

CHOICE BASED CREDIT SYSTEM

SYLLABUS FOR B.SC. WITH BIOTECHNOLOGY

JIS UNIVERSITY

2017-2018

Credit Distribution across the Course				
Course Type	Total Papers	Credit		Total Credit
		Theory	Practical	
CC	16	16X4=64	16×2=32	64+32=96
DSE	4	4X4=16	4×2=08	16+8=24
GE	4	6X2=12 4X2=8	2X2=4	20+4=24
SEC	2	2x2=4		04
AECC	2	2x2=4		04
SEMINAR				06
SKILL DEVELOPMENT				03
Grand Total Credit				= 161
Abbreviations used:				
CC = CORE COURSES				
DSE = DISCIPLINE SPECIFIC ELECTIVES				
GE = GENERAL ELECTIVES				
SEC = SKILL ENHANCEMENT COURSES				
AECC = ABILITY ENHANCEMENT COMPULSORY COURSES				

List of Core Courses (14 Papers for the Students of Biotechnology)		Semester
CORE I	BIOCHEMISTRY & METABOLISM	I
CORE II	CELL BIOLOGY	
CORE III	BIO ANALYTICAL TOOLS	
CORE IV	MAMMALIAN PHYSIOLOGY	II
CORE V	PLANT PHYSIOLOGY	
CORE VI	GENERAL MICROBIOLOGY	
CORE VII	GENETICS	III
CORE VIII	MOLECULAR BIOLOGY	
CORE IX	CHEMISTRY 1	
CORE X	BIOINFORMATICS	IV
CORE XI	IMMUNOLOGY	
CORE XII	CHEMISTRY 2	
CORE XIII	BIOPROCESS TECHNOLOGY	V

CORE XIV	RECOMBINANT DNA TECHNOLOGY	VI
CORE XV	VIROLOGY	
CORE XVI	GENOMICS AND PROTEOMICS	

Choices for DSE	
(2 Papers each to be selected by the Students of Biotechnology SemV and SemVI)	
DSE_1	Animal Biotechnology
DSE_2	Medical Microbiology
DSE_3	Ecology And Environmental Management
DSE_4	Environmental Biotechnology
DSE_5	Industrial Biotechnology
DSE_6	Plant Biotechnology
DSE_7	Food Biotechnology

Choices for SEC	
(1 Paper each to be selected by the Students of Biotechnology SemIII and SemIV)	
SEC_1	Molecular Diagnostics
SEC_2	Enzymology
SEC_3	Industrial Fermentations
SEC_4	Drug Designing
SEC_5	Basics of Forensic Science

Choices for GE	
(1 Paper each to be selected from GE_3 to GE_6 by the Students of Biotechnology SemIII and SemIV)	
GE_1	Math 1 (compulsory for Sem I)
GE_2	Math 2 (Compulsory for Sem II)
GE_3	Entrepreneurship Development
GE_4	Bioethics and Biosafety
GE_5	Biotechnology and Human Welfare
GE_6	Developmental Biology

SEMESTER	COURSE OPTED	COURSE CODE	COURSE NAME	L	T	P	CREDIT	CONTACT HOURS
I	CORE I		BIOCHEMISTRY & METABOLISM	3	1		4	4
	CORE I LAB		BIOCHEMISTRY & METABOLISM LAB	0	0	2	2	3
	CORE II		CELL BIOLOGY	3	1		4	4
	CORE II LAB		CELL BIOLOGY LAB	0	0	2	2	3
	CORE III		BIO ANALYTICAL TOOLS	3	1	0	4	4
	CORE III LAB		BIO ANALYTICAL TOOLS LAB	0	0	2	2	3
	GE 1		MATH 1	5	1	0	6	6
	AECC I		ENGLISH	2	0	0	2	2
	SEMINAR I		SEMINAR I				1	
			TOTAL				26	29

SEMESTER	COURSE OPTED	COURSE CODE	COURSE NAME	L	T	P	CREDIT	CONTACT HOURS
II	CORE IV		MAMMALIAN PHYSIOLOGY	3	1		4	4
	CORE IV LAB		MAMMALIAN PHYSIOLOGY LAB	0	0	2	2	3
	CORE V		PLANT PHYSIOLOGY	3	1		4	4
	CORE V LAB		PLANT PHYSIOLOGY LAB	0	0	2	2	3
	CORE VI		GENERAL MICROBIOLOGY	3	1	0	4	4
	CORE VI LAB		GENERAL MICROBIOLOGY LAB	0	0	2	2	3
	GE 2		MATH 2	5	1	0	6	6
	AECC 2		ENVIRONMENTAL SCIENCE	2	0	0	2	2
	SEMINAR II		SEMINAR II				1	
	SKILL DEVELOPMENT 1		SKILL DEVELOPMENT 1				1	
			TOTAL				26	29

SEMESTER	COURSE OPTED	COURSE CODE	COURSE NAME	L	T	P	CREDIT	CONTACT HOURS
III	CORE VII		GENETICS	3	1		4	4

	CORE VII LAB		GENETICS LAB	0	0	2	2	3
	CORE VIII		MOLECULAR BIOLOGY	3	1		4	4
	CORE VIII LAB		MOLECULAR BIOLOGY LAB	0	0	2	2	3
	CORE IX		CHEMISTRY 1	3	1	0	4	4
	CORE IX LAB		CHEMISTRY 3 LAB	0	0	2	2	3
	GE 3		GENERIC ELECTIVE SUBJECTS	3	1	0	4	4
	GE 3 LAB		GENERIC ELECTIVE SUBJECTS	0	0	2	2	3
	SEC I		SKILL ENHANCE COURCES	2	0	0	2	2
	SEMINAR III		SEMINAR III				1	
			TOTAL				26	30

SEMESTER	COURSE OPTED	COURSE CODE	COURSE NAME	L	T	P	CREDIT	CONTACT HOURS
IV	CORE X		BIOINFORMATICS	3	1		4	4
	CORE X LAB		BIOINFORMATICS LAB	0	0	2	2	3
	CORE XI		IMMUNOLOGY	3	1		4	4
	CORE XI LAB		IMMUNOLOGY LAB	0	0	2	2	3
	CORE XII		CHEMISTRY 2	3	1	0	4	4
	CORE XII LAB		CHEMISTRY 4 LAB	0	0	2	2	3
	GE 4		GENERIC ELECTIVE SUBJECTS	3	1	0	4	4
	GE 4 LAB		GENERIC ELECTIVE SUBJECTS	0	0	2	2	3
	SEC II		SKILL ENHANCE COURCES	2	0	0	2	2
	SEMINAR IV		SEMINAR IV				1	
	SKILL DEVELOPMENT 2		SKILL DEVELOPMENT 2				1	
				TOTAL				26

SEMESTER	COURSE OPTED	COURSE CODE	COURSE NAME	L	T	P	CREDIT	CONTACT HOURS
V	CORE XIII		BIOPROCESS TECHNOLOGY	3	1		4	4

	CORE XIII LAB		BIOPROCESS TECHNOLOGY LAB	0	0	2	2	3
	CORE XIV		RECOMBINANT DNA TECHNOLOGY	3	1		4	4
	CORE XIV LAB		RECOMBINANT DNA TECHNOLOGY LAB	0	0	2	2	3
	DSE I		DISCIPLINE CENTRIC SUBJECTS I	3	1		4	4
	DSE I LAB		DISCIPLINE CENTRIC SUBJECTS I LAB	0	0	2	2	3
	DSE II		DISCIPLINE CENTRIC SUBJECTS II	3	1		4	4
	DSE II LAB		DISCIPLINE CENTRIC SUBJECTS II LAB	0	0	2	2	3
	SEMINAR V		SEMINAR V				1	
							24	28

SEMESTER	COURSE OPTED	COURSE CODE	COURSE NAME	L	T	P	CREDIT	CONTACT HOURS
VI	CORE XV		VIROLOGY	3	1		4	4
	CORE XV LAB		VIROLOGY LAB	0	0	2	2	3
	CORE XVI		GENOMICS AND PROTEOMICS	3	1		4	4
	CORE XVI LAB		GENOMICS AND PROTEOMICS LAB	0	0	2	2	3
	DSE III		DISCIPLINE CENTRIC SUBJECTS I	3	1		4	4
	DSE III LAB		DISCIPLINE CENTRIC SUBJECTS I LAB	0	0	2	2	3
	DSE IV		DISCIPLINE CENTRIC SUBJECTS II	3	1		4	4
	DSE IV LAB		DISCIPLINE CENTRIC SUBJECTS II LAB	0	0	2	2	3
	SEMINAR VI		SEMINAR VI				1	
	SKILL DEVELOPMENT 3		SKILL DEVELOPMENT 3				1	
				TOTAL				24

CORE COURSES

Core I: BIOCHEMISTRY AND METABOLISM

UNIT I: Introduction to Biochemistry:

A historical prospective.

Amino acids & Proteins: Structure & Function. Structure and properties of Amino acids, Types of proteins and their classification, Forces stabilizing protein structure and shape. Different Level of structural organization of proteins, Protein Purification. Denaturation and renaturation of proteins. Fibrous and globular proteins.

Carbohydrates: Structure, Function and properties of Monosaccharides, Disaccharides and Polysaccharides. Homo & Hetero Polysaccharides, Mucopolysaccharides, Bacterial cell wall polysaccharides, Glycoprotein's and their biological functions

UNIT II:

Lipids: Structure and functions –Classification, nomenclature and properties of fatty acids, essential fatty acids. Phospholipids, sphingolipids, glycolipids, cerebrosides, gangliosides, Prostaglandins, Cholesterol.

