Syllabus

For

M.Sc. BIOTECHNOLOGY

MANDSAUR UNIVERSITY
MAKING FUTURE READY!

Faculty of Life Sciences

Mandsaur University, Mandsaur

M. P., India

M. Sc. Biotechnology
Semester –I
BIT070: Biochemistry and Metabolism [Credit: 6(4+2)]

UNIT I: Bioenergetics **12 Hours**

Stabilizing interactions (Van der Waals, electrostatic, hydrogen bonding, hydrophobic interaction etc.) Laws of thermodynamics, Gibbs free energy, endergonic & exergonic reactions, Standard state free energy changes, High energy compounds. Introduction to Metabolism - Catabolism, anabolism, catabolic, anabolic and amphibolic pathways.

UNIT II: Carbohydrates **12 Hours**

Structure and properties of mono, oligo and polysaccharides. Metabolism and regulation- Glycolysis, TCA cycle, Glyoxylate cycle. Pentose phosphate pathway, Gluconeogenesis, Entner – Doudoroff pathway. Substrate level phosphorylation; Oxidation- Reduction reactions. Redox potential**,** Electron transport chain, Oxidative phosphorylation and ATP synthesis.

UNIT III: Lipids **12 Hours**

Classification, structure of saturated and unsaturated fatty acids, triacylglycerol, phospholipids**,** glycolipids and sterols; Oxidation of fatty acids (α, β, ω oxidation). Biosynthesis of fatty acids (saturated and unsaturated) and sterol. Ketone bodies synthesis.

UNIT IV: Amino acids & proteins **12 Hours**

Classification, structure and properties of amino acids. General aspects of amino acid metabolism; amination, transamination, deamination. Decarboxylation, urea cycle. Classification, properties and structural organization of proteins- primary structure, secondary structure, Ramachandran plot, tertiary structure and quaternary structure.

UNIT V: Nucleic acids **12 Hours**

Structure of bases, nucleosides and nucleotides; Conformation of nucleic acids: helix (A, B, Z), t-RNA, micro-RNA. Biosynthesis: Purine and pyrimidine, *denovo* and salvage pathway.

PRACTICAL

1. Estimation of reducing sugars by DNS Method
2. Estimation of protein by Bradford method
3. Estimation of protein by Lowry method
4. Numerical related to Gibbs free energy change
5. Estimation of DNA by DPA Method
6. Estimation of RNA by Resorcinol Method
7. Extraction and estimation of ergosterol from fungi.
8. Lipid estimation by thin layer chromatography.

SUGGESTED READINGS

1. Voet, D. and Voet, J.G. (2004). Biochemistry, John Wiley and Sons.
2. Roger, L.P., Adams, Johm T., Knowler and David P., Leader. (1992). The Biochemistry of the Nucleic Acids. 11th edition. Chapman and Hall.
3. Smith and Wood (1991). Energy in Biological Systems. Chapman and Hall.
4. Berg, J. M., Tymoczko, J. L. and Stryer, L. (2006). Biochemistry. VI Edition. W.H Freeman & Co.
5. Buchanan, B., Gruissem, W. and Jones, R. (2000) Biochemistry and Molecular Biology of Plants. American Society of Plant Biologists.
6. Nelson, D.L., Cox, M.M. (2004) Lehninger Principles of Biochemistry, 4th Edition, WH Freeman and Company, New York, USA.
7. Hopkins, W.G. and Huner, P.A. (2008) Introduction to Plant Physiology. John Wiley and Sons.
8. Salisbury, F.B. and Ross, C.W. (1991) Plant Physiology, Wadsworth Publishing Co. Ltd.

M. Sc. Biotechnology
Semester –I
BIT080: Functional Cell Biology [Credit: 6(4 +2)]

UNIT I: Cellular Organization **12 Hours**

Structure, organization and composition of prokaryotic and eukaryotic cell. Plasma membrane structure and functions, membrane models. Structural organization and function of intracellular organelles- Cell wall, nucleus, mitochondria, Golgi bodies, lysosomes, endoplasmic reticulum, peroxisomes, plastids, vacuoles, chloroplast.

UNIT II: Cytoskeleton **12 Hours**

Nature of cytoskeleton, Actin filaments, Actin binding proteins, Intermediate filaments, Microtubules, MAPs, Structure and functions of cilia and flagella.

UNIT III: Membrane Transport **12 Hours**

Transport across membrane- passive diffusion, osmosis, active transport, Ion Channels, ABC transporters, Na^+ and K^+ pump, Ca^{2+} ATPase pump, co-transport, symport, antiport, endocytosis and exocytosis. Membrane vesicular traffic.

UNIT IV: Cell Signaling **12 Hours**

Cell to cell interactions, Cell adhesion-integrins, selectins, cadherins. Cell Junction- Tight and gap junctions, Desmosomes, plasmodesmata. extracellular matrix. General principles of cell signaling, Cell surface receptor, Role of secondary messengers, Signaling via G-protein coupled receptors, Signaling through Enzyme-Linked Cell-Surface Receptors.

UNIT V: Cell Cycle and Cancer **12 Hours**

Molecular events of cell division and cell cycle, regulation of cell cycle events- Cyclins, Cyclin dependent kinases, inhibitors. Introduction to cancer, oncogenes, tumor suppressor genes, cancer and the cell cycle, virus-induced cancer, metastasis, interaction of cancer cells with normal cells, apoptosis, necrosis.

PRACTICAL

1. Isolation of mitochondria.
2. Isolation of Chloroplast.
3. Cell fractionation and determination of enzyme activity in organelles.
4. Study of cell division in plant.
5. Study of meiosis in insect gonad.
6. RNA isolation from yeast cells.
7. Microtomy: Fixation, block making, section cutting and staining of tissues.
8. Study of the Barr body from the (female) smear of Buccal epithelial cells.

