JIWAJI UNIVERSITY, GWALIOR-474011
M.SC. BIOTECHNOLOGY

CURRICULUM *2013-2015*

Semester	Title of the Paper	Marks	
		EA	**IA**
First	101. Cell Biology	85	15
	102. Biomolecules and Metabolism	85	15
	103. Microbiology	85	15
	104. Bioinstrumentation	85	15
	105. Lab Course I	100	
	106. Lab. Course II	100	
Second			
	201. Molecular Biology	85	15
	202. Immunotechnology	85	15
	203. Enzymetechnology	85	15
	204. Part A: Environmental Biotechnology Part B: Animal Biotechnology	85	15
	205. Lab Course III	100	
	206. Lab Course IV	100	
Third			
	301. Genetic Engineering	85	15
	302. Plant Biotechnology	85	15
	303. Bioprocess Engineering and Microbial Technology	85	15
	304. Biostatistics and Computer Applications	85	15
	305. Lab Course V	100	
	306. Lab Course VI	100	
Fourth			
	401. Emerging Trends in Biotechnology	85	15
	402. Optional 1. Bioinformatics Optional 2. Entrepreneurship in Biotechnology & IPR Optional 3. Management and Marketing of Biotechnology Products	85	15
	403. Lab Course VII : Technical/ Review writing	100	
	404. Project Work*	300	

*Evaluated both by the Internal & External examiner at the time of presentation. There shall not be compulsory project works during first three semesters. There are weekly seminars and continuous internal assessment throughout the course.

101: CELL BIOLOGY

UNIT I

1. Cell Membrane: Physicochemical Properties; Molecular Organization – asymmetrical organization of lipids, proteins and carbohydrates; Biogenesis and Functions
2. Transport of Small Molecules Across Cell Membranes: Types and Mechanism
3. Active Transport by ATP-Powered Pumps Types: p-type, V-type, F-type ABC transporters.
4. Properties and mechanisms of transporters; Patch pump technique.

UNIT II

1. Structure, function and transport of proteins into mitochondria and chloroplast.
2. Transport of proteins and RNA into and of nucleus.
3. Transport of proteins into endoplasmic reticulum and Golgi bodies.
4. Transport by vesicle formation: Endocytosis and Exocytosis and olecular Mechanism of vesicular transport.

UNIT III

1. Ultra structure and function of lysosomes, peroxisomes and Vacuoles.
2. Cell motility and shape I: Structure and functions of microfilaments
3. Cell motility and shape II: Structure and functions of microtubules and intermediate filaments
4. Intracellular communication through cell junctions: Occluding junctions, anchoring junctions and communicating junctions

UNIT IV

1. Molecular mechanism of cell-cell adhesions: Ca^{++} dependent cell-cell adhesion
2. Molecular mechanism of cell-cell adhesion: Ca^{++} independent cell-cell adhesion
3. Extra-cellular matrix of animals: organization and functions
4. Extra-cellular matrix receptors on animal cells: integrins

UNIT V

1. Cell Signaling: Signaling via G-Protein linked cell surface receptors, MAP kinase pathways and tyrosine kinase pathway: Initiation, interaction and regulation.
2. Eukaryotic cell division cycle: Different phases and molecular events
3. Control of cell division cycle: In yeast and mammalian cells
4. Apoptosis: Phases and significance, Morphological and biochemical changes associated with apoptotic cells, Apoptotic pathways and regulators

Practical Exercises

1. Sub cellular fractionation
2. Chromosome preparation: Mitosis – Onion root tip, rat/mouse cornea, rat/mouse bone marrow, human lymphocytes
3. Chromosome preparation: Meiosis – Rat/mouse testis, Grasshopper testis
4. Polytene chromosome preparation from Drosophila salivary gland
5. Identification of tissue typing: Histological preparation of tissue
6. Identification of different biomolecules in different tissues by histochemical techniques
7. Electron microscopy: Demonstration and good photographs for interpretation.

Reference Books

1. Molecular Biology of the Cell (2002), Alberts et al
2. Molecular Cell Biology (2004), Lodish et al
3. Working with Molecular Cell Biology: A study Companion (2000), Storrie et al
4. Cell and Molecular Biology: Concepts and Experiments (3rd Ed., 2002), Gerald Karp
5. The Cell: A Molecular Approach (2004), G.M. Cooper
6. The Word of the Cell (1996), Becker et al
7. Cell Proliferation and Apoptosis (2003), Hughes and Mehnet
8. Essential Cell Biology (1998), Alberts et al
9. Biochemistry and Molecular Biology of Plants (2000), Buchanan et al
10. Harpers Biochemistry Murray et al

102. BIOMOLECULES & METABOLISM

UNIT I

1. Carbohydrates: Structure, classification, properties, chemical reactions, stereoisomerism and functions.
2. Home and hereo polysaccharides, animal, plant and microbe specific polysaccharides, bacterial cell wall, carbohydrate derivatives: peptidoglycans, glycolipids, sialic acid.
3. Lipids; Classification, structure, properties and functions of fatty acids, triacylglycerols, phospholoipids, wax, sterols, terpenes, prostaglandins.
4. Lipids with specific biological functions, lipoproteins and biological membrane, micelles and liposomes.

UNIT II

1. Amino acids: Structure, classification, properties and functions, peptides and polypeptides.
2. Proteins: Properties, primary, secondary, tertiary and quaternary structure.
3. Vitamins and cofactors: structure, distribution, interaction and biological properties.
4. Nucleic acids: DNA: Structure, conformation, properties of purines nad pyrimidine bases, nucleosides and nucleotides; RNA: Structure, types and functions of mRNA, tRNA and rRNA.

UNIT III

1. First and second laws of thermodynamics & concept of free energy.
2. High energy phosphor compounds, ATP cycle, structural basis of free energy change during hydrolysis of ATP.
3. Carbohydrate metabolism: Basic concepts of glycolysis, glycogenesis, gluconeogenesis pathway and regulation.
4. Krebs cycle:, pentose phosphate pathway, glyoxalate pathway, glycogenolysis pathway and regulation, associated Intracellular communication through cell junctions: Occluding junctions, anchoring junctions and communicating junctions

UNIT IV

1. Electron transport and oxidative phosphorylation : electron carriers, complexes I to IV, chemiosmotic theory, substrate level phosphorylation
2. Plant phenolics, alkaloids: classification and functions. Plant hormones: structure and biological functions.
3. Lipid metabolism: Biosynthesis and degradation of odd carbon and even carbon
4. Saturated and unsaturated fatty acids, formation and of ketone bodies, regulation of Lipid metabolism, associated inborn errors.