Nucleic acids: Structure and functions: Physical & chemical properties of Nucleic acids, Nucleosides & Nucleotides, purines & pyrimidines,. Biologically important nucleotides, Double helical model of DNA structure and forces responsible for A, B & Z – DNA, denaturation and renaturation of DNA

UNIT III:

Enzymes: Nomenclature and classification of Enzymes, Holoenzyme, apoenzyme, Cofactors, coenzyme, prosthetic groups, metalloenzymes, monomeric & oligomeric enzymes, activation energy and transition state, enzyme activity, specific activity, common features of active sites, enzyme specificity: types & theories, Biocatalysts from extreme thermophilic and hyperthermophilic archaea and bacteria. Role of: NAD⁺, NADP⁺, FMN/FAD, coenzymes A, Thiamine pyrophosphate, Pyridoxal phosphate, lipoic-acid, Biotin vitamin B12, Tetrahydrofolate and metallic ions

UNIT IV:

Carbohydrates Metabolism: Reactions, energetics and regulation. Glycolysis: Fate of pyruvate under aerobic and anaerobic conditions. Pentose phosphate pathway and its significance, Gluconeogenesis, Glycogenolysis and glycogen synthesis. TCA cycle.

Electron Transport Chain, Oxidative phosphorylation. β -oxidation of fatty acids.

PRACTICALS

1. To study activity of any enzyme under optimum conditions.
2. To study the effect of pH, temperature on the activity of salivary amylase enzyme.

3. Determination of - pH optima, temperature optima, Km value, Vmax value, Effect of inhibitor (Inorganic phosphate) on the enzyme activity.
4. Estimation of blood glucose by glucose oxidase method.
5. Principles of Colorimetry: (i) Verification of Beer's law, estimation of protein. (ii) To study relation between absorbance and % transmission.
6. Preparation of buffers.
7. Separation of Amino acids by paper chromatography.
8. Qualitative tests for Carbohydrates, lipids and proteins

SUGGESTED READING

1. Berg, J. M., Tymoczko, J. L. and Stryer, L. (2006). Biochemistry. VI Edition. W.H Freeman and Co.
2. Buchanan, B., Gruissem, W. and Jones, R. (2000) Biochemistry and Molecular Biology of Plants. American Society of Plant Biologists.
3. Nelson, D.L., Cox, M.M. (2004) Lehninger Principles of Biochemistry, 4th Edition, WH Freeman and Company, New York, USA.
4. Hopkins, W.G. and Huner, P.A. (2008) Introduction to Plant Physiology. John Wiley and Sons.
5. Salisbury, F.B. and Ross, C.W. (1991) Plant Physiology, Wadsworth Publishing Co.

Core II: Cell Biology

UNIT I

Cell: Introduction and classification of organisms by cell structure, cytosol, compartmentalization of eukaryotic cells, cell fractionation.

Cell Membrane and Permeability: Chemical components of biological membranes, organization and Fluid Mosaic Model, membrane as a dynamic entity, cell recognition and membrane transport.

UNIT II

Membrane Vacuolar system, cytoskeleton and cell motility: Structure and function of microtubules, Microfilaments, Intermediate filaments.

Endoplasmic reticulum: Structure, function including role in protein segregation.

Golgi complex: Structure, biogenesis and functions including role in protein secretion.

UNIT III

Lysosomes: Vacuoles and micro bodies: Structure and functions

Ribosomes: Structures and function including role in protein synthesis.

Mitochondria: Structure and function, Genomes, biogenesis.

Chloroplasts: Structure and function, genomes, biogenesis

Nucleus: Structure and function, chromosomes and their structure.

UNIT IV

Extracellular Matrix: Composition, molecules that mediate cell adhesion, membrane receptors for extra cellular matrix, macromolecules, regulation of receptor expression and function. Signal transduction.

Cancer: Carcinogenesis, agents promoting carcinogenesis, characteristics and molecular basis of cancer.

PRACTICALS

1. Study the effect of temperature and organic solvents on semi permeable membrane.
2. Demonstration of dialysis.
3. Study of plasmolysis and de-plasmolysis.
4. Cell fractionation and determination of enzyme activity in organelles using sprouted seed or any other suitable source.
5. Study of structure of any Prokaryotic and Eukaryotic cell.
6. Microtomy: Fixation, block making, section cutting, double staining of animal tissues like liver, oesophagus, stomach, pancreas, intestine, kidney, ovary, testes.
7. Cell division in onion root tip/ insect gonads.
8. Preparation of Nuclear, Mitochondrial & cytoplasmic fractions.

SUGGESTED READING

1. Karp, G. 2010. Cell and Molecular Biology: Concepts and Experiments. 6th Edition. John Wiley & Sons. Inc.
2. De Robertis, E.D.P. and De Robertis, E.M.F. 2006. Cell and Molecular Biology. 8th

edition. Lippincott Williams and Wilkins, Philadelphia.

3. Cooper, G.M. and Hausman, R.E. 2009. The Cell: A Molecular Approach. 5th edition.

ASM Press & Sunderland, Washington, D.C.; Sinauer Associates, MA.

4. 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.

Core III: BIO-ANALYTICAL TOOLS

UNIT I

Simple microscopy, phase contrast microscopy, fluorescence and electron microscopy (TEM and SEM), pH meter, absorption and emission spectroscopy

UNIT II

Principle and law of absorption fluorimetry, colorimetry, spectrophotometry (visible, UV, infrared), centrifugation, cell fractionation techniques, isolation of sub-cellular organelles and particles.

UNIT III

Introduction to the principle of chromatography . Paper chromatography, thin layer chromatography, column chromatography: silica and gel filtration, affinity and ion exchange chromatography, gas chromatography, HPLC.

UNIT IV

Introduction to electrophoresis. Starch-gel, polyacrylamide gel (native and SDS-PAGE), agarose-gel electrophoresis, pulse field gel electrophoresis, immuno- electrophoresis, isoelectric focusing, Western blotting. Introduction to Biosensors and Nanotechnology and their applications.

PRACTICAL

1. Native gel electrophoresis of proteins
2. SDS-polyacrylamide slab gel electrophoresis of proteins under reducing conditions.
3. Preparation of the sub-cellular fractions of rat liver cells.
4. Preparation of protoplasts from leaves.
5. Separation of amino acids by paper chromatography.
6. To identify lipids in a given sample by TLC.

7. To verify the validity of Beer's law and determine the molar extinction coefficient of NADH.

SUGGESTED READING

1. Karp, G. 2010. Cell and Molecular Biology: Concepts and Experiments. 6th Edition. John Wiley & Sons. Inc.
2. De Robertis, E.D.P. and De Robertis, E.M.F. 2006. Cell and Molecular Biology. 8th edition. Lippincott Williams and Wilkins, Philadelphia.
3. Cooper, G.M. and Hausman, R.E. 2009. The Cell: A Molecular Approach. 5th edition. ASM Press & Sunderland, Washington, D.C.; Sinauer Associates, MA.
4. 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.

Core IV: MAMMALIAN PHYSIOLOGY

UNIT I: Digestion and Respiration

Digestion: Mechanism of digestion & absorption of carbohydrates, Proteins, Lipids and nucleic acids. Composition of bile, Saliva, Pancreatic, gastric and intestinal juice

Respiration: Exchange of gases, Transport of O₂ and CO₂, Oxygen dissociation curve, Chloride shift.

UNIT II: Circulation

Composition of blood, Plasma proteins & their role, blood cells, Haemopoiesis, Mechanism of coagulation of blood.

Mechanism of working of heart: Cardiac output, cardiac cycle, Origin & conduction of heart beat.

UNIT III: Muscle physiology and osmoregulation

Structure of cardiac, smooth & skeletal muscle, threshold stimulus, All or None rule, single muscle twitch, muscle tone, isotonic and isometric contraction, Physical, chemical & electrical events of mechanism of muscle contraction.

Excretion: modes of excretion, Ornithine cycle, Mechanism of urine formation.

UNIT IV: Nervous and endocrine coordination

Mechanism of generation & propagation of nerve impulse, structure of synapse, synaptic conduction, saltatory conduction, Neurotransmitters

Mechanism of action of hormones (insulin and steroids)

Different endocrine glands– Hypothalamus, pituitary, pineal, thymus, thyroid, parathyroid and adrenals, hypo & hyper-secretions.

PRACTICALS

1. Finding the coagulation time of blood
2. Determination of blood groups
3. Counting of mammalian RBCs
4. Determination of TLC and DLC
5. Demonstration of action of an enzyme
6. Determination of Haemoglobin

SUGGESTED READING

1. Guyton, A.C. & Hall, J.E. (2006). Textbook of Medical Physiology. XI Edition. Hercul Asia PTE Ltd. /W.B. Saunders Company.
2. Tortora, G.J. & Grabowski, S. (2006). Principles of Anatomy & Physiology. XI Edition. John wiley & sons, Inc.

Core V: PLANT PHYSIOLOGY

UNIT I: Anatomy

The shoot and root apical meristem and its histological organization, simple & complex permanent tissues, primary structure of shoot & root, secondary growth, growth rings, leaf anatomy (dorsi-ventral and isobilateral leaf)

UNIT II: Plant water relations and micro & macro nutrients

Plant water relations: Importance of water to plant life, diffusion, osmosis, plasmolysis, imbibition, guttation, transpiration, stomata & their mechanism of opening & closing.

