cytogenetics

Chromosomal aberrations, Polyploidy, aneuploidy, chromosomal rearrangements - deletion, duplication, inversion, and translocation.

Mutation types, and causes; mutant types – lethal, conditional, biochemical, loss of function, gain of function, germinal verses somatic mutants.
Chromosome preparations, karyotyping, banding, chromosome, labeling, in-situ hybridization, chromosome painting; types of chromosome banding, uses of chromosome banding in cytogenetics.

Unit III: Population genetics

Introduction to the elements of population genetics: genetic variation, genetic drift, neutral evolution, mutation selection, balancing selection, Hardy- Weinberg equilibrium, population bottlenecks, migrations, spatial variation & genetic fitness.

Molecular population genetics, molecular evolution (neutral theory, punctuated equilibrium), DNA-based phylogenetic trees.

Linkage: Concepts, recombination, gene mapping in prokaryotes and eukaryotes, linkage disequilibrium.

Unit IV: Human and microbial genetics

Pedigree analysis, lod score for linkage testing, genetic disorders (single gene and multifactorial).
Methods of genetic transfers–transformation, conjugation, transduction and sex-duction, mapping genes by interrupted mating, fine structure analysis of genes.

Lab: Practicals based on the theory content.

Reference Books and Suggested Readings: (Latest editions)

1. Pierce, B. A. (2005). Genetics: A conceptual approach. New York: W.H. Freeman.
2. Hartl, D. L., & Jones, E. W. (1998). Genetics: Principles and analysis. Sudbury, MA: Jones and Bartlett.
3. Tamarin, R. H., & Leavitt, R. W. (1991). Principles of genetics. Dubuque, IA: Wm. C. Brown.
4. Concepts of Genetics by Klug and Cummings (latest edition).
5. Genes by Benjamin Lewis (latest edition)
6. Introduction to Genetics by T.A. Brown (latest edition)
7. iGenetics by Peter J Russell (latest edition)

MBIOIC005 T/BIOINFORMATICS

Credit: 4

Course Objective: To introduce the students to basics and advanced aspects of bioinformatics and its significance in research and drug designing.

Course learning outcome: Students will be able understand

1. The basic aspects of bioinformatics.
2. The biological data and its analysis *in silico*.
3. Role of bioinformatics in drug designing.
4. Significance of bioinformatics in prediction of protein structures *in silico*.
5. Scope and future prospects of bioinformatics.

Unit I: Introduction & biological databases

Bioinformatics- Goals, Scope, Applications and Limitations; Database and its types, biological background for sequence analysis; biological databases, Information retrieval from biological databases, resources on web; database mining tools.

Unit II: Sequence Alignment

DNA sequence analysis: Nucleic acid sequence databank - NCBI and EMBL. Protein sequence database NBRF-PIR, SWISSPROT, database searching, sequence alignment, pairwise alignment techniques, Motif discovery and gene prediction, Assembly of data from genome sequencing using various bioinformatics tools, NGS data analysis

Multiple sequence analysis; flexible sequence similarity searching packages: use of CLUSTAL W and CLUSTAL X for multiple sequence alignment; Submitting DNA protein sequence to databases

Unit III: Molecular Phylogenetics

Introduction to Phylogenetic analysis, Gene phylogeny versus species phylogeny, forms of tree presentation, Choice of molecular markers, Alignment, Multiple substitutions.

Phylogenetic tree construction methods and programmes- Distance-based methods, optimality-based and character-based methods, phylogenetic tree evaluation.

Unit IV: Structural Bioinformatics

Protein structure: Basic structural principles, building blocks of proteins, motifs of protein structures, alpha domain structures, alpha/beta structures.
Protein structure prediction: protein folding and model generation, secondary structure prediction; homology modeling, validation, sequence-based methods of structure prediction, prediction using inverse folding, fold prediction, significance analysis, scoring techniques, sequence-sequence scoring; protein function prediction, elements of *in- silico* drug design. Protein 3D structures and molecular dynamics

Lab: Practicals based on the theory content.

Reference Books and Suggested Readings: (Latest editions)

1. Jin Xiong, Essential Bioinformatics (2020), Cambridge University Press
2. Lesk, A. M. (2002). *Introduction to bioinformatics*. Oxford: Oxford University Press.
3. Mount, D. W. (2001). *Bioinformatics: Sequence and genome analysis*. Cold Spring Harbor, NY: Cold Spring Harbor Laboratory Press.
4. Baxevanis, A. D., & Ouellette, B. F. (2001). *Bioinformatics: A practical guide to the analysis of genes and proteins*. New York: Wiley-Interscience.
5. Pevsner, J. (2015). *Bioinformatics and functional genomics*. Hoboken, NJ.: WileyBlackwell.
6. Bourne, P. E., & Gu, J. (2009). *Structural bioinformatics*. Hoboken, NJ: Wiley-Liss.
7. Lesk, A. M. (2004). *Introduction to protein science: Architecture, function, and genomics*. Oxford: Oxford University Press.
8. Campbell, A. M., &Heyer, L. J. (2003). *Discovering genomics, proteomics, and bioinformatics*. San Francisco: Benjamin Cummings.

MBIOIC0067T / GENETIC ENGINEERING

Credit: 4

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

Course learning outcome: The impact of genetic engineering 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 genetic engineering

Impact of genetic engineering on modern society; general requirements for performing a genetic engineering experiment; DNA modifying enzymes; restriction endonucleases, DNA ligase, polynucleotide kinase, alkaline phosphatase. Labelling of DNA: nick translation, random priming, radioactive and non-radioactive probes, Blotting techniques: southern, northern and western blotting and colony hybridization.

Unit II: Cloning and expression vectors

Plasmids and Bacteriophages based vectors: PUC, Lambda phage, M13 Phage, Cosmids, phagemids vectors, Artificial chromosome vectors (PACs, BACs, YACs).