UNIT V

1. Overview of amino acid metabolism: biosynthetic families of amino acids, breakdown of amino acids into six (to check) common intermediates.
2. Regulation of amino acid metabolism (Steps for the biosynthesis and breakdown of amino acids are not required) , associated inborn errors.
3. Nucleic acid metabolism: biosynthesis and breakdown of purine, pyrimidines, nucleotides by *de novo* and salvage pathways,
5. Regulation of metabolism, associated inborn errors.

Practical Exercises

1. Titration of amino acids.
2. Colorometric determination of pK.
3. Model building using space filling/ ball and stick models.
4. Reactions of amino acids, sugars and lipids.
5. Quantitation of proteins and sugars.
6. Analysis of oils- iodine number, saponification value, acid number.

Reference Books

1. Principles of Biochemistry by Nelson, Cox and Lehninger.
2. Biochemistry by G. Zubay
3. Biochemistry by Stryer
4. Biochemistry by Garrett and Grisham
5. Biochemical Calculations, Irwin H. Segel, john Wiley and sons Inc
6. Biochemistry,DVoet and jG Voet , J Wiley and Sons.
7. Biochemistry, D Freifilder, W.H. Freeman & Company.
8. Laboratory Techniques in Biochemistry and molecular Biology, Work and Work.
9. A Biologists guide to Principles and Techniques of practical Biochemistry, K.Wilson & K.H. Goulding, ELBS Edition,

103. MICROBIOLOGY

UNIT I

1. Classification of Microorganisms: Bacterial & Fungal Classification.
2. Morphology and fine structure of eubacteria, archeobacterial cell wall and fungal cell wall.
3. Preparation of culture media, pure culture techniques and microbial staining.
4. Cyanobacteria : General account and their economic importance

UNIT II

1. Sterilization: Physical and chemical methods.
2. Microbial growth: Bacterial growth curve, Mathematical expression, measurement of growth and factors affecting growth.
3. Microbial Nutrition: Nutritional classification of Microorganisms, Different carbon and nitrogen sources, mode of nutrition, transport of nutrition across the bacterial membrane.
4. Oxygen toxicity: Study of catalase, peroxidase, superoxidase dismutase, mechanism of oxygen toxicity/ Taxonomic classification of microbes using molecular markers- 16 rRNA typing.

UNIT III

1. Infection and disease, types of infection, Mechanism of pathogenesis of bacterial and viral disease.
2. *Staphylococccal* and *Clostridial* food Poisoning, Bacterial Diseases: Salmonellosis and Shigellosis.
3. Fungal Diseases: Histoplasmosis, Aspergillosis and Candidasis.
4. Viral diseases: Chicken Pox, Hepatitis B and Poliomyelitis.

UNIT IV

1. Virus organization, Types, Isolation, cultivation, identification and viral replication.
2. Structure and morphology of bacteriophages, lytic and lysogenic cycle.
3. Life cycle of DNA viruses: SV 40, RNA viruses: Retroviruses.
4. Plant viruses: TMV, Gemini, CMV, Human Viruses: Influenza (SARS), Herpes Simples virus, Rubella.

UNIT V

1. Micoplasma and diseases caused by them.
2. Bacterial Recombination: Transformation, conjugation, transduction, Plasmids and Transposes.
3. Chemotherapeutic agents: Classification of Antibiotics, Broad and narrow spectrum antibiotics; Antibiotics from prokaryotes.
4. Anti-fungal and antiviral antibiotics, mode of action of antibiotics and mechanism of drug resistance, origin of drug resistance.

Practical Exercises

1. Preparation of Liquid and Solid media for growth of microorganisms.
2. Isolation and maintenance of organisms by plating, streaking and serial dilution method, slant and stab cultures, storage of microorganisms.
3. Isolation of pure cultures from soil and water
4. Growth; Growth curve; Measurement of bacteria population by turbidometry and serial dilution methods. Effect of temperature, pH and carbon and nitrogen sources on growth.
5. Microscopic examination of bacteria, Yeast and mold and study of organism by Gram's stain, acid fast stain and staining for spores
6. Study of mutation by Ame's Test.
7. Assay of antibiotics and demonstration of antibiotic resistance
8. Analysis of water for potability and determination of MPN.
9. Bacterial transformation.
10. Biochemical Characterization of selected microbes.
11. One Step growth curve of coliphage.

Reference Books

1. General microbiology, R.Y. Ingraham, J.L. Wheelis, M.L. and Painter, P.R. The Macmillan Press Ltd.
2. Brock Biology of microorganism, M.T. Martinko, J.M. and Parker, J. Prentice-Hall.
3. Microbiology, Pelczar, M.J., Chan E.C.S. and Kreig, N.R., Tata McGraw Hill.
4. Microbial Genetics, Malloy, S.R., Cronan, J.E. Jr and Freifelder, D.Jones, Bartlett Publishers
5. Microbiology-A Laboratory Manual, cappuccino, J.G. Sherman, N. Addison Wesley.
6. Microbiological Applications (A Laboratory Manual in General microbiology) Benson, H.J. WCB: Wm C Brown Publishers

104. BIOINSTRUMENTATION

UNIT I

1. Centrifugation: Principle, types and applications; sedimentation coefficient and factor affecting centrifugation
2. Photometry: Principle, instrumentation and application of UV-visible spectrophotometry
3. Infrared (IR) spectroscopy and its applications
4. Fluorescence spectroscopy: Principle, instrumentation and applications

UNIT II

1. Atomic absorption spectroscopy: Principle, instrumentation and application
2. Chromatography: Principle and applications of -Paper, thin layer and column chromatography
3. HPLC, Gas chromatography, Gel filtration and Ion exchange chromatography
4. Electrophoresis: Principle, types and applications; 2-D gel electrophoresis-Principle and its application

UNIT III

1. Electron spin resonance (ESR) spectroscopy
2. Nuclear Magnetic resonance: Principle, Instrumentation and applications
3. Circular dichrorism spectroscopy (CD): Principle, Instrumentation and applications:
4. X-ray crystallography: Principle, instrumentation and applications

UNIT IV

1. Mass spectrometry: Principle and components of mass spectrometer
2. Mass analyzers: Magnetic sector, Time of flight (TOF), Quadruople, advantages and disadvantages; LC-MS
3. Surface plasma resonance methods and its applications.
4. Flow cytometry: Principle, instrumentation and application

