

**Parvatibai Chowgule College of Arts and
Science**

(Autonomous)

DEPARTMENT OF BIOCHEMISTRY

THREE YEAR B.Sc.

DEGREE COURSE IN

BIOCHEMISTRY

B.SC. DEGREE COURSE IN BIOCHEMISTRY - COURSE STRUCTURE

Applicable from the academic year 2022-23

SEMESTER	CORE		ELECTIVE			
I	BCH-I.C-1 Molecules of Life	BCH-I.C-2 Cell Biology	-----	-----	-----	-----
II	BCH-II.C-3 Protein Chemistry	BCH-II.C-4 Biophysics	-----	-----	-----	-----
III	BCH-III.C-5A Metabolism of Biomolecules		BCH.E-1 Tools & Techniques in Biochemistry	BCH.E-17 Enzymology	BCH.E-18 Fundamentals of Microbiology	BCH.E-6 Nutritional Biochemistry
IV	BCH-IV.C-6A Immunology		BCH.E-5 Human Physiology	BCH.E-4 Plant Biochemistry	BCH.E-19 Endocrinology	BCH.E-8 Advanced Cell Biology
V	BCH-V.C-7 Molecular Biology		BCH.E-9 Concepts of Genetics	BCH.E-10 Regulation of Gene Expression	BCH.E-20 Industrial Microbiology	BCH.E-12 Bioinformatics
VI	BCH-VI.C-8A Clinical Biochemistry		BCH.E-21 Introduction to Pharmacology	BCH.E-22 Food Biochemistry	BCH.E-11 Genetic Engineering and Biotechnology	BCH.E-23 Environmental Chemistry

Generic Elective Course:

1. BCH.GEC-1 Contemporary Nutrition
2. BCH.GEC-2 Biochemical Correlation of Diseases

Skill Enhancement Course:

1. BCH.SEC-1 Nutraceutical Product Development

PROGRAMME OUTCOMES

Programme Outcomes (PO)	Short Title of the POs	Description of the Programme Outcomes
		Graduates will be able to :
PO-1	Problem Analysis and Solutions	Think critically, identify, analyze problems/ situations and further attempt to design/ develop solutions that meet the specified goals.
PO-2	Use of Technology	Apply appropriate IT tools efficiently in their daily activities of communication and academics.
PO-3	Environment Sustainability and	Analyze and attempt solutions to environmental issues and commit themselves to sustainable development in the local/ national and global context.
PO-4	Ethics	Recognize and understand professional ethics /human values and be responsible for the same.
PO-5	Individual and Team work	Function effectively at various levels, capacities and situations.
PO-6	Communication	Communicate proficiently (oral and written) as a responsible member of society.
PO-7	Research Aptitude	Understand general research methods and be able to analyse, interpret and derive rational conclusions.
PO-8	Life Skills	Recognize the need for, and have the preparation and ability to engage in independent and life-long learning in the broadest context of domain specific change.

PROGRAMME SPECIFIC OUTCOMES (PSO)

After successful completion of a Bachelor's degree in Biochemistry, the students will:

PSO-1	Fundamental Knowledge of Biochemistry	Possess a fundamental knowledge of the different aspects of Biochemistry, with the means and ability to specialize in a specific field.
PSO-2	Development of practical skills	Be equipped with practical skills and the ability to apply their theoretical concepts to design, perform experiments, analyze and interpret data and thus develop proficiency in laboratory management.
PSO-3	Critical thinking and analytical skills	Be able to demonstrate proficiency in quantitative reasoning (critical thinking) and analytical skills.
PSO-4	Analysis and Problem Solving	Be able to use these skills to analyze and solve industry related problems, thus preparing them for a successful career in industry and research institutes.
PSO-5	Understanding the need for sustainable solutions	Be able to understand the impact of Biochemistry in the development of sustainable solutions for the environment and societal context.
PSO-6	Developing an inclination towards research	Develop an inclination towards research through the compulsory internship in industry/research/academic institutes which promote and inculcate professional ethics and code of practice among students, enabling them to work in a team with a multidisciplinary approach.