Micro & macro nutrients: criteria for identification of essentiality of nutrients, roles and deficiency systems of nutrients, mechanism of uptake of nutrients, mechanism of food transport

UNIT III: Carbon and nitrogen metabolism

Photosynthesis- Photosynthesis pigments, concept of two photo systems, photophosphorylation, calvin cycle, CAM plants, photorespiration, compensation point

Nitrogen metabolism- inorganic & molecular nitrogen fixation, nitrate reduction and ammonium assimilation in plants.

UNIT IV: Growth and development

Growth and development: Definitions, phases of growth, growth curve, growth hormones (auxins, gibberlins, cytokinins, abscisic acid, ethylene)

Physiological role and mode of action, seed dormancy and seed germination, concept of photoperiodism and vernalization

PRACTICALS

1. Preparation of stained mounts of anatomy of monocot and dicot's root, stem & leaf.
2. Demonstration of plasmolysis by Tradescantia leaf peel.
3. Demonstration of opening & closing of stomata
4. Demonstration of guttation on leaf tips of grass and garden nasturtium.
5. Separation of photosynthetic pigments by paper chromatography.
6. Demonstration of aerobic respiration.
7. Preparation of root nodules from a leguminous plant.

SUGGESTED READING

1. Dickinson, W.C. 2000 Integrative Plant Anatomy. Harcourt Academic Press, USA.
2. Esau, K. 1977 Anatomy of Seed Plants. Wiley Publishers.
3. Fahn, A. 1974 Plant Anatomy. Pergmon Press, USA and UK.
4. Hopkins, W.G. and Huner, P.A. 2008 Introduction to Plant Physiology. John Wiley and Sons.
5. Mauseth, J.D. 1988 Plant Anatomy. The Benjamin/Cummings Publisher, USA.
6. Nelson, D.L., Cox, M.M. 2004 Lehninger Principles of Biochemistry, 4th edition, W.H. Freeman and Company, New York, USA.
7. Salisbury, F.B. and Ross, C.W. 1991 Plant Physiology, Wadsworth Publishing Co. Ltd.
8. Taiz, L. and Zeiger, E. 2006 Plant Physiology, 4th edition, Sinauer Associates Inc .MA, USA

Core VI: GENERAL MICROBIOLOGY

UNIT I

Fundamentals, History and Evolution of Microbiology.

Classification of microorganisms: Microbial taxonomy, criteria used including molecular approaches, Microbial phylogeny and current classification of bacteria.

Microbial Diversity: Distribution and characterization Prokaryotic and Eukaryotic cells, Morphology and cell structure of major groups of microorganisms eg. Bacteria, Algae, Fungi, Protozoa and Unique features of viruses.

UNIT II

Cultivation and Maintenance of microorganisms: Nutritional categories of micro-organisms, methods of isolation, Purification and preservation.

UNIT III

Microbial growth: Growth curve, Generation time, synchronous batch and continuous culture, measurement of growth and factors affecting growth of bacteria.

Microbial Metabolism: Metabolic pathways, amphi-catabolic and biosynthetic pathways

Bacterial Reproduction: Transformation, Transduction and Conjugation. Endospores and sporulation in bacteria.

UNIT IV

Control of Microorganisms: By physical, chemical and chemotherapeutic agents.

Water Microbiology: Bacterial pollutants of water, coliforms and non coliforms. Sewage composition and its disposal.

Food Microbiology: Important microorganism in food Microbiology: Moulds, Yeasts, bacteria. Major food born infections and intoxications, Preservation of various types of foods. Fermented Foods.

PRACTICALS

1. Isolation of bacteria & their biochemical characterization.
2. Staining methods: simple staining, Gram staining, spore staining, negative staining, hanging drop.
3. Preparation of media & sterilization methods, Methods of Isolation of bacteria from different sources.

4. Determination of bacterial cell size by micrometry.
5. Enumeration of microorganism - total & viable count.

SUGGESTED READING

1. Alexopoulos CJ, Mims CW, and Blackwell M. (1996). Introductory Mycology. 4th edition. John and Sons, Inc.
2. Jay JM, Loessner MJ and Golden DA. (2005). Modern Food Microbiology. 7th edition, CBS Publishers and Distributors, Delhi, India.
3. Kumar HD. (1990). Introductory Phycology. 2nd edition. Affiliated East Western Press.
4. Madigan MT, Martinko JM and Parker J. (2009). Brock Biology of Microorganisms. 12th edition. Pearson/Benjamin Cummings.
5. Pelczar MJ, Chan ECS and Krieg NR. (1993). Microbiology. 5th edition. McGraw Hill Book Company.
6. Stanier RY, Ingraham JL, Wheelis ML, and Painter PR. (2005). General Microbiology. 5th edition. McMillan.
7. Tortora GJ, Funke BR, and Case CL. (2008). Microbiology: An Introduction. 9th edition. Pearson Education.
8. Willey JM, Sherwood LM, and Woolverton CJ. (2008). Prescott, Harley and Klein's Microbiology. 7th edition. McGraw Hill Higher Education.

Core VII: GENETICS

UNIT I

Introduction: Historical developments in the field of genetics. Organisms suitable for genetic experimentation and their genetic significance.

Cell Cycle: Mitosis and Meiosis: Control points in cell-cycle progression in yeast. Role of meiosis in life cycles of organisms.

Mendelian genetics : Mendel's experimental design, monohybrid, di-hybrid and tri hybrid crosses, Law of segregation & Principle of independent assortment. Verification of segregates by test and back crosses, Chromosomal theory of inheritance, Allelic interactions: Concept of dominance, recessiveness, incomplete dominance, co-dominance, semi-dominance, pleiotropy, multiple allele, pseudo-allele, essential and lethal genes, penetrance and expressivity.

UNIT II

Non allelic interactions: Interaction producing new phenotype complementary genes, epistasis (dominant & recessive), duplicate genes and inhibitory genes.

Chromosome and genomic organization: Eukaryotic nuclear genome nucleotide sequence composition –unique & repetitive DNA, satellite DNA. Centromere and telomere DNA sequences, middle repetitive sequences- VNTRs & dinucleotide repeats, repetitive transposed sequences- SINEs & LINEs, middle repetitive multiple copy genes, noncoding DNA.

Genetic organization of prokaryotic and viral genome. Structure and characteristics of bacterial and eukaryotic chromosome, chromosome morphology, concept of euchromatin and heterochromatin. packaging of DNA molecule into chromosomes, chromosome banding pattern, karyotype, giant chromosomes, one gene one polypeptide hypothesis, concept of cistron, exons, introns, genetic code, gene function.

UNIT III

Chromosome and gene mutations: Definition and types of mutations, causes of mutations, Ames test for mutagenic agents, screening procedures for isolation of mutants and uses of mutants, variations in chromosomes structure - deletion, duplication, inversion and translocation (reciprocal and Robertsonian), position effects of gene expression, chromosomal aberrations in human beings, abnormalities– Aneuploidy and Euploidy.

Sex determination and sex linkage: Mechanisms of sex determination, Environmental factors and sex determination, sex differentiation, Barr bodies, dosage compensation, genetic balance theory, Fragile-X-syndrome and chromosome, sex influenced dominance, sex limited gene expression, sex linked inheritance.

UNIT IV

Genetic linkage, crossing over and chromosome mapping: Linkage and Recombination of genes in a chromosome crossing over, Cytological basis of crossing over, Molecular mechanism of crossing over, Crossing over at four strand stage, Multiple crossing overs Genetic mapping.

Extra chromosomal inheritance: Rules of extra nuclear inheritance, maternal effects, maternal inheritance, cytoplasmic inheritance, organelle heredity, genomic imprinting.

Evolution and population genetics: In breeding and out breeding, Hardy Weinberg law (prediction, derivation), allelic and genotype frequencies, changes in allelic frequencies, systems of mating, evolutionary genetics, natural selection.

PRACTICALS

1. Permanent and temporary mount of mitosis.
2. Permanent and temporary mount of meiosis.

3. Mendelian deviations in dihybrid crosses
4. Demonstration of - Barr Body -Rhoeo translocation.
5. Karyotyping with the help of photographs
6. Pedigree charts of some common characters like blood group, color blindness and PTC tasting.
7. Study of polyploidy in onion root tip by colchicine treatment.

SUGGESTED READING

1. Gardner, E.J., Simmons, M.J., Snustad, D.P. (2006). Principles of Genetics. VIII Edition John Wiley & Sons.
2. Snustad, D.P., Simmons, M.J. (2009). Principles of Genetics. V Edition. John Wiley and Sons Inc.
3. Klug, W.S., Cummings, M.R., Spencer, C.A. (2009). Concepts of Genetics. IX Edition. Benjamin Cummings.
4. Russell, P. J. (2009). Genetics- A Molecular Approach. III Edition. Benjamin Cummings.
5. Griffiths, A.J.F., Wessler, S.R., Lewontin, R.C. and Carroll, S.B. IX Edition. Introduction to Genetic Analysis, W. H. Freeman & Co.

Core VIII: MOLECULAR BIOLOGY

UNIT I: DNA structure and replication

DNA as genetic material, Structure of DNA, Types of DNA, Replication of DNA in prokaryotes and eukaryotes: Semiconservative nature of DNA replication, Bi-directional replication, DNA polymerases, The replication complex: Pre-priming proteins, primosome, replisome, Rolling circle replication, Unique aspects of eukaryotic chromosome replication, Fidelity of replication.

UNIT II: DNA damage, repair and homologous recombination

DNA damage and repair: causes and types of DNA damage, mechanism of DNA repair: Photoreactivation, base excision repair, nucleotide excision repair, mismatch repair, translesion synthesis, recombinational repair, nonhomologous end joining. Homologous recombination: models and mechanism.