UNIT V

1. Microtomy: Types, Principal and applications.
2. Microscopy: Basic Principle and components of microscope, phase contrast and fluorescent microscopes
3. Electron microscopes: TEM and SEM- Principle and applications
4. Radioactivity: Principle, detection and measurement of isotopes: Autoradiography, types of radio isotopes used in biology and their application in biological science

Practical Exercises

1. Verification of Beer's law
2. Determination of absorption maxima
3. Electrophoresis of Proteins- native and under denaturing conditions.
4. Amino acid and carbohydrate separations by paper & thin layer chromatography
5. Gas chromatography
6. Ion exchange and gel filtration chromatography
7. Separation of subcellular organelles by differential centrifugation
8. Separation of blood cells by density gradient centrifugation

Reference Books

1. Physical Biochemistry: Applications to Biochemistry and Molecular Biology by Freifelder
2. Biochemical Techniques : Theory and Practice by Robyt and White
3. Principles of Instrumental Analysis by Skoog and West
4. Analytical Biochemistry by Holme and Peck
5. Biological Spectroscopy by Campbell and Dwek
6. Organic Spectroscopy by Kemp
7. A Biologist's Guide to Pronciples and Techniques of Practical Biochemistry by Wilson and Goulding
8. Principles of Instrumental Analysis by Skoog, Hollar and Nicman

201. MOLECULAR BIOLOGY

UNIT I

1. Nature of Gene: Evolution of Gene Concept, Chemical Nature of Gene, Gene-cistron Relationship in prokaryotes and eukaryotes, Overlapping genes, Nested Genes, Gene families and pseudogenes. Proof of DNA as genetic material.
2. Denaturation and Renaturation of DNA. Molecular Basis of Gene Mutation:, Biological Repair Mechanisms, Repair Defects and Human Diseases
3. DNA Replication: General features of Chromosomal Replication. DNA Replication Machinery in Prokaryotes and its comparision with Eukaryotes.
4. Enzymology of DNA Replication : DNA Polymerases; Primases; Ligases; Helicases; Topoisomerases; Gyrases and Single stranded Binding Proteins. Regulation of DNA Replication ; Inhibitors of DNA Replication

UNIT II

1. Transcription in prokaryotes: Initiation, elongation and termination
2. Structure and Function of prokaryotic promoter
3. Control of transcriptional initiation in prokaryotes: Structure and function of RNA Polymerase: Sigma factors- Types and functions
4. Control of transcriptional termination: Attenuation and anti termination

UNIT III

1. Regulation of gene expression in prokaryotes: Operon concept, induction and repression, Structure and regulation of lactose, arabinose and tryptophan operons
2. Initiation of transcription in Eukaryotes: RNA Polymerases Types and properties
3. Transcription factors- Types and properties; Enhancers- Structure and properties; Response Elements
4. Post-transcriptional Modification Eukaryotes- 5’ and 3’ modification of mRNA

UNIT IV

1. Post- transcriptional Processing of pre mRNA, pre rRNA and pre tRNA transcripts
2. Genetic Code: Evidence and properties; Wobble hypothesis; Transcriptional adaptors and amino acyl tRNA synthases
3. Translation: Successive stages of protein synthesis in prokaryotes and its comparison with eukaryotes
4. Post-translational Modification: Types and Significance

UNIT V

1. Regulation of Gene Expression in Eukaryotes: cis- acting DNA elements; Chromatin organization and regulation of gene expression; regulation at the level of processing of transcripts
2. Regulation of Gene Expression in Eukaryotes: RNA editing; Gene Alteration; DNA methylation and gene regulation; Regulation of gene expression by hormones: regulation of gene expression at translational level
3. Transposable elements in Prokaryotes and Eukaryotes: Types and Significance
4. Oncogenes and Tumor Suppressor Genes: Properties and Significance

Practical Exercises

1. Isolation of Genomic DNA and restriction Digestion
2. Size fractionation of restricted DNA fragments by Agarose Gel Electrophoresis
3. Quantitations of DNA
4. Determination of Amax of purified DNA fragments
5. Determination of Tm of nucleic acid
6. Isolation of RNA
7. Fractionation of poly (A) RNA
8. *In vitro* transcription
9. *In vitro* translation
10. Metabolic labeling of proteins and immunoprecipitation
11. Protein-DNA interaction

Reference Books

1. Genes IX Benjamin Lewin
2. Molecular Biology , turner et al
3. Cell and Molecular Biology: Concepts and Experiments, Gerald Karp
4. Translational regulation in eukaryotes (2000), Carey and Smale
5. Translational control of Gene Expression (2000), Sonenberg et al
6. Chromatin and Gene Regulation (2001), Turner
7. An Introduction to Genetic Analysis, Griffiths et al
8. Genome (1999), Brown
9. Concepts pf Genetics, Klug and Cummings
10. Proteins, Creighton
11. Molecular Cell Biology, Lodish et al
12. Biochemistry and Molecular Biology of Plants (2000), Buchanan
13. Plant Biochemistry and Molecular Biology, Lea and Leegood
14. Plant Biochemistry (1997), Dey and Harborne

202 IMMUNOTECHNOLOGY

UNIT I

1. Immune response: Innate and adaptive immune system: Cells and molecules involved, characteristics and mechanism. hematopoiesis and differentiation of hematopoietic cells by cytokines. Toll-like receptor-component of innate immune system; clonal selection theory.
2. Anatomical organization of immune system: Primary lymphoid organ, secondary lymphoid organs. Ontogeny and phylogeny of lymphocytes, lymphocyte traffic.
3. Cell of immune system: Mononuclear cells and granulocyte, antigen presenting cells; APCs: professional and Nonprofessional;
   Lymphocytes and their subsets, lymphocyte surface molecules and receptors and flow cytometry. Artigens, Heptanes: factor effecting immunogenicity; super antigen, Antigenicity and immunogenicity.
4. Inflammation: its mediators and the process, cell-adhesion molecules and their role in inflammation, Leukocyte migration, lymphocyte homing, tissue injury and immune response leading to an inflammatory reaction, role of anaphylotoxins, granulocytes in inflammatory process.

