

**DEPARTMENT OF BIOCHEMISTRY**

**Semester wise proposed distribution of Core & Elective Papers**

**3 Year Degree course in Biochemistry (self financed)**

**COURSE STRUCTURE**

<b>Semester</b>	<b>Core</b>		<b>Elective</b>			
I	<b>BCH-I.C-1</b> Molecules of Life	<b>BCH-I.C-2</b> Cell Biology	-----	-----	-----	-----
II	<b>BCH-II.C-3</b> Protein chemistry	<b>BCH-II.C-4</b> Biophysics	-----	-----	-----	-----
III	<b>BCH-III.C-5</b> Enzymology		<b>BCH-III.E-1</b> Tools & Techniques in Biochemistry	<b>BCH-III.E-2</b> Microbiology	<b>BCH-III.E-3</b> Bioethics and Bio-safety	<b>BCH-III.E-4</b> Plant Biochemistry
IV	<b>BCH-IV. C-6</b> Metabolism of Biomolecules		<b>BCH-IV.E-5</b> Human physiology	<b>BCH-IV.E-6</b> Nutritional Biochemistry	<b>BCH-IV.E-7</b> Hormone: Biochemistry and Function	<b>BCH-IV.E-8</b> Advanced Cell Biology
V	<b>BCH-V.C-7</b> Molecular biology		<b>BCH-V.E-9</b> Concepts in genetics	<b>BCH-V.E-10</b> Regulation of gene expression	<b>BCH-V.E-11</b> Genetic Engineering and Biotechnology	<b>BCH-V.E-12</b> Bioinformatics
VI	<b>BCH-VI.C-8</b> Immunology		<b>BCH-VI.E-13</b> Biochemical correlation of Diseases	<b>BCH-VI.E-14</b> Clinical Biochemistry	<b>BCH-VI.E-15</b> Environmental Biochemistry	<b>BCH-VI.E-16</b> Industrial Biochemistry

## **BCH-I.C-1 MOLECULES OF LIFE (THEORY)**

**COURSE TITLE: MOLECULES OF LIFE (THEORY)**

**COURSE CODE: BCH-I.C-1**

**MARKS: 75**

**CREDITS: 3**

**COURSE OBJECTIVES:** This paper provides basic foundation on biomolecules of life with reference to their properties, and biological functions. The course also provides detailed knowledge on how cellular structure and function arise as a result of the properties of cellular macromolecules.

**LEARNING OUTCOMES:** Students will understand the importance of proteins, carbohydrates, lipids and nucleic acids and their role in living organisms. It will also help to understand the clinical significance of vitamins.

### **BCH-I.C-1 MOLECULES OF LIFE (THEORY)**

**Total hours: 45**

#### **Unit 1 The foundations of biochemistry**

**No. of Hours: 2**

Cellular and chemical foundations of life

#### **Unit 2 Water**

**No. of Hours: 3**

Unique properties, weak interactions in aqueous systems, ionization of water, water as a reactant and fitness of the aqueous environment

#### **Unit 3 Carbohydrates**

**No. of Hours: 10**

Monosaccharides: structure of aldoses and ketoses, ring structure of sugars, conformations of sugars, stereochemistry: mutarotation, anomers, epimers and enantiomers, formation of disaccharides, reducing and non-reducing disaccharides, Polysaccharides: homo and heteropolysaccharides, structural and storage polysaccharides

#### **Unit 4 Proteins**

**No. of Hours: 8**

Types of amino acids and their chemistry, derivatives of amino acids and their biological role. Introduction to biologically important peptides. Polypeptides and proteins.

**Unit 5 Lipids****No. of Hours: 7**

Various classes of lipids and their distribution, storage lipids, structural lipids in membranes, lipids as signal molecules, cofactors and pigments

**Unit 6 Nucleic acids****No. of Hours: 10**

Structures and chemistry: DNA structures and their importance, different types of RNA, unusual DNA structures, other functions of nucleotides: source of energy, component of coenzymes, second messengers.

**Unit 7 Vitamins****No. of Hours: 5**

Structure and active forms of water soluble and fat soluble vitamins, deficiency diseases and symptoms, hypervitaminosis

**BCH-I.C-1: MOLECULES OF LIFE (PRACTICAL)****COURSE TITLE: MOLECULES OF LIFE (PRACTICAL)****COURSE CODE: BCH-I.C-1****MARKS: 25 MARKS****CREDITS: 1****TOTAL HOURS: 30**

Introduction to safety measures in laboratories	1P
Preparation of solutions (normal, molar, ppm, %)	1 P
Mutarotation of sugars	2P
Determination of pKa of acetic acid and glycine	2 P
Qualitative tests for carbohydrates, lipids, amino acids, proteins and nucleic acids	5 P
Preparation of TLC plates and separation of amino acids and sugars by thin layer chromatography	3 P
Estimation of vitamin C	1 P

**REFERENCES**

- Nelson, D. L. & Cox, M.M. (2000), Lehninger's Principles of Biochemistry (3rd Edition),Worth Publishers, New York, USA.
- Stryer, L. (1995). Biochemistry, W.H. Freeman and Co., New York, USA.

- Jain, J.L (1999), Fundamentals of Biochemistry, S.Chand and Company, Ltd., New Delhi.
- Murray, R.K., Granner, D.K., Mayes, P.A. & Rodwell, V.W. (2003), Harper's Illustrated Biochemistry, McGraw-Hill Companies.
- Donald Voet, Judith G. Voet & Charlotte W. Pratt, Principles of Biochemistry, John Wiley & Sons.
- S. Sadasivam and A. Manickam (1996), Biochemical Methods, New Age International (P) Limited
- J. Jayaraman (1971), Laboratory Manual in Biochemistry, John Wiley & Sons, Limited.

## **BCH-I.C-2 CELL BIOLOGY (THEORY)**

**COURSE TITLE: CELL BIOLOGY (THEORY)**

**COURSE CODE: BCH-I.C-2**

**MARKS: 75**

**CREDITS: 3**

**COURSE OBJECTIVES:** The course will give a detailed description of the organization of the cell, the structure and functions of various organelles. The course also focuses on the communication cells and the importance of cell division.

**LEARNING OUTCOMES:** Students will have a clear knowledge on the function of each cell organelle with proper coordination and establish the concept of how proper conformations of lipids and proteins in a membrane are needed for optimum functioning.

**BCH-I.C-2 CELL BIOLOGY (THEORY)**

**TOTAL HOURS: 45**

**Unit 1 Introduction to cell biology**

**No. of Hours: 6**

Cell theory, ultra-structure of prokaryotic and eukaryotic cell; cell matrix proteins; components of extracellular matrix

**Unit 2 Ultra- structure and function of organelles**

**No. of Hours: 15**

Cilia and flagella; endoplasmic reticulum, golgi apparatus, lysosomes, microbodies, mitochondria, chloroplast, ribosomes, centrioles and basal bodies, nucleus, chloroplasts and peroxisomes

**Unit 3 Cell wall & Plasma membrane****No. of Hours: 10**

Chemical composition, structure and functions of the cell wall and plasma membrane, monolayer, planer bilayer and liposomes as model membrane systems. Fluid mosaic model, lipid rafts, caveolae, membrane fluidity, factors affecting membrane fluidity, techniques used to study membrane dynamics – FRAP

**Unit 4: Cell cycle****No. of Hours: 4**

Overview of the cell cycle; prokaryotic & eukaryotic cell cycle; events of mitotic & meiotic phases, cytokinesis.

**Unit 5: Cell-Cell interaction****No. of Hours: 10**

Interactions of cells with extracellular materials: integrins, focal adhesions and hemidesmosomes; interactions of cells with other cells: selectins, the immunoglobulin superfamily, cadherins, adheren junctions and desmosomes; tight junctions, gap junctions and plasmodesmata

**BCH-I.C-2 CELL BIOLOGY (PRACTICAL)****COURSE TITLE: CELL BIOLOGY (PRACTICAL)****COURSE CODE: BCH-I.C-2****MARKS: 25****CREDITS: 1****TOTAL HOURS: 30**

Examination of prokaryotic cell, eukaryotic cell and cell organelles using Photomicrographs	2P
Visualization of animal and plant cell using methylene blue	2P
Study of cell viability using phenol red and trypan blue	1P
Visualization of Permanent slides of:	1P
A. Different cell types: Epithelium, Endothelium, Muscle cells, Nerve cell	
B. Different stages of cell division	
Identification of different stages of mitosis in onion root tip`	1P
Identification of different stages of meiosis in grasshopper testis	1P
Isolation of chloroplast from spinach leaves and estimation of chlorophyll	2P
Prokaryotic cell harvesting & lysis using osmotic (salt) and Chemical (detergent) methods	3P
RBC and WBC count using haemocytometer	2P

## REFERENCES

- Karp, G. & Harris, D. (2008) Cell and Molecular Biology – Concepts and Experiments, John Wiley & Sons Inc, New York.
- Robertis, E.D.P. & Robertis, E.M.F. (1998). Cell Biology and Molecular Biology, 8<sup>th</sup> edition, Sauder College.
- Cooper, G.M. and Hausman, R.E. 2009. The Cell: A Molecular Approach. 5<sup>th</sup> edition. ASM Press & Sunderland, Washington, D.C.
- Gupta, P.K. (1999). A Text-book of Cell and Molecular Biology. Rastogi Publications, Meerut, India.
- Verma P.S. and Agarwal V. K. (1998).Cell Biology, Genetics, Molecular Biology, Evolution and ecology. Edn.14

### **BCH-II.C-3 PROTEIN CHEMISTRY (THEORY)**

**COURSE TITLE: PROTEIN CHEMISTRY (THEORY)**

**COURSE CODE: BCH-II.C-3**

**MARKS: 75**

**CREDITS: 3**

**COURSE OBJECTIVES:** The main objective of the course is to understand the importance of structure of proteins for their biological functions and the analytical techniques to isolate and characterize proteins.

**LEARNING OUTCOMES:** Students will be able to describe the four levels of protein structure, types of bonding and how a protein's structure relates to its cellular function. Also students will be familiar with many of the biophysical techniques used in research and industry for analyzing the structure and function of proteins.

**BCH-II.C-3 PROTEIN CHEMISTRY (THEORY)**

**TOTAL HOURS: 45**

**Unit 1 Protein structure**

**No. of Hours: 15**

Bonds in protein structure (covalent, non covalent,peptide), importance of primary & secondary structure, tertiary and quaternary structures, bond lengths and configuration,

Dihedral angles, psi and phi, helices, sheets and turns, Ramachandran map; techniques used in studying 3-D structures - X-ray diffraction and NMR; motifs and domains; structures of myoglobin and haemoglobin, multimeric proteins and conjugated proteins, diversity of function.

### **Unit 2 Isolation and analysis of proteins**

**No. of Hours: 12**

Techniques to isolate and analyze proteins: salt fractionation, ion-exchange chromatography, gel permeation, HPLC, SDS-PAGE, IEF; Protein primary structure: sequencing by Edman degradation, use of enzymes and chemical reagents to obtain overlap peptides, synthesis of peptides using Merrifield method

### **Unit 3 Characterization of proteins**

**No. of Hours: 5**

Determination of purity, molecular weight, extinction coefficient, sedimentation coefficient, 2-D electrophoresis

### **Unit 4 Enzymes**

**No. of Hours: 5**

Nature of enzymes: protein and non-protein (ribozyme); cofactor and prosthetic group, apoenzyme, holoenzyme; IUBMB classification of enzymes

### **Unit 5 Membrane proteins**

**No. of Hours: 8**

Integral and membrane associated proteins, hydropathy plots to predict transmembrane domains; significance of membrane proteins; bacteriorhodopsin, myoglobin and haemoglobin: structure and function (Oxygen binding curves, cooperativity models for haemoglobin)

## **BCH-II.C-3 PROTEIN CHEMISTRY (PRACTICAL)**

**COURSE TITLE: PROTEIN CHEMISTRY (PRACTICAL)**

**COURSE CODE: BCH-II.C-3**

**MARKS: 25**

**CREDITS: 1**

**TOTAL HOURS: 30**

Determination of the absorption maxima and molar extinction coefficient of protein sample	2P
Protein assay by Lowry/Bradford method	2P
Ammonium sulphate fractionation of crude homogenate from mung bean	1P

Ammonium sulphate fractionation of serum proteins	2P
Protein dialysis	1P
Solubility of proteins in distilled water and salt solutions	2P
Separation of proteins by SDS-PAGE (demonstration)	2P
Gel filtration chromatography	2P
Denaturation of proteins by heat	1P

## REFERENCES

- Nelson D.L and Cox M.M (2013). Lehninger's Principles of Biochemistry, Worth Publishers, New York, USA.
- Cooper T.G (2011). The Tools of Biochemistry, Wiley India Pvt. Ltd, NewDelhi.
- Voet, D. and Voet, J.G ( 2004). Biochemistry, 3rd Edition, John Wiley & Sons, Inc. USA.
- Plummer D. T (1998). An Introduction to Practical Biochemistry, 3rd ed., Tata McGraw Hill Education Pvt. Ltd. New Delhi.
- Sadasivam S. and A. Manickam (1996), Biochemical Methods, New Age International (P) Limited, New Delhi.
- J. Jayaraman (1971), Laboratory Manual in Biochemistry, John Wiley & Sons, Limited, New Delhi.