UNIT III: Transcription and RNA processing (17 Periods)

RNA structure and types of RNA, Transcription in prokaryotes: Prokaryotic RNA polymerase, role of sigma factor, promoter, Initiation, elongation and termination of RNA chains

Transcription in eukaryotes: Eukaryotic RNA polymerases, transcription factors, promoters, enhancers, mechanism of transcription initiation, promoter clearance and elongation RNA splicing and processing: processing of pre-mRNA: 5' cap formation, polyadenylation, splicing, rRNA and tRNA splicing.

UNIT IV: Regulation of gene expression and translation

Regulation of gene expression in prokaryotes: Operon concept (inducible and repressible system), Genetic code and its characteristics, Prokaryotic and eukaryotic translation: ribosome structure and assembly, Charging of tRNA, aminoacyl tRNA synthetases, Mechanism of initiation, elongation and termination of polypeptides, Fidelity of translation, Inhibitors of translation., Posttranslational modifications of proteins.

PRACTICALS

1. Preparation of solutions for Molecular Biology experiments.
2. Isolation of chromosomal DNA from bacterial cells.
3. Isolation of Plasmid DNA by alkaline lysis method
4. Agarose gel electrophoresis of genomic DNA & plasmid DNA
5. Preparation of restriction enzyme digests of DNA samples
6. Demonstration of AMES test or reverse mutation for carcinogenicity

SUGGESTED READING

1. Karp, G. (2010). Cell and Molecular Biology: Concepts and Experiments. VI Edition. John Wiley & Sons. Inc.
2. De Robertis, E.D.P. and De Robertis, E.M.F. (2006). Cell and Molecular Biology. VIII Edition. Lippincott Williams and Wilkins, Philadelphia.
3. Becker, W.M., Kleinsmith, L.J., Hardin. J. and Bertoni, G. P. (2009). The World of the Cell. VII Edition. Pearson Benjamin Cummings Publishing, San Francisco.
4. Watson, J. D., Baker T.A., Bell, S. P., Gann, A., Levine, M., and Losick, R., (2008) Molecular Biology of the Gene (VI Edition.). Cold Spring Harbour Lab. Press, Pearson Pub.

Core IX: CHEMISTRY 1

Core X: BIOINFORMATICS

UNIT I

History of Bioinformatics. The notion of Homology. Sequence Information Sources, EMBL, GENBANK, Entrez, Unigene, Understanding the structure of each source and using it on the web.

UNIT II

Protein Information Sources, PDB, SWISSPROT, TREMBL, Understanding the structure of each source and using it on the web. Introduction of Data Generating Techniques and Bioinformatics problem posed by them- Restriction Digestion, Chromatograms, Blots, PCR, Microarrays, Mass Spectrometry.

UNIT III

Sequence and Phylogeny analysis, Detecting Open Reading Frames, Outline of sequence Assembly, Mutation/Substitution Matrices, Pairwise Alignments, Introduction to BLAST, using it on the web, Interpreting results, Multiple Sequence Alignment, Phylogenetic Analysis.

UNIT IV

Searching Databases: SRS, Entrez, Sequence Similarity Searches-BLAST, FASTA, Data Submission.

Genome Annotation: Pattern and repeat finding, Gene identification tools.

PRACTICALS

1. Sequence information resource
2. Understanding and use of various web resources: EMBL, Genbank, Entrez, Unigene, Protein information resource (PIR)
3. Understanding and using: PDB, Swissprot, TREMBL
4. Using various BLAST and interpretation of results.
5. Retrieval of information from nucleotide databases.
6. Sequence alignment using BLAST.

7. Multiple sequence alignment using Clustal W.

SUGGESTED READING

1. Ghosh Z. and Bibekand M. (2008) Bioinformatics: Principles and Applications. Oxford University Press.
2. Pevsner J. (2009) Bioinformatics and Functional Genomics. II Edition. Wiley-Blackwell.
3. Campbell A. M., Heyer L. J. (2006) Discovering Genomics, Proteomics and Bioinformatics. II Edition. Benjamin Cummings.

Core XI: IMMUNOLOGY

UNIT I

Immune Response - An overview, components of mammalian immune system, molecular structure of Immuno-globulins or Antibodies, Humoral & Cellular immune responses, T lymphocytes & immune response (cytotoxic T-cell, helper T-cell, suppressor T-cells), T-cell receptors, genome rearrangements during B-lymphocyte differentiation, Antibody affinity maturation class switching, assembly of T-cell receptor genes by somatic recombination.

UNIT II

Regulation of immunoglobulin gene expression – clonal selection theory, allotypes & idiotypes, allelic exclusion, immunologic memory, heavy chain gene transcription, genetic basis of antibody diversity, hypotheses (germ line & somatic mutation), antibody diversity.

UNIT III

Major Histocompatibility complexes – class I & class II MHC antigens, antigen processing.

Immunity to infection – immunity to different organisms, pathogen defense strategies, avoidance of recognition. Autoimmune diseases , Immunodeficiency-AIDS.

UNIT IV

Vaccines & Vaccination – adjuvants, cytokines, DNA vaccines, recombinant vaccines, bacterial vaccines, viral vaccines, vaccines to other infectious agents, passive & active immunization. Introduction to immunodiagnostics – RIA, ELISA.

PRACTICALS

1. Differential leucocytes count
2. Total leucocytes count

3. Total RBC count
4. Haemagglutination assay
5. Haemagglutination inhibition assay
6. Separation of serum from blood
7. Double immunodiffusion test using specific antibody and antigen.
8. ELISA.

SUGGESTED READING

1. Abbas AK, Lichtman AH, Pillai S. (2007). Cellular and Molecular Immunology. 6th edition Saunders Publication, Philadelphia.
2. Delves P, Martin S, Burton D, Roitt IM. (2006). Roitt's Essential Immunology. 11th edition Wiley-Blackwell Scientific Publication, Oxford.
3. Goldsby RA, Kindt TJ, Osborne BA. (2007). Kuby's Immunology. 6th edition W.H. Freeman and Company, New York.
4. Murphy K, Travers P, Walport M. (2008). Janeway's Immunobiology. 7th edition Garland Science Publishers, New York.
5. Peakman M, and Vergani D. (2009). Basic and Clinical Immunology. 2nd edition Churchill Livingstone Publishers, Edinberg.
6. Richard C and Geiffrey S. (2009). Immunology. 6th edition. Wiley Blackwell Publication.

Core XII: CHEMISTRY 2

Core XIII: BIOPROCESS TECHNOLOGY

UNIT I

Introduction to bioprocess technology. Range of bioprocess technology and its chronological development. Basic principle components of fermentation technology. Types of microbial culture and its growth kinetics– Batch, Fedbatch and Continuous culture.

UNIT II

Design of bioprocess vessels- Significance of Impeller, Baffles, Sparger; Types of culture/production vessels- Airlift; Cyclone Column; Packed Tower and their application in production processes. Principles of upstream processing – Media preparation, Inocula development and sterilization.

UNIT III

Introduction to oxygen requirement in bioprocess; mass transfer coefficient; factors affecting KLa. Bioprocess measurement and control system with special reference to computer aided process control.

UNIT IV

Introduction to downstream processing, product recovery and purification. Effluent treatment. Microbial production of ethanol, amylase, lactic acid and Single Cell Proteins.

PRACTICALS

1. Bacterial growth curve.
2. Calculation of thermal death point (TDP) of a microbial sample.
3. Production and analysis of ethanol.
4. Production and analysis of amylase.
5. Production and analysis of lactic acid.
6. Isolation of industrially important microorganism from natural resource.

SUGGESTED READING

1. Casida LE. (1991). Industrial Microbiology. 1st edition. Wiley Eastern Limited.
2. Crueger W and Crueger A. (2000). Biotechnology: A textbook of Industrial Microbiology. 2nd edition. Panima Publishing Co. New Delhi.
3. Patel AH. (1996). Industrial Microbiology. 1st edition, Macmillan India Limited.
4. Stanbury PF, Whitaker A and Hall SJ. (2006). Principles of Fermentation Technology. 2nd edition, Elsevier Science Ltd.

Core XIV: RECOMBINANT DNA TECHNOLOGY

UNIT I

Molecular tools and applications- restriction enzymes, ligases, polymerases, alkaline phosphatase. Gene Recombination and Gene transfer: Transformation, Episomes, Plasmids and other cloning vectors (Bacteriophage-derived vectors, artificial chromosomes), Microinjection, Electroporation, Ultrasonication, Principle and applications of Polymerase chain reaction (PCR), primer-design, and RT- (Reverse transcription) PCR.

UNIT II

Restriction and modification system, restriction mapping. Southern and Northern hybridization.

Preparation and comparison of Genomic and cDNA library, screening of recombinants, reverse transcription,. Genome mapping, DNA fingerprinting, Applications of Genetic Engineering.

Genetic engineering in animals: Production and applications of transgenic mice, role of ES cells in gene targeting in mice, Therapeutic products produced by genetic engineering-blood proteins, human hormones, immune modulators and vaccines (one example each).

UNIT III

Random and site-directed mutagenesis: Primer extension and PCR based methods of site directed mutagenesis, Random mutagenesis, Gene shuffling, production of chimeric proteins, Protein engineering concepts and examples (any two).

UNIT IV

Genetic engineering in plants: Use of *Agrobacterium tumefaciens* and *A. rhizogenes*, Ti plasmids, Strategies for gene transfer to plant cells, Direct DNA transfer to plants, Gene targeting in plants, Use of plant viruses as episomal expression vectors.