Expression vectors; pMal; GST; pET-based vectors; Protein purification; His-tag; GST-tag; MBP-tag; Intein-based vectors; Mammalian expression and replicating vectors; Inclusion bodies, Baculovirus expression system, plant-based vectors, yeast vectors, shuttle vectors.

Unit III: Gene manipulation and PCR techniques

Insertion of foreign DNA into host cells: transformation, electroporation, transfection. Construction of libraries; isolation of mRNA and total RNA. Reverse transcriptase and cDNA synthesis. cDNA and genomic libraries. Study of protein-DNA interactions: electrophoretic mobility shift assay; DNase footprinting. Chromatin immunoprecipitation.

Principles of PCR: primer design, types of PCR: multiplex, nested; reverse-transcription PCR, real time PCR, touchdown PCR, colony PCR. Cloning of PCR products, PCR in molecular diagnostics; viral and bacterial detection.

Unit IV: Gene silencing and genome editing technologies

Gene silencing techniques, introduction to siRNA, principle and application of gene silencing; CRISPR Cas, gene knockouts and gene therapy. Transgenics - gene replacement; gene targeting; creation of transgenic and knock-out mice; disease models

Production of recombinant therapeutic products, applications of genetic engineering in industry, agriculture, medicine, environment and forensic science

Lab: Practicals based on the theory content.

Reference Books and Suggested Readings: (Latest editions)

1. S.B. Primrose, R.M. Twyman and R.W.Old; Principles of Gene Manipulation. 7th Edition, S.B. University Press, 2006.
2. J. Sambrook and D.W. Russel; Molecular Cloning: A Laboratory Manual, Vols 1-3, CSHL, 2001.
3. Brown TA, Genomes, 3rd ed. Garland Science 2006.
4. Technical Literature from Stratagene, Promega, Novagene, New England Biolab etc.
5. Krebs, J. E., Lewin, B., Kilpatrick, S. T., & Goldstein, E. S. (2014). Lewin's genes XI. Burlington, MA: Jones & Bartlett Learning.
6. Hardin, J., Bertoni, G., Kleinsmith, L. J., & Becker, W. M. (2012). Becker's world of the cell. Boston: Benjamin Cummings.
7. Watson, J. D. (1987). Molecular biology of the gene (7th ed.). Menlo Park, CA: Benjamin/Cummings.

: MEDICAL BIOTECHNOLOGY AND DIAGNOSTICS (UMBIO10005T) Credit: 4

Course objective: The objective of the course is to make students understand the role of basic and advanced molecular techniques for improved diagnosis and prognosis of human genetic and infectious diseases.

Course learning outcome: On completion of the course students will be able to understand various medical diagnostic techniques and their significance in disease biology

Unit I: Introduction to disease biology

Common bacterial, viral, fungal and parasitic infections; Recent pandemics and epidemics; Chromosomal, Single gene, Infectious disorders, Methods of culturing and assaying: bacterial, viral and parasitic infections; retroviruses; Hospital-acquired (nosocomial) infections, immune compromised states;

UNIT II: Good Laboratory practices

Quality control, GMP, records; biohazard hoods; containment facilities, BSL 2, 3, 4 facilities and their significance

UNIT III: Molecular diagnostics

History and scope of molecular diagnostics; Chromosomes, Cytogenetic Analysis: karyogram analysis, Fluorescence in situ hybridization (FISH), ELISA, Immunodiagnosis, dot hybridization; PCR and RT PCR-based detection of pathogens, Microarray technology- genomic and cDNA arrays, application to disease diagnosis

UNIT IV: Advanced diagnostic techniques

Approaches to diagnose inborn errors of metabolism, haemoglobinopathies and glycogen storage disorders, FACS, Lab-on-a-Chip approach for molecular diagnosis, Introduction to SELDI-TOF and diagnostic proteomics; Molecular detection of inherited diseases like Sickle cell disorders, Hemophilia A, Huntington chorea, Tay-Sachs disorder, CRISPR Cas based diagnosis

UNIT V: Biomarkers in disease prediction

Introduction to disease markers, FDA definition of disease biomarkers, Difference between diagnostic and prognostic biomarkers, sources for disease markers, Role of predictive biomarkers in prognosis of diseases, Emerging disease biomarkers (eg. Metabolic markers), sepsis, diabetes and cancer (eg. Breast cancer) and molecular oncologic prediction.

Reference Books and Suggested Readings: (Latest editions)

1. Brooker, R. J. Genetics: Analysis & Principles. New York, NY: McGraw-Hill.
2. Biology of Disease, by Nessar Ahmed, Maureen Dawson, Chris Smith, Ed Wood, Publisher: Taylor & Francis; ISBN-13: 978-0748772100
3. Gordis, L. Epidemiology. Third edition. Philadelphia: Elsevier Saunders. (The second edition is also acceptable.
4. Glick, B. R., Pasternak, J. J., & Patten, C. L. Molecular Biotechnology: Principles and Applications of Recombinant DNA. Washington, DC: ASM Press.
5. Coleman, W. B., & Tsongalis. G. J. Molecular Diagnostics: for the Clinical Laboratorian. Totowa, NJ: Humana Press.
6. Molecular Diagnostics: Techniques and Applications for the Clinical Laboratory Wayne W. Grody, Robert M. Nakamura, Frederick L. Kiechle, Charles Strom, Publisher: Academic Press; ASIN: B003FQM2OI, 1st Edition.

Credit: 4

UMBIO10006T/ENZYME TECHNOLOGY

Course objective: To understand the fundamental concepts of enzymes, enzymatic reactions, and parameters affecting enzyme kinetics and to study its application in various industries.

Course learning outcome: This course is designed to develop an understanding of an applied aspect of enzymes in the industry. The course focuses on techniques used in industry for the improvement and production of industrial enzymes. The students will acquire a comprehensive knowledge and understanding of enzymes and their application in various industries.

UNIT I. Introduction and classification of enzymes

Historical highlights of enzyme technology, Bio- and Chemocatalysts – Similarities and Differences; Nomenclature, Characteristics, and Classification of Enzymes. Type of Enzyme- Constitutive enzyme, induced enzymes, Intracellular and

Extracellular enzymes; Effects of substrate, pH, temperature and inhibitors on enzyme activity; Enzyme Kinetics Parameters using Michaelis-Menten and Lineweaver-Burk.