SEMESTER I

<u>CORE COURSE: MOLECULES OF LIFE</u>	
COURSE CODE:	BCH-I.C-1
MARKS:	100 (75 – Theory; 25 – Practical)
CREDITS:	4 (03 – Theory; 01 – Practical)
CONTACT HOURS:	Theory: 45 Hours (03 Lectures per week) Practical: 30 Hours (03 Practical per week)
COURSE OUTCOMES:	On the successful completion of the course, the students will be able to: CO1: Gain an understanding of the various theories of the origin of life CO2: Comprehend the importance of water in the sustenance of life. CO3: Compare and contrast the various different biomolecules (carbohydrates, proteins, lipids, nucleic acids, vitamins), their categories as well as functions. CO4: Understand and apply general laboratory safety measures as well as calculate for preparation of various chemicals for experiments. CO5: Prepare different solutions such as buffers, reagents and stock solutions for experiments independently.

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

MODULE	TOPICS	CONTACT HOURS	TOTAL CONTACT HOURS
MODULE 1: The foundations of Biochemistry, Water, Carbohydrates	1.1 : The foundations of Biochemistry Chemical and cellular foundations of life	02	15
	1.2: Water Unique properties of water; Weak interactions in aqueous systems; Ionization of water; Water as a reactant and fitness of the aqueous environment	03	
	1.3: Carbohydrates Classification of carbohydrates; Monosaccharides - structures of aldoses and ketoses, the ring structure of sugars, conformations of sugars; Stereochemistry: mutarotation, anomers, epimers, and enantiomers; The formation of disaccharides; Reducing and non-reducing disaccharides; Polysaccharides: homo and heteropolysaccharides; Structural and storage polysaccharides; Glycoconjugates; Functions of carbohydrates	10	
MODULE 2: Proteins and Lipids	2.1: Proteins Amino acids - structure, classification; Derivatives of amino acids and their biological role. Titration of amino acids; Introduction to biologically important peptides; Polypeptides and proteins.	08	

	<p>2.2: Lipids</p> <p>Classification of lipids and their distribution; Storage lipids; Structural lipids; Lipids as signaling molecules, cofactors and pigments</p>	07	15
MODULE 3:	<p>3.1: Nucleic Acids</p> <p>Nucleotides and nucleic acids, phosphodiester bond; Nucleic acid structure and chemistry: DNA as genetic material; DNA structures and their importance, unusual DNA structures; Different types of RNA; Other functions of nucleotides: a source of energy, a component of coenzymes, second messengers.</p> <p>3.2: Vitamins</p> <p>Structure and active forms of water soluble and fat soluble vitamins; Deficiency diseases and symptoms; Hypervitaminosis</p>	<p>10</p> <p>05</p>	15

BCH-I.C-1: MOLECULES OF LIFE (PRACTICAL)

SR. NO.	PRACTICAL	NO. OF PRACTICALS
1.	Introduction to safety measures in laboratories	01
2.	Preparation of buffers & solutions (normal, molar, ppm, %)	01
3.	Mutarotation of sugars	01
4.	Qualitative tests for carbohydrates, lipids, proteins, and nucleic acids	04
5.	Estimation of reducing sugars by DNSA method	01
6.	Determination of pKa of amino acids	02
7.	Preparation of TLC plates and separation of amino acids and sugars by thin layer chromatography	04
8.	Determination of peroxide value of oil	01
9.	Estimation of Vitamin C	01

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.
- Sadasivam, S. and Manickam, A. (1996), Biochemical Methods, New Age International (P) Limited
- Jayaraman, J. (1971), Laboratory Manual in Biochemistry, John Wiley & Sons, Limited.
- Plummer, D.T. (1993). An Introduction to Practical Biochemistry, Sixth Reprint. Tata McGraw-Hill Publishing Company Limited, New Delhi.
- Harvey, R.A. & Ferrier, D.R. (2011). Lippincott's Illustrated Reviews, Biochemistry Fifth Edition, Lippincott Williams and Wilkins.