PRACTICALS

1. Isolation of chromosomal DNA from plant cells
2. Isolation of chromosomal DNA from *E.coli*
3. Qualitative and quantitative analysis of DNA using spectrophotometer
4. Plasmid DNA isolation
5. Restriction digestion of DNA
6. Making competent cells
7. Transformation of competent cells.
8. Demonstration of PCR

SUGGESTED READING

1. Brown TA. (2006). Gene Cloning and DNA Analysis. 5th edition. Blackwell Publishing, Oxford, U.K.
2. Clark DP and Pazdernik NJ. (2009). Biotechnology-Appling the Genetic Revolution. Elsevier Academic Press, USA.
3. Glick, B.R., Pasternak, J.J. (2003). Molecular Biotechnology- Principles and Applications of recombinant DNA. ASM Press, Washington
4. Primrose SB and Twyman RM. (2006). Principles of Gene Manipulation and Genomics, 7th edition. Blackwell Publishing, Oxford, U.K.
5. Sambrook J, Fritsch EF and Maniatis T. (2001). Molecular Cloning-A Laboratory Manual. 3rd edition. Cold Spring Harbor Laboratory Press.

Core XV: VIROLOGY

Core XVI: GENOMICS & PROTEOMICS

UNIT I

Introduction to Genomics, DNA sequencing methods – manual & automated: Maxam & Gilbert and Sangers method. Pyrosequencing, Genome Sequencing: Shotgun & Hierarchical (clone contig) methods, Computer tools for sequencing projects: Genome sequence assembly software.

UNIT II

Managing and Distributing Genome Data: Web based servers and softwares for genome analysis: ENSEMBL, VISTA, UCSC Genome Browser, NCBI genome. Selected Model Organisms' Genomes and Databases.

UNIT III

Introduction to protein structure, Chemical properties of proteins. Physical interactions that determine the property of proteins. Short-range interactions, electrostatic forces, van der waal interactions, hydrogen bonds, Hydrophobic interactions. Determination of sizes (Sedimentation analysis, gel filtration, SDS-PAGE); Native PAGE, Determination of covalent structures – Edman degradation.

UNIT IV

Introduction to Proteomics, Analysis of proteomes. 2D-PAGE. Sample preparation, solubilization, reduction, resolution. Reproducibility of 2D-PAGE. Mass spectrometry based methods for protein identification. De novo sequencing using mass spectrometric data.

PRACTICALS

1. Use of SNP databases at NCBI and other sites
2. Use of OMIM database
3. Detection of Open Reading Frames using ORF Finder
4. Proteomics 2D PAGE database
5. Softwares for Protein localization.
6. Hydropathy plots
7. Native PAGE
8. SDS-PAGE

SUGGESTED READING

1. Genes IX by Benjamin Lewin, Johns and Bartlett Publisher, 2006.
2. Modern Biotechnology, 2nd Edition, S.B. Primrose, Blackwell Publishing, 1987.
3. Molecular Biotechnology: Principles and Applications of Recombinant DNA, 4th Edition, B.R. Glick, J.J. Pasternak and C.L. Patten, 2010.
5. Molecular Cloning: A Laboratory Manual (3rd Edition) Sambrook and Russell Vol. I to III, 1989.
6. Principles of Gene Manipulation 6th Edition, S.B.Primrose, R.M.Twyman and R.W. Old. Blackwell Science, 2001.
7. Snustad, D.P., Simmons, M.J. (2009). Principles of Genetics. V Edition. John Wiley and Sons Inc.
3. Klug, W.S., Cummings, M.R., Spencer, C.A. (2009). Concepts of Genetics. IX Edition. Benjamin Cummings.
4. Russell, P. J. (2009). iGenetics- A Molecular Approach. III Edition. Benjamin Cummings.
5. Glick, B.R., Pasternak, J.J. (2003). Molecular Biotechnology- Principles and Applications of recombinant DNA. ASM Press, Washington.

6. Pevsner, J. (2009). Bioinformatics and Functional Genomics. II Edition. John Wiley & Sons.

DISCIPLINE SPECIFIC ELECTIVES

DSE_1: ANIMAL BIOTECHNOLOGY

UNIT I

Gene transfer methods in Animals – Microinjection, Embryonic Stem cell, gene transfer, Retrovirus & Gene transfer.

UNIT II

Introduction to transgenesis. Transgenic Animals – Mice, Cow, Pig, Sheep, Goat, Bird, Insect.

Animal diseases need help of Biotechnology – Foot-and mouth disease, Coccidiosis, Trypanosomiasis, Theileriosis.

UNIT III

Animal propagation – Artificial insemination, Animal Clones. Conservation Biology – Embryo transfer techniques. Introduction to Stem Cell Technology and its applications.

UNIT IV

Genetic modification in Medicine - gene therapy, types of gene therapy, vectors in gene therapy, molecular engineering, human genetic engineering, problems & ethics.

PRACTICALS

1. Sterilization techniques: Theory and Practical: Glass ware sterilization, Media sterilization, Laboratory sterilization
2. Sources of contamination and decontamination measures.
3. Preparation of Hanks Balanced salt solution
4. Preparation of Minimal Essential Growth medium

5. Isolation of lymphocytes for culturing
6. DNA isolation from animal tissue
7. Quantification of isolated DNA.
8. Resolving DNA on Agarose Gel.

SUGGESTED READING

1. Brown, T.A. (1998). Molecular biology Labfax II: Gene analysis. II Edition. Academic Press, California,USA.
2. Butler, M. (2004). Animal cell culture and technology: The basics. II Edition. Bios scientific publishers.
3. Glick, B.R. and Pasternak, J.J. (2009). Molecular biotechnology- Principles and applications of recombinant DNA. IV Edition. ASM press, Washington, USA.
4. Griffiths, A.J.F., J.H. Miller, Suzuki, D.T., Lewontin, R.C. and Gelbart, W.M. (2009). An introduction to genetic analysis. IX Edition. Freeman & Co., N.Y., USA.
5. Watson, J.D., Myers, R.M., Caudy, A. and Witkowski, J.K. (2007). Recombinant DNA genes and genomes- A short course. III Edition. Freeman and Co., N.Y., USA.

DSE_2: MEDICAL BIOTECHNOLOGY

Unit I: Gene therapy: Background, types of gene therapy (ex vivo & in vivo), choosing targets for gene therapy, vectors in gene therapy, retroviruses, adenoviruses, adeno-associated viruses, types of gene delivery, Weismann barrier (soma-to-germ line barrier), epigenetic inheritance, problems & ethics.

Unit II: Gene Delivery methods: Viral delivery (through Retroviral vectors, through Adenoviral vectors), Non-viral delivery, Antibody engineering.

Unit III: Gene therapy Models: Liver diseases, Lung diseases, Hematopoietic diseases, Circulated gene products, Cancer & Auto-immune diseases.

Unit IV: Vaccines: Vaccine vectors, nucleic acid vaccines, immuno-enhancing technology.

Unit V: Synthetic therapy: synthetic DNAs, therapeutic Ribozymes, synthetic drugs.

Unit VI: Tissue Engineering: Skin, Liver, Pancreas.

Unit VII: Xenotransplantation: terminology, technology behind it, organ donors, social & ethical issues.

Unit VIII: Cell Adhesion-based therapy: integrins, inflammation, cancer & metastasis.

Unit IX: Drug delivery: conventional & new approaches to drug delivery.

Practical:

Test Books

1. Albert Sasson. Medical Biotechnology: Achievements, Prospects and Perceptions. United Nations University Press, 2005.
2. Lee Yaun Kun. Microbial Biotechnology Principles and applications. World Science publications, 2004
3. Michels et al., Genetic techniques for Biological Research. Wiley Publications, 2002.
4. Glazer AN, Nikaido H. Microbial Biotechnology Fundamentals of Applied Microbiology WH Freeman, New York 1994.
5. Vyas. Methods in Biotechnology and Bioengineering, CBS publications, 2003.
6. Marshak et al., Stem cell Biology. CSHL publications, 2002.

DSE_3: ECOLOGY AND ENVIRONMENT MANAGEMENT

UNIT-I

Our Environment: Geological consideration of Atmosphere, Hydrosphere, Lithosphere Scope of Ecology. Development & Evolution of Ecosystem. Principles & Concepts of Ecosystem. Structure of ecosystem. Strata of an ecosystem. Types of ecosystem including habitats. Cybernetics & Homeostasis. Biological control of chemical environment.

UNIT II

Energy transfer in an Ecosystem. Food chain, food web, Energy budget, Production & decomposition in a system. Ecological efficiencies, Trophic structure & energy pyramids, Ecological energetic, principles pertaining to limiting factors, Bio-geochemical cycles (N,C,P cycles).

UNIT-III

Pollution & environmental Health related to Soil, Water, Air, Food, Pesticides, Metals, Solvents, Radiations ,Carcinogen, Poisons. Detection of Environmental pollutant. Indicators & detection systems. Bio-transformation, Plastic, Aromatics, Hazardous wastes
Environmental cleanup: Case studies

UNIT-IV (10 Periods)

Environmental biotechnologies, Biotechnologies in protection and preservation of environment. Bioremediation, Waste disposal.

PRACTICALS

1. Study of all the biotic and abiotic components of any simple ecosystem- natural pond or terrestrial ecosystem or human modified ecosystem.
2. Determination of population density in a terrestrial community or hypothetical community by quad rate method and calculation of the Simpson's and Shannon- Weiner diversity index for the same community.
3. Principle of GPS (Global Positioning System).
4. Study of the life table and fecundity table, plotting of the three types of survivorship curves from the hypothetical data.