SUGGESTED READINGS

1. Freifelder. D. (2003) – Essentials of molecular Biology – fourth edition, Jones and Bartlett Publications Inc.
2. Lewin.B. (2007) – Genes IX, Jones and Bartlett Publishers
3. Watson, J.D. (1987) – Molecular Biology of Gene – The Benjamin / Cummings Publishing Company Inc., California
4. Brown. T.A. (2006), Genomes 3, Garland Science Publications
5. Bruce Alberts, Alexander Johnson, Julian Lewis, Martin Raff. Keith Roberts, Peter Walter, (2002), Molecular Biology of the Cell, IV edition, Garland Publishing, New York
6. Lodish, Harvey, Arnold, Matsudaira, Paul, Kaiser, Chris. A,. Krieger, Monty Scott, Matther P. Zipuruky, Lawrence, Darnell, James (2004), Molecular Cell Biology, W.H. Freeman & Company
7. Karp, G. 2010. Cell and Molecular Biology: Concepts and Experiments. 6th Edition. John Wiley & Sons. Inc.
8. Cooper, G.M. and Hausman, R.E. 2009. The Cell: A Molecular Approach. 5th edition. ASM Press & Sunderland, Washington, D.C.; Sinauer Associates, MA.
9. Becker, W.M., Kleinsmith, L.J., Hardin. J. and Bertoni, G. P. 2009. The World of the Cell. 7th edition. Pearson Benjamin Cummings Publishing, San Francisco.

M. Sc. Biotechnology
Semester –I
BIT090: Microbiology [Credit: 5(3+2)]

UNIT I: Microbial Systematic classification **9 Hours**

Classical and modern methods and concepts; Binomial nomenclature, Whittaker's five kingdom and Carl Woese's three kingdom classification systems and their utility. Introduction of Bergey's manual of bacteriological classification. 16s rRNA sequence and bacterial phylogeny.

UNIT I: Microbial Diversity **9 Hours**

General structure, characteristics and applications in biotechnology: Bacteria, Algae, Fungi and slime moulds, Viruses (Viruses, Viroids, Prions) , Life cycles: T4 and lamda phage.

UNIT III: Microbial growth and control **9 Hours**

Measurement of microbial growth, Batch and continuous culture, generation time and specific growth rate, synchronous growth, diauxic growth curve. Microbial growth in response to environment: Temperature, pH, solute and water activity, oxygen, barophilic. Microbial growth in response to nutrition and energy.

UNIT IV: Microbial Control **9 Hours**

Fundamentals of control: the rate of death of bacteria, conditions influencing antimicrobial action, mode of action of antimicrobial agents. Physical and chemical method of microbial control. Mode of action of antibiotics.

UNIT V: Microbial genetics **9 Hours**

Types of plasmids – F plasmid, R Plasmids, colicinogenic plasmids. Transformation: mechanism of natural competence. Conjugation: mechanism, Hfr and F' strains, Interrupted mating technique and time of entry mapping. Transduction: Generalized transduction, specialized transduction, LFT & HFT lysates.

PRACTICAL

1. Isolation of microorganism by plating, streaking & serial isolation methods.
2. Viable count of bacteria from soil sample (Dilution Plating Method)
3. Microscopic observation - Gram staining, Capsule & Spore Staining
4. Study of Diauxic growth curve
5. Effect of environmental factors on growth of bacteria: Salt, Temp, pH.
6. Isolation of bacteriophages from sewage sample
7. Enrichment and Isolation of: a) Halophiles b) Acidophiles c) Phenol Degraders d) Nitrogen Fixers e) Antibiotic Producers f) Kojic Acid Producers
8. Determination of minimum inhibitory concentration (MIC) and minimum bactericidal concentration (MBC) of various antibiotics on different organisms

SUGGESTED READINGS

1. Pelczar MJ, Chan ECS and Krieg NR. (1993). Microbiology. 5th edition. McGraw Hill Book Company.
2. Singleton Sainsbury, Dictionary of Microbiology & Molecular Biology, John Wiley
3. Madigan MT, Martinko JM and Parker J. (2009). Brock Biology of Microorganisms. 12th edition. Pearson/Benjamin Cummings.
4. Stanier RY, Ingraham JL, Wheelis ML, and Painter PR. (2005). General Microbiology. 5th edition. McMillan.
5. Tortora GJ, Funke BR, and Case CL. (2008). Microbiology: An Introduction. 9th edition. Pearson Education.
6. Willey JM, Sherwood LM, and Woolverton CJ. (2008). Prescott, Harley and Klein's Microbiology. 7th edition. McGraw Hill Higher Education.
7. Dubey, R.C. and D.K.Maheswari . A Text Book of Microbiology, S. Chand and Co. Ltd. New Delhi.

M. Sc. Biotechnology
Semester –I

BIT 100: Enzymology and Bioinstrumentation [Credit: 5(3+2)]

UNIT I: Enzyme – General Account **9 Hours**

Definition, Classification of enzymes, specificity, active sites, coenzymes, enzyme units, isozymes, Mechanism of enzyme action- lock and key, induced fit hypothesis, acid-base, covalent and metal ion catalysis. Factors affecting rate of enzymatic reactions: temperature, pH, modulators etc., significance of activation energy and free energy in biochemical reactions. Ribozymes and abzyme.

UNIT II: Enzyme Kinetics **9 Hours**

Michaelis-Menten hypothesis, Transformation of Michaelis- Menten equation and determination of Km and Vmax, Significance of Km and Vmax, Lineweaver–Burk plot, Determination of kinetic parameters, multi substrate kinetics. Haldane relationship, Hills equations. Enzymes inhibition: Covalent, allosteric and feedback inhibition; Reversible (competitive, noncompetitive and uncompetitive) and irreversible inhibitions.

UNIT III: Protein Engineering **8 Hours**

Concept and Methods, Site directed mutagenesis, Active site mapping, Nature of the active site, Identification of functional groups at the active site, Enzyme immobilization - types, advantages, drawbacks and applications; Artificial enzymes; Isolation and purification of industrially important enzymes.

UNIT IV: Enzyme technology for industrial application **8 Hours**

Large scale production of enzymes, Applications of enzyme technology in environment, medical, agricultural, food and chemical industries.

UNIT V: Bioinstrumentation **11 Hours**

Microscopy: Simple, phase contrast, florescence and electron microscopy (TEM and SEM),. Chromatography: paper chromatography, thin layer chromatography, gel filtration, affinity and ion exchange Chromatography, gas chromatography, HPLC, HPTLC. Spectrometry: UV-Vis, atomic absorption spectrophotometer. Electrophoresis: Agarose gel, native and SDS PAGE.