## BCH-II.C-4 BIOPHYSICS (THEORY)

**COURSE TITLE: BIOPHYSICS (THEORY)**

**COURSE CODE: BCH-II.C-4**

**MARKS: 75 MARKS**

**CREDITS: 3**

**COURSE OBJECTIVES:** The course will give a detailed description of the physical concepts required to study various biochemical aspects, to understand the basic concepts of origin and evolution of life and the concepts of bioenergetics.

**LEARNING OUTCOMES:** Students will have a clear concept on thermodynamic principles which are essential to carry out the cellular reactions. It will also help to understand the mechanism of deriving energy through bioenergetic reactions in living cells.

**Unit 1 The chemical basis of life****No. of Hours: 5**

Introduction, prebiotic earth, theories of origin and evolution of life; covalent bonds, non-covalent bonds: ionic bonds, hydrogen bonds, hydrophobic interactions, van der Waals forces

**Unit 2 Basic principles of biochemical studies****No. of Hours: 7**

Units of measurement; weak electrolytes- the biochemical importance of weak electrolytes, ionisation of weak acids and bases, calculation of pH, ionisation of a weak electrolyte, buffer solutions, buffer capacity, buffer action and pH of blood, measurement of pH

**Unit 3 Introduction to bioenergetics****No. of Hours: 10**

Laws of thermodynamics, equilibrium constant, coupled reactions, ATP cycle, phosphoryl group transfers; chemical basis of high standard energy of hydrolysis of ATP, other phosphorylated compounds and thioesters. Redox reactions, standard redox potentials and Nernst equation, universal electron carriers

**Unit 4 Ion channels****No. of Hours: 4**

Sodium, Potassium, Calcium, Chlorine, ligand gated, Donnan's equilibrium experiments

**Unit 5 Oxidative phosphorylation****No. of Hours: 7**

Mitochondrial electron transport chain: its organization and function, inhibitors of ETC and uncouplers, Peter Mitchell's chemiosmotic hypothesis, proton motive force, structure and mechanism of ATP synthesis, regulation of oxidative phosphorylation

**Unit 6 Photo-phosphorylation****No. of Hours: 12**

General features of photophosphorylation, Hills reaction, photosynthetic pigments, light harvesting systems of plants and microbes; bacterial photophosphorylation in purple bacteria, green sulfur bacteria. Photophosphorylation in plants - structure of chloroplast, molecular architecture of Photosystem I and Photosystem II, Z-scheme of photosynthetic electron flow, oxygen evolving complex and action of herbicides; cyclic photo-phosphorylation and its significance; photo inhibition, evolution of oxygenic photosynthesis

## BCH-II.C-4 BIOPHYSICS (PRACTICAL)

**COURSE TITLE: BIOPHYSICS (PRACTICAL)**

**COURSE CODE: BCH-II.C-4**

**MARKS: 25**

**CREDITS: 1**

**TOTAL HOURS: 30**

Preparation of buffers	2P
Determination of buffering capacity	1P
To determine Osmolarity of solutions proteins/ sugars/ lipids/ nucleic acids using Osmometer	4P
Effect of detergents and other membrane active substances on cells (Erythrocytes)	2P
Determination of $\lambda_{\text{max}}$ and Molar extinction coefficient of a given compound	2P
Determination of pka of Bromophenol blue	2P
Photooxidation of photosynthetic pigments	1P
Oxygen evolution (by hydrilla )	1P

### REFERENCES

- Nelson D.L and Cox M.M (2013). Lehninger's Principles of Biochemistry, Worth Publishers, New York, USA.
- Cooper T.G (2011). The Tools of Biochemistry, Wiley India Pvt. Ltd, NewDelhi.
- Voet, D. and Voet, J.G ( 2004). Biochemistry, 3rd Edition, John Wiley & Sons, Inc, USA.
- Stryer, L. (1995). Biochemistry, W.H. Freeman and Co., New York, USA.
- Jain, J.L (1999), Fundamentals of Biochemistry, S.Chand and Company, Ltd., New Delhi.
- Wilson K and Walker J (2010). Principles and Techniques of Biochemistry and Molecular Biology, Seventh edition Cambridge University Press, UK.

**PARVATIBAI CHOWGULE COLLEGE OF ARTS & SCIENCE  
(AUTONOMOUS)  
DEPARTMENT OF BIOCHEMISTRY (SELF FINANCED)  
COURSE STRUCTURE**

Semester	Core		Elective			
	I	<b>BCH-I.C-1</b> Molecules of Life	<b>BCH-I.C-2</b> Cell Biology	-----	-----	-----
II	<b>BCH-II.C-3</b> Protein chemistry	<b>BCH-II.C-4</b> Biophysics	-----	-----	-----	-----
III	<b>BCH-III.C-5</b> Enzymology		<b>BCH-III.E-1</b> Tools & Techniques in Biochemistry	<b>BCH-III.E-2</b> Microbiology	<b>BCH-III.E-3</b> Bioethics and Bio-safety	<b>BCH-III.E-4</b> Plant Biochemistry
IV	<b>BCH-IV. C-6</b> Metabolism of Biomolecules		<b>BCH-IV.E-5</b> Human physiology	<b>BCH-IV.E-6</b> Nutritional Biochemistry	<b>BCH-IV.E-7</b> Hormone: Biochemistry and Function	<b>BCH-IV.E-8</b> Advanced Cell Biology
V	<b>BCH-V.C-7</b> Molecular biology		<b>BCH-V.E-9</b> Concepts in genetics	<b>BCH-V.E-10</b> Regulation of gene expression	<b>BCH-V.E-11</b> Genetic Engineering and Biotechnology	<b>BCH-V.E-12</b> Bioinformatics
VI	<b>BCH-VI.C-8</b> Immunology		<b>BCH-VI.E-13</b> Biochemical correlation of Diseases	<b>BCH-VI.E-14</b> Clinical Biochemistry	<b>BCH-VI.E-15</b> Environmental Biochemistry	<b>BCH-VI.E-16</b> Industrial Biochemistry

## **BCH-III.C-5 ENZYMOLOGY (THEORY)**

### **SEMESTER III**

**COURSE TITLE: ENZYMOLOGY (THEORY)**

**COURSE CODE: BCH-III.C-5**

**MARKS: 75**

**CREDITS: 3**

**COURSE OBJECTIVES:** The course will introduce students to various theoretical and practical aspects of enzymology; and stimulate their interest in learning the structure, function and kinetics of enzyme. Serve as foundation for more advanced enzymology courses.

**LEARNING OUTCOMES:** Students will have a clear knowledge to explain relationship between the structure and function of enzymes; explain how enzymes are able to increase speed of the biochemical reaction, differentiate between equilibrium and steady state kinetics and to estimate important parameters such as  $K_m$ ,  $V_{max}$ ,  $K_{cat}$

### **BCH-III.C-5 ENZYMOLOGY (THEORY)**

**TOTAL HOURS: 45**

#### **Unit 1 Introduction to enzymes**

**No. of Hours: 6**

Nature of enzymes - protein and non-protein

Co-enzymes, Cofactor and prosthetic group, apoenzyme, holoenzyme, ribozymes & isoenzymes

Specificity of enzymes, concept of active site

Nomenclature and Classification of enzymes

#### **Unit 2 Features of enzyme catalysis**

**No. of Hours: 6**

Fischer's lock and key hypothesis

Koshland's induced fit hypothesis

Factors affecting the rate of reactions, (time, enzyme concentration, substrate concentration, pH, temperature)

#### **Unit 3 Enzyme kinetics**

**No. of Hours: 8**

Enzyme activity - international units, specific activity, turnover number

Principles of reaction rates, order of reactions and equilibrium constants. Derivation of

Michaelis-Menten equation and Lineweaver- Burk plot  
Significance of  $K_m$  and  $V_{max}$ ,  $K_{cat}$  and turnover number

**Unit 4 Enzyme inhibition**

**No. of Hours: 8**

Reversible inhibition (competitive, uncompetitive, non-competitive, mixed and suicide, end product)

Types of irreversible Inhibition, Allosteric inhibition

**Unit 5 Mechanisms of enzyme action and regulation**

**No. of Hours: 6**

Mechanism of action of chymotrypsin

Regulation of enzyme activity and its importance - aspartate transcarbamoylase

**Unit 6 Enzyme purification**

**No. of Hours: 6**

Purification of enzymes: salt precipitation; dialysis; molecular exclusion chromatography;

Molecular weight determination by PAGE, SDS-PAGE

**Unit 7 Applications of enzymes**

**No. of Hours: 5**

Enzymes in diagnostics (SGPT, SGOT, creatine kinase, alkaline and acid phosphatases), enzyme immunoassay (HRPO)

Immobilized enzymes

**BCH-III.C-5 ENZYMOLOGY (PRACTICAL)**

**COURSE TITLE: ENZYMOLOGY (PRACTICAL)**

**COURSE CODE: BCH-III.C-5**

**MARKS: 25**

**CREDITS: 1**

**TOTAL HOURS: 30**

Preparation of buffers and solutions for the study of enzyme activity 1P

Enzyme assay and rate of reaction 1P

Determination of optimal pH for enzyme activity 1P

Determination of optimal temperature for enzyme activity 1P

Effect of substrate concentration and determination of $K_m$ and $V_{max}$	4P
Production and isolation of enzyme from any source (plant/microbial)	2P
Partial purification of an enzyme (salting out and Dialysis)	3P
PAGE- Preparation of reagents; Demonstration	2P

## REFERENCES

- Jain, J.L (1999). Fundamentals of Biochemistry, S. Chand and Company, Ltd., New Delhi.
- Murray, R.K., Granner, D.K., Mayes, P.A. & Rodwell, V.W. (2003), Harper's Illustrated Biochemistry, McGraw-Hill Companies.
- Nelson, D. L. & Cox, M.M. (2000). Lehninger's Principles of Biochemistry (3rd Edition), Worth Publishers, New York, USA.
- Stryer, L. (1995). Biochemistry, W.H. Freeman and Co., New York, USA.
- Zubay, G. (1993). Biochemistry (3<sup>rd</sup> Edition), WCB Publishers, Iowa, USA.
- Nicholas C.P. & Lewis S. (1999). Fundamentals of Enzymology (3<sup>rd</sup> Ed), Oxford University Press Inc. New York. USA.

## BCH-III.E-1 TOOLS AND TECHNIQUES IN BIOCHEMISTRY (THEORY)

### SEMSESTER III

**COURSE TITLE: TOOLS AND TECHNIQUES IN BIOCHEMISTRY (THEORY)**

**COURSE CODE: BCH-III.E-1**

**MARKS: 75**

**CREDITS: 3**

**COURSE OBJECTIVES:** This course is designed to expose the students to the basic principles underlying some biochemical methods and techniques, their methodologies and applications.

**LEARNING OUTCOMES:** To understand the principles and applications behind major biochemical methods such as chromatography, electrophoresis, centrifugation, spectrophotometry and isotopic techniques

## **BCH-III.E-1 TOOLS AND TECHNIQUES IN BIOCHEMISTRY (THEORY)**

**TOTAL HOURS: 45**

### **Unit 1 Separation Techniques**

**No. of Hours: 4**

Different methods of protein precipitation: Precipitation using inorganic salts (salting out) and organic solvents, dialysis and ultra-filtration.

### **Unit 2 Chromatography**

**No. of Hours: 10**

Basic principles of chromatography: Partition coefficient, concept of theoretical plates, various modes of chromatography (paper, thin layer, column), HPLC, Molecular Sieve (Gel Filtration) Chromatography, Ion Exchange Chromatography, Affinity Chromatography, Gas Liquid Chromatography.