UNIT II

1. Major histocompatibility systems: Structure of MHC I and II molecule, polymorphism, distribution variation and function. Organization of MHC with complex in Mouse and human. Association of MHC with disease.
2. Recognition of antigens by T and B Cells: Antigen processing, role of MHC molecules in antigen presentation and co stimulatory signals.
3. T-cell receptor complex, T-cell accessory membrane molecules, activation of T-cell, organization and arrangement of T-cell receptor genes.
4. B-cell receptor complex, activation and differentiation of B-cells, Immunoglobulin's (Class and subclass): Molecular Structures, type and function. Antigenic determinants of immunoglobulins (isotype, allotype and idiotype).

UNIT III

1. Molecular mechanism of antibody diversity organization of genes coding for constant and variable regions of heavy and light chain .Mechanism of antibody diversity, Class switching .
2. Antigen-Antibody infestation and affinity amusement.
3. Monoclonal Antibodies: Principle of hybridoma technology, production characterization and application in diagnosis, therapy and basic research, Fusion methods.
4. Compliment system, components, Activation pathway and regulation of activation pathway, complement deficiency, role of complement system in immune responses opsonization (opsonin)

UNIT IV

1. Cytokines: Suctions and function, cytokine receptors, Signal transduction mediated by cytokine receptors, cytokine regulation of immune response, cytokine related diseases and therapeutic application of cytokine.
2. Cytotoxic T-Cell and their mechanism of action, NK cell and mechanism of target cell destruction, Antibody dependent cell mediated cytotoxicity , techniques of cell mediated immunity.
3. Immunoregulation by antigens, Antibodies, immune complexes, MHC and cytokines.

4. Hypersensitivity : Definition, l_gE mediated Hypersensitivity, mechanism of mart cell degranulation, mediators of type I reactions and consequences type II reaction, immune complex mediated Hypersensitivity and delayed type Hypersensitivity.

UNIT V

1. Autoimmunity: Organ specific and systemic diseases, mechanism of autoimmunity.
2. Immune response during bacterial (tuberculosis), Parasitic (malaria) and viral (HIV.) infection, congenital and acquired immunodeficiency; diagnosis and therapeutic approaches.
3. Vaccines: Active and passive immunization, whole organism vaccines, macromolecules as vaccines, Recombinant-vector vaccines, DNA vaccines, synthetic peptide vaccines and sub-unit vaccines, Anti-idiotype vaccines.
4. Immunodiagnostics: development of immunodiagnostics kits for infectious and non infectious diseases with example. Precipitation techniques, Agglutination, fluorescence techniques (FACS), ELISA, RIA, western Blotting and immuno-histochemical techniques (Avidin and Biotin system), Antibody engineering.

Practical Exercises

1. Blood Film Preparation and identification of cells.
2. Lymphoid organs and their microscopic organization.
3. Immunization and production of polyclonal antibodies.
4. Double diffusion and Immuno-electrophoresis.
5. Radial immunodiffusion.
6. Purification of IgG from serum.
7. Separation of mononuclear cell by Ficoll-paque.
8. Con-A induced proliferation of thymocytes (by MTT Method).
9. Western blotting.
10. ELISA
11. Preparation o antibody-enzyme conjugates.

Reference Books

1. Immunology, Kubey, R.A. Goldsby, Thomas J.Kindt, Barbara, A. Osbarne (Freeman).
2. Immunology- A short Course, Eli Benamini, Richard Coico, Geoffrey Sunshine.
3. Immunology by Tizzard
4. Fundamentals of Immunology, William Paul.
5. Immunology by Roitt and others.
6. Immunology by Abbas

203. ENZYME TECHNOLOGY

UNIT I

1. Enzyme: Historical aspects, classification and nomenclature, EC number
2. Mechanism of enzyme action and properties of enzymes as catalysts
3. Sub-cellular localization and organization of enzymes
4. Methods of enzyme assay: continuous and sampling techniques, coupled enzyme assays, specific activity, turn over number

UNIT II

1. Enzyme purification: Objectives and strategy, methods of isolation overview of purification techniques and crystallization
2. Criteria of purity and tabulation of purification data, stable storage of enzymes
3. Characterization of purified enzyme.
4. Enzyme engineering: Site directed mutagenesis

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UNIT III

1. Enzyme kinetics: Equilibrium and steady state theory, rate equation and determination of Km and V_{max}
2. Factors affecting rate of enzyme reaction: pH, temperature and pressure
3. Enzyme inhibition: reversible and irreversible inhibition, Applications of inhibitors
4. Rapid reaction techniques

UNIT IV

1. Isoenzymes and their physiological significance
2. Allosteric enzymes: co-operativity, MWC and KNF Models
3. Regulation of enzymes
4. Ribozymes and catalytic antibodies

UNIT V

1. Enzyme Immobilization: methods, applications and its effect on kinetic parameters
2. Enzyme Biosensor: Principle, components of biosensor, types
3. Development of enzyme biosensors
4. Applications of biosensor for clinical diagnosis

Practical Exercises

1. Urease estimation by tritrimetric method
2. Urease estimation by colorimetric method
3. Acid phosphatase estimation
4. Alkaline phosphatase estimation
5. Determination of optimum time, optimum temperature & optimum pH
6. Determination of Km value
7. Acetylcholine esterase/pseudocholinesterase estimation
8. Enzyme purification

Reference Books

1. The nature of Enzymology by R.L. Foster
2. Enzymes by Dixon and Webb
3. Fundamentals of Enzymology by Price and Stevens
4. Enzyme Catalysis and Regulation by Hammes
5. Enzyme Reaction Mechanisms by Walsch
6. The Enzymes vol I and II by Boyer
7. Enzyme Structure and Mechanism by Alan Fersht
8. Enzyme Assays : A Practical Approach by Eisenthal and Danson

204. PART A: ENVIORNMENTAL BIOTECHNOLOGY

UNIT I

1. Environment pollution: types, methods for measurement of pollution
2. Solid waste treatment: Composting process, Vermicomposting and its advantages.
3. Biomedical waste and its management
4. Xenobiotics and its degradation

UNIT II

1. Microbial waste treatments: aerobic and anaerobic processes
2. An Integrated pest management- Biopesticides: types and impact on environment.
3. Bioremediation: *In situ* and *Ex situ* techniques advantages and applications of genetically engineered microbes (GEM) in bioremediation.
4. Phytoremediation: Types and its applications, Bioindicators, GMOs and assessment of environmental impact and monitoring.