PRACTICAL

1. Isolation of extra cellular enzymes.
2. Enzyme kinetic (Vmax and Km values) study of amylase
3. Enzyme assay: protease, lipase
4. Enzyme purification: ammonium sulphate method
5. Molecular weight determination of enzyme by electrophoresis
6. Quantitative estimation of enzyme using UV-Vis spectrophotometer
7. To perform enzyme immobilization
8. Separation of analytes using different chromatographic techniques.

SUGGESTED READINGS

1. Mahler HR, Cordes EH. Biological Chemistry, Harper and Row. New York.
2. Dizon & Webb Enzymes 2nd Edition, Academic Press
3. Benjemin Lewin, Genes VII, 1994. Oxford University Press. Oxford
4. Principles of Biochemistry, AL. Lehninger, D.L. Nelson and M. M. Cox. 1993. Worth Publishers, New York.
5. Palmer, T. (2001). Enzymes: Biochemistry, Biotechnology and Clinical Chemistry, Horwood Publishing Chichester.

M.Sc. Biotechnology
Semester II
BIT 110: Molecular Biology [Credit: 6(4+2)]

UNIT I: DNA replication, repair & recombination **12 Hours**

Organization of bacterial genome; structure and organization of eukaryotic chromosome; DNA reassociation kinetics (Tm and Cot curve analysis); DNA Imprinting. DNA replication**:** replication machinery and enzymology in prokaryotes and eukaryotes. Gene stability and DNA repair: Photoreactivation; Base and Nucleotide excision repair; Mismatch correction; SOS repair. Recombination: Homologous and non - homologous recombination; site specific recombination.

UNIT II: RNA Synthesis and processing **12 Hours**

Transcription: Prokaryotic and eukaryotic transcription; RNA polymerases; general and specific transcription factors. Post Transcriptional Modifications: Processing of pre mRNA, tRNA and rRNA; 5'cap formation; 3'-end processing and polyadenylation; Splicing; nuclear export of mRNA.

UNIT III: Protein synthesis and processing **12 Hours**

Translation machinery in prokaryotes and eukaryotes; Ribosomes; universal genetic code and wobble hypothesis; Genetic code in mitochondria; Isoaccepting tRNA; mechanism of initiation, elongation and termination; Co- and post- translation modification of protein; Transport of proteins and molecular chaperones; protein turn over and degradation. Antibiotic inhibitors and translation.

UNIT IV: Regulation of gene expression **12 Hours**

Transcriptional regulation-Positive and negative; Operon concept-lac, trp, ara, his, and gal operons; Transcriptional control in lambda phage. Transcriptional and post-transcriptional gene silencing: Antisense & ribozyme technology; RNA interference (RNAi).

UNIT V: Mutations, Transposition and Genome mapping **12 Hours**

Mutations: Spontaneous mutations; Physical, chemical and biological mutagens; Transposition: Transposable genetic elements in prokaryotes and eukaryotes; retrotransposones; Mechanisms of transposition; Role of transposons in mutation. Genome mapping: genetic & physical map; Molecular markers in genome analysis-RFLP, RAPD & AFLP analysis.

PRACTICAL

1. Isolation of genomic DNA from Prokaryotic cell.
2. Agarose Gel Electrophoresis.
3. Determination of Tm of nucleic acid.
4. Cot curve analysis
5. Study of the effect of UV radiation as a mutagen.
6. Study of spontaneous mutation using gradient plate technique.
7. Isolation of mutant using replica plate technique
8. Demonstration of UV repairs mechanism.

SUGGESTED READINGS

1. Benjamin Lewin, Gene IX, 9th Edition, Jones and Barlett Publishers, 2007.
2. J.D. Watson, N.H. Hopkins, J.W Roberts, J. A. Seitz & A.M. Weiner; Molecular Biology of the Gene, 6th Edition,Benjamin Cummings Publishing Company Inc, 2007.
3. Freifelder. D. (2003) – Essentials of molecular Biology – fourth edition, Jones and Bartlett Publications Inc.
4. Strickberger (1996), Genetics, Prentice Hall of India Pvt. Ltd., New Delhi
5. Brown. T.A. (2006), Genomes 3, Garland Science Publications
6. Bruce Alberts, Alexander Johnson, Julian Lewis, Martin Raff. Keith Roberts, Peter Walter, (2002), Molecular Biology of the Cell, IV edition, Garland Publishing, New York
7. Lodish, Harvey, Arnold, Matsudaira, Paul, Kaiser, Chris. A,. Krieger, Monty Scott, Matther P. Zipuruky, Lawrence, Darnell, James (2004), Molecular Cell Biology, W.H. Freeman & Company

M.Sc. Biotechnology

Semester II

BIT 120: Genetic Engineering [Credit: 6(4+2)]

UNIT I: Cloning and Expression strategies **12 Hours**

Introduction to gene cloning; DNA manipulative and modifying enzymes; Restriction endonucleases; Generation of sticky ends onto blunt ended DNA molecules; Vectors - plasmid, bacteriophage, viral, cosmids, Ti plasmid, Yeast; Expression of recombinant proteins.

UNIT II: Molecular techniques **12 Hours**

Polymerase chain reaction; DNA Sequencing; In-situ hybridization; Random amplified polymorphic DNA, Restriction fragment length polymorphism; Site-directed mutagenesis; Southern and northern blotting.

UNIT III: Construction of Library and Screening **12 Hours**

Genomic DNA library; cDNA construction: hairpin loop strategies, directional and non-directional cDNA synthesis, Okayama and berg method, oligo capping; Immune screening; Purification of recombinant proteins.

UNIT IV: Gene transfer and Selection of Recombinant Clones **12 Hours**

Strategies of integration of DNA insert into the vector; Gene transfer methods - biological, chemical, physical or mechanical; Agrobacterium - mediated gene transfer in plants, chloroplast transformation; Selection of recombinant clones - complementation, colony hybridization

UNIT V: Recombinant DNA Applications **12 Hours**

Gene therapy - introduction and methods; Gene therapy in the treatment of diseases; Challenges and future of gene therapy; Engineering microbes for the production of antibiotics, enzymes, recombinant insulin, growth hormones, monoclonal antibodies, clearing oil spills.