### **Unit 3 Electrophoresis**

**No. of Hours: 10**

Basic Principle of electrophoresis, Paper electrophoresis, Gel electrophoresis, discontinuous gel electrophoresis, PAGE, SDS-PAGE, Native gels, denaturing gels, agarose gel electrophoresis

### **Unit 4 Centrifugation**

**No. of Hours: 10**

Principle of centrifugation, basic rules of sedimentation, sedimentation coefficient, various types of centrifuges, different types of rotors, differential centrifugation, density gradient centrifugation (Rate zonal and Isopycnic)

### **Unit 5 Spectrophotometry**

**No. of Hours: 4**

UV-Visible spectrophotometry- Principle, instrumentation and applications

### **Unit 6 Radioisotopes in Biology**

**No. of Hours: 7**

Concept of half-life, decay constant, detection - GM counter, solid and liquid scintillation counter, autoradiography; Applications of radioisotopes in Biology

## **BCH-III.E-1 TOOLS AND TECHNIQUES IN BIOCHEMISTRY (PRACTICAL)**

**COURSE TITLE: TOOLS AND TECHNIQUES IN BIOCHEMISTRY (PRACTICAL)**

**COURSE CODE: BCH-III.E-1**

**MARKS: 25**

**CREDITS: 1**

**TOTAL HOURS: 30**

Estimation of proteins by Biuret and Lowry's Methods	4P
Separation and identification of amino acids by paper chromatography	2P
Precipitation of protein by salt precipitation and solvent precipitation	2P
Demonstration of gel filtration chromatography	2P
SDS-PAGE analysis of proteins	3P
Determination of pKa values of glycine and aspartate/glutamate	2P

### **REFERENCES**

- Wilson K and Walker J. 2005. Principles and Techniques of Practical Biochemistry, 6<sup>th</sup> Edition, Cambridge University Press.
- Upadhyay A, Upadhyay K and Nath N. 2009. Biophysical Chemistry: Principles and Techniques, 3<sup>rd</sup> Edition, Himalaya Publishing, New Delhi.
- Plummer D. 1988. An introduction to Practical Biochemistry, Tata McGraw Hill Publishing Company, New Delhi.
- Jayraman J. 2011. Laboratory Manual in Biochemistry. New Age International Pvt Ltd Publishers, New Delhi.
- Sadasivam S. and Manickam A. 2007. Biochemical Methods, 3<sup>rd</sup> edition, New Age International Publishers, New Delhi.



Respiration (aerobic and anaerobic)

Bacterial growth curve- characteristics of growth phases; diauxic growth curve

### **Unit 3 Fungi**

**No. of Hours: 8**

General characteristics of fungi: habitat, nutritional requirements, cell ultra- structure, thallus organization, cell wall structure. Pigments. Mycotoxins.

Reproduction: sexual and asexual reproduction; parasexual mechanism.

Heterokaryosis, heterothallism.

### **Unit 4 Viruses**

**No. of Hours: 5**

Structure; Bacterial, plant and animal viruses

Viral multiplication (lytic and lysogenic)

### **Unit 5 Cultivation of microorganisms**

**No. of Hours: 10**

Sterilisation, disinfection, decontamination: Principle and methods

Types of culture media: Synthetic/defined, complex, solid, liquid, enrichment, selective, differential.

Cultivation of microorganisms: Broth culture, agar plate, pour plate

Determination of viable count: Serial dilution, spread plating, determination of colony forming units (cfu) and calculation of viable count

Isolation of pure cultures: Streak plate; colony morphology

### **Unit 6 Maintenance and preservation of microbial cultures**

**No. of hours: 4**

Slant and stab cultures, periodic transfer, storage in sterile soil, overlaying with mineral oil, glycerol stocks, preservation in liquid nitrogen, lyophilisation

## **BCH-III.E-2 MICROBIOLOGY (PRACTICAL)**

**COURSE TITLE: MICROBIOLOGY (PRACTICAL)**

**COURSE CODE: BCH-III.E-2**

**MARKS: 25**

**CREDITS: 1**

**TOTAL HOURS: 30**

Introduction to microbiology laboratory equipments: Autoclave, millipore filters and assembly, biological safety cabinets (Laminar air flow and HEPA filter), incubators, hot air oven, microscope, pH meter	1P
Sterilization of glassware: Flasks, test tubes, petri plates, pipettes	1P
Preparation and sterilization of media (liquid and solid)	1P
Study of different shapes of bacteria using permanent slides/pictographs	1P
Determination of viable count: Serial dilution, spread plating, determination of colony forming units (cfu) and calculation of viable count	2P
Isolation of pure cultures: Streak plate; colony morphology	2P
Pour Plate Technique	2P
Gram stain of Gram positive and Gram negative bacteria	1P
Use of biochemical tests for bacterial identification: Sugar fermentations, IMViC test	3P
Decontamination and disposal of cultures	1P

### **REFERENCES**

- Prescott, Harley, Klein. 2008. Microbiology. McGraw-Hill Higher Education, Boston.
- Pelczar M.J, Chan E.C.S, Krieg N.R. 1993. Microbiology, McGraw-Hill, New York.
- Dubey R.C., Maheshwari D.K., A textbook of Microbiology. 2008. S. Chand and Company Ltd, New Delhi.
- Powar, C.B & Dagainawala, H.F.1982. General Microbiology – Volume II. Himalaya Publishing house: Bombay.
- Ananthanarayan R and Paniker CKJ. 2009. Text book of Microbiology, Eight edition, University Press.
- Madigan M., Martinko., Parker J. Brock's Biology of Microorganisms. 2007. Pearson Prentice Hall.

## **BCH-III.E3 BIOETHICS AND BIOSAFETY**

### **SEMESTER III**

**COURSE TITLE: BIOETHICS AND BIO-SAFETY (THEORY)**

**COURSE CODE: BCH-III.E3**

**MARKS: 75**

**CREDITS: 3**

**COURSE OBJECTIVES:** This paper aims at introducing the importance of the basic concepts of bioethics and bio-safety and their relationship with several fields such as ecology, agriculture, medicine, chemistry etc. The course deals with answers to ethical questions that arise in the relationships among the life sciences, biotechnology, medicine, politics, law, philosophy, theology and their importance in the field of biotechnology.

**LEARNING OUTCOME:** The students will understand the importance of bioethics and biosafety procedures to be followed, with knowledge of the basic concepts, its principles, and use.

**BCH-III.E3 BIOETHICS AND BIOSAFETY TOTAL HOURS: 45**

#### **Unit 1 Introduction to Bioethics**

**No. of Hours: 5**

Introduction, Principles of bioethics and ethical conflicts, Social and ethical issues in biotechnology

#### **Unit 2 Bioethics in Genetic Engineering**

**No. of Hours: 5**

Bioethical issues in plant and animal genetic engineering, Bioethics in IVF

#### **Unit 3 Introduction to Biosafety**

**No. of Hours: 6**

Introduction, History and Definition of Biosafety

Biosafety Guidelines and Regulations

Operation of Biosafety Guidelines and Regulations

#### **Unit 4 Safety in Laboratories**

**No. of Hours: 3**

Hazards: Physical, Biological and Chemical; Good laboratory practices

**Unit 5 International and Indian Biosafety guidelines** **No. of Hours: 5**

Biosafety Guidelines in India

International Biosafety Guidelines: OECD, FAO, WHO, CAC

**Unit 6 Biosafety levels** **No. of Hours: 8**

Levels of Physical containment, Levels of Biological containment

Biosafety of GMOs and GEMs, Planned introduction and field trials of: GMOs and GEMs

**Unit 7 Introduction and Protection of Intellectual Property Right** **No. of Hours: 8**

Introduction, history of Intellectual Property Rights

Trade secrets, Copyrights, Trademarks, Plant variety protection (PVP)

World Intellectual Property Organization (WIPO), GATT & TRIPs

Patent status – International Scenario , Patenting of Biological materials

Significance of Patents in India

**Unit 8 Protection of Biotechnological Inventions** **No. of Hours: 5**

Patenting of genes and DNA sequences, Gene patents and Genetic resources

Farmers rights, Plant breeder's rights, Patenting of life forms

**BCH-III.E3 BIOETHICS AND BIO-SAFETY (PRACTICAL)**

**COURSE TITLE: BIOETHICS AND BIO-SAFETY (PRACTICAL)**

**COURSE CODE: BCH-III.E3**

**MARKS: 25**

**CREDITS: 1**

**TOTAL HOURS: 30**

General safety measures and study of safety notices	2P
Study of symbols and warnings on reagent bottles	1P
Study of preventive measures and first aid during laboratory hazards	1P
Demonstration of handling of fire extinguisher	1P
Practice of GLP	1P
Case study on handling and disposal of radioactive waste	2P

Case study on handling and disposal of medical/microbial waste	2P
Study of components and design of a Biosafety laboratory	2P
Study of steps of a patenting process	3P

## REFERENCES

- Das, H.K. (2008). Text book of Biotechnology, 3rd edition. 3rd Edition, Wiley India (P) Ltd, New Delhi.
- Dubey, R.C. (1993). A Textbook of Biotechnology, 1<sup>st</sup> Edition, S. Chand and Company (P), Ltd. Delhi. Hill Publishing Company Limited, New Delhi.
- Krishna, V.S. (2007). Bioethics & Biosafety in Biotechnology, New Age Publishers, Bangalore.
- Plummer, D.T. (1988). An Introduction to Practical Biochemistry, 3<sup>rd</sup> Edition, Tata McGraw
- Singh, B.D. (2003). Biotechnology - Expanding Horizons, 1<sup>st</sup> edition, Kalyani Publishers, Ludhiana.
- Thomas, J.A. & Fush R.L. (2002). Biotechnology & Safety Assessment, 3<sup>rd</sup> Edition, Academic press.

## BCH III.E-4 PLANT BIOCHEMISTRY (THEORY)

### SEMESTER III

**COURSE TITLE: PLANT BIOCHEMISTRY (THEORY)**

**COURSE CODE: BCH III.E-4**

**MARKS: 75**

**CREDITS: 3**

**COURSE OBJECTIVES:** The course will give a detailed description of the structural organization of plant cells, overview of photosynthesis and its significance, secondary metabolites and their potentials and the role of plant hormones.

**LEARNING OUTCOMES:** Students will be able to understand the biochemical processes that take place in plant such as photosynthetic reactions, importance of plant hormones and secondary metabolites to plant growth and development.

**BCH III.E-4 PLANT BIOCHEMISTRY (THEORY)****TOTAL HOURS: 45****Unit 1 Introduction to Plant cell structure****No. of Hours: 4**

Structural and functional organization of a plant cell

**Unit 2 Photosynthesis and Carbon assimilation****No. of Hours: 10**

Structure of organelle involved in photosynthesis, Structure of PSI and PSII complexes, proton gradient and electron transfer in plants and purple bacteria, Light reaction (Cyclic and non cyclic photophosphorylation), Calvin cycle and regulation; C4 cycle and Crassulacean acid metabolism (CAM), Photorespiration

**Unit 4 Nitrogen metabolism****No. of Hours: 8**

Biological Nitrogen fixation by free living and in symbiotic association, structure and function of nitrogenase enzyme.

Nitrate assimilation: Nitrate and Nitrite reductase

Primary and secondary ammonia assimilation in plants; ammonia assimilation by glutamine synthetase-glutamine oxoglutarate amino transferase (GS-GOGAT) pathway.

**Unit 5 Regulation of plant growth****No. of Hours: 6**

Plant growth hormones and their effect on plant growth and development

**Unit 6 Secondary metabolites****No. of Hours: 10**

Representatives alkaloid group and their amino acid precursors, function of alkaloids.

Examples of major phenolic groups; simple phenylpropanoids, coumarins, benzoic acid derivatives, flavonoids, tannins and lignin, biological role of plant phenolics

Classification of terpenoids and representative examples from each class, biological functions of terpenoids

**Unit 6 Plant tissue culture****No. of Hours: 7**

Cell and tissue culture techniques, types of cultures: organ and explants culture, callus culture, cell suspension culture and protoplast culture.

Plant regeneration pathways: organogenesis and somatic embryogenesis.

Applications of cell and tissue culture and somoclonal variation

## **BCH III.E-4 PLANT BIOCHEMISTRY (PRACTICAL)**

**COURSE TITLE: PLANT BIOCHEMISTRY (PRACTICAL)**

**COURSE CODE: BCH III.E-4**

**MARKS: 25**

**CREDITS: 1**

**TOTAL HOURS: 30**

Induction and assay of hydrolases: proteinase /amylase/lipase during germination	3P
Extraction and assay of urease	2P
Estimation of $\beta$ -carotene and ascorbic acid in fruits and vegetables	3P
Estimation of phenols and tannins in fruits and vegetables	2P
Extraction and separation of photosynthetic pigments by TLC	2P
Tissue culture of plant (explants)	3P

### **REFERENCES**

- Chawla, H.S. (2002) Introduction to Plant Biotechnology, Science Publishers Inc. USA.
- De, K.K. (2008) Plant Tissue Culture, New Central Book Agency Pvt. Ltd.
- Jha, T.B. & Ghosh,B. (2005) Plant Tissue Culture, University Press (India) Pvt. Ltd.
- Singh, B.D. (2005) Plant Biotechnology, Kalyani Publishers.
- Kumar U. (2008). Methods in plant tissue culture. Agrobios, India
- Narayanswamy S. (1994). Plant cell and Tissue Culture, Tata McGraw-Hill Education.