SEMESTER I

<u>CORE COURSE: CELL BIOLOGY</u>	
COURSE CODE:	BCH-I.C-2
MARKS:	100 (75 – Theory; 25 – Practical)
CREDITS:	4 (03 – Theory; 01 – Practical)
CONTACT HOURS:	Theory: 45 Hours (03 Lectures per week) Practical: 30 Hours (01 Practical per week)
COURSE OUTCOMES:	On the successful completion of the course, the students will be able to: CO1: Demonstrate an understanding of cell communication CO2: Correlate the function of each cell organelle with proper coordination. CO3: Identify and analyze different biological cells using a compound microscope CO4: Prepare various plant and animal specimen for the observation of cell structures.

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

MODULE	TOPICS	CONTACT HOURS	TOTAL HOURS
MODULE 1: Introduction to Cell Biology, Cell Wall and Plasma Membrane	1.1: Introduction to cell biology Cell theory; ultrastructure of prokaryotic and eukaryotic cell; cell matrix proteins; components of the extracellular matrix. 1.2: Cell wall & Plasma membrane Chemical composition; structure and functions of the cell wall and plasma membrane; monolayer; planar bilayer and liposomes as model membrane systems; Fluid mosaic model; lipid rafts; membrane fluidity; factors affecting membrane fluidity; techniques used to study membrane dynamics – FRAP.	06 09	15
MODULE 2: Ultrastructure and Function of Organelles	2.1: Ultrastructure and function of organelles Cilia and Flagella; Endoplasmic reticulum; Golgi apparatus; Lysosomes; Microbodies; Mitochondria; Ribosomes; Centrioles and basal bodies; Nucleus; Chloroplasts and Peroxisomes.	15	15
MODULE 3: Cell Cycle and Cell-cell Interactions	3.1: Cell Cycle Overview of the cell cycle; prokaryotic & eukaryotic cell cycle; events of mitotic & meiotic phases, cytokinesis.	03	

	3.2: Cell-Cell interaction Interactions of cells with extracellular materials: integrins, focal adhesions, and hemidesmosomes; interactions of cells with other cells: selectins, the immunoglobulin superfamily, cadherins, adherens junctions, and desmosomes; tight junctions, gap junctions, and plasmodesmata	05	15
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BCH-I.C-2: CELL BIOLOGY (PRACTICAL)

SR. NO.	PRACTICAL	NO. OF PRACTICALS
1.	Examination of a prokaryotic cell, eukaryotic cell and cell organelles using photomicrographs	01
2.	Visualization of animal and plant cell using methylene blue	01
3.	Study of cell viability using phenol red/trypan blue	01
4.	Visualization of Permanent slides of: A. Different cell types: Epithelium, Endothelium, Muscle cells, Nerve cell B. Different stages of cell division	02
5.	Identification of different stages of mitosis in onion root tip`	02
6.	Identification of different stages of meiosis in onion flower buds	02
7.	Isolation of chloroplast from spinach leaves	04
8.	Prokaryotic cell harvesting & lysis using osmotic (salt) and Chemical (detergent) methods	02

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, 8th edition, Sauder College.
- Cooper, G.M. and Hausman, R.E. 2009. The Cell: A Molecular Approach. 5th edition. ASM Press & Sunderland, Washington, D.C.
- Verma P.S. and Agarwal V. K. (1998). Cell Biology, Genetics, Molecular Biology, Evolution, and ecology. 14th edition.