PRACTICAL

1. In Vitro amplification of gene of interest by PCR.
2. Purification of PCR amplified product.
3. Ligation of gene of interest into the vector.
4. Competent cell preparation using CaCl2
5. Transformation and Blue white screening.
6. Conformation of clone gene by PCR.
7. Isolation of recombinant plasmid DNA.
8. Restriction digestion of DNA.

SUGGESTED READINGS

1. Brown TA. (2006). Gene Cloning and DNA Analysis. 5th edition. Blackwell Publishing, Oxford, U.K.
2. Glick, B.R., Pasternak, J.J. (2003). Molecular Biotechnology- Principles and Applications of recombinant DNA. ASM Press, Washington
3. Primrose SB and Twyman RM. (2006). Principles of Gene Manipulation and Genomics, 7th edition. Blackwell Publishing, Oxford, U.K.
4. Sambrook J, Fritsch EF and Maniatis T. (2001). Molecular Cloning-A Laboratory Manual. 3rd edition. Cold Spring Harbor Laboratory Press.
5. B.D Singh- Biotechnology: Expanding Horizons, Kalyani publication, New Delhi , India
6. R C Dubey (2006). A Textbook of Biotechnology 4th Rev. Edition, S. Chand Publishing, New Delhi , India

M.Sc. Biotechnology

Semester II

BIT 130: Environmental Biotechnology [Credit: 5(3+2)]

UNIT I: Environment and monitoring **9 Hours**

Introduction, renewable and non-renewable sources of energy; Enviromental pollution: water pollution, soil pollution and air pollution-sources. Xenobiotic compounds and their sources; Bio magnification; Bio indicators. Bio monitoring: Biosensors and biochips.

UNIT II: Water Management and waste water treatments **9 Hours**

Water as a scarce natural resource; water management. Waste water treatment: physical, chemical, biological processes. Aerobic processes: Activated sludge; oxidation ditches; trickling filter; oxidation ponds. Anaerobic processes: Anaerobic digestion; anaerobic filters; anaerobic sludge; membrane bioreactors. Reverse osmosis and ultra-filtration. Treatment of industrial effluents.

UNIT III: Bio mining and Biodiesel **9 Hours**

Bioleaching of ores to retrieve scarce metals; Microorganisms used in leaching; chemistry of leaching; Direct leaching, indirect leaching. Leaching process: slope leaching, heap leaching and *in situ* leaching. Bio- mining; Biodiesel production from Jatropa, Pongamia and Castor.

UNIT IV: Bioremediation **9 Hours**

Concept and principles; Bioremediation using microbes; *In situ* and *ex situ* bioremediation; biosorption and bioaccumulation of heavy metals; Phytoremediation; bioremediation of xenobiotics (heavy metals, pesticides, oil slicks, plastic). Bioremediation of soil and water contaminated with hydrocarbons and surfactants, biofilms.

UNIT V: Bio waste treatment **9 Hours**

Microorganisms involved in the degradation of plant and pulping of wood. Pitch problems and processing by fungi enzymes in pulp and paper. pulp bleaching: Problems and solutions.

Solid wastes: Sources and management. Production of oils and fuels from solid waste, composting, vermiculture, Biogas production, methanol production from organic wastes, byproducts of sugar industries. Disposal of medical waste, recycling of waste.

PRACTICAL

1. Enumeration of microorganisms present in different environment.
2. Determination of Hardness and alkalinity of water sample.
3. Determination of total dissolved solids, BOD and COD of sewage /Water sample
4. Determination of Phosphate and nitrate from sewage /Water sample
5. Determination of chlorine from sewage /Water sample
6. Detection of coliforms for determination of purity of potable water.
7. Isolation of xenobiotic degrading bacteria by selective enrichment technique.
8. Production of biofuel from organic waste.

SUGGESTED READINGS

1. Rittman B, McCarty PL, Environmental Biotechnology: Principles and Applications, 2nd edn, McGraw-Hill, 2000.
2. Milton Wainwright, An Introduction to Environmental Biotechnology, Kluwer Academic Publishers, Boston. Hardbound, 1999.
3. Vallero D, Environmental Biotechnology: A Biosystems Approach (1st Ed.) Academic press. New York.2010
4. Evans G G and Judy Furlong., Environmental Biotechnology: Theory and Application (2nd Ed.).Wiley publishers. 2011
5. Gareth G. Evans, Judy Furlong (2010) Environmental Biotechnology: Theory and Application (2nd Ed.).Wiley publishers.
6. Tortora GJ, Funke BR, Case CL (2003) Microbiology: An Introduction 8th Edition Benjamin-Cummings, San Francisco, CA
7. B.D Singh- Biotechnology: Expanding Horizons, Kalyani publication, New Delhi , India
8. R C Dubey (2006). A Textbook of Biotechnology 4th Rev. Edition, S. Chand Publishing, New Delhi

M.Sc. Biotechnology
Semester II
BIT 140: Bioprocess Engineering [Credit: 5(3+2)]

UNIT I: Bioreactors **9 Hours**

Introduction to Bioprocesses Engineering; Typical structure of advanced Bioreactor and their working mechanism; Design features; Specialized bioreactors- design and their functions; Continuous stirred-tank reactor; Airlift bioreactor; Tubular bioreactors; Membrane bioreactors; Tower bioreactors; Fluidized bed reactor; Packed bed reactors and Photo bioreactors.

UNIT II: Upstream processing and Fermentation **9 Hours**

Natural and synthetic media; Strategies for media formulation; sources of carbon, nitrogen, vitamins and minerals. Role of buffers, precursors, inhibitors, inducers and antifoam agents; Isolation, preservation & maintenance of Industrial microorganisms; Strain improvement. Types of fermentation processes; kinetics of fermentation process. Flow behavior of fermentation fluids; Gas-Liquid mass transfer; Solid and Liquid mass transfer and Heat transfer. Measurement and control of bioprocess parameters: temperature, agitation, pressure, pH.