## **BCH-IV.C-6 METABOLISM OF BIOMOLECULES**

### **SEMSESTER IV**

**COURSE TITLE: METABOLISM OF BIOMOLECULES (THEORY)**

**COURSE CODE: BCH-IV. C-6**

**MARKS: 75**

**CREDITS: 3**

**COURSE OBJECTIVE:** The aim of this paper is to understand simple concepts related to metabolism, its importance in the proper functioning of each cell and its regulation by enzymes.

**LEARNING OUTCOME:** Students will understand the metabolism of biomolecules of life, their contribution to body requirements of calories and energy, and comprehend how any defect in a pathway could lead to diseases.

### **BCH-IV.C-6 METABOLISM OF BIOMOLECULES**

**TOTAL HOURS: 45**

#### **Unit 1 Basic concepts and design of metabolism**

**No. of Hours: 4**

Metabolism: catabolism and anabolism, ATP as energy currency, energy relationship between catabolic and anabolic pathways, ATP cycle

#### **Unit 2 Carbohydrate metabolism**

**No. of Hours: 10**

Glycolysis, Tri-Carboxylic Acid cycle, Pentose-phosphate pathway, Gluconeogenesis, glycogen synthesis and breakdown, glyoxylate pathway

#### **Unit 3 Oxidative phosphorylation**

**No. of Hours: 8**

The respiratory chain in mitochondria, proton gradient powering ATP synthesis

Transfer of cytosolic reducing equivalents to mitochondria: glycerol-3- phosphate and malate-aspartate shuttle

#### **Unit 4 Fatty acid synthesis and degradation**

**No. of Hours: 10**

Digestion, mobilisation and transport of cholesterol and triacyl glycerols

$\beta$ -oxidation of fatty acids, ketone bodies

Biosynthesis of saturated and unsaturated fatty acids, and elongation of fatty acids

**Unit 5 Amino acid metabolism**

**No. of Hours: 6**

Overview of biosynthesis and catabolism of amino acids; regulation of amino acid biosynthesis, Urea cycle

**Unit 6 Nucleotide metabolism**

**No. of Hours: 7**

Biosynthesis - *de novo* and salvage pathways, degradation

**BCH- IV. C-6 METABOLISM OF BIOMOLECULES (PRACTICAL)**

**COURSE TITLE: METABOLISM OF BIOMOLECULES (PRACTICAL)**

**COURSE CODE: BCH-IV. C-6**

**MARKS: 25**

**CREDITS: 1**

**TOTAL HOURS: 30**

Alcohol fermentation by yeast	2P
Estimation of blood glucose	1P
Separation of fatty acids by TLC	2P
Isolation of lecithin and its estimation	3P
Isolation of cholesterol from egg yolk and its estimation	3P
Estimation of protein and nucleic acid by direct spectroscopy	1P
Urea estimation	1P
Uric acid estimation	1P

**REFERENCES**

- Gupta, P.K. (1999). A Text-book of Cell and Molecular Biology, Rastogi Publications, Meerut, India.
- Jain, J.L (1999). Fundamentals of Biochemistry, S.Chand and Company, Ltd., New Delhi.

- Murray, R.K., Granner, D.K., Mayes, P.A. & Rodwell, V.W. (2003), Harper's Illustrated Biochemistry, McGraw-Hill Companies.
- Nelson, D. L. & Cox, M.M. (2000). Lehninger's Principles of Biochemistry (3rd Edition), Worth Publishers, New York, USA.
- Stryer, L. (1995). Biochemistry, W.H. Freeman and Co., New York, USA.
- Zubay, G. (1993). Biochemistry (3<sup>rd</sup> Edition), WCB Publishers, Iowa, USA.

### **BCH-IV.E-5 HUMAN PHYSIOLOGY (THEORY)**

#### **SEMESTER IV**

**COURSE TITLE: HUMAN PHYSIOLOGY (THEORY)**

**COURSE CODE: BCH-IV.E-5**

**MARKS: 75**

**CREDITS: 3**

**COURSE OBJECTIVES:** This course is designed to provide students with an understanding of the function & regulation of the human body and physiological integration of the organ systems to maintain homeostasis.

**LEARNING OUTCOMES:** Students will develop in-depth insight into the function of the major organs and organ systems of the human body and will understand the unique role of each organ and organ system in maintaining constancy of the internal environment.

#### **BCH-IV.E-5 HUMAN PHYSIOLOGY (THEORY)**

**TOTAL HOURS: 45**

#### **Unit 1 Homeostasis and the organization of body fluid compartments      No. of Hours: 8**

Intracellular, extracellular and interstitial fluid, Plasma,

Homeostasis

Blood coagulation: molecular mechanism, role of vitamin K.

Anemias, polycythemia, haemophilia and thrombosis

#### **Unit 2 Digestion**

**No. of Hours: 6**

Gastrointestinal tract, secretory functions, digestion, absorption

Liver metabolism: glycogen storage, bile secretion, detoxification

Liver function tests, jaundice, fatty liver, liver cirrhosis.

**Unit 3 Muscular System**

**No. of Hours: 5**

Introduction to the muscular system

Types of Muscles, Physiology of muscle contraction

**Unit 4 Respiration and Circulation**

**No. of Hours: 6**

The Respiratory system – organs and their function

The Circulatory system: cardiovascular and lymphatic systems- components and their function

**Unit 5 Excretory system**

**No. of Hours: 6**

The excretory system and associated functions

Anatomy of the kidney and the nephron

Renal function tests

**Unit 6 Nervous system**

**No. of Hours: 6**

The nervous system and associated functions

Membrane potential, Synaptic transmission, Neurotransmitters

**Unit 7 Reproductive physiology**

**No. of Hours: 8**

Spermatogenesis and Oogenesis

Mammalian reproductive physiology – male and female reproductive system

## **BCH-IV.E-5 HUMAN PHYSIOLOGY (PRACTICAL)**

**COURSE TITLE: HUMAN PHYSIOLOGY (PRACTICAL)**

**COURSE CODE: BCH-IV.E-5**

**MARKS: 25**

**CREDITS: 1**

**TOTAL HOURS: 30**

Study of the physiology systems in human using charts	1P
Determination of blood group	1P
RBC and WBC counting	1P
Differential leucocyte count	1P
Determination of Clotting time	1P
Estimation of haemoglobin	1P
Determination of ESR	1P
Determination of PCV	1P
Observation of permanent slides – Transverse section of mammalian gonads	2P
Analysis of human blood pressure and pulse rate in man	1P
Osmolarity of RBC's (Effect of different salt solutions of RBC's)	2P
Determination of glucose in urine	1P
Determination of albumin in urine	1P

### **REFERENCES**

- Arora M.P. (2011). Animal physiology, Himalaya publishing house, New Delhi.
- Sembulingam K. & Sembulingam P. (2012). Essentials of Medical Physiology, Sixth edition., Jaypee brothers medical publishers (P) Ltd, New Delhi.
- Verma S.K., Tyagi A.K. & Agarwal B.B.L. (2000). Animal Physiology, S. Chand and Company.
- Guyton A.C and Hall J.E. (2011). Textbook of Medical Physiology, 10<sup>th</sup> ed., Reed Elseviers India Pvt. Ltd. New Delhi.

## **BCH-IV.E-6 NUTRITIONAL BIOCHEMISTRY (THEORY)**

### **SEMSESTER IV**

**COURSE TITLE: NUTRITIONAL BIOCHEMISTRY (THEORY)**

**COURSE CODE: BCH-IV.E-6**

**MARKS: 75**

**CREDITS: 3**

**COURSE OBJECTIVES:** The course will give a detailed description of the knowledge and understanding of human nutrition, nutritional aspects of the various classes of food with the nutritional requirements.

**LEARNING OUTCOMES:** Students will acquire detailed knowledge regarding the biological basis of nutrition and the mechanisms by which diet can influence health, and understand the implications of nutritional status and nutritional disorders.

**BCH-IV.E-6 NUTRITIONAL BIOCHEMISTRY (THEORY)      TOTAL HOURS: 45**

**Unit 1 Introduction to Nutrition and Energy Metabolism      No. of Hours: 6**  
Defining Nutrition, role of nutrients, Unit of energy, Biological oxidation of foodstuff, measurement of energy content of food, Physiological energy value of foods  
Antioxidants and their role  
Recommended Nutrient Intakes (RNI) and Recommended Dietary Allowances (RDA) for different age groups  
Basal Metabolic Index (BMI)

**Unit 2 Dietary Carbohydrates      No. of Hours: 8**  
Dietary requirements and source of carbohydrates, Hormonal regulation of blood glucose, hypo- and hyper-glycemic disorders  
Fibre and its significance in diet

**Unit 3 Dietary Lipid      No. of Hours: 8**  
Essential Fatty Acids (EFA); Functions and deficiency

Significance of: a) Mono- and Poly-unsaturated fatty acids, b) Saturated fatty acids, c) Omega fatty acids, d) Phospholipids, e) Triglycerides, f) Cholesterol.

#### **Unit 4 Dietary Proteins**

**No. of Hours: 8**

Essential and Nonessential amino acids, Food source, Nitrogen balance

Supplements – risk of imbalance and toxicity of amino acids

Protein deficiency: Protein energy malnutrition (PEM) – Kwashiorkar

#### **Unit 5 Vitamins**

**No. of Hours: 8**

Fat soluble vitamins: physiological role, deficiency disorders, toxicity of Vitamin A.

Water soluble vitamins: physiological role, differential diagnosis of B12 and folate, deficiency disorders

#### **Unit 6 Mineral metabolism**

**No. of Hours: 7**

Physiologic role and deficiency disorders of Macro- and micro-nutrients – calcium, magnesium, sodium, potassium, iron, phosphorus, sulphur and chlorine and trace elements

Assessment of anaemia, glycosylated Hb

### **BCH-IV.E-6 NUTRITIONAL BIOCHEMISTRY (PRACTICAL)**

**COURSE TITLE: NUTRITIONAL BIOCHEMISTRY (PRACTICAL)**

**COURSE CODE: BCH-IV.E-6**

**MARKS: 25**

**CREDITS: 1**

**TOTAL HOURS: 30**

Preparation of Probiotics, microscopy and sensory evaluation	2P
Assessment of food constituents	10P
• Vitamin C	
• Lycopene from tomatoes	
• $\beta$ -carotene from carrot	
• Calcium from milk	
• Phosphorus	
Assessment of nutritional disorders:	3P

- Hyperglycemia
- Cholesterol
- Anaemia

## REFERENCES

- Gibson R. (2005). Principles of Nutritional Assessment. Oxford University Press.
- Frazier W.C & Westhoff D.C. (2015). Food Microbiology. 5<sup>th</sup> edition. McGraw Hill Education (India) Private Limited: New Delhi
- Tiwari R.P, Hoondal G.S. & Tewari R. (2009). Laboratory Techniques in Microbiology and Biotechnology, Abhishek Publications Chandigarh (India).
- Murray R.K, Granner D.K, Mayes P.A and Rodwell V.W. (2003). Harper's Illustrated Biochemistry, Twenty-Sixth Edition Lange Medical Publications. New York
- Williams M.H, Anderson D.E, Rawson E.S. (2013). Nutrition for health, fitness and sport; McGraw Hill international edition.

## **BCH-IV.E-7 HORMONE: BIOCHEMISTRY AND FUNCTION (THEORY)**

### **SEMESTER IV**

**COURSE TITLE: HORMONE BIOCHEMISTRY AND FUNCTION (THEORY)**

**COURSE CODE: BCH-IV.E-7**

**MARKS: 75**

**CREDITS: 3**

**COURSE OBJECTIVES:** The course will give a detailed description of the roles of the endocrine system in maintaining homeostasis, integrating growth and development, and the different mechanisms of action of hormones.

**LEARNING OUTCOMES:** Students will understand the physiological actions of hormones, the relation to human disorders and the consequences of under- and over-production of hormones.

## **BCH-IV.E-7 HORMONE: BIOCHEMISTRY AND FUNCTION (THEORY)**

**TOTAL HOURS: 45**

### **Unit 1 Introduction to endocrinology**

**No. of Hours: 7**

Chemical classification of hormones

Functions of hormones and their regulation

Chemical signalling

### **Unit 2 Hypothalamic and pituitary hormones**

**No. of Hours: 8**

Hypothalamic hormones

Pituitary hormones eg GH, TSH, oxytocin, vasopressin

Feedback regulation cycle

Endocrine disorders – gigantism, dwarfs and diabetes insipidus

### **Unit 3 Thyroid hormone**

**No. of Hours: 6**

Biosynthesis of thyroid hormone and its regulation; its physiological and biochemical action

Pathophysiology - Goiter, Grave's disease, cretinism

### **Unit 4 Parathyroid hormones**

**No. of Hours: 6**

Role of PTH, Vitamin D and calcitonin in regulation of Ca<sup>+</sup> homeostatis.