UNIT II. Industrial enzyme production and applications

Industrial applications of enzymes in pharmaceutical, detergent, food, leather, dairy, waste treatment and chemical industry.

Isolation, purification and Large-scale production of enzymes, principles and applications of the techniques involved for enzyme purification- gel filtration, ion- exchange and affinity chromatography, centrifugation and electrophoretic techniques. Genetic engineering for microbial enzyme production.

UNIT III. Enzyme Immobilization

Introduction, methods, applications, advantages and disadvantages. Immobilization techniques, i.e, Adsorption, entrapment, microencapsulation, covalent binding and cross-linking.

Immobilized enzyme reactors- Continuous flow, Packed bed, Continuous flow stirred tank and Fluidized bed reactors, large scale enzyme production, case study for the manufacture of commercial enzymes and applications.

UNIT IV. Enzyme based biosensors and their applications

Enzyme-based biosensors and types- electrochemical, thermometric, optical, piezoelectric, whole-cell and immune biosensors. Applications of biosensors in industry, healthcare and environment.

UNIT V. Enzyme engineering

Protein engineering strategies to improve enzyme stability, specificity and activity, Advanced concepts and strategies, high throughput screening and assay techniques, directed evolution of approach, Rational protein design approach, Case studies of few relevant engineered enzymes, Engineering thermostable and cryostable enzymes and Site-directed mutagenesis.

Reference Books and Suggested Readings: (Latest editions)

1. David Lee Nelson, Michael M. Cox. Lehninger Principles of Biochemistry. WH Freeman;7th ed. (2017)
2. Trudy McKee, James R. McKee Biochemistry: The Molecular Basis of Life, 6th Edition Oxford University Press, (2015).
3. Thomas M. Devlin, Textbook of Biochemistry with Clinical Correlations. 7th Edition, John Wiley & Sons (2010)
4. Cornish-Bowden, A. Principles of Enzyme Kinetics. United Kingdom: Butterworths. (1976).
5. Fundamentals of Enzyme Kinetics by Athel Cornish-Bowden; Portland Press. (20113)
6. Fundamentals of Enzymology by Nicholas Price and Lewis Stevens; Oxford University Press. (1989)

UMBIO10007T OMICS IN BIOTECHNOLOGY

Credit: 2

Course Objectives: The aim of this course is to provide a detailed understanding of major Omics technologies such as genomics, transcriptomics, proteomics and metabolomics etc. To provide knowledge about the data analysis of next-generation sequencing. To provide an understanding of applications of the Omics technologies.

Course learning outcomes: After completing this course, a student is expected to understand modern Omics technologies in the field of biotechnology. A better understanding of data analysis generated through next-generation sequencing and applications of the Omics technologies in different industries.

Unit I Genomics and transcriptomics

Introduction to omics techniques, Integration of different omic techniques for various applications in medical, agriculture, and other branches of Biotechnology, History of DNA sequencing, DNA sequencing, Next Generation Sequencing, Human genome sequencing project –advances and implications

Tools for genomics and metagenomics, Prospecting for novel genes from metagenomes and their biotechnological applications. tools for transcriptomics; Transcriptome profiling: (Microarray, ChIP, SAGE).

Unit II Proteomics

Introduction to proteome and proteomics, Separation technologies in Proteomics, Bottom-Up Versus Top-Down Proteomics, Protein level separations and analysis (Chromatography, Gel-based, Spectroscopic), Gel-based and gel-free techniques in proteomics, Protein expression analysis by SDS, 2-DE. Peptide level separations: MALDI-TOF, ESI, Quantitative proteomics from MS and MS/MS Data. Mass spectrometry-based Proteomics, Tandem mass spectrometry, peptide mass fingerprinting, Interactomics

Unit III Metabolomics

Introduction to metabolomics, Targeted vs non-targeted metabolomics, Basics tools and techniques used for metabolome characterization and analysis, Potential and applications of metabolomics, Introduction to databases and software used for the analysis of metabolomics data, methods of metabolite identification and fingerprinting.

Techniques in metabolomics (HPLC, GCMS, LCMS), Nuclear magnetic resonance spectroscopy and mass spectrometry in metabolomics. Applications of metabolomics in medical and agriculture biotechnology.

Reference Books and Suggested Readings: (Latest editions)

1. Watson, J. D. (2004). Molecular biology of the gene (Vol. 1). Pearson Education India

2. Alberts, B., Bray, D., Lewis, J., Raff, M., Roberts, K., & Watson, J. D. (1994). Molecular biology of the cell. Garland Publishing, New York.

3. Brown, T. A. (2016). Gene cloning and DNA analysis: an introduction. John Wiley & Sons. Malacinski, G. M. (2005). Essentials of molecular biology. Jones & Bartlett Learning.

SEMESTER-III

MBIO2C001T: ANIMAL AND PLANT BIOTECHNOLOGY **Credit: 4**

Course Objectives: To introduce the basic principles and handling of plant/animal tissue culture and gene transfer technology in plants and animals.

Course Learning Outcomes: Students should be able to gain fundamental knowledge of transgenics and their applications in different fields.

Unit I: Introduction to plant tissue culture

History of plant tissue culture, Requirements of tissue culture lab, Nutrient media – macronutrients and micronutrients, media additives; Plant growth regulators; Initiation of callus cultures and cell suspension cultures; Organogenesis and embryogenesis, Embryo culture and embryo rescue; Protoplast culture and fusion, Development of somatic hybrids and cybrids and their applications, Somaclonal variation, germplasm cryopreservation.