UNIT III: Downstream processing **9 Hours**

Cell disruption; precipitation methods; solid-liquid separation; liquid-liquid extraction; filtration; centrifugation; chromatography; drying devices (Lyophilization and spray dry technology); crystallization; biosensors-construction and applications. Food processing: food preservation, and spoilage. Sterilization and pasteurization; canning and packing of foods. Safety consideration in downstream processing.

UNIT IV: Immobilization and Biotransformation **9 Hours**

Methods of immobilization: adsorption, crosslinking, ionic bonding, entrapment, encapsulation; Advantages and industrial applications of Immobilization of enzymes and whole cells. Biotransformation of antibiotics, steroids and their applications. Basics of neutrigenomics: food-gene interactions; Process flow sheet and process economics.

UNIT V: Production of Industrially important products **9 Hours**

Alcohol: Ethanol, glycerol, butanol; Acetone; Organic acids: citric, acetic, and gluconic acid. Amino acids: lysine, glutamic acid. Antibiotics: penicillin, streptomycin, tetracycline. Vitamins: riboflavin; Enzymes: amylase, protease, biodegradable plastic: polyhydroxyalkanoates (butyarate, propionate); Recombinant protein: Insulin, hepatitis-B vaccine. Fermented foods: sausages, olives, bread, idly and acidophilus milk.

PRACTICAL

1. Study of fermentor- Demonstration.
2. Bacterial growth curve analysis
3. Secondary metabolites Production by using microbes
4. Production and analysis of ethanol
5. Isolation of Amylase producing organisms from soil
6. Production and analysis of lactic acid
7. Production and analysis of amylase
8. Determination of thermal death point [TDP] and thermal death time [TDT] of microorganism

SUGGESTED READINGS

1. Jackson AT., (1991).Bioprocess Engineering in Biotechnology, Prentice Hall, Engelwood Cliffs,
2. Shuler ML and Kargi F., (2002). Bioprocess Engineering: Basic concepts, 2nd Edition, Prentice Hall, Engelwood Cliffs,
3. Colin Ratledge and Bjorn Kristiansen, (2002). Basic Biotechnology (2nd Ed.).Cambridge University Press.
4. Prescott, Sc and Dunn, C. (1984) Industrial Microbiology, McGraw Hill, New York.
5. Casida LE. (1991). Industrial Microbiology. 1st edition. Wiley Eastern Limited.
6. Crueger W and Crueger A. (2000). Biotechnology: A textbook of Industrial Microbiology. 2nd edition. Panima Publishing Co. New Delhi.
7. Patel AH. (1996). Industrial Microbiology. 1st edition, Macmillan India Limited.
8. Stanbury PF, Whitaker A and Hall SJ. (2006). Principles of Fermentation Technology. 2nd edition, Elsevier Science Ltd
9. Satyanarayana U (2013) Biotechnology, Books And Allied (p) Ltd.

M.Sc. Biotechnology
Semester III

BIT350: Applied Biotechnology [Credit: 5(3+2)]

UNIT I: Nano biotechnology **9 Hours**

Introduction to Nano biotechnology: From biotechnology to Nano biotechnology; Approaches for synthesis of nanomaterial; Nano scale; Nanomaterial and their applications: Nano medicines, Nano probes, Nanotubes, Nano tissue engineering, Nano Submarines, Quantum Dots; Biosensors: Enzyme based and microbial based biosensors; DNA Bio nanotechnology; Lipid Bio nanotechnology; Application of Nano biotechnology in Agriculture, Medicine, Diagnostic and Environment.

UNIT II: Marine Biotechnology **9 Hours**

Isolation of Marine Natural Products (medicine, dyes etc.); Aqua culture technology; Aqua farm engineering; Pisciculture (cultivated species); Seed production technology of carps; Carp culture: Mono and Poly culture; Pearl oyster culture; Pearl culture technology; Quality and composition of pearl and their prospects; Seaweed culture: Economically important species culture and post-harvest technology.

UNIT III: Food and Dairy Biotechnology **9 Hours**

Prokaryotes & Eukaryotes based products (fermented meats, milk products, yoghurt, cheese, cereal, wine, beer); Role of biotechnology in food industry; Traditional methodology and new approaches (Gene probes, RDT, Bioluminescence) of food testing; Safety evaluation of genetically engineered enzymes/novel food products; Natural Control of Microorganism and preservation; Biogums; Bio- colours; Fumaric acid; Sweetener; Fat substitutes; Natural & modified starch, fats & oils food.

UNIT IV: Pharmaceutical and Medical Biotechnology **9 Hours**

Production of recombinant products: Growth Hormones, Human interferon, Vaccines & Monoclonal Antibodies; Antibiotics; Chemotherapeutic agents: Major classes and mechanism of action; Minimal inhibitory concentration (MIC); Microbial Drug resistance; Stem cells: Hematopoietic and Pleuripotent stem cells, Stem cell therapy; Gene therapy.

UNIT V: Bio-Entrepreneurship **9 Hours**

Entrepreneurship definition; Factors necessary for entrepreneurship; Desirables in a start-up; Pillars of bio-entrepreneurship; Promoting bio-entrepreneurship; Biotech company roadmap; Legal, regulatory and other business factors; Funding of biotech business; Bio-entrepreneurship efforts in India; Organizations supporting biotech growth; Areas of scope; Funding agencies in India; Biotech policy initiatives; Role of knowledge centers and R&D.

PRACTICAL

1. Isolation of nanoparticles from biological source.
2. Demonstration on development of biosensors.
3. Phenotypic characterization of carp.
4. Sterility testing of canned food.
5. Estimation of MIC of antibiotic.
6. Isolation of antibiotic resistant bacteria.
7. Case studies in Bio-entrepreneurship in India and world.
8. Startup proposal writing skill development.