Practical Exercises

1. Determination of dissolved oxygen concentration of water sample
2. Determination of biological oxygen demand (BOD) of sewage sample
3. Determination of Chemical oxygen demand (COD) of sewage sample
4. Isolation of xenobiot ic degrading bacteria by selective enrichment technique
5. Test for the degradation of aromatic hydrocarbons by bacteria
6. Survey of degradative plasmids in microbes growing in polluted environment
7. Study on biogenic methane production in different habitats

Reference Books

1. Comprehensive Biotechnology. Vol. 4,M. moo- young (Ed-in-chief), Pergmon Press Oxford
2. Environmental chemistry. A.K.De, Wiley Eastern Ltd., New Delhi
3. Introduction to Biodeterioration. D.Allsopp and Seal, ELBS/ Edward Arnold
4. Environmental Biotechnologies and Cleaner Bioprocess by Eugenia J Olguuin et al
5. Environmental Science: Physical Principles and applications by Egbert Boeker et al

204: Part B ANIMAL BIOTECHNOLOGY

UNIT III

1. Animal cell culture: Organization of animal cell and tissue culture laboratory
2. Culture Medium: types, functions of different constituents of media, role of Co_2
3. Primary and established cell line cultures
4. Measurement of parameters of growth

UNIT IV

1. Scaling up of animal cell culture, Cell synchronization
2. Cell cloning and micromanipulation
3. Measurement of cell viability, methods of separation of cell types
4. Stem cell cultures, embryonic stem cells and their applications

UNIT V

1. Commercial applications of cell culture: cytotoxicity and diagnostic tests
2. Cell culture based vaccines
3. 3-D animal cell culture
4. Transgenic animals

Practical Exercises: Part B

1. Preparation of tissue culture medium and membrane filtration
2. Preparation of single cell suspension from spleen and thymus
3. Cell counting and viability
4. Macrophage monolayer from PEC and measurement of phagocytic activity
5. Cell fusion with PEG

Reference Books

1. Culture of Animal Cells by RI Freshney
2. Animal Cell Culture: Practical Approach John R W Masters
3. Animal Cell Culture Techniques by Ed. Martin Clynes
4. Methods in Cell Biology Vol. 57, Animal cell culture methods

301. GENETIC ENGINEERING

UNIT I

1. The recombinant DNA Technology : General concept and Principle of cloning
2. Enzymes : Nucleases and restriction endonucleases – properties and types; phosphomonoesterases; polynucleotide kinase; DNA ligase; DNA polymerase I; RNA Dependent DNA Polymerase; terminal deoxynucleotidyl transferase; poly A polymerase
3. Prokaryotic host-vector system : Characteristics of *E. coli* as host; vectors for cloning in *E. coli* (plasmid, bacteriophage and plasmid-phage)
4. Other Prokaryotic host vector systems : Characteristics of Gram positive and Gram negative organisms as host and suitable vectors for cloning; Shuttle Vectors

UNIT II

1. Design and characteristics of expression vectors for cloning in prokaryotes, factors that affect expression.
2. Cloning in yeast: Properties of yeast as host for cloning and different types of vectors designed for cloning in yeast.
3. Cloning in animal system: Animal system as model host, methods of introduction of foreign DNA in animal system; Vectors for cloning in animal system-SV-40, vaccinia virus, baculovirus and retrovirus vectors, pMal, GST, pET based vectors, Pichia based vectors.
4. Plant transformation technology: Features of Ti and Ri plasmids, mechanism of DNA transfer

UNIT III

1. Methods for constructing rDNA and cloning: Inserts; vector insert ligation; Infection, Transferring and cloning
2. Methods for screening and selection of recombinant clones
3. DNA Libraries: types, advantages and disadvantages of different types of libraries; Different methods for constructing genomic and full length cDNA libraries
4. Gross anatomy of cloned insert-size, restriction mapping and location

UNIT IV

1. Fine anatomy of DNA segment-General principle of chemical and enzymatic methods of nucleotide sequence analysis and advantages of automatic gene sequencers.
2. Localization of cloned segments in genomes – molecular and chromosomal location
3. Methods for determination of copy number of a cloned gene in genome
4. Mutant construction: Introduction, deletion, insertion and point mutation

UNIT V

1. Principles and applications of Blotting techniques – Southern, Northern, Western and Eastern blotting; Polymerase Chain reaction and types (multiplex, nested, RT, real time, touchdown PCR, hot start PCR, colony PCR), Oligonucleotide synthesis,
2. Principle and applications of Gel Mobility Shift Assay, DNA Fingerprinting and DNA Foot printing, Restriction fragment length polymorphism, Chromosome mapping and chromosome painting
3. Applications of Recombinant DNA Technology in Medicine and Industry
4. Si RNA and Si RNA technology: Micro RNA construction of Si RNA vectors: Gene silencing and its applications in agro industry.

Practical Exercises

1. Bacterial Culture and antibiotic selection media. Preparation of competent cells
2. Isolation of plasmid DNA
3. Isolation of phage DNA
4. Quantitation of nucleic acids
5. Restriction mapping of plasmid DNA
6. Cloning in plasmid/phagemid vectors
7. Preparation of helper phage and its titration
8. Preparation of single stranded DNA template
9. Gene expression in *E .coli* and analysis of gene product
10. Polymerase Chain Reaction

Reference Books

1. Recombinant DNA – By Watson et al
2. Principles of Gene Manipulation, Old and Primrose
3. Gene Cloning: An introduction , Brown
4. Biotechnology: Theory and Techniques (Vol I & II, 1995), Chirikjian
5. Molecular Genetics of Bacteria , Dale
6. Molecular Cloning (Vol I, II & III, 2001), Sambrook & Russell
7. Applied Molecular Genetics (1999), Miesfeld
8. Genes and Genome (1991), Singer & Berg
9. Molecular Biotechnology , Glick & Pasternak
10. Plant Molecular Biology (Vol I & II, 2002), Gilmartin & Bowler

Note: All text books are of latest edition.

302. PLANT BIOTECHNOLOGY

UNIT I

1. Objectives, roles and landmarks in plant breeding.
2. Special breeding techniques: Mutational breeding and distant hybridization.
3. Generation of genetically modified crops for resistance against biotic and abiotic stresses and nutritional quality.
4. Seed production techniques: release of new varieties.

UNIT II

1. Introduction to plant tissue culture: Tissue Culture Media preparation.
2. Initiation of callus culture and its maintenance.
3. Cell synchronization
4. Organogenesis: Somatic embryo hybridization.