SEMESTER II

<u>CORE COURSE: PROTEIN CHEMISTRY</u>	
COURSE CODE:	BCH-II.C-3
MARKS:	100 (75 – Theory; 25 – Practical)
CREDITS:	4 (03 – Theory; 01 – Practical)
CONTACT HOURS:	Theory: 45 Hours (03 Lectures per week) Practical: 30 Hours (01 Practical per week)
COURSE OUTCOMES:	On the successful completion of the course, the students will be able to: CO1: Comprehend the various levels of protein structure CO2: Explain the mechanism and significance of membrane proteins. CO3: Correlate the techniques used in studying protein structure CO4: Review enzymes and their classification system. CO5: Assess and compare the various methods employed in protein estimation/concentration and measuring the protein content.

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

MODULE	TOPICS	CONTACT HOURS	TOTAL HOURS
MODULE 1: Protein Structure	1.1: Protein structure 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.	15	15
MODULE 2: Isolation & Analysis of proteins	2.1: Isolation & analysis of protein Techniques to isolate and analyze proteins: salt fractionation, ion-exchange chromatography, gel permeation, HPLC, SDS-PAGE, IEF; Protein primary structure: sequencing by Edman degradation, the use of enzymes and chemical reagents to obtain overlap peptides, synthesis of peptides using Merrifield method 2.2: Characterization of proteins Determination of purity, molecular weight, extinction coefficient, sedimentation coefficient, 2-D electrophoresis	12 03	15

MODULE 3:	<p>3.1 : Enzymes</p> <p>Nature of enzymes: protein and non-protein (ribozyme); cofactor and prosthetic group, apoenzyme, holoenzyme; IUBMB classification of enzymes; mechanism of enzyme activity</p> <p>3.2: Membrane and Transport proteins</p> <p>Integral and membrane-associated proteins, hydropathy plots to predict transmembrane domains; the significance of functional proteins - bacteriorhodopsin, myoglobin, and hemoglobin: structure and function (Oxygen binding curves, cooperativity models for hemoglobin)</p>	<p>06</p> <p>09</p>	<p>15</p>
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BCH-II.C-3: PROTEIN CHEMISTRY (PRACTICAL)

SR. NO.	PRACTICAL	NO. OF PRACTICALS
1.	Determination of absorption maxima and molar extinction coefficient of protein sample	02
2.	Protein Assay (Biuret/Lowry/Bradford method)	02
3.	Ammonium sulfate fractionation of proteins	02
4.	Protein Dialysis	02
5.	The solubility of proteins in distilled water and salt solutions	02
6.	Denaturation of proteins by pH and temperature	01
7.	Separation of proteins by SDS-PAGE (demonstration)	02
8.	Gel filtration chromatography (demonstration)	02

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, New Delhi.
- 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.

SEMESTER II

<u>CORE COURSE: BIOPHYSICS</u>	
COURSE CODE:	BCH-II.C-4
MARKS:	100 (75 – Theory; 25 – Practical)
CREDITS:	4 (03 – Theory; 01 – Practical)
CONTACT HOURS:	Theory: 45 Hours (03 Lectures per week) Practical: 30 Hours (01 Practical per week)
COURSE OUTCOMES:	On the successful completion of the course, the students will be able to: CO1: Explain the basic concepts of the origin and evolution of life CO2: Understand how cellular reactions take place in accordance with thermodynamic principles CO3: Describe the mechanism of the derivation of energy through bioenergetic reactions in living cells CO4: Elucidate energy transductions in organisms. CO5: Understand the concepts of buffer capacity and osmolarity. CO6: Demonstrate a practical understanding of spectrophotometry.

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

MODULE	TOPICS	CONTACT HOURS	TOTAL HOURS
MODULE 1: The chemical basis of life, Basic principles of biochemical studies, Ion channels	1.1 : The chemical basis of life 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	05	15
	1.2:1.1:c principles of biochemical studies Units of measurement; weak electrolytes- the biochemical importance of weak electrolytes, ionisation of weak acids and bases, calculation of pH, ionization of a weak electrolyte, buffer solutions, buffer capacity, buffer action and pH of blood, measurement of pH, pH meters	06	
	1.3: Ion Channels Sodium, Potassium, Calcium, Chlorine, ligand-gated, Donnan's equilibrium experiments	04	
MODULE 2: Bioenergetics and oxidative phosphorylation	2.1: Introduction to bioenergetics 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	08	