SUGGESTED READINGS

1. Nanotechnology; Principles and Practices by Sulabha K. Kulkarni, (2009 Revised edition), Capital Publishing company, New Delhi.
2. Biological Nanostructures and Application of Nanostructures in Biology by Michael A. Stroscio and Mitra Dutta (2004) , Kulwer Academic Publishers.
3. Springer Handbook of Marine Biotechnology, Se-Kwon Kim (2015) Springer-Verlag Berlin Heidelberg Publisher
4. Microbiology by Pelczar, Chan and Krieg, (2015) Tata Mac Graw Hills Publications.
5. Food Microbiology, William Freizer Fifth Edition (2014) Tata MacGraw Hills Publications.
6. Bernhard Palsson and Sangeeta N Bhatia, Tissue Engineering, 2nd Edition, Prentice Hall, 2004.
7. Essentials of Stem Cell Biology, 2nd edition, (2009) Robert Lanza, et al. Elsevier Academic Press, USA
8. Stem cells and the future of regenerative medicine, 1st edition, (2002), National research council and Institute of medicine, National Academic press, Washington DC

M.Sc. Biotechnology
Semester III
BIT360: Immunology [Credit: 5(3+2)]

UNIT I: Immune System and Immunity **9 Hours**

History of immunology; Innate and adaptive immunity; Cells: Lymphoid progenitor cells- T-cells, B- cells, and Natural Killer cells, Myeloid Progenitor cells- Monocytes, Macrophages, Dendritic cells, Basophils, Eosinophils, Neutrophils, Mast cell; Primary and secondary lymphoid organs; Immune responses – Cell mediated and Humoral, Clonal selection theory.

UNIT II: Antigen, Antibodies and Complement Pathway **9 Hours**

Immunogenicity and Antigenicity; Types, structure and properties of antigens; Haptens; Adjuvant;. Immunoglobulins: structure, types and subtypes, properties; Primary and secondary immune responses; Antibody diversity; Antigen-Antibody reaction; Complement system – Structure, components, properties and functions; Complement pathways.

UNIT III: MHC and Hypersensitivity **9 Hours**

Major histocompatibility complex and their classes: Structure and functions; Human Leucocytes Antigen and Tissue transplantation; T cell and B cell receptors; Antigen processing and presentation; Chemokines; Cytokines; Hypersensitivity: Types and Mechanisms; Immunological tolerance and Autoimmunity; Autoimmune Diseases: Grave's disease, Myasthenia gravis, Rheumatoid arthritis; Immunodeficiency Diseases: SCID, Chediak-Higashi syndrome, DiGeorge syndrome.

UNIT IV: Immunization **9 Hours**

Active and passive immunization; Vaccine technology- Live, killed, attenuated and sub unit vaccines, Role and properties of adjuvants, conjugate vaccines, recombinant DNA and protein based vaccines; Hybridoma technology for monoclonal antibody production; Antibody engineering; Abzymes.

UNIT V: Immunotechnology **9 Hours**

Precipitation reactions: RID, ODD; Agglutination reaction: Coomb's test; Immunoassay: Immunoelectrophoresis, Immunofluorescence, ELISA, RIA and Flow cytometry; Immunological test: Montoux test, WIDAL, VDRL, Complement Fixation test and Western blot.

PRACTICAL

1. To perform Ouchterlony Double diffusion.
2. To perform Radial-Immuno diffusion.
3. To perform Enzyme Linked Immunosorbent assay.
4. To perform Latex agglutination.
5. To perform agglutination for blood group determination.
6. To perform serum separation from Blood.
7. To perform Staining for blood cell differentiation.
8. Demonstration of Immuno electrophoresis.

SUGGESTED READINGS

1. Delves P, Martin S, Burton D, Roitt IM. (2006). Roitt's Essential Immunology.11th edition Wiley-Blackwell Scientific Publication, Oxford.
2. Kuby, J. (2006). Immunology 6th Edition. WH. Freeman and Company, New York.
3. Murphy K, Travers P, Walport M. (2008). Janeway's Immunobiology. 7th edition Garland Science Publishers, New York.
4. Peakman M, and Vergani D. (2009). Basic and Clinical Immunology. 2nd edition Churchill Livingstone Publishers, Edinberg.
5. Richard C and Geiffrey S. (2009). Immunology. 6th edition. Wiley Blackwell Publication.

M.Sc. Biotechnology

Semester III

BIT370: Plant and Agricultural Biotechnology [Credit: 5(3+2)]

UNIT I: Fundamentals of Plant Tissue Culture **9 Hours**

Introduction to cell and tissue culture; Scope and Importance of plant tissue culture; Media composition and types; Plant growth regulators; Callus and Suspension culture; Single cell culture; Organogenesis: Root and Shoot regeneration; Somatic embryogenesis, Micro propagation: Somaclonal variation and Artificial seeds; Protoplast culture; Somatic hybridization and Cybrids; Anther and Ovule culture; Germplasm conservation and cryopreservation.

UNIT II: Commercialization of Plant Tissue Culture **9 Hours**

Applications of Micropropagation in forestry, floriculture and agriculture; Conservation of biodiversity and threatened plants; Hardening and acclimatization – success and bottlenecks; Greenhouse: design, management and operation; Quality control, packaging, shipment and cost-benefit analysis; Global market; Commercial opportunities with special reference to plant tissue culture industries in India.

UNIT III: Crop Improvement **9 Hours**

Gene constructs; Vectors for the production of transgenic plants: Viral vectors, Ti and Ri plasmid; *Agrobacterium* mediated gene transfer; Genetic transformation of chloroplast; Transgenic plants: Resistance to biotic stress (Herbicide, Insect, Virus, Fungal and Bacterial Resistance) and abiotic stresses (Drought and Salt resistance); Terminator gene technology; Current status of transgenic plants; Application of transgenic plants; Biofortification for quality enhancement: Starch, Oil, Seed protein, Golden rice, Transgenic sweet potato etc.; Biofertilizers; Plant growth promoting rhizobacteria (PGPR).

UNIT IV: Molecular Mapping & Marker Assisted Selection (MAS) **9 Hours**

Quantitative and qualitative traits; Plant DNA fingerprinting: Molecular polymorphism in plant, RFLP, STS, SSRs, SNP, RAPD, QTLS , SCARS, AFLP etc; Marker-Assisted Selection; Construction of genetic and physical map; QTL mapping and cloning.

UNIT V: Metabolic Engineering in Plants and IPR **9 Hours**

Production of useful chemicals and secondary metabolites; Production of Industrial enzymes; Production of biodegradable plastics; Production of therapeutic proteins; Production of edible vaccines; Production of antibiotics; Control mechanism and manipulation of phenyl propanoid pathway, Shikimate pathway; Petrocrops; IPR and IPP; Plant Breeders Rights; Bio-safety guidelines; Patenting of biological product-turmeric, Basmati rice, Neem; Bioethics.