5. Study of the types of soil, their texture by sieve method and rapid tests for –pH, chlorides, nitrates, carbonates and organic carbon

6. Study any five endangered/ threatened species- one from each class.

SUGGESTED READING

1. Chapman, J.L., Reiss, M.J. 1999. Ecology: Principles and applications (2nd edition) Cambridge University Press.

2. Divan Rosencraz, Environmental laws and policies in India, Oxford Publication.

3. Ghosh, S.K., Singh, R. 2003. Social forestry and forest management. Global Vision Publishing House

4. Joseph, B., Environmental studies, Tata Mc Graw Hill.

5. Michael Allabay, Basics of environmental science, Routledge Press.

6. Miller, G.T. 2002. Sustaining the earth, an integrated approach. (5th edition) Books/Cole, Thompson Learning, Inc.

7. Mohapatra Textbook of environmental biotechnology IK publication.

8. Rana SVS, Environmental pollution – health and toxicology, Narosa Publication

9. Sinha, S. 2010. Handbook on Wildlife Law Enforcement in India. TRAFFIC, India.

10. Thakur, I S, Environmental Biotechnology, I K Publication.

DSE_4: ENVIRONMENTAL BIOTECHNOLOGY

UNIT I

Conventional fuels and their environmental impact – Firewood, Plant, Animal, Water, Coal and Gas. Modern fuels and their environmental impact – Methanogenic bacteria, Biogas, Microbial hydrogen Production, Conversion of sugar to alcohol Gasohol

UNIT II

Bioremediation of soil & water contaminated with oil spills, heavy metals and detergents.

Degradation of lignin and cellulose using microbes. Phyto-remediation. Degradation of pesticides and other toxic chemicals by micro-organisms- degradation aromatic and chlorinated hydrocarbons and petroleum products.

UNIT III

Treatment of municipal waste and Industrial effluents. Bio-fertilizers Role of symbiotic and asymbiotic nitrogen fixing bacteria in the enrichment of soil. Algal and fungal biofertilizers (VAM)

UNIT IV

Bioleaching, Enrichment of ores by microorganisms (Gold, Copper and Uranium).
Environmental significance of genetically modified microbes, plants and animals.

PRACTICALS

1. Calculation of Total Dissolved Solids (TDS) of water sample.
2. Calculation of BOD of water sample.
3. Calculation of COD of water sample.
4. Bacterial Examination of Water by MPN Method.

SUGGESTED READING

1. Environmental Science, S.C. Santra
2. Environmental Biotechnology, Pradipta Kumar Mohapatra
3. Environmental Biotechnology – Concepts and Applications, Hans-Joachim Jordening and Jeseff Winter
4. Waste Water Engineering, Metcalf and Eddy, Tata McGraw hill
5. Agricultural Biotechnology, S.S. Purohit
6. Environmental Microbiology : Methods and Protocols, Alicia L. Ragout De Spencer, John F.T. Spencer
7. Introduction to Environmental Biotechnology, Milton Wainwright
8. Principles of Environmental Engineering, Gilbert Masters
9. Wastewater Engineering – Metcalf & Eddy

DSE_5: Industrial Biotechnology

Unit I: Commercial Production of Microorganisms: Industrial Fermenters, Single-cell Protein.

Unit II: Bioconversions: Biomining and bioleaching of ores (Use of thermophilic microorganisms in industrial microbiology Bio-gas, Bio-leaching, Bio-diesel.

Unit III: Microorganisms & Agriculture: Microorganisms in Agricultural Waste water treatment, Vermiculture, Microbial pesticides.

Unit IV: Products from Microorganisms: Metabolites, Enzymes, Antibiotics.

Unit V: Bioremediation: Petroleum prospecting and formation of oil spills, Wastewater treatment, chemical degradation, heavy Metals.

Unit VI: Principles of Microbial growth: introduction, the ways of growing microorganisms, ways to increase yield of microbes, Batch, fed-batch and continuous cultures (definition and kinetics).

Unit VII: Downstream processing: extraction, separation, concentration, recovery & purification, operations (Insulin, Vitamins, Metabolites), Industrial production of Ethyl alcohol, Acetic Acid (Vinegar), Citric acid, lactic acid, α -amylase, protease penicillin, tetracycline and vitamin B12, with reference to easily available raw materials, Production of herbal drugs. .

Unit VIII: Biological fuel generation: photosynthesis, sources of biomass, ethanol from biomass, methane from biomass, hydrogen, microbial recovery of petroleum.

PRACTICAL

Text Books

1. Industrial Microbiology (1992): 4th edition-Prescott & Dunn.,CBS
2. Perspectives in Biotechnology and applied Microbiology. Elsevier Publication, Alani,D.I., and Murray Moo-Young (1986):
3. Applied Microbiology (1968)Cassida Jr. Tata McGraw hill. Microbiology- Concepts and applications (1994): Paula A.Ketchun
4. Fermentation Technology -(1998) Staneberry et al.
5. Molecular Biotechnology -Principles & applications of Recombinant DNA - Bernad R.Glick and JackJ.Pasternak.

DSE_6: PLANT BIOTECHNOLOGY

UNIT I

Introduction, Cryo and organogenic differentiation, Types of culture: Seed , Embryo, Callus, Organs, Cell and Protoplast culture. Micropropagation Axillary bud proliferation, Meristem and shoot tip culture, cud culture, organogenesis, embryogenesis, advantages and disadvantages of micropropagation.

UNIT- II

In vitro haploid production Androgenic methods: Anther culture, Microspore culture androgenesis Significance and use of haploids, Ploidy level and chromosome doubling, diploidization, Gynogenic haploids, factors effecting gynogenesis, chromosome elimination techniques for production of haploids in cereals.

UNIT - III

Protoplast Isolation and fusion Methods of protoplast isolation, Protoplast development, Somatic hybridization, identification and selection of hybrid cells, Cybrids, Potential of somatic hybridization limitations. Somaclonal variation. Nomenclature, methods, applications basis and disadvantages.

UNIT - IV

Plant Growth Promoting bacteria. Nitrogen fixation, Nitrogenase, Hydrogenase, Nodulation, Biocontrol of pathogens, Growth promotion by free-living bacteria.

PRACTICALS

1. Preparation of simple growth nutrient (knop's medium), full strength, half strength, solid and liquid.
2. Preparation of complex nutrient medium (Murashige & Skoog's medium)
3. To selection, Prune, sterilize and prepare an explant for culture.
4. Significance of growth hormones in culture medium.
5. To demonstrate various steps of Micropropagation.

SUGGESTED READING

1. Bhojwani, S.S. and Razdan 2004 Plant Tissue Culture and Practice.
2. Brown, T. A. Gene cloning and DNA analysis: An Introduction. Blackwell Publication.
3. Gardner, E.J. Simmonns, M.J. Snustad, D.P. 2008 8th edition Principles of Genetics. Wiley India.

4. Raven, P.H., Johnson, G.B., Losos, J.B. and Singer, S.R. 2005 Biology. Tata MC Graw Hill.
5. Reinert, J. and Bajaj, Y.P.S. 1997 Applied and Fundamental Aspects of Plant Cell, Tissue and Organ Culture. Narosa Publishing House.
6. Russell, P.J. 2009 Genetics – A Molecular Approach. 3rd edition. Benjamin Co.
7. Sambrook & Russel. Molecular Cloning: A laboratory manual. (3rd edition)
8. Slater, A., Scott, N.W. & Fowler, M.R. 2008 Plant Biotechnology: The Genetic Manipulation of Plants, Oxford University Press.

DSE_7: FOOD BIOTECHNOLOGY

UNIT I: Methods for the microbiological examination of water and foods; Control of Microbiological quality and safety; Food borne illnesses and diseases

UNIT II: Microbial cultures for food fermentation, their maintenance, strain development; Production of organic acids (vinegar, lactic acid), alcoholic beverages (beer, wine, and distilled alcoholic beverages such as whiskey, rum, vodka), glycerol

UNIT III: Propagation of baker's yeasts; Microbial production of vitamins (B2 and B12), antibiotics (penicillin, streptomycin, tetracycline); Enzymatic production of glucose, fructose, starch, SCP and mushrooms

UNIT IV: Basics of microbial genetics – Gene, DNA, RNA; Replication, transcription, transformation, transduction, conjugation; Regulation of gene expression; Application in GM foods.

PRACTICAL

1. Alcohol fermentation
2. Organic acid fermentation – Vinegar / citric / lactic acid production
3. Propagation of baker's yeast
4. Fermented dairy products
5. Production of antibiotics
6. Enzyme preparation
7. Amino acid production

8. Vitamin B12 production

Books:

1. Industrial Microbiology Prescott & Dunn, CBS Publishers
2. Modern Food Microbiology by Jay JM, CBS Publishers
3. Comprehensive Biotechnology by Murray & Mooyoung, Academic press
4. Industrial Microbiology by Casida L.R., New Age International Pvt. Ltd.
5. Food Microbiology; Frazier WC; 4th ed, Tata-McGrowhill Pub.
6. Microbiology by Pelczar, Chan, and Krieg, TMH
7. Fermentation Biotechnology, Principles, Processed Products by Ward OP, Open University Press.