	<p>2.2: Oxidative phosphorylation</p> <p>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</p>	07	15
<p>MODULE 3:</p> <p>Photo-phosphorylation</p>	<p>3.1: Photo-phosphorylation</p> <p>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 - the structure of chloroplast, the molecular architecture of Photosystem I and Photosystem II, Z-scheme of photosynthetic electron flow, oxygen-evolving complex and action of herbicides; cyclic photophosphorylation and its significance; photoinhibition, the evolution of oxygenic photosynthesis; Comparison of phosphorylation in mitochondria and chloroplasts</p>	15	15

BIO-II.C-4: BIOPHYSICS (PRACTICAL)

SR. NO.	PRACTICAL	NO. OF PRACTICALS
1.	Preparation of buffers	01
2.	Determination of buffer capacity	02
3.	To determine osmolarity of solutions proteins/sugars/lipids/ nucleic acids using osmometer	04
4.	Effect of detergents and other membrane active substances on cells	02
5.	Determination of lambda max and molar extinction coefficient of a given compound	02
6.	Determination of pKa of Bromophenol blue	02
7.	Photooxidation of photosynthetic pigments (demonstration)	01
8.	Oxygen evolution (by Hydrilla) (demonstration)	01

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, New Delhi.
- 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.

SEMESTER III

<u>CORE COURSE: METABOLISM OF BIOMOLECULES</u>	
COURSE CODE:	BCH-III.C-5A
MARKS:	100 (75 – Theory; 25 – Practical)
CREDITS:	4 (03 – Theory; 01 – Practical)
CONTACT HOURS:	Theory: 45 Hours (03 Lectures per week) Practical: 30 Hours (01 Practical per week)
COURSE OUTCOMES:	On the successful completion of the course, students will be able to: CO1: Explain the metabolic processes of the cell CO2: Discuss the interconnections of metabolic pathways. CO3: Isolate and estimate different biomolecules using various techniques CO4: Describe the causes and treatment of various metabolic disorders.

BCH-III.C-5A: METABOLISM OF BIOMOLECULES (THEORY)

MODULE	TOPICS	CONTACT HOURS	TOTAL HOURS
MODULE 1: Concepts of Metabolism; Carbohydrate metabolism	1.1: Basic Concepts and Design of Metabolism Metabolism: Catabolism and Anabolism, ATP as energy source, ATP cycle, ATP as energy currency, energy relationship between catabolic and anabolic pathways, other energy rich molecules	04	15
	1.2: Carbohydrate Metabolism Glycolysis, Fate of pyruvate, Fermentation, Tri-Carboxylic Acid cycle, Pentose-Phosphate pathway, Gluconeogenesis, Glycogen synthesis and breakdown, Glyoxylate pathway, Lactose intolerance, Wernicke-Korsakoff Syndrome	11	
MODULE 2: Oxidative Phosphorylation and Fatty acid metabolism	2.1: Oxidative Phosphorylation The respiratory chain in mitochondria, proton gradient powering ATP synthesis, inhibitors of oxidative phosphorylation: Cyanide, Carbon monoxide, Oligomycin. Transfer of cytosolic reducing equivalents to mitochondria: glycerol-3- phosphate and malate-aspartate shuttle	05	15
	2.2: Fatty Acid Synthesis and Degradation Digestion, mobilisation and transport of cholesterol and triacyl glycerols, β -oxidation of fatty acids, ketone bodies, ketoacidosis Biosynthesis of saturated and unsaturated fatty acids, and elongation of fatty acids	10	
MODULE 3: Amino acid and Nucleotide metabolism	3.1: Amino acid Metabolism Overview of biosynthesis and catabolism of amino acids, Phenylketonuria; regulation of amino acid biosynthesis, Urea cycle, urea cycle disorders	07	15
	3.2: Nucleotide Metabolism Biosynthesis - de novo and salvage pathways, degradation, ADA deficiency, Lesch-Nyhan syndrome, Gout	08	