UNIT III

1. Somaclonal variation and its application for plant improvement
2. Anther culture: haploid and diploid plant cell production and their applications
3. Protoplast isolation and fusion, selection of hybrid cell and cybrids, artificial seed production.
4. Cryopreservation techniques and application

UNIT IV

1. Plant cloning vectors: *Ti* Plasmid, RNA interference (RNAi) technology
2. Transgenic in crop improvement: Methods for gene transfer
3. Marker assisted selection: Morphological, Biochemical and Molecular markers, advantages and disadvantages, choice of mapping populations, Association mapping in plants
4. Plant DNA fingerprinting: Hybridization and PCR based markers (RFLP, SSR's, RAPD, QTLs, SCAR, AFLP etc.)

UNIT V

1. Plant Genome mapping: Physical and molecular maps, Gene tagging, classification and types of gene families in plants.
2. Insect resistance: Bt genes, Non-Bt like protease inhibitors, lectins, PR proteins etc.
3. Plant breeders' right: UPOV 369,370, 372. Germplasm maintenance
4. Intellectual property right (IPR) and Patenting of Biological material

Practical Exercises

1. Preparation of media .
2. Surface sterilization .
3. Organ Culture.
4. Callus propagation , organogenesis, transfer of plants to soil.
5. Protoplast isolation and culture.
6. Anther culture, production of Haploids.
7. Agrobacterium culture, selection of transformants , receptor gene (GUS) assays.
8. Genomic DNA isolation from seeds and plant tissues, electrophoretic analysis
9. Restriction digestion of plant genomic DNA
10. Setting up of PCR reactions.

Reference Books

1. Plant Biotechnology. Springer Verlag, 2000. J. Hammond,P. McGarvey and V.Yusibov (Eds.) :
2. Introduction to plant tissue culture by Kalyan Kumar
3. Plant tissue culture by Bhojwani
4. Practical applications of plant molecular biology by Henry et al
5. Principles of Plant Biotehcnology by Montell SH et al
6. Plant Genome analysis by PM Gresshoff
7. Essentials of plant breeding by Phundan Singh
8. Biotechnology: Theory and Techniques Vol I & II by Jack Chirikjian
9. Genetic engineering by Sandhya Mitra
10. Plant Molecular Biology Vol I & II by Phillip M Gimartin & Chris Bowler

303. BIOPROCESS ENGINEERING AND MICROBIAL TECHNOLOGY

UNIT I

1. Introduction and basic principle of Biochemical engineering
2. Isolation, preservation and maintenance of industrially important microbes: Strain improvement of industrially important microorganisms
3. Kinetics of microbial growth and death
4. Media for industrial fermentation, media formulation; Sterilization; Aeration and agitation in bioprocess. Air sterilization

UNIT II

1. Scale of fermentation process: small scale, large scale and pilot scale fermentations
2. Biorecators: Principle, types, design and applications
3. Types of fermentation processes; batch, fed-batch, and continuous bioreactions.
4. Measurement and control of fermentation: pH, temperature, pressure, media, air, Automation of the monitoring and control process

UNIT III

1. Upstream processing and down stream processing: Introduction and concept.
2. Down stream processing: removal of microbial cells and solid matter, foam separation, precipitation, centrifugation, cell disruption, chromatography, reverse osmosis
3. Extraction: Solvent, two phases, liquid extraction
4. Product recovery process. Crystallization, storage, packaging and quality control

UNIT IV

1. Industrial production of important bioproducts: Vitamins and amino acids (Vit B12 & Glutamic acid)
2. Industrial production of important bioproducts: antibiotics-Penicillin; and streptomycin
3. Enzyme- Amylase, Protease, Production, recovery and scaling up of enzymes and their role in food and other industries.
4. Immobilization of enzymes and their industrial applications.

UNIT V

1. Microbial production of alcoholic beverages: Distilled alcoholic beverages-Beer, microbial production of Vinegar.
2. Microbial production of organic acids: Citric acid and Acetic acid
3. Microbial production of solvents: Ethanol and acetone
4. Microbial production of food- SCP Mushroom cultivation, Biofertilizers and their applications

Practical Exercises

1. Isolation of industrially important microbes from the environment
2. Determination of TDP and TDT of microorganisms for a design of a sterilizer
3. Determination of growth curve of a industrial organism and compute substrate, degradation profile, specific growth rate and growth yield
4. Screening and enrichment for a primary/ secondary metabolite from the environment
5. Strain improvement for higher yield of a product
6. Random and strategic screening for a metabolite
7. Media balancing experiments
8. Alcohol fermentation using different substrates and its downstream processing

Reference Books

1. Biochemical Engineering, Aiba, S., Humphrey, A.E. and millis, N.F. Univ. Tokyo Press, Tokyo.
2. Biochemical Reactors, Atkinson, B., Pion Ltd. London.
3. Biochemical Engineering Fundamentals, Baily. J. E. and ollis , D.F. Mcgraw- Hill Book Co. New York.
4. Bioprocess Technology: Fundamentals and Applications , KTH, Stockhlom.
5. Process Engineering in Biotechnology, Jackson, A.T. , Prentice Hall, Engelwood Cliffs.
6. Bioprocess Engineering: Basic Concepts Shuler, M.L. and Kargi , F., Prentice Hall, Englewood Cliffs..
7. Principles of fermentation Technology, Stanbury,P.F. and Whitakar A., Pergmon Press, Oxford.
8. Bioreaction Engineering Principles, Nielson, J and Villadsen , J., Plenum Press.
9. Chemical Engineering, Problems in Biotechnology, Shuler, M.L.(Ed.), AICHE.
10. Biochemical Engineering, Lee, J.M., Prentice Hall Inc.
12. Bioprocess Engineering- Kinetics, Mass Transport, Reactiors and Gene Expression, Vieth, W.F., John Wiley & Sons, Inc.