SKILL ENHANCEMENT COURSES

SEC_1: MOLECULAR DIAGNOSTICS

UNIT I

Enzyme Immunoassays:

Comparison of enzymes available for enzyme immunoassays, conjugation of enzymes. Solid phases used in enzyme immunoassays. Homogeneous and heterogeneous enzyme immunoassays. Enzyme immunoassays after immuno blotting. Enzyme immuno histochemical techniques. Use of polyclonal or monoclonal antibodies in enzymes immuno assays. Applications of enzyme immunoassays in diagnostic microbiology

UNIT II

Molecular methods in clinical microbiology: Applications of PCR, RFLP, Nuclear hybridization methods, Single nucleotide polymorphism and plasmid finger printing in clinical microbiology

Laboratory tests in chemotherapy: Susceptibility tests: Micro-dilution and macro-dilution broth procedures. Susceptibility tests: Diffusion test procedures. Susceptibility tests: Tests for bactericidal activity. Automated procedures for antimicrobial susceptibility tests.

UNIT III

Automation in microbial diagnosis, rapid diagnostic approach including technical purification and standardization of antigen and specific antibodies. Concepts and methods in idiotypes. Anti-idiotypes and molecular mimicry and receptors. Epitope design and applications. Immunodiagnostic tests. Immunofluorescence. Radioimmunoassay.

UNIT IV

GLC, HPLC, Electron microscopy, flow cytometry and cell sorting. Transgenic animals.

SUGGESTED READING

1. Practical Biochemistry, Principles and Techniques, Keith Wilson and John Walker
2. Bioinstrumentation, Webster
3. Advanced Instrumentation, Data Interpretation, and Control of Biotechnological Processes, J.F. Van Impe, Kluwer Academic
4. Ananthanarayan R and Paniker CKJ. (2005). Textbook of Microbiology. 7th edition (edited by Paniker CKJ). University Press Publication.
5. Brooks GF, Carroll KC, Butel JS and Morse SA. (2007). Jawetz, Melnick and Adelberg's Medical Microbiology. 24th edition. McGraw Hill Publication.
6. Goering R, Dockrell H, Zuckerman M and Wakelin D. (2007). Mims' Medical Microbiology. 4th edition. Elsevier.
7. Joklik WK, Willett HP and Amos DB (1995). Zinsser Microbiology. 19th edition. Appleton-Century-Crofts publication.
8. Willey JM, Sherwood LM, and Woolverton CJ. (2008). Prescott, Harley and Klein's Microbiology. 7th edition. McGraw Hill Higher Education.
9. Microscopic Techniques in Biotechnology, Michael Hoppert

SEC_2: ENZYMOLOGY

UNIT - I

Isolation, crystallization and purification of enzymes, test of homogeneity of enzyme preparation, methods of enzyme analysis. Enzyme classification (rationale, overview and specific examples) Zymogens and their activation (Proteases and Prothrombin).

Enzyme substrate complex: concept of E-S complex, binding sites, active site, specificity, Kinetics of enzyme activity, Michaelis-Menten equation and its derivation, Different plots for the determination of K_m and V_{max} and their physiological significance, factors affecting initial rate, E, S, temp. & pH. Collision and transition state theories, Significance of activation energy and free energy.

UNIT – II

Two substrate reactions (Random, ordered and ping-pong mechanism) Enzyme inhibition types of inhibition, determination of K_i , suicide inhibitor. Mechanism of enzyme action: General mechanistic principle, factors associated with catalytic efficiency: proximity, orientation, distortion of strain, acid-base, nucleophilic and covalent catalysis. Techniques for studying mechanisms of action, chemical modification of active site groups, specific examples-: chymotrypsin, Isozyme, GPDH, aldolase, RNase, Carboxypeptidase and alcohol dehydrogenase. Enzyme regulation: Product inhibition, feed backcontrol, covalent modification.

UNIT – III

Allosteric enzymes with special reference to aspartate transcarbomylase and phosphofructokinase. Qualitative description of concerted and sequential models. Negative cooperativity and half site reactivity. Enzyme - Enzyme interaction, Protein ligand binding, measurements analysis of binding isotherm, cooperativity, Hill and scatchard plots, kinetics of allosteric enzymes. Isoenzymes– multiple forms of enzymes with special reference to lactate dehydrogenase. Multienzyme complexes. Ribozymes. Multifunctional enzyme-eg Fatty Acid synthase.

UNIT – IV (12 Periods)

Enzyme Technology: Methods for large scale production of enzymes. Immobilized enzyme and their comparison with soluble enzymes, Methods for immobilization of enzymes. Immobilized enzyme reactors. Application of Immobilized and soluble enzyme in health and industry. Application to fundamental studies of biochemistry. Enzyme electrodes. Thermal stability and catalytic efficiency of enzyme, site directed mutagenesis and enzyme engineering– selected examples, Delivery system for protein pharmaceuticals, structure function relationship in enzymes, structural motifs and enzyme evolution.

Methods for protein sequencing. Methods for analysis of secondary and tertiary structures of enzymes. Protein folding invitro & invivo.

SUGGESTED READING

1. Biochemistry, Lubert Stryer, 6th Edition, WH Freeman, 2006.
2. Harper's illustrated Biochemistry by Robert K. Murray, David A Bender, Kathleen M.Botham, Peter J. Kennelly, Victor W. Rodwell, P. Anthony Weil. 28th Edition, McGrawHill, 2009.
3. Biochemistry, Donald Voet and Judith Voet, 2nd Edition, Publisher: John Wiley and Sons, 1995.
4. Biochemistry by Mary K.Campbell & Shawn O.Farrell, 5th Edition, Cenage Learning, 2005.
5. Fundamentals of Enzymology Nicholas Price and Lewis Stevens Oxford University Press 1999
6. Fundamentals of Enzyme Kinetics Athel Cornish-Bowden Portland Press 2004
7. Practical Enzymology Hans Bisswanger Wiley–VCH 2004
8. The Organic Chemistry of Enzyme-catalyzed Reactions Richard B. Silverman Academic Press 2002

SEC_3: INDUSTRIAL FERMENTATIONS

UNIT I

Production of industrial chemicals, biochemicals and chemotherapeutic products. Propionic acid, butyric acid, 2-3 butanediol, gluconic acid, itaconic acid, Biofuels: Biogas, Ethanol, butanol, hydrogen, biodiesel, microbial electricity, starch conversion processes; Microbial polysaccharides; Microbial insecticides; microbial flavours and fragrances, newer antibiotics, anti cancer agents, amino acids.

UNIT II

Microbial products of pharmacological interest, steroid fermentations and transformations. Over production of microbial metabolite, Secondary metabolism – its significance and products. Metabolic engineering of secondary metabolism for highest productivity. Enzyme and cell immobilization techniques in industrial processing, enzymes in organic synthesis, proteolytic enzymes, hydrolytic enzymes, glucose isomerase, enzymes in food technology/organic synthesis.

UNIT III

Purification & characterization of proteins, Upstream and downstream processing, solids and

liquid handling. Distribution of microbial cells, centrifugation, filtration of fermentation broth, ultra centrifugation, liquid extraction, ion-exchange recovery of biological products. Experimental model for design of fermentation systems, Anaerobic fermentations.

UNIT IV

Rate equations for enzyme kinetics, simple and complex reactions. Inhibition kinetics; effect of pH and temperature on rate of enzyme reactions. Mathematical derivation of growth kinetics, mathematical derivations of batch and continuous culture operations; single stage CSTR; mass transfer in aerobic fermentation; resistances encountered; overall mass transfer co-efficient (K_a) determination, factors depending on scale up principle and different methods of scaling up. Metabolic engineering of antibiotic biosynthetic pathways.

SUGGESTED READING

1. Casida LE. (1991). Industrial Microbiology. 1st edition. Wiley Eastern Limited.
2. Crueger W and Crueger A. (2000). Biotechnology: A textbook of Industrial Microbiology. 2nd edition. Panima Publishing Co. New Delhi.
3. Patel AH. (1996). Industrial Microbiology. 1st edition, Macmillan India Limited.
4. Stanbury PF, Whitaker A and Hall SJ. (2006). Principles of Fermentation Technology. 2nd edition, Elsevier Science Ltd.
5. Salisbury, Whitaker and Hall. Principles of fermentation Technology,

SEC_4: DRUG DESIGNING

UNIT I: Introduction to The Drug Discovery/Development: Drug Discovery, Drug Development, Source of Drugs, Structural effects on drug action

UNIT II: Approaches to New Drug Discovery : Drugs Derived from Natural Products, Existing Drugs as a Source for New Drug Discovery, Using Disease Models as Screens for New Drug Leads, Physiological Mechanisms: the Modern “Rational Approach” to Drug Design.

Approaches to Lead Optimization:

1. Bioisosteric replacement
2. Conformation restriction
 - a. Increase selectivity, b. Increase affinity
3. Pharmacophore

4. Molecular dissection

5. Metabolic stabilization

UNIT III: Enzymes as Targets of Drug Design: Enzyme kinetics, Enzyme inhibition and activation, Approaches to the Rational Design of Enzyme Inhibitors

UNIT IV: Receptors as Targets of Drug Design: Receptor Theory, Receptor Complexes and Allosteric Modulators, Second and Third Messenger Systems, Molecular Biology of Receptors, Receptor Models and Nomenclature, Receptor Binding Assays, Lead Compound Discovery of Receptor agonists and antagonists

UNIT V: Prodrug Design and Applications: Definition, Applications, Prodrug Design Considerations, Prodrug Forms of Various Functional Groups, Ester prodrugs of compounds containing –COOH or –OH, Prodrugs of compounds containing amides, imides, and other acidic NH, Prodrugs of Amines, Prodrugs for compounds containing carbonyl groups

Drug release and activation mechanisms:

1. Simple one-step activation

2. Cascade release/activation systems

UNIT VI: Computer-Aided Drug Design: Docking and virtual screening, Molecular Dynamics and binding free energy methods

SEC_5: BASICS OF FORENSIC SCIENCE

Unit I

Introduction and principles of forensic science, forensic science laboratory and its organization and service, tools and techniques in forensic science, branches of forensic science, causes of crime, role of modus operandi in criminal investigation. Classification of injuries and their medico-legal aspects, method of assessing various types of deaths.