BCH-III.C-5A: METABOLISM OF BIOMOLECULES (PRACTICAL)

SR. NO.	PRACTICAL	NO. OF PRACTICALS
1.	Lactic Acid fermentation	01
2.	Alcohol Fermentation by Yeast	02
3.	Estimation of blood glucose	01
4.	Separation of lipids by TLC	02
5.	Isolation of lecithin from egg yolk	03
6.	Isolation of cholesterol from egg yolk	03
7.	Estimation of protein and nucleic acid by direct spectroscopy	01
8.	Urea estimation	01
9.	Uric acid estimation	01
	Total	15

Mandatory Reading

- Nelson, D. L. and Cox, M.M. Lehninger's Principles of Biochemistry. Worth Publishers, New York, USA

Supplementary Reading

- Stryer, L., Berg, J., Tymoczko, J. and Gatto, G. Biochemistry. W. H. Freeman and Co., New York, USA.
- Murray, R. K., Granner, D. K., Mayes, P. A. and Rodwell, V. W. Harper's Illustrated Biochemistry. McGraw-Hill Companies.
- Jain, J. L., Jain, S. and Jain, N. Fundamentals of Biochemistry. S. Chand and Company, Ltd., New Delhi.
- Plummer, D. T. An Introduction to Practical Biochemistry. Tata McGraw-Hill Publishing Company Limited, New Delhi.
- Harvey, R.A. and Ferrier, D.R. Lippincott's Illustrated Reviews, Biochemistry. Lippincott Williams and Wilkins.
- Voet, D. and Voet, J. G. Biochemistry John Wiley and Sons, Inc, USA.

Web References

- <https://www.coursera.org/learn/energy-metabolism>
- <https://online-learning.harvard.edu/course/principles-biochemistry-1>
- <https://nptel.ac.in/courses/102/105/102105034/>
- <https://openstax.org/details/books/biology-2e>

SEMESTER III

ELECTIVE COURSE: TOOLS AND TECHNIQUES IN BIOCHEMISTRY

COURSE CODE:	BCH.E-1
MARKS:	100 (75 – Theory; 25 – Practical)
CREDITS:	4 (03 – Theory; 01 – Practical)
CONTACT HOURS:	Theory: 45 Hours (03 Lectures per week) Practical: 30 Hours (01 Practical per week)
COURSE OUTCOMES:	<p>On the successful completion of the course, students will be able to:</p> <p>CO1: Comprehend the basic concepts of the principle, working, and applications of different types of chromatography.</p> <p>CO2: Compare, analyze and apply concepts of the principle and working of various types of centrifuges and electrophoretic techniques</p> <p>CO3: Compare, analyze and apply concepts of the principle and working of various types of spectroscopic and microscopic techniques.</p> <p>CO4: Acquire knowledge about different radioisotopes and their applications in biochemistry</p>

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

MODULE	TOPICS	CONTACT HOURS	TOTAL HOURS
MODULE 1: Chromatography and Centrifugation Techniques	<p>1.1: Chromatographic techniques</p> <p>Basic principles of chromatography: Partition coefficient, concept of theoretical plates. Various modes of chromatography, Instrumentation and Applications – Plane chromatography (paper, TLC, 2D), Column chromatography - HPLC, Molecular Sieve Chromatography, Ion Exchange Chromatography, Affinity Chromatography, Gas Chromatography.</p>	09	15
	<p>1.2: Centrifugation</p> <p>Basic principle of sedimentation, sedimentation coefficient, various types of centrifuges, different types of rotors, Preparative centrifuge - differential centrifugation, density gradient centrifugation (Rate zonal and Isopycnic), Analytical centrifuge.</p>	06	
MODULE 2: Electrophoretic and Spectroscopic Techniques	<p>2.1: Electrophoretic and Blotting techniques</p> <p>Basic Principle of electrophoresis, Electrophoresis of protein and nucleic acids - Paper electrophoresis, Gel electrophoresis, discontinuous gel electrophoresis, PAGE, SDS-PAGE, Native gels, denaturing gels, agarose gel electrophoresis, Northern Blotting, Southern Blotting and Western blotting techniques – principle and applications</p>	08	15
	<p>2.2: Spectroscopic techniques</p> <p>Basic principle and working of – UV/VIS light spectroscopy, Fluorescence spectroscopy, NMR, IR spectroscopy, X-ray diffraction.</p>	07	
MODULE 3: Microscopy and Radioisotopes	<p>3.1: Microscopic techniques</p> <p>Basic components of the microscope.</p> <p>Working and representation and application of – compound microscope, electron microscope, Scanning electron microscope and confocal</p>	08	