304. BIOSTATISTICS AND COMPUTER APPLICATIONS

UNIT I

1. Introduction to Biostatistics, Common terms, notions and Applications
2. Statistical population and Sampling Methods
3. Classification and tabulation of data
4. Diagrammatic and graphical presentation
5. Frequency Distribution, Measures and central value
6. Measures of variability, Standard deviation, Standard error, Range, Mean Deviation Coefficient of variation, Analysis of variance

UNIT II

1. Basic tests, Test of Significance, t-test, chi-square test.
2. Regression; Basics of regression, regression analysis, Estimation, Testing, prediction, checking and residual analysis.
3. Multivariate Analysis
4. Design of Experiment, randomization, replication, local control, complimentary randomized, randomized block design

UNIT III

1. Factor Analysis
2. Path Analysis
3. Introduction to data mining
4. Virtuous cycle

UNIT IV

1. Classification and Discriminant Analysis Tools: CART, random forests
2. Fischer's discriminant functions
3. Neural networks
4. Multilayer perception, predictive ANN model building using back propagation Algorithm, exploratory data analysis

UNIT V

1. Introduction to computer basics, concept of hardware windows XP and LINUX
2. Concept of life, folders, directories and their management by windows XP and LINUX
3. Office applications: MS-office, MS-Word, MS-Excel, and MS-PowerPoint
4. Open Office on Linux: Word Processor, spread sheets, Impress
5. Statistical packages: Sigma plot etc.

Reference Books

1. An Introduction to Computational Biochemistry by C Stan T sai
2. Statistics for Agricultral Sciences by Nageswara Rao, G.
3. Fundamentals of statistics by Goon et al, 1962..
4. Methods in Biostatistics by B.K. Mahajan
5. Statistical methods by S.P. Gupta
6. Statistical methods by G.W. Snedecor and W.G. Cochran
2. Fundamental of artificial Neural Networks, Prentice-Hall of India, N.Delhi

305 Lab Course: V

Consists of Practical Exercises listed out under 301 and 302

305 Lab Course: VI

Consists of Practical Exercises listed out under 303 and 304.

401. EMERGING TRENDS IN BIOTECHNOLOGY

UNIT I

1. Stem cell Technology: Types of Stem cells.
2. Manipulation of stem cells and applications in medicine.
3. *In vitro* fertilization: Principle, Methods, applications and ethics.
4. Cloning of animals: Methods and applications.

UNIT II

1. Genome & Genomics: Concept and methods of genome analysis, genome projects.
2. Transcripome & Transcriptomics: Concept and methods.
3. Proteome and Proteomics: Concept and methods of Proteome analysis.
4. Metabolome and Metabolomics.

UNIT III

1. Nano biotechnology: Introduction and biological materials-example and uses.
2. DNA nanotechnology:-Structural DNA assembly-Nanopores and
3. Nanoparticles-biological arrays-nanoprobes for analytical applications.
4. Nano biosensors-nano scale organization-characterizarion-quantum size effects-sensors of the future.
5. Tools for measuring nanostructures. Microscopies-SEM, TEM, AFM modern advances-microanalysis-optical detection of single molecule.

UNIT IV

1. Biochemical diagnostics: Biochemical markers of disease diagnosis and their applications.
2. Introduction and Concept of Molecular Diagnostics: DNA diagnostics: PCR based diagnostics, RAPD and RFLP etc. in diagnostics.
3. Microarray Technology, Aray-based diagnostics, SNP's (Single Nucleotide Polymorphism) and GMS (Genome Mismatch Signals) and diagnostic significance.
4. Western blot diagnostics, Immunoarrays, Phage display concept and applications of phage display.

UNIT V

1. Biosensors: Concept, principle, Organization of biosensor and types.
2. Biosensors: Health and medicine.
3. Biosensors: Food technology, Environmental monitoring.
4. Bacterial biosensors; Array Biosensors.

Practical Exercises

Appropriate exercises based on theory.

Reference Books

1. DNA Microarrays and gene expression by P. Baldi & GW Hatfield
2. Protein – Protein Interactions by Erica Golemis
3. A passion for DNA (Genesm genomes and Soceity) By JD Watson
4. Modern Genetic analysis by Anthony JF Griffiths et al.
5. Nanobiotechnology- next big idea by Mark, Ratner, Daniel Ratner
6. Gene cloning by TA Brown
7. Latest information on academic Web sites.

Note: All books are of latest editions

402: BIOINFORMATICS

[Optional I]

UNIT I

1. Overview of Bioinformatics: Merger of life sciences with computers.
2. Search engines: Google, Pub Med, NCBI, EMBL,
3. Protein and DNA databases: Swiss port, PIR, OMIM, Embark, ENTREZ, DDJB, MIPS, Hovered, ECDC, Cambridge small molecular crystal structure data bank.
4. Analysis packages: Commercial databases and packages, GPL software for bioinformatics, web based analysis protocol.

UNIT II

1. Sequence Databases: Contents, Structure, and annotation for Human Genome Databases, Plant Genome Databases, Retrieving and Installing a program (Tree Tool), Multiple sequence alignment program- Clustal W, X.
2. Genome analysis programs: BLAST, FASTA, CGC, Motif and Profile, Sequence search.
3. Phylogenetic analysis: Phylogenetic reconstruction, distance matrices, Parsimony, Philip.
4. Data models: Instances and schemes; E-R model, E-R diagrams, reducing E-R diagrams to tables, network data model.

UNIT III

1. Methods of predication of Proteins, DNA, RNA, fold recognition, Ab initio methods for structure predication.
2. Computer aided drug designing: Basic principles, docking, ADME/ TOX
3. Genome mapping applications: EST and Functional genomics, EST clustering gene discovery, ORF prediction.
4. Use of genome analysis programs, primer designing tools.

UNIT IV

1. Cluster analysis: Phylogenetic clustering by simple matching coefficients.
2. Sequence comparison; Sequence pattern; Regular expression based pattern; Theory of profiles and their use in sequence analysis.
3. Markov models; Concept of HMMS; Baum-Welch algorithm; Use of profile HMM for protein family classification; Pattern recognition methods.
4. Structure determination: X-ray crystallography; NMR spectroscopy; PDB (Protein data bank) and NDB (Nucleic acid data bank); File formats for the storage nad dissemination of molecular structure.

UNIT V

1. Modeling and conformational analysis: Homology modeling; Threading and protein structure prediction.
2. Force fields; Molecular energy minimization, Monte Carlo and molecular dynamics simulation.
3. Tagging of genes and molecular modeling.
4. Modeling and Drug Design.