Pathophysiology - rickets, osteomalacia, osteoporosis

### **Unit 5 Pancreatic and GI tract hormones**

**No. of Hours: 6**

Regulation of release of insulin, glucagon, gastrin, secretin, CCK

Pathophysiology - diabetes type I and type II

### **Unit 6 Adrenal hormones**

**No. of Hours: 6**

Epinephrine and norepinephrine. Fight or flight response, stress response.

Pathophysiology – Addison's disease, Cushing syndrome

### **Unit 7 Reproductive hormones**

**No. of Hours: 6**

Male and female sex hormones, Hormones during reproductive cycle, pregnancy, parturition and lactation

## **BCH-IV.E-7 HORMONE: BIOCHEMISTRY AND FUNCTION (PRACTICAL)**

**COURSE TITLE: HORMONE: BIOCHEMISTRY AND FUNCTION (PRACTICAL)**

**COURSE CODE: BCH-IV.E-7**

**MARKS: 25**

**CREDITS: 1**

**TOTAL HOURS: 30**

Histology of endocrine structures	2P
Glucose tolerance test	1P
Estimation of serum Ca <sup>2+</sup>	2P
HCG based pregnancy test	1P
Estimation of serum electrolytes: sodium and potassium	2P
ELISA	2P
Case studies	5P

### **REFERENCES**

- Talwar G.P, Srivastava L.M. and Moudgil K.D. (1989). Textbook of Biochemistry and Human Biology (2nd Edition), Prentice-Hall of India Private Limited, New Delhi, India.
- Nelson D.L. and Cox, M.M. (2013). Lehninger: Principles of Biochemistry, 3rd edition, Worth Publishers, New York, USA.
- Sembuligam K. and Sembulingam P (2010). Essentials of Medical Physiology (5th Edition), Jaypee Brothers Medical Publishers, New Delhi, India.
- Hadley M.C. and Levine. (2007). Endocrinology 6th ed., J.E. Pearson Education, New Delhi.
- Cooper G.M. and Hausman R.E (2009). The Cell: A Molecular Approach 5th Ed. ASM Press & Sunderland, Washington DC.



**Unit 3 Cell Cycle and Programmed Cell Death****No. of Hours: 12**

Cell cycle; events of mitosis; cytokinesis;  
Events of meiosis; regulation of cell division;  
Apoptosis (extrinsic and intrinsic pathway)

**Unit 4 Cancer Biology****No. of Hours: 8**

Development and causes of cancer; genetic basis; oncogenes, tumor viruses

**Unit 5 Tools in Cell Biology****No. of Hours: 9**

Microscopy: Light microscope, Phase contrast microscope, Inverted microscope, Fluorescence microscope, Confocal microscope, Electron microscope  
Centrifugation: Differential and gradient centrifugation for sub-cellular fractionation

**BCH-IV.E-8 ADVANCED CELL BIOLOGY (PRACTICAL)****COURSE TITLE: ADVANCED CELL BIOLOGY (PRACTICAL)****COURSE CODE: BCH-IV.E-8****MARKS: 25****CREDITS: 1****TOTAL HOURS: 30**

Identification of different stages of mitosis (in onion root tip) `	1P
Identification of different stages of meiosis (in flower buds)	1P
Study of cell viability by neutral red (viable cells) and trypan blue (non-viable cells)	1P
Identification and study of cancerous cells using permanent slides/ photomicrographs	2P
Study of plant, animal and human tumour viruses using photomicrographs	2P
Differential centrifugation for separation of cellular components	1P
Preparation of sucrose density gradient and purification of sub cellular organelles:	5P
visualization of nuclear fraction by acetocarmine stain and mitochondria by Janus green stain	
Study of electron micrographs of sub-cellular organelles	2P

## REFERENCES

- Krebs, J.E., Goldstein, E.S. & Kilpatrick, S.T. (2014). *Lewin's Genes XI*, Jones and Bartlett India Pvt. Ltd.
- Nelson, D. L. & Cox, M.M. (2000). *Lehninger's Principles of Biochemistry* (3rd Edition), Worth Publishers, New York, USA.
- Karp, G. & Harris, D. (2008) *Cell and Molecular Biology – Concepts and Experiments*, John Wiley & Sons Inc, New York.
- Robertis, E.D.P. & Robertis, E.M.F. (1998). *Cell Biology and Molecular Biology*, 8<sup>th</sup> edition, Sauder College.
- Watson, J.D., Hopkins, N.H. et al. (2008). *Molecular Biology of the Gene*, Garland Publishing (Taylor & Francis Group), New York & London.
- Rastogi, S.C. (2003). *Cell and Molecular Biology*, 2<sup>nd</sup> Edition, New Age International Ltd.
- Verma, P.S. & Agarwal, V.K. (2013). *Cell Biology, Genetics, Molecular Biology, Evolution and Ecology*, S. Chand & Company Pvt. Ltd.
- Verma, A.S., Das, S. & Singh, A. (2014). *Laboratory Manual for Biotechnology*, 1<sup>st</sup> Edition, S. Chand & Company Pvt. Ltd.

## DEPARTMENT OF BIOCHEMISTRY

### 3 Year Under-Graduate Degree Programme in Biochemistry (Self financed)

#### COURSE STRUCTURE

Sem	Core		Elective			
I	<b>BCH-I.C-1</b> Molecules of Life	<b>BCH-I.C-2</b> Cell Biology	-----	-----	-----	-----
II	<b>BCH-II.C-3</b> Protein chemistry	<b>BCH-II.C-4</b> Biophysics	-----	-----	-----	-----
III	<b>BCH-III.C-5</b> Enzymology		<b>BCH-III.E-1</b> Tools and Techniques in Biochemistry	<b>BCH-III.E-2</b> Microbiology	<b>BCH-III.E-3</b> Bioethics and Bio-safety	<b>BCH-III.E-4</b> Plant Biochemistry
IV	<b>BCH-IV. C-6</b> Metabolism of Biomolecules		<b>BCH-IV.E-5</b> Human physiology	<b>BCH-IV.E-6</b> Nutritional Biochemistry	<b>BCH-IV.E-7</b> Hormone: Biochemistry and Function	<b>BCH-IV.E-8</b> Advanced Cell Biology
V	<b>BCH-V.C-7</b> Molecular biology		<b>BCH-V.E-9</b> Concepts in genetics	<b>BCH-V.E-10</b> Regulation of gene expression	<b>BCH-V.E-11</b> Genetic Engineering and Biotechnology	<b>BCH-V.E-12</b> Bioinformatics
VI	<b>BCH-VI.C-8</b> Immunology		<b>BCH-VI.E-13</b> Biochemical correlation of Diseases	<b>BCH-VI.E-14</b> Clinical Biochemistry	<b>BCH-VI.E-15</b> Environmental Biochemistry	<b>BCH-VI.E-16</b> Industrial Biochemistry

**PARVATIBAI CHOWGULE COLLEGE OF ARTS & SCIENCE (AUTONOMOUS)**

**SEMESTER: V**

**COURSE TITLE: MOLECULAR BIOLOGY (THEORY)**

**COURSE CODE: BCH-V.C-7**

**MARKS: 75**

**CREDITS: 3**

**COURSE OBJECTIVE:** This paper provides insight on replication, transcription and translation process in prokaryotes and eukaryotes, various mutations and their repair mechanisms.

**LEARNING OUTCOME:** On completion of this module, students will be able to understand the basic concepts and the nature of genetic materials in Molecular Biology.

**BCH-V.C-7 MOLECULAR BIOLOGY (THEORY)**

**Total hours: 45**

**Unit 1 Chemical Nature of Genetic Materials**

**No. of Hours: 8**

Structural components of nucleic acid: Sugar, Phosphate, Nucleosides and Nucleotides

Structure of DNA: Watson – Crick Model, Different forms of DNA (A, B, C, D, E, Z),

Forces stabilizing the structure of DNA, Unusual structures of DNA (palindromic, mirror repeat,

hairpin bent, cruciform); Structure of RNA, Different forms of RNA (mRNA, rRNA, tRNA);

Differences between DNA and RNA

**Unit 2 Basic Concepts in Molecular Biology**

**No. of Hours: 8**

DNA/RNA as genetic material: S. F. Griffith's transforming principle, and Avery, Hershey and Chase Experiment proving DNA as genetic material; RNA as the genetic material of some viruses, Chargaff's experiments and Law

**Unit 3 DNA Replication**

**No. of Hours: 8**

Experimental evidence for semi-conservative DNA replication in *E.coli* - Messelson and Stahl's experiment

The basic requirements of DNA replication: DNA template, DNA polymerases: Structure and function, Ancillary proteins associated with replication

Mechanism of replication: Initiation, Elongation and Termination

**Unit 4 DNA Damage and its Repair****No. of Hours: 5**

Mutations and types of mutations: Spontaneous and Induced mutation, Physical and Chemical Mutagens (ethidium bromide, alkylating agents, base analogs)

DNA Repair Mechanisms: Mismatch, Photo-reactivation repair, Excision repair

**Unit 5 Transcription****No. of Hours: 8**

Mechanism of prokaryotic transcription: Transcription factors and machinery, Formation of initiation complex, RNA polymerase enzyme; Initiation, Elongation and Termination; RNA processing: Capping, Splicing, Polyadenylation

**Unit 6 Translation****No. of Hours: 8**

Central dogma, the translation machinery, Ribosomes: composition and assembly;

Mechanism of protein synthesis - Initiation, Elongation and Termination; Genetic code

**BCH-V.C-7 MOLECULAR BIOLOGY (PRACTICAL)****COURSE TITLE: MOLECULAR BIOLOGY (PRACTICAL)****COURSE CODE: BCH-V.C-7****MARKS: 25****CREDITS: 1****TOTAL HOURS: 30**

Isolation of genomic DNA from prokaryotes	2P
Isolation of genomic DNA from eukaryotes	2P
Isolation of plasmid DNA from prokaryotes	2P
Purity of DNA by spectrophotometric method	1P
Agarose gel electrophoresis of plasmid DNA and determination of its molecular size	2P
Agarose gel electrophoresis of genomic DNA and determination of its molecular size	2P
Elution of DNA from agarose gel	1P
Mutagenesis in <i>E.coli</i> cells – UV or Chemical mutagens	3P

**REFERENCES**

- Krebs, J. E., Goldstein, E. S. and Kilpatrick, S. T. (2014). Lewin's Genes XI, Jones and Bartlett India Pvt. Ltd.

- Nelson, D. L. and Cox, M.M. (2000). *Lehninger's Principles of Biochemistry* (3rd Edition), Worth Publishers, New York, USA.
- Karp, G. and Harris, D. (2008). *Cell and Molecular Biology – Concepts and Experiments*, John Wiley & Sons Inc, New York.
- De Robertis, E. D. P. and De Robertis, E. M. F. (2006). *Cell and Molecular Biology*. VIII Edition. Lippincott Williams and Wilkins, Philadelphia.
- Watson, J. D. and Hopkins, N. H. et al. (2008). *Molecular Biology of the Gene*, Garland Publishing (Taylor and Francis Group), New York and London.
- Verma, P. S. and Agarwal, V. K. (2013). *Cell Biology, Genetics, Molecular Biology, Evolution and Ecology*, S. Chand and Company Pvt. Ltd.

**PARVATIBAI CHOWGULE COLLEGE OF ARTS & SCIENCE (AUTONOMOUS)**

**SEMESTER: V**

**COURSE TITLE: CONCEPTS IN GENETICS (THEORY)**

**COURSE CODE: BCH-V.E-9**

**MARKS: 75**

**CREDITS: 3**

**COURSE OBJECTIVE:** Overall, this paper provides a platform for delving further into studies of Molecular Biology and Genetics. It allows for the understanding of the structure and function of genes and chromosomes as well as the harmful effects of mutations which can cause various genetic disorders.

**LEARNING OUTCOME:** On completion of this module, students will be able to understand the inheritance patterns and the basic principles of genetics. They will learn about the different mutations, its effects on cells and the application of the same to research.

**BCH-V.E-9 CONCEPTS IN GENETICS (THEORY)**

**Total hours: 45**

**Unit 1: Mendelian Genetics and deviations from Mendel's laws** **No. of Hours: 8**

Mendelian Genetics: History of Mendelian Genetics, First Law of Inheritance, Second Law of Inheritance, Monohybrid and Dihybrid cross, Test cross and Back cross and their significance.