Unit II: Applications of plant biotechnology

Application of plant transformation for productivity and performance; herbicide resistance, insect resistance; Bt. Genes, non-Bt like protease inhibitors, Disease resistance, abiotic stress; terminator gene technology, Chloroplast transformation: advantages, vectors, success with tobacco and potato, Transgenics for antibodies, Transgenics for Biopharmaceuticals, Biofortification, Transgenic plants as Bioreactor, Biodegradable plastics

UNIT III: Introduction to animal tissue culture

Cell culture equipment and aseptic conditions, Different tissue culture techniques including primary and secondary cultures; Monolayer and Suspension cultures, Different types of cell culture media, serum and serum free media, Behavior of cells in cell culture conditions and their growth pattern, measurement of cell viability and cytotoxicity, Organ, Organotypic and Histotypic culture; three dimension culture; concept and importance of Tissue engineering; Stem cell culture and its applications

Unit IV: Applications of animal biotechnology

Commercial applications, Cell based manufacturing (vaccines), toxicity testing and tissue engineering, *in vitro* testing of drugs; production of pharmaceutical proteins, Somatic cell cloning and hybridization; transfection and transformation of cells, Transgenic animal production, animals as bioreactors and application in expression of therapeutic proteins, Ethical concerns in embryonic stem cell research

Lab: Practicals based on the theory content.

Reference Books and Suggested Readings: (Latest editions)

1. Winnaker, E.L. (1987). From genes to clones: Introduction to Gene Technology. VCH, Germany.
2. Old, R.N. and Primose, S.B. Principles of Gene manipulation
3. Razdan,M.K. (2005). An introduction to plant tissue culture, Oxford and IBH.
4. Chawla, H.S. (2003). Biotechnology in Crop Improvement. International book Distributing Co. Lucknow.
5. Freshney, R.I (2007) Culture of animal cells: A manual of Basic Technique. Jonh Wiley and Sons Inc., USA.
6. Gordon I. 2005. Reproductive Techniques in Farm animals. CABI.
7. Portner R. 2007. Animal Cell Biotechnology. Humana Press.

MBIO2C002T: IMMUNOLOGY & IMMUNOTECHNOLOGY **Credit: 4**

Course Objectives: This course is designed to make students familiar with the field of immune system, its components and how the immune system works. Besides the basic knowledge of the immune system, this course also provides an opportunity to learn about the therapeutic applications of the immune system and how to perform various immunology related test for diagnostic purpose.

Course Learning Outcomes: After completion of the course, the student will be familiar with:

1. Components of an immune system
2. Difference between innate and adaptive immunity

3. Role of vaccination against pathogens
4. Disorders related to immune system
5. Routinely used immunology test in diagnostics.

Unit I: Basic concepts of Immunology

Properties and overview of the immune system. Components of innate and adaptive immunity.

Cells and tissues of the immune system: Haematopoiesis, primary lymphatic organs, NK cells, dendritic cells, macrophages, T and B lymphocytes.

Immunotolerance, Hypersensitivity, autoimmunity and autoimmune diseases, major histocompatibility complex (MHC) and Toll like receptors.

Unit II: Antigens and Immunoglobulins

Characteristics of antigens and their immunogens, epitopes, haptens, activation and maturation of B-lymphocytes, lymphocyte cell surface receptors/proteins.

Antigen Recognition: MHC molecules, Antigen processing and presentation, recognition of endogenous and exogenous antigens

Basic structure of Immunoglobulins and their classification, antibody diversity by gene recombination, production and maturation of antibodies and self/nonself-discrimination.

Antigen-antibody interaction, Cross reactivity, Generation of immunological diversity, Complement system- component, properties and functions.

Unit III: Applied aspects of immunology

T and B cell activation and differentiation; Mode of recognition of target cells by CTL and NK cells and mechanism of killing; Antibody-dependent cell-mediated cytotoxicity (ADCC). Cytokines; properties, receptors and therapeutic uses; Development of Vaccines- Principles of vaccination, primary and secondary responses, conventional vaccines- attenuated, killed organisms and subunit vaccines. Modern vaccines- recombinant vaccines, DNA and mRNA vaccines, plant-based vaccines, T cell based vaccine.

Unit IV: Immunological Techniques

Antibody generation, detection of molecules using ELISA, RIA, Western blot, immunoprecipitation, fluocytometry, Agglutination, Immuno-diffusion and immune-electrophoresis, Immunoblotting, ELISA; Flow cytometry-technique and applications, Monoclonal antibodies and hybridoma technology; Immune response during bacterial, viral and parasitic infections.

Lab: Practicals based on the theory content.

Reference Books and Suggested Readings: (Latest editions)

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. P[illegible] W. E. (1993). Fundamental immunology. New York: Raven Press.
5. Go[illegible]ng, J. W. (1986). 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.

[illegible]: **FOOD BIOTECHNOLOGY(UMBIO10008T)** **Credit: 4**

Course Objectives: This course is designed to make students familiar with the role of biotechnology in food production, quality, processing and safety.

Course Learning Outcomes: After completion of the course, the student will be familiar with:

1. Relationship between food and health, balanced diet and different food components.
2. Role of microbes in fermented foods.

3. Deficiency diseases.
4. Food processing, preservation and safety.
5. Different food laws for food safety.

Unit I: Introduction to food and its properties

The relationship between food and health; Food-definition, five food groups, balanced diet, fermented foods and role of microbes in fermentation.

Nutrition deficiency diseases.–Nutrition related diseases and relevant functional foods- Atherosclerosis, cardiovascular disease, obesity, Diabetes mellitus, Kwashiokar, scurvy, Beri-beri.

Unit II: Prebiotics and Probiotics

Prebiotics: definition, types of new prebiotics and their bifidogenic effects, health effects of prebiotics and synbiotics

Probiotics; characteristics of probiotics, potential health benefits, advantages and disadvantages. Lactic acid bacteria; *Lactobacillus, Bifidobacterium, Lactococcus, and Streptococcus etc.* Lactic acid fermented foods.

Unit III: Functional Foods

Functional food and its categories: Microorganisms for functional food, Genetically modified (GM) foods and their regulations, nutraceuticals in foods and its applications, role of biotechnology in food-building up of high value proteins

Unit IV: Food processing and preservation

Scope and importance of food processing; Processing of pulses, cereals, and oilseeds; Technology used in food processing; baking, milk products, cheese-making and alcohol production.