PRACTICAL

1. Preparation of MS solid and liquid medium for plant tissue culture.
2. Sterilization of plant tissue- Chemical and Physical methods.
3. Induction of callus from carrot explants.
4. Demonstration of various stages of Micro propagation.
5. Isolation and fusion of protoplasts.
6. Plants extract preparation and its antifungal and antibacterial activity analysis.
7. Phosphate solubilization activity of PGPR.
8. Testing *Rhizobium*/ PGPR isolates for nitrogen fixing ability.

SUGGESTED READINGS

1. Chawla HC (2004) – Introduction to plant biotechnology (Science Publ)
2. Bhojwani SS. & Razdan MK (1996). - Plant Tissue Culture : Theory & Practice (Elsevier)
3. H K Das Textbook of Biotechnology 4th edition
4. Hou CT, Shaw JF (2009) – Biocatalysis and agricultural biotechnology, CRC Press,USA
5. Rawat H, Oxford Book Co,India. Agricultural Biotechnology, 1st edition, (2008)
6. B.D. Singh- Biotechnology: Expanding Horizons, Kalyani publication, New Delhi , India
7. R. C. Dubey (2006). A Textbook of Biotechnology 4th Rev. Edition, S. Chand Publishing, New Delhi , Indi

M.Sc. Biotechnology
Semester III
BIT381: Animal Biotechnology [Credit: 3(3+0)]

UNIT I: Introduction to Animal Cell Culture **9 Hours**

Introduction to basic animal cell culture techniques – minimal facilities, contamination, aseptic methods and sterilization, advantages and limitations of tissue culture, risks and safety regulations; Culture media – natural and artificial media, important physicochemical properties of culture media, balanced salt solutions, supplements; serum and serum-free media; Characteristics of cultured cells, cell adhesion, proliferation and differentiation, metabolism and characterization; Measurement of growth parameters of cultured cells; Cell separation methods, senescence and apoptosis.

UNIT II: Cell Lines and Scale-up Methods **9 Hours**

Primary culture; mechanical and enzymatic disaggregation; primary explant technique; medical ethics; Cell lines (finite and continuous; commonly used cell lines, maintenance of cell lines); subculture of adhesion and suspension cultures; Stem cell cultures. Types of culture processes for scale-up (batch vs. continuous); Scale-up in suspension (stirrer, bio stat, air-lift fermenter, rotating chambers, perfused chambers); Scale-up in monolayer (roller bottles, micro carrier, fixed-bed and fluidized-bed); Monitoring of cell growth in scale-up cultures.

UNIT III: Cell Viability, Cell Cloning and Organ Cultures **9 Hours**

Assays for cell viability and cytotoxicity – viability assays, survival assays, metabolic assays, transformation assays, inflammation assays; Transformation of cells, tumorigenicity, cell cloning (dilution cloning and suspension cloning); Organ cultures, Histiotypic cultures, Organotypic cultures; Sources of cells for tissue engineering (autologous, allogeneic and xenogeneic).

UNIT IV: Gene Therapy and Diagnosis **9 Hours**

Approaches for gene therapy; ex vivo and in vivo method; anti-sense therapy; diagnosis of diseases; DNA fingerprinting or profiling; DNA markers; hybridoma technology, production of monoclonal antibodies (MAbs), applications.

UNIT V: Assisted Reproduction and Transgenic Animals **9 Hours**

Manipulation of reproduction (Embryo Transfer, IVF); cryopreservation; Concepts of transgenic animal technology; Transgenic mice - introduction of transgene by retroviral, microinjection and embryonic stem cell methods; Transgenic cattle; Transgenic sheep & goats; Transgenic pigs; Transgenic chickens and fish; Transgenic animals in xenotransplantation; Strategies for the production of transgenic animals and their importance in biotechnology; stem cell cultures in the production of transgenic animals

SUGGESTED READINGS

1. Freshney, I. Culture of Animal Cell. John Wiley.
2. Martin, C. (Ed). Animal Cell Culture Techniques. Springer,1998
3. Mather and Barnes. (Ed). Methods in Cell Biology. Vol. 5-7, Animal Cell Culture Method. Academic Press.
4. Butler, M. and Dawson, M. Lab Fax : Cell Culture. Bios Scientific Publications.
5. Jenkins, N. Animal Cell Biotechnology. Panima Books Distributors.8.
6. Singh B, Gautam S K, and Chauhan M S-Textbook of Animal Biotechnology, TERIPress.
7. Bench (2004) Animal Cell Culture & Technology – Basic from Background to Taylor &Fracis.
8. Ballinic C.A., Philips J.P and Moo Young M. Animal Biotechnology. Pergamon press, New York.1989.
9. Richard D. Turd,(2003) Instant Notes in Animal Biology.
10. Singh B.D. (2017) Biotechnology: Expanding Horizons, Kalyani publication, New Delhi , India
11. Dubey R C (2006) A Textbook of Biotechnology 4th Rev. Edition, S. Chand Publishing, New Delhi , India

M.Sc. Biotechnology
Semester III
BIT382: IPR, Biosafety and Bioethics [Credit: 3(3+0)]

UNIT I: Introduction to IPR **9 Hours**

Introduction to intellectual property; Types of IP: Patents, Trademarks, Copyright & Related rights, Industrial design, Traditional knowledge, Geographical indications, Protection of new GMOs; International framework for the protection of IP; IP as a factor in R&D; IPs of relevance to biotechnology and few case studies; Introduction to history of GATT, WTO, WIPO and TRIPS; Concept of 'prior art': invention in context of "prior art"; Patent databases - country-wise patent searches (USPTO, EPO, India); analysis and report formation.

UNIT II: Basics of Patents **9 Hours**

Types of patents; Indian Patent Act 1970; Recent Amendments; Filing of a patent application; Precautions before patenting-disclosure/non-disclosure; WIPO Treaties; Budapest Treaty; Patent Cooperation Treaty (PCT) and Implications; Role of a Country Patent Office; Procedure for filing a PCT application.