Reference Books

1. Introduction to Bioinformatics: A theoretical and practical approach by Stephen A Krawetz and DD Womble
2. Bioinformatics Genes, Proteins & Computers by CA Orengo, DT Jopnes and JM Thornton
3. An Introduction to Computational Biochemistry by C Stan T Sai
4. Instant notes on Bioinformatics by DR Westhead, JM Perish & RM Toyman
5. Essential Bioinformatics by Jin Xiong
6. An Introduction to Bioinformatics Algorithms by Neil C. Jones, Pavel Pevzner
7. Bioinformatics: Sequence and Genome Analysis by David W. Mount
8. Statistical Methods in Bioinformatics: An Introduction by Stephen Misener, Stephen A. Krawetz.
9. Bioinformatics: databases and Algorithms by N. Gautham
10. Bioinformatics Technologies by Yi-Ping Phoebe Chen
11. Data Mining: Multimedia, Soft Computing and Bioinformatics by Sushmita Mitra, Tinku Acharya

402: ETERPRENEURSHIP IN BIOTECHNOLOGY

[Optional 2]

UNIT I

1. Creativity and Entrepreneurial personality and Entrepreneurship in Biotechnology
2. Organizational Structure and management
3. Capital management
4. Product innovation and management
5. Government schemes for commercialization of technology (Eg. Biotech Consortium).

UNIT II

1. Basics of production management: Methods of manufacturing-Project/ jobbing, Batch production, process production-Characteristics of each method. Plant location-Importance-Factors affecting location-Factory building-Plant layout- Installation of facilities.
2. Operational research: Linear programming, PERT and CPM; Production planning and Control-Scheduling-Gantt Charts-Documentation-Production-Work Order.
3. Basics of material management.

UNIT III

1. Kaizen (Continuous improvement in product and management)
2. Six Sigma
3. Biotech enterprises: Small, Medium and Large
4. Quality control in Biotech industries.

UNIT IV

1. Government regulations for Biotech products
2. Public policy, regulatory and ethical challenges facing the biotechnology entrepreneurship
3. Business development for medical products
4. Business development for consumable products.

UNIT v

1. Patenting System: WTO, Paris Convention, Indian Legislations.
2. Intellectual Property: A. Copy Right and Industrial Properties, Trade Marks, Designs, geographical Indications.
3. IPR and Technology Transfer, Role if patentee and Licensor
4. Patent process and Patent Laws and e-filing.

Reference Books

1. Innovation and Entrepreneurship in Biotechnology: Concept, Theories and Cases by Hyne & Others.
2. John Kapeleris, 2006.
3. The business of Biotechnology: From the bench to the Street: by Richard Dano Ono, published by Butterworth-Heinemann, 1991.
4. Entrepreneurship in Biotechnology: Managing For Growth from start-up: By Martin Gross Mann, 2003.
5. Best Practices inBiotechnology Education: By Yali Friedman, published by Logos Press, 2008.
6. Plant Development and Biotechnology: By Robert Nicholas Trigiano, Dennis John Gray; published by CRC Press, 2004.

402: MANAAGEMENT AND MARKETING OF BIOTECH PRODUCTS

[Optional 3]

UNIT I

1. Basics of marketing: Marketing concepts-Approaches to marketing-Study approaches and Functional approaches, Marketing Process-Functions of Marketing.
2. Marketing Planning-Nature and Process-Contents of Marketing Plan-Analyzing need and Trends in Macro Environment, Technical Environment, Political Environment and Socio-cultural Environment.
3. Consumer Behavior- Factors influencing buyer behavior-Buyer decision process-Consumer Psychology-Industrial buyer behavior vs. domestic buyer behavior-Customer satisfaction vs. customer delight.
4. Market Segmentation-bases for marker segmentation of customer goods, industrial goods and services-targeting and positioning strategies.
5. Marker Evaluation and Control-Types, process, obstacle to marketing control-marketing Ethics.

UNIT II

1. Management Accounting: Double Entry Book Keeping-Data entry in the primary and secondary books of accounts-Preparation if Trial Balance-Rectification of errors-Final Account of Non-corporate organizations like Proprietary firms and Partnership firms-Bank Reconciliation Statements.
2. Cost accounting- Relationship with financial accounting- elements of cost-Preparation of Cost Sheet.
3. Materials Cost-Material purchasing, receiving, storing, issuing, including pricing of issues.
4. Labor Cost-Time Keeping and Time Booking-Idle Time-Labor Turnover.
5. Overheads- Identifying the overheads with the cost center-Allocation, Appointment and Absorption-Under Absorption and Over Absorption of Overheads.

UNIT III

1. Materials and Logistic Management: materials management- Evolution, Scope and Objectives-interface with other functions.
2. Forecasting-Methods of forecasting-Moving Average Method, Regression Analysis, Exponential Smoothing Method.
3. Inventory-Types of Inventory-Need of Inventory- Cost associated with Inventory-Basic EOQ model-EOQ with discounts-Classification of material-ABC Analysis- VED, FSN, GOLF, SOS-fixing of inventory levels.
4. Material requirement Planning- Master Production Schedule-Bill of Material-Material flow in MRP.
5. Purchasing Management-Responsibilities of Purchase Department- Purchase Cycle-Relevant provisions of state/ Central Sales Tax Act, Central Excise Act and Impoert/ Export procedures.

UNIT IV

1. Logistics-concept and significance-Distribution Strategies-Customer Service policies and Integrated Logistics Management.
2. Distribution Network Planning system-Location-Number and size of facilities-Stocking Policies-Storage and handling capacities.
3. Packaging-Principles, functions and type-Containerization-Concepts-Infrastructure-Customs Issues-Service Utilization Modes-Rail, Sea and Road.
4. Role of Freight and Insurance in Logistics.
5. Concept of Supply Chain Management and its strategic role in the organization-Intra and Inter Organization Supply Chain.

UNIT V

1. Market Research
2. Impact of Govt. policies on marketing
3. International marketing
4. Consumer laws

Practical Exercises: Appropriate exercises based on theory

References Books

1. Pharma management: Smith
2. Establishment of pharmaceutical factory: Aganil
3. Despensing of pharmaceutical students: Cooper and Gunn's.
4. The science and practice of pharmacy: Remington
5. The theory and practice of industrial pharmacy: Lachman, Lieberman & Kanig.
6. Sales management: Still, Candiff & Goroni.
7. Marketing channels: Stern & Adel
8. Theory on distribution channel structure: Louis Bucklin.
9. Marketing Management by Philip Kotler
10. Best practices in Biotechnology business development: Yali Friedman, Ph.D., Editor First Edition, March 2008,
11. Building Biotechnology, Yali Friedman, Ph.D., Third Edition, August 2008
12. Challenges of 21st Century by Peter Drucker

403: Lab course VII: Based on exercises in 401 and 402
Technical / Review Writing

404: Project Work