Food spoilage and preservation: general principle of spoilage, microbial toxins (endotoxins and exotoxins), contamination and preservation, factors affecting spoilage. Methods of food preservation (thermal processing, cold preservation, chemical preservatives & food dehydration).

Unit V: Food quality and safety

Biological controls and monitoring of food quality, packaging of food: Need & requirement of packaging, containers for packaging (glass, metal, plastics, molded pulp and aluminium foil), dispensing devices. Food adulteration detection.

Food safety: introduction to food laws in force in India, importance and functions of quality control. HACCP, Food and hygiene regulations. International and National food laws. USFDA/ISO-9000 and FSSAI.

Reference Books and Suggested Readings: (Latest editions)

1. Shankuntala Manay N and Shadaksharaswamy M, Foods: facts and principles, 3rd edition, New Age International Publishers, India, 2009.
2. Sri Lakshmi B, Food Science, New Age International Publishers, India, 2007.
3. Adams, M.R. and Moss M.O., Food microbiology, New Age International Publishers, India, 2008.
4. Anthony Pometto, Kalidas Shetty, Gopinadhan Paliyath, Robert E. Levin, Food biotechnology,2nd edition, CRC Press, 2006.
5. Bruce J German and Jean-Richard Neeser, Bioprocesses and Biotechnology for Functional Foods and Nutraceuticals. CRC Press, 2004.

. FERMENTATION & BIOPROCESS TECHNOLOGY (UMBI010009T) **CREDIT: 4**

Course Objectives:

The objectives of this course are to provide fundamental concepts of different fermentation and microbial bioprocess strategies and their related applications. To provide general information about the operation of various types of bioreactors, upstream and downstream processing. To overcome the challenges of the new and emerging areas of biotechnology industry.

Course Outcome:

After completing this course, a student is expected to understand the basic concept of fermentation strategies. Understand design and operations of a process for bio-based products; Appreciate the relevance of microorganisms from an industrial context; Give an account of structure, design and operations of various bioreactors; able to formulate bio-process media for commercial production of microbial metabolites and biomass. Critical analyse and improve bioprocess from a commercial point of view.

Unit I: Introduction to Fermentation and Bioprocess technology

Introduction and history of fermentation: Concept of fermentation vs bioprocess, Different types of fermentations-Batch, Fed-batch and continuous fermentation, Factors affecting fermentation, Isolation, screening, characterization and preservation of industrially important microorganisms, Principles of microbial growth and culture systems, methods of strain improvement and optimization of physiological parameters and media formulation for fermentation processes, Sterilization of culture media, an overview of submerged and solid-state fermentation, advantages & disadvantages of solid substrate and liquid fermentations.

UNIT II: Bioreactors

Types and operation of Bioreactors, Bioreactor- structure and applications of a laboratory bioreactor; Different types of bioreactors like-Stirred tank reactor, air-lift, packed bed, fluidized and bubble column- their structure and applications; Bioreactor configuration and operation, Bioprocess control and monitoring variables-oxygen requirement and uptake rate, volumetric oxygen transfer rate (Kla), measurement of KLa, power requirement for agitation, pressure and pH, medium rheology. Flow measurement and control, manual and automatic PID control. Limitations of bioreactors, Application and the role of computers in bioprocess.

Unit III: Downstream processing

Introduction, recovery of microbial cells and products, Solid-liquid separation, Membrane filtration, Types of filtration processes; microfiltration, reverse osmosis and ultra-filtration, precipitation, Centrifugation, ultrafiltration, Cell disruption - mechanical, enzymatic, and chemical methods. Extraction-liquid-liquid extraction and aqueous two-phase extraction. Electrophoresis, Chromatography, membrane separation processes, drying, spray drying, Freeze drying and crystallization, storage and packing.

Unit IV: Production and Processing

Production of health care products: Antibiotics-Penicillin, Streptomycin etc. Pharmacologically active and related microbial products, Production strategies for Organic solvents: ethanol, acetone and butanol; Organic solvents: citric acid, lactic acid. Food and beverage products: modern brewing technology, Production of wines, whisky, beer, amino acids, vitamins, single-cell protein, baker's yeast, microbial biomass, industrial enzymes & cheese.

Unit V: Economics of fermentation processes:

Strategies for introducing economy in bioprocessing, Isolation of micro-organisms of potential industrial interest; strain improvement; market analysis. cost analysis for R & D decision making, Equipment and plant costs; media; sterilization, heating and cooling; aeration and agitation; bath-process cycle times and continuous cultures Recovery costs; water usage and recycling; effluent treatment and disposal.

Reference Books and Suggested Readings: (Latest editions)

1. Sastry, A.S. & Bhat, K.S. (2018). Essentials of Practical Microbiology. Jaypee Brothers Medical Publishers, New Delhi.
2. Bioprocess Engineering: Basic Concepts (2017) 3rd ed. Shuler, ML, and Kargi, F. Pearson Prentice Hall, ISBN: 0137062702.
3. Principles of Fermentation Technology (2016) 3rd ed. Stanbury P, Allan Whitaker, Stephen Hall. Imprint (Butterworth-Heinemann), ISBN: 9780080999531.Schuler ML and Fikret Kargi, 2002, Bioprocess Engg: Basic Concepts, Prentice Hall, NJ.
4. Biochemical Engineering Fundamentals (2013) 5th reprint J. E. Bailey and Ollis, D. F. McGraw- Hill Education (India) Pvt Ltd., ISBN: 0070701237.
5. El-Mansi, EMT., Bryle, CFA., Demain, A., Allman, A.R. 2012. (Ed: 3). Fermentation Microbiology and Biotechnology. CRC Press.
6. Bioreactors Analysis and Design (2011) Panda T, Tata McGraw Hill, ISBN: 978-0-07-070424-4.
7. Biotechnology for Agro-Industrial Residues Utilisation, Springer, Netherland (2009
8. Bailley, J E and Ollis, F. 1986, Biochemical Engg Fundamentals, McGraw Hill, New York.