Deviations: Dominance, Co-dominance, Incomplete dominance; Multiple alleles: ABO blood group, Rh incompatibility

Gene interaction - Epistasis: Dominant and Recessive epistasis with example; Non epistatic gene interactions

**Unit 2: Model organisms used for study of Genetics** **No. of Hours: 4**

Model organisms: *Escherichia coli*, *Saccharomyces cerevisiae*, *Neurospora crassa*, *Drosophila melanogaster*, *Caenorhabditis elegans*

**Unit 3 Genetic exchange in microorganisms** **No. of Hours: 3**

Mechanism of genetic exchange - Conjugation, Transformation and Transduction

**Unit 4 Linkage and crossing over** **No. of Hours: 8**

Sutton-Boveri chromosome theory of heredity

Bateson and Punnet's coupling and repulsion hypothesis, Morgan's views on linkage,

Theory of linkage; Kinds of linkage: Complete linkage, Incomplete linkage; Significance of linkage

Types of crossing over: Somatic or mitotic crossing over, Germinal or meiotic crossing over; Mechanism of meiotic crossing over: Synapsis, Duplication of chromosomes, Crossing over by breakage and union, Terminalisation, Significance of crossing over

#### **Unit 5 Human genetics**

**No. of Hours: 4**

Pedigree analysis; Human traits

Disorders due to mutant genes: PTC tasters, Huntington's chorea, Tongue rolling

#### **Unit 6 Chromosomal aberrations**

**No. of Hours: 8**

Types of structural changes (Deletion, Duplication, Inversion, Translocation, Variation in chromosome morphology)

Types of numerical changes (Euploidy and Aneuploidy) - Monosomy and Trisomy of Sex and Autosomes

Disorders due to inborn errors of metabolism — Phenylketonuria (PKU), Alkaptonuria, Sickle-cell anaemia

Disorders due to autosomal and sex chromosomal anomalies involving numerical and structural aberrations (Down's, Cri-du-chat, Klinefelter's and Turner's syndromes)

#### **Unit 7 Determination of Sex and Sex Differentiation**

**No. of Hours: 6**

Genetically controlled sex determining mechanisms: (Heterogametes); Types: Heterogametic males, Heterogametic females; Genic balance mechanism; Sex determination in *Drosophila melanogaster* and man; Male haploidy or haplodiploidy mechanism;

Hormonally controlled sex determining mechanism eg Sex in Bonellia; Environmentally controlled sex determining mechanism- eg Marine annelid *Ophryotrocha*

#### **Unit 8 Population genetics**

**No. of Hours: 4**

Hardy-Weinberg law, Factors affecting Hardy Weinberg theory, Predicting allele and Genotype frequencies and exceptions to Hardy-Weinberg principle

## **BCH-V.E-9 CONCEPTS IN GENETICS (PRACTICAL)**

**COURSE TITLE: CONCEPTS IN GENETICS (PRACTICAL)**

**COURSE CODE: BCH-V.E-9**

**MARKS: 25**

**CREDITS: 1**

**TOTAL HOURS: 30**

Study of a Dissection microscope	1P
Study of Mendelian traits in Human Population	3P
Pedigree analysis and problem solving	3P
Karyotype analysis of chromosomal abnormalities	3P
Smear technique to demonstrate sex chromatin in buccal epithelial cells	1P
Study of Barr bodies in sex determination	1P
Problem solving on Mendel's laws and Hardy-Weinberg's law	3P

### **REFERENCES**

- Gardner, E. J., Simmons, M. J. and Snustad, D. P. (2013). Principles of Genetics, 8<sup>th</sup> Edition, John Wiley and Sons.
- Jayaraman, K. and Jayaraman, R. (1979). Laboratory manual in Molecular Genetics, John Wiley and Sons.
- Krebs, J.E., Goldstein, E.S. and Kilpatrick, S.T. (2014). Lewin's Genes XI, Jones and Bartlett India Pvt. Ltd.
- Tamarin, R.H. (2002). Principles of Genetics, 7<sup>th</sup> Edition, Tata McGraw-Hill Publishing Company Ltd.
- Verma, P.S. and Agarwal, V.K. (2013). Cell Biology, Genetics, Molecular Biology, Evolution and Ecology, S. Chand and Company Pvt. Ltd.

**PARVATIBAI CHOWGULE COLLEGE OF ARTS & SCIENCE (AUTONOMOUS)**

**SEMESTER: V**

**COURSE TITLE: REGULATION OF GENE EXPRESSION (THEORY)**

**COURSE CODE: BCH-V.E-10**

**MARKS: 75**

**CREDITS: 3**

**COURSE OBJECTIVE:** This paper provides insight on genetic code, operons, comparison of transcription, translation and gene regulation in prokaryotes and eukaryotes.

**LEARNING OUTCOME:** On completion of this module, students will be able to understand the concept of operon, differences between prokaryotic and eukaryotic transcription, translation and gene regulation.

**BCH-V.E-10 REGULATION OF GENE EXPRESSION (THEORY) Total hours: 45**

**Unit 1 The genetic code No. of Hours: 3**

Degeneracy of the genetic code, Wobble in the anticodon, Features of the genetic code

**Unit 2 Transcription in prokaryotes No. of Hours: 8**

Prokaryotes: RNA polymerases, Sigma factor, Bacterial promoters; RNA synthesis, Rho-dependent and Rho-independent termination; Inhibitors of transcription and applications as anti-microbial drugs

**Unit 3 Transcription in eukaryotes No. of Hours: 8**

Transcription by RNA polymerase II, RNA polymerase II core promoters, General transcription factors, Various types of RNA processing, Transcription by RNA polymerase I and III.  
Inhibitors of eukaryotic transcription and their Applications  
Comparison between Prokaryotic and Eukaryotic transcription

**Unit 4 RNA splicing No. of Hours: 2**

The spliceosome machinery, Group I and group II introns, Alternative splicing, Exon shuffling

**Unit 5 Translation in prokaryotes and eukaryotes No. of Hours: 8**

Ribosomes in Prokaryotes and Eukaryotes; Messenger RNA, Transfer RNA, Attachment of amino acids to tRNA, Ribosomal RNAs in Prokaryotes and Eukaryotes

Comparison of Translation in Prokaryotes and Eukaryotes  
Inhibitors of Translation and Applications as anti-microbial drugs

**Unit 6 Regulation of gene expression in prokaryotes**

**No. of Hours: 8**

Role of operators in prokaryotic transcription  
Operon; Lactose operon, Tryptophan operon  
Coordination of transcription and translation in prokaryotes- Stringent response regulatory ribosomal proteins

**Unit 7 Regulation of gene expression in eukaryotes**

**No. of Hours: 8**

Trans-acting molecules, Cis-acting regulatory elements,  
Regulation by co- and post transcriptional processing of mRNA- Splicing, mRNA editing, RNA interference (RNAi), Regulation of mRNA at translational level  
Regulation through modifications to DNA

**BCH-V.E-10 REGULATION OF GENE EXPRESSION (PRACTICAL)**

**COURSE TITLE: REGULATION OF GENE EXPRESSION (PRACTICAL)**

**COURSE CODE: BCH-V.E-10**

**MARKS: 25**

**CREDITS: 1**

**TOTAL HOURS: 30**

Isolation of genomic DNA from prokaryotes and eukaryotes	2P
Isolation of RNA from prokaryotes and eukaryotes	4P
UV absorption spectra and direct spectrophotometric estimation of DNA and RNA	1P
Determination of the T <sub>m</sub> and GC content of DNA	2P
To study the viscosity of DNA solutions	1P
To study gene expression by induction of enzyme(s) from suitable sources and confirmation by qualitative/quantitative assay/electrophoresis	5P

**REFERENCES**

- Krebs, J. E., Goldstein, E. S. and Kilpatrick, S. T. (2014). Lewin's Genes XI, Jones and Bartlett India Pvt. Ltd.

- Nelson, D. L. and Cox, M. M. (2000). *Lehninger's Principles of Biochemistry* (3rd Edition), Worth Publishers, New York, USA.
- Karp, G. and Harris, D. (2008). *Cell and Molecular Biology – Concepts and Experiments*, John Wiley & Sons Inc, New York.
- De Robertis, E. D. P. and De Robertis, E. M. F. (2006). *Cell and Molecular Biology*. VIII Edition. Lippincott Williams and Wilkins, Philadelphia.
- Watson, J. D., Hopkins, N. H. et al. (2008). *Molecular Biology of the Gene*, Garland Publishing (Taylor and Francis Group), New York & London.
- Verma, P. S. and Agarwal, V. K. (2013). *Cell Biology, Genetics, Molecular Biology, Evolution and Ecology*, S. Chand & Company Pvt. Ltd.

**PARVATIBAI CHOWGULE COLLEGE OF ARTS & SCIENCE (AUTONOMOUS)**

**SEMESTER: V**

**COURSE TITLE: GENETIC ENGINEERING AND BIOTECHNOLOGY (THEORY)**

**COURSE CODE: BCH-V.E-11**

**MARKS: 75**

**CREDITS: 3**

**COURSE OBJECTIVES:** The paper aims to introduce the students to the principles and techniques involved in Genetic Engineering. This paper defines the meaning of Genetic engineering and the methods used in Genetic engineering of genes through the use of genetic material and vehicles for suitable manipulation of genes.

**LEARNING OUTCOME:** On completion of this module, students will be able to understand how genes are genetically engineered and the need for the same. The practical component will train them towards performing with understanding genetic manipulations of genes.

**BCH-V.E-11 GENETIC ENGINEERING AND BIOTECHNOLOGY Total hours: 45**

**Unit 1 Introduction to Genetic engineering and Biotechnology No. of Hours: 2**

General features and mechanisms of genetic engineering, Concept of biotechnology, Applications and ethical issues of recombinant DNA technology, Gene cloning

**Unit 2 DNA modifying enzymes and Vectors for Gene cloning No. of Hours: 12**

Nucleases- Endonucleases (Restriction enzymes recognition sequences, Cleavage pattern), Exonucleases, Host control restriction and modification, DNA ligases, Reverse Transcriptases, Polynucleotide kinases, Alkaline phosphatases, Nucleotidyl transferases

Vectors, Properties of ideal cloning vectors, Types of cloning vectors;

Plasmid vectors: Properties, Classification, pBR322, pUC 18

Bacteriophage vectors, Lambda phage: Features, Insertional vectors and Replacement vectors, M13 Bacteriophage

Hybrid vectors: Cosmids, Phagemids and Phasmids; Shuttle vectors; Plant vectors

**Unit 4 Transformation methods and identification of recombinants No. of Hours: 12**

DNA insertion into vectors: Ligation, Use of linkers and Adaptors, Homopolymer tailing

Competence (transformation in bacteria): Microinjection, Lipofection, Electroporation, Macroinjection, Sonication, Silicon carbide fibre vortex, DNA co-precipitation, Ultrasonication, Laser induced

Identification of Recombinants: Principle and importance of identification of recombinants: Antibiotic resistance (amp, tet resistance), lac Z selection, Colony hybridization

**Unit 5 Blotting techniques for DNA and RNA** **No. of Hours: 4**

Isolation of Genomic DNA and RNA, Agarose gel electrophoresis,  
Southern blotting: Blotting of DNA from agarose gel by capillary action onto nitrocellulose membrane, Denaturing of DNA, Hybridisation with radiolabelled P<sup>32</sup>, Autoradiography  
Northern blotting: Blotting of RNA from agarose gel onto nitrocellulose membrane, Hybridisation with radiolabelled probe, Autoradiography

**Unit 6 DNA amplification and sequencing** **No. of Hours: 8**

DNA amplification: Polymerase chain reaction (PCR) – Principle, Components, Method and Applications  
DNA sequencing: Significance and importance, Basic methods: Maxam Gilbert's method, Sanger's method. Advanced method: Shotgun method, Automatic DNA sequencer

**Unit 7 Genomic / cDNA libraries** **No. of Hours: 2**

Preparation of genomic library, cDNA library, Screening of Libraries

**Unit 8 Genetic engineering in Biotechnology** **No. of Hours: 5**

Genetic engineering applications:

In agriculture – Flavr Savr tomato, Golden rice, Plant resistance to desiccation, cold, heat, pests

In pharmaceuticals – Recombinant insulin, Blood clotting factor VIII, Edible vaccines

In environment – Superbug

## **BCH-V.E-11 GENETIC ENGINEERING AND BIOTECHNOLOGY (PRACTICAL)**

**COURSE TITLE: GENETIC ENGINEERING AND BIOTECHNOLOGY (PRACTICAL)**

**COURSE CODE: BCH-V.E-11**

**MARKS: 25**

**CREDITS: 1**

**TOTAL HOURS: 30**

Isolation of plasmid DNA by alkaline lysis and boiling prep method, and molecular weight determination by gel electrophoresis	4P
Restriction digestion of plasmid DNA and analysis by gel electrophoresis	2P
Preparation of competent cells in bacteria	2P
Transformation in bacteria using plasmid vector (pUC 18)	2P
Screening of transformants	2P
Deciphering the DNA sequence from a sequencing gel photograph by Maxam and Gilbert's method and Sanger's method	2P
Blotting techniques (virtual laboratory)	1P

### **REFERENCES**

- Jogdand, S. N. (2008). Gene Biotechnology, 2nd edition, Himalaya Publishing House, Mumbai.
- Primrose, S. B. and Twyman, R. M. (2009). Principles of Gene Manipulation and Genomics, Blackwell Publishing.
- Purohit, S. S. (2009). Biotechnology: Fundamentals and Applications, Student Edition.
- Singh, B. D. (2008). Biotechnology: Expanding Horizons, Kalyani publishers.
- Watson, J. D., Tooze, J. and Kurtz, D. T. (1983). Recombinant DNA: A short Course, Scientific American Books (WH Freeman), New York.