UNIT III: Patent filing and Infringement **9 Hours**

Patent application: forms and guidelines, fee structure, time frames; Types of patent applications: provisional and complete specifications; PCT and convention patent applications; International patenting-requirement, procedures and costs; Financial assistance for patenting-introduction to existing schemes; Publication of patents-gazette of India, status in Europe and US; Patenting by research students, lecturers and scientists-University/organizational rules in India and Abroad; Credit sharing by workers; Financial incentives; Patent infringement-meaning, scope, litigation, case studies and examples.

UNIT IV: Biosafety **9 Hours**

Introduction; Historical backround; Introduction to Biological Safety Cabinets; Primary containment for Biohazards; Biosafety levels; Biosafety Levels of specific microorganisms; Recommended Biosafety Levels for infectious agents and infected animals; Biosafety guidelines, Definition of GMOs & LMOs; 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 Cartagena protocol.

UNIT V: Bioethics **9 Hours**

Introduction, Ethical conflicts in biological sciences - interference with nature, Bioethics in health care - patient confidentiality, informed consent, euthanasia, artificial reproductive technologies, prenatal diagnosis, genetic screening, gene therapy, transplantation; Bioethics in research: cloning and stem cell research, Human and animal experimentation, animal rights/welfare; Agricultural biotechnology - Genetically engineered food, environmental risk, labeling and public opinion; Sharing benefits and protecting future generations - Protection of environment and biodiversity; Biopiracy

SUGGESTED READINGS

1. Ganguli, P. (2001). Intellectual Property Rights: Unleashing the Knowledge Economy. New Delhi: Tata McGraw- Hill Pub.
2. Kuhse, H. (2010). Bioethics: an Anthology. Malden, MA: Blackwell.
3. Karen F. Greif and Jon F. Merz, Current Controversies in the Biological Sciences -Case Studies of Policy Challenges from New Technologies, MIT Press
4. Recombinant DNA Safety Guidelines, 1990 Department of Biotechnology, Ministry of Science and Technology, Govt. of India. Retrieved from http://www.envfor.nic.in/divisions/csurv/geac/annex-5.pdf
5. Craig, W., Tepfer, M., Degrassi, G., & Ripandelli, D. (2008). An Overview of General Features of Risk Assessments of Genetically Modified Crops. Euphytica, 164(3), 853-880.
6. Guidelines for Safety Assessment of Foods Derived from Genetically Engineered Plants. 2008.

M.Sc. Biotechnology

Semester III

BIT390: Biostatistics and Bioinformatics [Credit: 4(4+0)]

UNIT I: Biostatistics **12 Hours**

Brief description of tabulation of data and their graphical representation; Measures of central tendency and dispersion: Mean median, mode, range, standard deviation; Simple linear regression and correlation. Brief idea of statistical software and their applications; Elementary idea of probability; Analysis of Variance (ANOVA); Idea of two types of errors and level of significance; Test of significance: chi-square test of independence and homogeneity test based on Z, T and F statistics.

UNIT II: Introduction to Bioinformatics **12 Hours**

Concepts of Bioinformatics; Biological Databases- Concept, Types, Specialization, Limitations; DBMS; Data retrieval from various databases; sequence database; genome database; Introduction to different database: Gene Bank, NCBI, EMBL, DDBJ, SWISS PROT, NCBL & PDB, Pubmed, KEGG Pathway Database; NCBI Homology searching and their applications; Concept of ORF and ORF finder; Sequence Alignments: Algorithms, Scoring Matrices, Multiple Sequence Alignment (MSA).

UNIT III: Gene Annotation **12 Hours**

Analysis of Sanger sequence data and sequence optimization; Sequence submission tools in NCBI; Molecular Modeling; Acquisition and visualization of molecular structures; Sequence and Structure based predictions: Simulation of Molecular interactions; Phylogenetic analysis and tree construction methods: Comparative genomics, Orthologs, Paralogs, UPGMA, WPGMA, neighbor joining method, Bootstrap method, Fitch-Margoliash method, Character Based Methods.

UNIT IV: Protein Structure Prediction **12 Hours**

Protein structure basics; Ramachandran plot; SCOP and CATH; Introduction to Protein motifs and domain prediction; Protein profiles and Hidden Markov Model (HMM); 3D Structure Database: PDB, NDB, Knowledge driven Databases & utility; Pattern Sequence: InterPro, Prosite, Pfam, ProDom; Protein localization software; Hydropathy software.

UNIT V: Application in Drug Design **12 Hours**

Chemical databases like NCI / PUBCHEM; Fundamentals of Receptor-ligand interactions; Ligand and Structure-based drug design: Identification and Analysis of Binding sites and virtual screening; Structure Activity Relationship – QSARs & Pharmacophore etc, In-silico predictions of drug activity and ADMET, Drug target finding, Immunoinformatics, vaccinology and Applications of bioinformatics.

SUGGESTED READINGS

1. Gupta, S.C. and Kapoor, V.K. Fundamentals of applied statistics. S. Chand and Company.
2. Sharma, Munjal and Shankar.A text book of bioinformatics (2008) Rastogi Publications, Meerut.
3. Neil Jones, Pavel Pevzner. An introduction to Bioinformatics Algorithms (2004) A Bradford Book, The MIT Press, USA
4. Thomas Langauer (editor)Bioinformatics - From Genomes to Drugs (2001) Wiley- VCH; 1st edition, New York
5. laurie J. Heyer Discovering genomics, Proteomics and Bioinformatics (2006) Pearson-Benjamin Cummings; 2nd edition, USA
6. Arthur M. Lesk Introduction to Bioinformatics (2008) OUP, Oxford
7. Buehler L.K and Rashidi H.H. (2005). Bioinformatics Basics: Applications in Biological Science and Medicine. Second edition. CRC press, Taylor and Francis Group.
8. McEntyre J and Ostell J (2012). eNCBI Handbook. Bethesda (MD): National Center for Biotechnology Information (US)
9. Banerjee P. K. (2004) Introduction to Biostatistics, S Chand & Company LTD.
10. Kumar S and Veeri S (2008) Basic Biostatistics, Campus book International.