9. Wulf Crueger and Anneliese Cruger, 2004, Biotechnology: A Textbook of Industrial Microbiology, 2nd Edn., Panima Publishing Co.
10. Sharma, P.D. (2016). Microbiology. Rastogi Publishers, Meerut, U.P.

: ECOLOGY AND ENVIRONMENTAL BIOTECHNOLOGY (UMBIO100101T) Credit: 4

Course Objective: To introduce the students to basics and advanced aspects of ecosystem, ecological principles and role of microbes in combating environmental problems.

Course learning outcome: Students will be able understand:

1. The environmental factors controlling and influencing the global warming and climate change.
2. The microbe-microbe and plant –microbe interactions operating in the soil ecosystems.
3. Role of microbes in bioremediation and sustainability.
4. Exploitation of beneficial microbes for industry, agriculture and human welfare.

Unit I: Environment, Habitat and Microbial Niche

Physical and biotic aspects of environment, biotic and abiotic interactions, concept of habitat and niche, fundamental and realized niche, Microbial niches, elements of biodiversity and conservation strategies.

Unit II: Population Ecology and species interactions

Characteristics of population, population growth curves, population regulation, life history strategies (r and k selection), types of species interactions, interspecific competition, herbivory, carnivory, pollination, symbiosis

Unit III: Community Ecology, Succession and Ecosystem

Nature of communities, community structure and attributes, edges and ecotones, Ecological succession-types, mechanism, changes involved in succession, concept of climax, ecosystem structure, function and energy flow in ecosystem.

Unit IV: Bioremediation

Application of bacteria and fungi in bioremediation: White rot fungi vs specialized degrading bacteria: examples, uses and advantages vs disadvantages, historical perspective, scope and challenges, extremophiles and their role in industry, Bioremediation- methods and strategies of application (biostimulation, bioaugmentation) – examples, bioremediation of metals (Cr, As, Se, Hg).,

Unit V: Biofertilizers and biopesticides

Biofertilizers and biopesticides: Bio control agents for sustainable agriculture- PGPFs & PGPRs, microbial consortia for beneficial use, biofungicides and biopesticides, Description of mode of actions and mechanisms (e.g. Trichoderma, Pseudomonas fluorescens); Symbiotic systems between plants – microorganisms (nitrogen fixing symbiosis, mycorrhiza fungi symbiosis).

Reference Books and Suggested Readings: (Latest editions)

1. Willey, J. M., Sherwood, L., Woolverton, C. J., Prescott, L. M., & Willey, J. M. (2011). Prescott's microbiology. New York: McGraw-Hill.
2. Raina M. Maier, Ian L. Papper. Charles P. Gerba, Environmental Microbiology, Second Edition, Academic Press, British Libaray.
3. Matthai, W., Berg, C. Y., & Black, J. G. (1999). Microbiology, principles and explorations. Boston, MA: John Wiley & Sons. 6th Edition; Wiley; 2006.
4. Eugene P. Odum, Fundamentals of Ecology & Environment, 2015.

. NANOBIOTECHNOLOGY (UMBIO100111T) (Credits 2)

Course Objective: To introduce the students to basics and advanced aspects of Nanobiotechnology and its applications.

Course learning outcome: Students will be able understand the concepts and historical aspects of Nanobiotechnology, applications of nanomaterials, nano particles for drug delivery, challenges and prospects.

Unit I: Introduction to Nanobiotechnology

Introduction to Nanobiotechnology; Concepts, historical perspective. Different form of nanomaterials and applications.

SEMESTER-IV

DISSERTATION (RESEARCH PROJECT) (MBI02C001D) (Credits 18)

Course Objective: The students will execute research projects based on expertise available.

Course learning outcome: Students will learn and equip themselves with the fundamental tools of research. This will help the students in getting placed in industry *vis-a-vis* research organizations.

RESEARCH METHODOLOGY & REVIEW WRITING (UMBI0100012T) (Credits 2)

Course Objectives

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

Student Learning Outcomes

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

Unit I: History of science and science methodologies

Definitions and characteristics of research, Types of research,Research and scientific method,types of research, Formulating a research problem, research Process.

Basic principles of experimental designs, Literature survey and documentation, methods of data collection, analysis and testing of hypothesis, manipulative experiments and controls,Generalizations and interpretation, presentation of the results.

Unit II: Preparation for research and Process of communication

Choosing a mentor, lab and research question; maintaining a lab notebook. Concept of effective communication- setting clear goals for communication; determining outcomes and results.

Presentation skills: PowerPoint; scientific poster preparation & presentation; participating in group discussions; Computing skills for scientific research - web browsing for information search.

Unit III: Scientific communication

Technical writing skills: Importance of communicating science; problems while writing a scientific document. Scientific publication writing: elements of a scientific paper; drafting titles including abstract, introduction, materials & methods, results, discussion, references.

Publishing scientific papers: peer review process and problems.Plagiarism; types of plagiarism, software for plagiarism, ethical issues; scientific misconduct.

Reference Books and Suggested Readings: (Latest editions)

1. Valiela, I. (2001). Doing Science: Design, Analysis, and Communication of Scientific Research. Oxford: Oxford University Press.
2. Gopen, G. D., & Smith, J. A. The Science of Scientific Writing. American Scientist, 78 (Nov-Dec 1990), 550-558.
3. On Being a Scientist: a Guide to Responsible Conduct in Research. (2009). Washington, D.C.: National Academies Press.

Nanomaterials in biotechnology: Carbon Nano Tubes (CNTs), Quantum Dots (QDs), metallic nanoparticles. Synthesis and characterization of different nanomaterials.

Biomacromolecules in nanobiotechnology: lipids, proteins and DNA based nanostructures.