**PARVATIBAI CHOWGULE COLLEGE OF ARTS & SCIENCE (AUTONOMOUS**

**SEMESTER: V**

**COURSE TITLE: BIOINFORMATICS (THEORY)**

**COURSE CODE: BCH-V.E-12**

**MARKS: 75**

**CREDITS: 3**

**COURSE OBJECTIVES:** This paper aims at introducing the importance of the basics of computers, concept of Human Genome Project, storage of biological information and tools and techniques of bioinformatics used and their importance in the field of biotechnology.

**LEARNING OUTCOME:** On completion of this paper the students will be able to understand the importance of computers and networking and the various types of biological databases used for storing genetic information of various organisms and the use of various tools and techniques used for retrieving the same that maybe used in present life and be able to solve interesting and novel scientific problems.

**BCH-V.E-12 BIOINFORMATICS (THEORY)**

**Total hours: 45**

**Unit 1 Introduction to Bioinformatics**

**No. of Hours: 10**

Definition, Scope of bioinformatics

Introduction to use of computers in biology, Internet and software in biology, Medicine and research, Historical developments in biology

Bioinformatics: Components and applications

**Unit 2 Information resources**

**No. of Hours: 6**

Information resources: Introduction, Aim and objectives (NCBI, NLM, NIH, EBI and SRS)

**Unit 3 Types of databases**

**No. of Hours: 15**

Biological databases: Primary databases – Gen Bank and EMBL, DDBJ; Secondary databases - Swiss-PROT, PDB and PIR; Composite databases – OWL and PROSITE

Structural databases: PDB, MMDB, CATH and SCOP; Visualization of proteins – Cn3D and Rasmol

Literature databases: Pubmed, MedLINE and OMIM

**Unit 4 Sequence Alignment tools and Phylogeny****No. of Hours: 10**

Introduction to sequence alignment and phylogeny;

BLAST and FASTA, and their types; ORF

Pairwise sequences alignment, Multiple sequence alignment using Clustal-W Omega

Phylogenetic tree: Introduction, Definition, Structure, Types and Construction

Cladogram and differences with phylogenetic tree

**Unit 5 Human Genome Project****No. of Hours: 4**

Introduction to Human Genome Project (HGP), Objectives, Ethical and social issues

**BCH-V.E-12 BIOINFORMATICS (PRACTICAL)****COURSE TITLE: BIOINFORMATICS (PRACTICAL)****COURSE CODE: BCH-V.E-12****MARKS: 25****CREDITS: 1****TOTAL HOURS: 30**

Usage of NCBI resources for biological databases	5P
– Protein or amino acid sequences	
– DNA or gene sequences	
Usage of NCBI resources for	3P
– Structure databases	
– Literature databases	
Database search and Pairwise sequence alignment using NCBI BLAST: BLASTp, BLASTn	2P
Multiple sequence alignment using Clustal-W	1P
Construction of phylogenetic tree using Clustal-W	1P
DNA sequence analysis to find restriction enzymes sites using NEB cutter	1P
Visualization of protein structures using Cn3D/ Rasmol	2P

**REFERENCES**

- Harisha, S. (2007). Fundamentals of Bioinformatics, I. K. International Publishing House, Mumbai.
- Ignacimuthu, S. (2005). Basic Bioinformatics, Narosa Publishing House, New Delhi.
- Mount, D. W. (2004). Bioinformatics – sequence and Genome analysis, CBS Publishers.
- Murthy, C. S. V. (2003). Bioinformatics, Himalaya Publishing House, Mumbai.

- Rastogi, S. C., Mendiratta, N. and Rastogi, P. (2004). Bioinformatics: Concepts, Skills and Applications, CBS Publishers.
- Xiong, J. (2006). Essential Bioinformatics, Cambridge University Press.

**PARVATIBAI CHOWGULE COLLEGE OF ARTS & SCIENCE (AUTONOMOUS)**

**SEMESTER VI**

**COURSE TITLE: IMMUNOLOGY (THEORY)**

**COURSE CODE: BCH-VI.C-8**

**MARKS: 75**

**CREDITS: 3**

**COURSE OBJECTIVES:** This paper aims at introducing the basic concepts of the immune system and its defence mechanisms. A section on vaccination, monoclonal and polyclonal antibodies stresses on the importance of these for treatment of lethal diseases.

**LEARNING OUTCOME:** On completion of this module, the student will be able to understand all about the immune system and various antigen-antibody interactions involved in certain immune reactions.

**BCH-VI.C-8 IMMUNOLOGY (THEORY)**

**Total hours: 45**

**Unit 1 Immune system and Autoimmunity**

**No. of Hours: 10**

Types of Immunity (Innate and Acquired)

Barriers of Innate Immunity – Anatomic, Physiologic, Phagocytic, Inflammatory

Collaboration between Innate and Adaptive immunity

Introduction to Humoral and Cell mediated immunity

B-cells and T-cells

Maturation, Activation of B-cells and T-cells

Introduction to Autoimmunity (with example)

**Unit 2 Cells and Organs of the Immune system**

**No. of Hours: 8**

Cells (Myeloid and Lymphoid lineage)

Immuno-reactive Cells (Macrophages, Granulocytes, NK Cells)

Primary lymphoid organs (Bone marrow and Thymus)

Secondary lymphoid organs (Spleen, Lymph nodes, GALT and MALT)

**Unit 3 Antigens- Antibodies and their interactions**

**No. of Hours: 10**

Introduction to Antigens and Antibodies

Antigen: Structure, Types, Classes, Properties and variants, Adjuvants

Antibody: Structure, Types, Kinds, Paratope, Epitope, Abnormal Immunoglobulin, Antibody diversity, Functions, Factors affecting antibody production.

Antigen – Antibody interaction

Forces involved in antigen-antibody reaction

Concept of affinity, Avidity, Precipitation, Agglutination reactions

#### **Unit 4 MHC and Hypersensitivity**

**No. of Hours: 10**

Major Histocompatibility Complex (MHC)

Introduction and discovery of Human Histocompatibility complex

Structure of MHC I and II

Presence of MHC I and II on different cells and their significance

Hypersensitivity - Introduction

Hypersensitive reactions (Type I and Type II, III, IV)

#### **Unit 5 Complement system**

**No. of Hours: 7**

Functions, Components and Activation pathways (Classical, Alternate and Lectin)

### **BCH-VI.E-8 IMMUNOLOGY (PRACTICAL)**

**COURSE TITLE: IMMUNOLOGY (PRACTICAL)**

**COURSE CODE: BCH-VI.E-8**

**MARKS: 25**

**CREDITS: 1**

**TOTAL HOURS: 30**

Total count of WBC and RBC using haemocytometer	2P
Differential count of WBC	1P
Blood grouping and Rh factor	1P
Single Radial Immunodiffusion	2P
Ouchterlony's double diffusion method	2P
Immuno-electrophoresis	2P
Determination of antibody titre	1P
Serological tests involving precipitations (hCGH and Widal tests)	2P
Estimation of haemoglobin by Sahali's method	1P
ELISA (virtual laboratory)	1P

## REFERENCES

- Arora, M. P. (2006). Cell Biology, Immunology and Environmental Biology, Himalaya Publishing House.
- Richard A. Goldsby, Thomas J. Kindt, Barbara A. Osborne, Kuby, J (2000). Immunology, W.H. Freeman and Company
- Rao, C.V. (2011). Immunology, Narosa Book Distributors Pvt. Ltd.
- Roitt, I.M., Brostoff, J. and Male, D.K. (1993). Immunology, Mosby-Year book Europe Limited.

**PARVATIBAI CHOWGULE COLLEGE OF ARTS & SCIENCE (AUTONOMOUS)**

**SEMSESTER VI**

**COURSE TITLE: BIOCHEMICAL CORRELATION OF DISEASES (THEORY)**

**COURSE CODE: BCH- VI.E-13**

**MARKS: 75**

**CREDITS: 3**

**COURSE OBJECTIVES:** This paper aims to make students familiar with various control and metabolic regulation and integrating mechanisms of diverse biochemical events in different metabolic processes, and to understand normal and abnormal human metabolism.

**LEARNING OUTCOME:** On completion of this module, the student will be able to understand how chemical and biochemical analysis are applied to the study of disease and the function and mode of action of hormones in health and disease and understand their roles in controlling various metabolic pathways.

**BCH-VI.E-13 BIOCHEMICAL CORRELATION OF DISEASES** **Total hours: 45**

**Unit 1 Inborn errors of metabolism** **No. of hours: 6**  
Alkaptonuria, Phenylketonuria, Glycogen and Lipid storage diseases, clotting disorders

**Unit 2 Nutritional deficiency based diseases** **No. of hours: 6**  
Kwashiorkar, Marasmus, Beri-beri, Scurvy, Pellagra, Anaemia, Night blindness, Rickets, Osteomalacia, Osteoporosis, Wilson's disease

**Unit 3 Life style diseases** **No. of hours: 6**  
Obesity, Cardiovascular diseases, Atherosclerosis, Diabetes mellitus - type II

**Unit 4 Hormonal imbalances** **No. of hours: 6**  
Outline of hormone action and imbalances leading to disease: Precocious puberty, Hyper- and Hypopituitarism, Hyper- and hypothyroidism

**Unit 5 Autoimmune diseases** **No. of hours: 8**  
Concepts in immune recognition: Self and non-self-discrimination, Organ specific autoimmune diseases – Hashimoto's thyroiditis, Grave's disease, Myasthenia gravis, Rheumatoid arthritis

**Unit 6 Infectious diseases****No. of hours: 13**

Viral infection (Polio, Measles, Mumps, Influenza, HIV)

Bacterial infections (Tetanus, Diphtheria, Tuberculosis, Typhoid, Cholera)

Protozoan (Plasmodium and Trypanosoma) and parasitic infections

**BCH VI.E-13 : BIOCHEMICAL CORRELATIONS IN DISEASES (PRACTICAL)****COURSE TITLE: BIOCHEMICAL CORRELATIONS IN DISEASES (PRACTICAL)****COURSE CODE: BCH VI.E-13****MARKS: 25****CREDITS: 1****TOTAL HOURS: 30**

Determination of Serum Sodium and Potassium	2P
Determination of serum triglycerides	1P
Physical and chemical examination of urine (sugar, protein)	2P
Blood pressure measurement	1P
Glucose tolerance test	2P
Bone density measurements	2P
Case studies - Clinical Characteristics, Diagnosis and Management of Nutritional deficiency based diseases, Life style diseases, Inborn errors of metabolism, Autoimmune diseases, Infectious diseases	5P

**REFERENCES**

- Ananthanarayan R. and Paniker C. K. J. (2009) Textbook of Microbiology. 8th edition, University Press Publication
- Berg, J. M., Tymoczko, J. L. and Stryer, L., Biochemistry (2012) 7th ed., W.H Freeman and Company (New York)
- Godkar, P. and Godkar, D. Textbook of Medical Laboratory Technology, 2003, Bhalani Publishing House (Mumbai).
- Murray, R. K, Granner, D. K, Mayes, P.A. and Rodwell, V.W. (2003), Harper's Illustrated Biochemistry, McGraw-Hill Companies.

## PARVATIBAI CHOWGULE COLLEGE OF ARTS & SCIENCE (AUTONOMOUS)

### SEMSESTER VI

**COURSE TITLE: CLINICAL BIOCHEMISTRY (THEORY)**

**COURSE CODE: BCH-VI.E-14**

**MARKS: 75**

**CREDITS: 3**

**COURSE OBJECTIVES:** This course is designed to prepare the students for a career in clinical biochemistry and to provide them a sound knowledge of the clinical principles underlying the application of clinical biochemistry investigations in human disease.