Unit II

Classification of fire arms and explosives, introduction to internal, external and terminal ballistics. Chemical evidence for explosives. General and individual characteristics of handwriting, examination and comparison of handwritings and analysis of ink various samples.

Unit III

Role of the toxicologist, significance of toxicological findings, Fundamental principles of fingerprinting, classification of fingerprints, development of finger print as science for personal identification,

Unit IV

Principle of DNA fingerprinting, application of DNA profiling in forensic medicine, Investigation Tools, eDiscovery, Evidence Preservation, Search and Seizure of Computers, Introduction to Cyber security.

SUGGESTED READING

1. Molecular Biotechnology- Principles and Applications of recombinant DNA. ASM Press, Washington.
2. B.B. Nanda and R.K. Tiwari, Forensic Science in India: A Vision for the Twenty First Century, Select Publishers, New Delhi (2001).
3. M.K. Bhasin and S. Nath, Role of Forensic Science in the New Millennium, University of Delhi, Delhi (2002).
4. S.H. James and J.J. Nordby, Forensic Science: An Introduction to Scientific and Investigative Techniques, 2nd Edition, CRC Press, Boca Raton (2005).
5. W.G. Eckert and R.K. Wright in Introduction to Forensic Sciences, 2nd Edition, W.G. Eckert (ED.), CRC Press, Boca Raton (1997).
6. R. Saferstein, Criminalistics, 8th Edition, Prentice Hall, New Jersey (2004).
7. W.J. Tilstone, M.L. Hastrup and C. Hald, Fisher's Techniques of Crime Scene - Investigation, CRC Press, Boca Raton (2013)

GENERAL ELECTIVES

GE_1: MATH 1

GE_2: MATH 2

GE_3: ENTREPRENEURSHIP DEVELOPMENT

UNIT I: INTRODUCTION

Meaning, Needs and Importance of Entrepreneurship, Promotion of entrepreneurship, Factors influencing entrepreneurship, Features of a successful Entrepreneurship.

UNIT II: ESTABLISHING AN ENTERPRISE

Forms of Business Organization, Project Identification, Selection of the product, Project formulation, Assessment of project feasibility.

UNIT III: FINANCING THE ENTERPRISE

Importance of finance / loans and repayments, Characteristics of Business finance, Fixed capital management: Sources of fixed capital, working capital its sources and how to move for loans, Inventory direct and indirect raw materials and its management.

UNIT IV: MARKETING MANAGEMENT

Meaning and Importance, Marketing-mix, product management – Product line, Product mix, stages of product like cycle, marketing Research and Importance of survey, Physical Distribution and Stock Management.

UNIT V: ENTREPRENEURSHIP AND INTERNATIONAL BUSINESS

Meaning of International business, Selection of a product, Selection of a market for international business, Export financing, Institutional support for exports.

Project Report on a selected product should be prepared and submitted.

SUGGESTED READING

1. Holt DH. Entrepreneurship: New Venture Creation.
2. Kaplan JM Patterns of Entrepreneurship.
3. Gupta CB, Khanka SS. Entrepreneurship and Small Business Management, Sultan Chand & Sons.

GE_4: BIOETHICS AND BIOSAFETY

Unit I

Biotechnology and social responsibility, public acceptance issues in biotechnology, issues of access, ownership, monopoly, traditional knowledge, biodiversity, benefit sharing, environmental sustainability, public vs private funding, biotechnology in international relations, globalization and development divide.

Introduction to bioethics: Social and ethical issues in biotechnology. Principles of bioethics.

Ethical conflicts in biotechnology- interference with nature, unequal distribution of risk and benefits of biotechnology, bioethics vs business ethics.

Unit II

Biosafety: Definition of bio-safety, Biotechnology and bio-safety concerns at the level of individuals, institutions, society, region, country and world with special emphasis on Indian concerns.

Biosafety in laboratory institution: laboratory associated infection and other hazards, assessment of biological hazards and level of biosafety. Bio safety regulation: handling of recombinant DNA products and process in industry and in institutions (Indian context).

Unit III

Introduction to IPR: IPR, forms of IPR and Intellectual property protection. Concept of property with respect to intellectual creativity, Tangible and Intangible property.

WTO: agency controlling trade among nations, WTO with reference to biotechnological affairs, TRIPs. WIPO, EPO.

Unit IV

Concept related to patents novelty, non-obviousness, utility, anticipation, prior art etc. Type of patents. Indian patent act and foreign patents. Patentability, Patent application, Revocation of patent, Infringement and Litigation with case studies on patent, Commercialization and Licensing.

PRACTICAL:

Books Recommended:

1. Fleming, D.A., Hunt, D.L., (2000). Biotechnology and Safety Assessment (3rd Ed) Academic press. ISBN-1555811804, 9781555811808.
2. Thomas, J.A., Fuch, R.L. (1999). Biotechnology and safety assessment (3rd Ed). CRC press, Washington. ISBN: 1560327219, 9781560327219
3. Law and Strategy of biotechnological patents by Sibley. Butterworth publication. (2007) ISBN: 0750694440, 9780750694445.
4. Intellectual property rights- Ganguli-Tat McGrawhill. (2001) ISBN-10: 0074638602,
5. Intellectual Property Right- Wattal- Oxford Publication House. (1997) ISBN: 0195905024.
6. Biotechnology - A comprehensive treatise (Vol. 12). Legal economic and ethical dimensions VCH. (2nd ed) ISBN-10 3527304320.
7. Encyclopedia of Bioethics 5 vol set, (2003) ISBN-10: 0028657748.
8. Thomas, J.A., Fuch, R.L. (2002). Biotechnology and safety Assessment (3rd Ed) Academic press.
9. B.D. Singh. Biotechnology expanding horizons.
10. H.K. Das. Text book of biotechnology 3rd edition.

GE_5: BIOTECHNOLOGY AND HUMAN WELFARE

UNIT I

Industry: protein engineering; enzyme and polysaccharide synthesis, activity and secretion, alcohol and antibiotic formation.

UNIT II

Agriculture: N₂ fixation; transfer of pest resistance genes to plants; interaction between plants and microbes; qualitative improvement of livestock.

UNIT III

Environments: e.g. chlorinated and non-chlorinated organ pollutant degradation; degradation of hydrocarbons and agricultural wastes, stress management, development of biodegradable polymers such as PHB..

UNIT IV

Forensic science: e.g. solving violent crimes such as murder and rape; solving claims of paternity and theft etc. using various methods of DNA finger printing.

UNIT V

Health: e.g. development of non-toxic therapeutic agents, recombinant live vaccines, gene therapy, diagnostics, monoclonal in E.coli, human genome project.

PRACTICALS

(Wherever wet lab experiments are not possible the principles and concepts can be demonstrated through any other material or medium including videos/virtual labs etc.)

1. Perform of ethanolic fermentation using Baker's yeast
2. Study of a plant part infected with a microbe
3. To perform quantitative estimation of residual chlorine in water samples
4. Isolation and analysis of DNA from minimal available biological samples
5. Case studies on Bioethics (any two)

SUGGESTED READING

1. Sateesh MK (2010) Bioethics and Biosafety, I. K. International Pvt Ltd.
2. Sree Krishna V (2007) Bioethics and Biosafety in Biotechnology, New age international Publishers

GE_6: DEVELOPMENTAL BIOLOGY

UNIT I: Gametogenesis and Fertilization

Definition, scope & historical perspective of development Biology, Gametogenesis – Spermatogenesis, Oogenesis Fertilization - Definition, mechanism, types of fertilization. Different types of eggs on the basis of yolk.

UNIT II: Early embryonic development

Cleavage: Definition, types, patterns & mechanism Blastulation: Process, types & mechanism Gastrulation: Morphogenetic movements– epiboly, emboly, extension, invagination, convergence, de-lamination. Formation & differentiation of primary germ layers, Fate Maps in early embryos.

UNIT III: Embryonic Differentiation

Differentiation: Cell commitment and determination- the epigenetic landscape: a model of determination and differentiation, control of differentiation at the level of genome,

transcription and post-translation level Concept of embryonic induction: Primary, secondary & tertiary embryonic induction, Neural induction and induction of vertebrate lens.

UNIT IV: Organogenesis

Neurulation, notogenesis, development of vertebrate eye. Fate of different primary germ layers Development of behaviour: constancy & plasticity, Extra embryonic membranes, placenta in Mammals.

PRACTICALS

1. Identification of developmental stages of chick and frog embryo using permanent mounts
2. Preparation of a temporary stained mount of chick embryo
3. Study of developmental stages of Anopheles.
4. Study of the developmental stages of Drosophila from stock culture/ photographs..
5. Study of different types of placenta.

SUGGESTED READING

1. Gilbert, S. F. (2006). Developmental Biology, VIII Edition, Sinauer Associates, Inc., Publishers, Sunderland, Massachusetts, USA.
2. Balinsky, B.I. (2008). An introduction to Embryology, International Thomson Computer Press.
3. Kalthoff, (2000). Analysis of Biological Development, II Edition, McGraw-Hill Professional