Unit II: Nano-particles and its application

Nanoparticles for drug delivery, concepts, optimization of nanoparticle properties for suitability of administration through various routes of delivery and their advantages

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

Unit III: Nanotechnology in food, agriculture and environment

Food quality monitoring; adulteration; food packaging; food grade nanomaterials and safety assessment

Environmental sensors for monitoring pollutants. Nanomaterials based remediation approaches Nanomaterials for catalysis, development and characterization of nanobiocatalysts.

Introduction to Safety of nanomaterials, Basics of nanotoxicity, Models and assays for Nanotoxicity assessment.

Reference Books and Suggested Readings: (Latest editions)

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.

जम्मूकेंद्रीयविश्वविद्यालय
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CENTRE FOR MOLECULAR BIOLOGY

OPEN ELECTIVES

M.Sc Biotechnology

Course Title: ENVIRONMENTAL MICROBIOLOGY (UMBI0100137)

Course code: UMBI0100137

Credit: 2 Credit

Course prerequisite: B.Sc. in Life Sciences/Microbiology/ Biotechnology/ Biochemistry

Course Objective: To introduce the students to basics and advanced aspects of microbes and their importance in industry and ecosystem functioning.

Course learning outcome: Students will be able understand:

1. The historical aspects and scope of Environmental Microbiology.
2. Challenges for Environmental Biologists
3. Microbes in extreme environments and their industrial significance
4. Applications of bacterial proteins in biochips for new generation of computers
5. Uses of *taq polymerase* in Biotechnology

Syllabus:

Unit I: Introduction to Environmental microbiology

Brief account of microbes found in Environment- viroids, prions, viruses, bacteria and fungi, Environmental microbiology as a discipline, Microbial influences on our daily life, Brief history and scope of Environmental Microbiology.

Unit II: Microbial Communication and role of microbes for Bioremediation

Introduction, signaling via quorum sensing in bacteria, communication signals, Bioremediation, uses of microbes for cleaning the polluted sites, Use of Pseudomonas super bug for cleaning oil spills.

Unit III: Microbes for sustainable agriculture

Role of agriculture in India, use of chemical fertilizers and pesticides in agriculture and their impact on human health, Sustainable agricultural practices, Biofertilizers and biopesticides: Bio control agents for sustainable agriculture- PGPFs & PGPRs, *Trichoderma* as bio control agent.

Reference Books and Suggested Readings: (Latest editions)

1. Willey, J. M., Sherwood, L., Woolverton, C. J., Prescott, L. M., & Willey, J. M. (2011). Prescott's microbiology. New York: McGraw-Hill.
2. Matthai, W., Berg, C. Y., & Black, J. G. (1999). Microbiology, principles and explorations. Boston, MA: John Wiley & Sons.
3. Raina M. Maier, Ian L. Pepper and Charles P. Gerba, Environmental Microbiology

Course title- Introduction to Biology

Course code: UMBIO100147

Credit- 2

Course prerequisite: Elementary biology up to class 10th or 12th.

Course Objective: To provide foundational understanding of biology to engineering students, enabling them to apply their biology knowledge in conjunction with engineering, to address environmental, human health, and others' problems for greater good of community.

Course **learning outcome:**

1: After passing the course, the student will have a basic understanding of how a cell is structured, functions, and operates at the microscopic level.

2: Students will also learn about how different cells in a multicellular creature work together to complete specific tasks.

3: They will learn how problems pertaining to the environment and health could be addressed using a basic understanding of biology.

Syllabus

UNIT-1 (Cells, tissue, organ, and system)

What is a cell? Cell theory, Cell Shape, Prokaryotic and eukaryotic cell, Compartmentalization in eukaryotic cell. Cell membrane and transport, Difference between plant and animal cell. What is tissue, organ, and system? Brief introduction to Digestive system. Respiratory system, Nervous system, and Excretory system. Neuronal signalling.

UNIT-2 (Molecules of life and Molecular Biology)

What are biomolecules? Carbohydrate, Protein, Fats and Nucleic acid (DNA and RNA), Double helix model of DNA, Bioenergetics. Concept of gene, Difference between prokaryotic and Eukaryotic gene, what is chromosome, Replication, Transcription and Translation in Prokaryote and Eukaryotes. Recombinant DNA technologies.

UNIT 3- (Application of Biology)

Transgenic plants and animals, Concept of biosensors, bio-chip and bio-fuel, Bioengineering (Tissue engineering, Robotic surgeons, Nanorobots, Mini bioreactors), Biomimetics (some example).

SUGGESTED READING

- David Lee Nelson, Michael M. Cox. Lehninger Principles of Biochemistry. WH Freeman;7th ed. (2017)
- Cooper, G. M., & Hausman, R. E. (2019). The cell: A molecular approach. Washington: ASM ; Sunderland.
- Biology for engineers, G. K. Suraishkumar, Oxford University Press.
- Human Physiology, Stuart Fox, Krista Rompolski, McGraw-Hill eBook. 16th Edition, 2022
- Biology for Engineers, Arthur T. Johnson, CRC Press, Taylor and Francis, 2011

Course Title: MICROBIAL TECHNOLOGY

Course code: UMBIO10016T

Credit: 4

Course prerequisite: Basic knowledge of Microbiology Course designed for Postgraduate level students.

Course Learning Outcome- This course offers an applied aspect of Microbiology, which emphasizes the potential role of microbes in industries, environmental and health.

Syllabus:

Unit I: Introduction

Basic concepts and techniques for isolation and purification of microbes; Role, Design and Preparation of Media for Bioprocesses; Advantages of using microbial technology over chemical and physical technology.

UNIT II Microbial Technology for Agriculture

Improvement of N_2- fixing strain, production of biofertilizers, biopesticides; Development of disease and insect resistant plants; Biocontrol agents.

UNIT III Microbial Technology in Human Health

Nutraceuticals, Prebiotics, Synbiotics, Probiotics, Bioactives, Production of recombinant vaccines, interferon, and insulin, Nanobiotechnology.

UNIT IV Microbial Technology in Bioremediation and Biomining

Bioremediation of pollutants- Petroleum hydrocarbons and Heavy metal contaminants of water bodies, Concept of microbially assisted phytoremediation; Extraction of Cu, Au, U from ore by microbes, Bio-recovery of petroleum, Bioplastics.