**LEARNING OUTCOME:** This course equips the students with the knowledge and understanding of the scientific basis and use of the major analytical technologies and diagnostic platforms used in clinical biochemistry.

### **BCH-VI.E-14 CLINICAL BIOCHEMISTRY (THEORY)**

**Total hours: 45**

#### **Unit 1 Laboratory setup and analysis**

**No. of hours: 15**

Requirements of setting up of clinical laboratory, SI units in clinical laboratory

Safety measures in clinical laboratory; Collection, Preservation and Handling of clinical samples

Blood: Haemoglobin, Total cell and Differential cell (TC/DC) counts, Erythrocyte sedimentation Rate (ESR); Clotting time, Glucose; Lipid profile; Urea

Serum: Proteins, Albumin/Globulin Ratio; Bilirubin; Creatinine; Uric acid; Electrolytes

Urine: Colour, Odour, Sediment, Crystals, Glucose; Protein/Albumin

Use of LDH, SGPT, SGOT, Acid and Alkaline phosphatase, Amylase, Lipase, Cholesterol, Albumin, Creatinine in diagnosis of disorders

#### **Unit 2 Tests for diseases**

**No. of hours: 15**

Blood: Total and differential blood count, Blood groups and Rh factor incompatibility, Plasma proteins, Types of anaemia and porphyries

Liver: Bilirubin metabolism, Types of jaundice and clinical assessment, Acute and chronic liver diseases, Cirrhosis, Viral, Metabolic and Drug induced/toxic liver diseases, Liver function tests

Kidney: Glomerular filtration rate, Renal threshold and clearance values, Disorders of kidney, Renal failure and proteinuria, Renal tubular disorders and renal stones, Renal function tests

Heart: Ischemic heart disease, Role of enzymes and other proteins in assessment of myocardial infarction: SGOT; CPK; LDH isozyme

### **Unit 3 Metabolic Disorders**

**No. of hours: 15**

Inborn errors of metabolism:

Disorders associated with carbohydrate metabolism- Glycogen storage diseases, Galactosemia

Protein metabolism – Phenylketonuria, Alkaptonuria

Lipid metabolism – Niemann – Pick disease, Tay-Sach’s disease

Disorders due to chromosomal aberrations – Molecular basis and symptoms of Down’s, Turner’s and Klinefelter’s syndrome

Metabolic disorders:

Carbohydrate – Diabetes mellitus Type I and Type II; Ketosis

Lipids – Dyslipidemia

Proteins – Albuminuria

Blood – Anaemia: Haemolytic, Pernicious, Sickle cell anaemia; Acidosis, Alkalosis

Heart – Hypertension, Arteriosclerosis

Liver – Hepatitis

Kidney –Diabetes insipidus

### **BCH-VI.E-14 CLINICAL BIOCHEMISTRY (PRACTICAL)**

**COURSE TITLE: CLINICAL BIOCHEMISTRY (PRACTICAL)**

**COURSE CODE: BCH-VI.E-14**

**MARKS: 25**

**CREDITS: 1**

**TOTAL HOURS: 30**

Estimation of blood glucose	1P
Blood Urea estimation	1P
Bleeding time and clotting time	1P
Erythrocyte Sedimentation Rate	1P
Determination of serum triglycerides	1P
Serum creatinine	1P
Physical and chemical examination of urine (sugar, protein)	3P

Determination of Urinary calcium, inorganic phosphates, Sodium and chlorides	4P
Urine Uric acid estimation	1P
Blood pressure measurements	1P

## REFERENCES

- Pattabiraman R. N. Text book of Biochemistry, All India Publisher distribution.
- Chatterjee M. N., Shinde, R. Text book of Medical Biochemistry, Jaypee Publishers.
- Vasudevan, D. M., Sreekumari S., Text book of Biochemistry for Medical Students, Jaypee Publishers.
- Berg, Jeremy M., Tymoczko, John L., Stryer Lubert. Biochemistry, W.H. Freeman, N. York.
- David, L. N., Michael, M. C., Lehninger, Albert, Biochemistry, Kalyani Publications, N.

## PARVATIBAI CHOWGULE COLLEGE OF ARTS & SCIENCE (AUTONOMOUS)

### SEMESTER VI

**COURSE TITLE: ENVIRONMENTAL BIOCHEMISTRY (THEORY)**

**COURSE CODE: BCH-VI.E-15**

**MARKS: 75**

**CREDITS: 3**

**COURSE OBJECTIVES:** The main aim of this paper is to introduce the students to the hazards of our environment, the effects of pollution on living systems, solutions to protect the environment for sustainable development.

**LEARNING OUTCOME:** On completion of this module, students will be able to understand the effects of various types of pollution and gain knowledge in areas like development of biological systems for remediation of contaminated environments and environment-friendly processes such as green manufacturing technologies and sustainable development.

**BCH-VI.E-15 ENVIRONMENTAL BIOCHEMISTRY (THEORY) Total hours: 45**

**Unit 1 Basic ecological concepts and principles No. of hours: 5**

Structure of ecosystem (biotic and abiotic components), Food chain and food webs, Ecological pyramids; Productivity and eco-energetic (10% law)

**Unit 2 Anthropogenic activities, its effects and control No. of hours: 15**

**Air pollution:** Major air pollutants and their sources

Impacts of air pollution on human health, animals, plants and climate

Removal of gaseous contaminants: Bioscrubbers, Biotrickling filters and Biofilters/Biobeds

**Water pollution:** Principal forms of water pollutants and their sources

Wastewater treatment: Activated sludge process, Rotating biological discs, Oxidation ponds, Trickling filters

**Soil pollution:** Major soil pollutants and their sources

Treatment of solid wastes: Hazardous, Non hazardous, Composting and Vermitechnology

**Unit 3 Pollution Monitoring No. of hours: 8**

Bioindicators: Concept and examples (indicators of water quality; air pollution indicators)

Applications using plant test systems and animal Test Systems

Tests for assessing Genetic damage: AMES Test

Concept and applications of molecular biology in environmental monitoring: reporter gene

Concept and applications of biosensors in pollution detection

**Unit 4 Pollution abatement: Bioremediation and biodegradation**

**No. of hours: 10**

Bioremediation: Definition, Mechanism of microbial bioremediation, Microbial desulphurization of coal (indirect mechanisms), Phytoremediation

Biodegradation: Biodegradation of two xenobiotics: Aromatic hydrocarbons (benzene) and alkanes

Biosorption: Principle, Use of Fungi and Algae

Genetically engineered microorganisms: Super Bug (*Pseudomonas* species)

**Unit 5 Ecofriendly Bioproducts**

**No. of hours: 7**

Biogas (Biomethanisation)

Bio hydrogen production: anaerobic bacteria and photolysis by photosynthetic algae

Bioplastics: Biopol and Biolac

Biodiesel, Bioethanol

**BCH-VI.E-15 ENVIRONMENTAL BIOCHEMISTRY (PRACTICAL)**

**COURSE TITLE: ENVIRONMENTAL BIOCHEMISTRY (PRACTICAL)**

**COURSE CODE: BCH-VI.E-15**

**MARKS: 25**

**CREDITS: 1**

**TOTAL HOURS: 30**

Water quality by MPN method	2P
Detection of coliforms in the water sample/routine analysis of potable water sample using Presumptive, Confirmatory and Confirmed tests	4P
Determination of Dissolved Oxygen concentration of water sample by Winkler's method	1P
Determination of Biological Oxygen Demand (BOD) of the water sample	1P
Determination of Chemical Oxygen Demand (COD) of the water sample	1P
Determination of Total Solids (TS) of the given water sample	1P
Isolation of xenobiont degrading bacteria by selective enrichment	2P

## REFERENCES

- Agarwal S. K. (2009). Environmental Biotechnology, APH Publishing Corporation New Delhi.
- Anjaneyulu Y. (2005). Introduction to environmental Science, BS publications, India.
- Chatterji A. K. (2009). Introduction to Environmental Biotechnology, 2<sup>nd</sup> ed, Prentice Hall of India Pvt. Ltd. New Delhi.
- Jogdand B. N. (2008). Environmental Biotechnology (Industrial Pollution Management), Himalaya Publishing House, Mumbai.
- Santra S. C. (2001). Environmental Science, New central book agency (P) Ltd. Calcutta.
- Singh B. D. (2008). Biotechnology, 3<sup>rd</sup> edition, Kalyani Publishers.
- Thakur I. S. (2006). Environmental Biotechnology: Basic concepts and applications, I. K. International Pvt. Ltd. New Delhi.

**PARVATIBAI CHOWGULE COLLEGE OF ARTS & SCIENCE (AUTONOMOUS)**

**SEMESTER VI**

**COURSE TITLE: INDUSTRIAL BIOCHEMISTRY (THEORY)**

**COURSE CODE: BCH-VI.E-16**

**MARKS: 75**

**CREDITS: 3**

**COURSE OBJECTIVES:** This paper is designed to introduce the students to the basic concepts in Industrial Biochemistry, mainly introducing the basics of upstream processes in fermentation technology on an industrial scale.

**LEARNING OUTCOME:** On completion of this module, students will be able to understand the concept of a bioprocess and its importance in today's world of fast pacing technology. They will be able to apply concepts of fermentation technology to the industrial sector and understand how large scale bioprocesses are carried out.

**BCH-VI.E-16 INDUSTRIAL BIOCHEMISTRY (THEORY) Total hours: 45**

**Unit 1 Introduction No. of hours: 2**

Scope and applications of industrial biochemistry

**Unit 2 Industrial bioreactor No. of hours: 8**

Fermenters: Structure of an Ideal fermentor

Parts of the fermentor and their uses – Impellers, Spargers, Baffles, Headspace, Controls and Sensors (temperature, pH, antifoam)

Types of reactors (definition, description, diagram and uses) - Bubble columns, Airlift, Fluidized bed, Packed bed, Tray bioreactors, Photobioreactors

**Unit 3 Fermentation media No. of hours: 6**

Characteristics of an Ideal fermentation medium

Types of media – Crude and Synthetic

Composition of fermentation media

**Unit 4 Types of fermentation No. of hours: 6**

Introduction to the types of fermentation processes: Submerged, Surface/Solid state, Batch, Fed-batch and Continuous; Pilot fermentor

**Unit 5 Screening of microorganisms for fermentation processes** **No. of hours: 7**

Primary screening: Definition, Methods of primary screening – Crowded plate, Auxanography, Enrichment, Indicator dye

Secondary screening: Definition and features, Example of secondary screening (giant colony method)

**Unit 6 Detection and assay of fermentation products** **No. of hours: 8**

An overview of the working principle involved in:

Physical and Chemical assays - Titration and gravimetric assay, Turbidity analysis and Cell determination, Spectrophotometric assay

Biological assays - Diffusion assays, Turbidometric and Growth assay

**Unit 7 Industrial production of biochemically important products** **No. of hours: 8**

Industrial production of Citric acid, Vinegar and Industrial alcohol: Organisms, Fermentation media, Fermentation conditions and Production processes

**BCH-VI.E-16 INDUSTRIAL BIOCHEMISTRY (PRACTICAL)**

**COURSE TITLE: INDUSTRIAL BIOCHEMISTRY (PRACTICAL)**

**COURSE CODE: BCH-VI.E-16**

**MARKS: 25**

**CREDITS: 1**

**TOTAL HOURS: 30**

Study of a fermentor	1P
A study on the phases of growth of microorganisms during fermentation	2P
Preparation and sterilization of medium for batch fermentation process	1P
Batch fermentation	1P
Decontamination and sterilization of the fermentor	1P
Primary screening of antibiotic producing bacteria by crowded plate technique	1P
Secondary screening for antibiotic producers by giant colony technique	1P
Production of wine (from fruit) using yeast	2P
Production of vinegar	2P

Estimation of total reducing sugars and acidity (total and volatile) in wine and vinegar before and after fermentation	1P
MIC of an antibiotic	2P

## REFERENCES

- Casida L. E. (2009). Industrial Microbiology, New Age International (P) Ltd. New Delhi.
- Okafor N. (2007). Modern Industrial Microbiology and Biotechnology, Science Publishers Enfield, NH, USA.
- Patel A. H. (2012). Industrial Microbiology, MacMillan Publishers India Ltd.
- Prescott and Dunn. (1982). Industrial Microbiology, 4<sup>th</sup> edition, AVI Publishinhg Co.
- Ratlege C. and Kristiansen B. (2001). Basic Biotechnology, 2<sup>nd</sup> edition. Cambridge university press.
- Stanbury P. F, Whitaker A. and Hall. (1997). Principles of fermentation technology, 2<sup>nd</sup> Edition, Aditya Books Pvt. Ltd, New Delhi.