UNIT V Microbial Technology for energy production and Waste treatment

Biofuel production- Microbial fuel cell, Biogas, biodiesel and H2 as fuel by microbes; Biogas, Microbial cell mass; Waste treatment: Composting & vermicomposting; Hospital waste management, Municipal solid waste management assisted by microbes

SUGGESTED READING

1. Advanced Microbial Technology for Sustainable Agriculture and Environment. Saurabh Gangola, Saurabh Kumar, Samiksha Joshi, Pankaj Bhatt. ISBN: 9780323950909; eBook ISBN: 9780323950916. ELSEVIER 2023
2. Microbial Biotechnology, Volume 2. Application in Food and Pharmacology. 2018. Jayanta Kumar Patra, Gitishree Das, Han-Seung Shin. SPRINGER
3. Microbiology, PRESCOTT. Latest Edition.
4. Manual of Industrial Microbiology and Biotechnology, Richard H. Baltz (Editor), Arnold L. Demain (Editor), Julian E. Davies (Editor). Latest Edition.

Course Title: FUNDAMENTALS OF VIROLOGY

Course code: UMBJ010015T

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Credit: 4

Course Prerequisite- Basic knowledge of Biology Course designed for Postgraduate level students

Course Learning Outcome- A systematic learning in the basic and applied areas of Virology by introducing students to the concepts related to identification, characterization, detection of emerging viruses infecting microbes, plants, animals and humans.

Syllabus:

Unit I. Basic Virology

History and principles of Virology; Viral taxonomy; Infrastructural requirements of a virology laboratory- Principles of bio-safety, contaminant facilities, maintenance and handling

UNIT II Virus Structure and Classification

Physical characteristics- morphology and structure of viruses; Biochemical composition; Types of viruses on the basis of the nuclear material- major classes of DNA/RNA viruses

UNIT III Biological Host range

Bacterial Viruses- Bacteriophage structural organization; life cycle: lytic and lysogenic cycle, brief details on M13, T7 and Lamda; Structure and life cycle of major *Plant viruses* like TMV, Cauliflower MosaicVirus; *Animal Viruses* like Herpes, Adeno, Hepatitis, HIV

UNIT IV Assay and Detection

Assay of viruses: Infectivity assay methods (plaque, pock, end point, local / systemic assay of viruses), physical (EM), serological (HA, HI, immunofluorescence, ELISA) and molecular (viral protein and nucleic acid based) approaches.

UNIT V VIRUSES AND THE FUTURE

Drug discovery and development for treatment of the emerging viral diseases in recent pandemic (COVID) and epidemics, sources and causes of emergent virus diseases; Prevention and cure

SUGGESTED READING

1. Evidence-Based Diagnosis: An Introduction to Clinical Epidemiology 2nd Edition, by Thomas B. Newman, Michael A. Kohn (2020).2nd edition, Publisher: Cambridge University Press.
2. Virusphere: From Common Colds to Ebola Epidemics--Why We Need the Viruses That Plague Us (2020). 1st edition, Frank Ryan (Author), Publisher: Prometheus.
3. Guide to Clinical and Diagnostic Virology (2019), (ASM Books) 1st Edition, by Reeti Khare, Publisher: ASM Press.
4. Virology (2019), P. Saravanan.
5. Recent Advances in Animal Virology (2019) 1st Edition, Kindle Edition, by Yashpal Singh Malik, Raj Kumar Singh, Mahendra Pal Yadav, 471 pages, Publisher: Springer

Skill Enhancement / Value Additions Courses ✓

Course Title: Genome Editing Technologies: Yeast-Based Approach

Course code: UMBIO1004T

Credit: 2 Credit

Course prerequisite: B.Sc. in Life Sciences/Microbiology/ Biotechnology/ Biochemistry

Course outcome: After completion of this course students will be able to

1. Understand about the current genome editing tools and their application
2. Acquire basic skills for genetic manipulation of yeast genome and analyze the outcome.
3. Design and carry out the experiments and publish the findings.

Syllabus:

Unit I: Introduction to Genome, Genome Editing Technologies, Application, and Ethical Concern

Introduction to the genome; Archaea, Prokaryotes and Eukaryotes, Model organisms; bacteria, fungal and yeast, worm, zebrafish, and mammalian, History of genome editing and biology, synthetic cells, and their applications. Ethical issues and concerns of genome editing. Introduction to synthetic

Unit II: Yeast genome editing tools

Study of model organism *S. cerevisiae*; cell biology, genome architecture, and genetics. Introduction to yeast as bio-factory, Tools of gene editing in yeast: homologous recombination, plasmid shuffling, mating, and CRISPER- Cas9 tools.

Unit III. Genome editing skills

Culture and maintenance of yeast laboratory strain, Genome analysis of Yeast, PCR primer design for gene deletion, transformation and selection of yeast colonies, Yeast DNA preparation, Yeast colony PCR, and confirmation of gene deletion. Data interpretation and analysis. CRISPR-based primer design for the target gene and transformation. Data interpretation and analysis.

References and Books

1. Budding Yeast: A Laboratory Manual (2016) edited by Brenda Andrews, Charles Boone, Trisha N. Davis, Stanley Fields. ISBN 978-1-621820-56-7Yeast: Molecular and Cell Biology (2012) edited by Prof. Dr. Horst Feldmann, *2012 Wiley-VCH Verlag GmbH & Co. KGaA*, ISBN:9783527333097
2. *CRISPR People: The Science and Ethics of Editing Humans edited by Henry T. Greely. MIT Press, **ISBN electronic:** 9780262363563 **DOI:** https://doi.org/10.7551/mitpress/13492.001.0001*
3. *Recent Research and Review articles using the NCBI database*
4. *CRISPR/Cas9: Unlocking the Potential of Genome Editing (CRISPR/CAS: THE 100 SERIES (2023) by Rickbed Nandi ISBN 979-8857529386*