	<p>microscope, Specimen preparation for electron microscope, scanning electron microscope and confocal microscope.</p> <p>3.2: Radioisotopes</p> <p>Concept of half-life, decay constant, detection methods - GM counter, solid and liquid scintillation counter, autoradiography; handling and safety of radioisotope, Applications of radioisotopes in biology.</p>	07	15
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BCH.E-1: TOOLS AND TECHNIQUES IN BIOCHEMISTRY (PRACTICAL)

SR.NO.	PRACTICAL	NO. OF PRACTICAL
1.	Estimation of proteins by Bradford's method	02
2.	Estimation of carbohydrate by DNSA method	02
3.	Separation and identification of amino acids by paper chromatography	02
4.	Isolation of cell organelle using density gradient centrifugation	02
5.	Demonstration of gel filtration chromatography	02
6.	SDS-PAGE analysis of proteins	03
7.	Lipid isolation by reverse phase chromatography	02
	Total	15

REFERENCES:

Mandatory Reading:

- Wilson K and Walker J. 2005. Principles and Techniques of Practical Biochemistry, 6th Edition, Cambridge University Press.

Additional Reading:

- Upadhyay A, Upadhyay K and Nath N. 2009. Biophysical Chemistry: Principles and Techniques, 3rd 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, 3rd edition, New Age International Publishers, New Delhi.

Web-links:

- <https://www.khanacademy.org/science/high-school-biology/hs-human-body-systems/hs-the-reproductive-system/a/hs-the-reproductive-system-review>
- <https://www.khanacademy.org/science/high-school-biology/hs-cells/hs-introduction-to-cells/a/microscopy>
- <https://www.khanacademy.org/test-prep/mcat/physical-processes/atomic-nucleus/a/decay-graphs-and-half-lives-article>
- <https://www.khanacademy.org/science/organic-chemistry/spectroscopy-jay/uv-vis-spectroscopy/v/uv-vis-spectroscopy>

ELECTIVE COURSE: ENZYMOLOGY

COURSE CODE:	BCH.E-17
MARKS:	100 (75 – Theory; 25 – Practical)
CREDITS:	4 (03 – Theory; 01 – Practical)
CONTACT HOURS:	Theory: 45 Hours (03 Lectures per week) Practical: 30 Hours (01 Practical per week)
COURSE OUTCOMES:	<p>On the successful completion of the course, students will be able to:</p> <p>CLO1: Explain the structure of an enzyme and kinetics of enzyme catalyzed reactions</p> <p>CLO2: Differentiate between types of enzyme inhibitions</p> <p>CLO3: Comprehend the wide applications of enzymes and future potential.</p> <p>CLO4: Isolate and purify crude forms of enzyme extract and apply appropriate method for determination of activity of enzyme</p> <p>CLO5: Discuss factors that affect enzymatic activity</p>

BCH.E-17: ENZYMOLOGY (THEORY)

MODULE	TOPICS	CONTACT HOURS	TOTAL HOURS
MODULE 1: Introduction to enzymes and Features of enzyme catalysis	1.1: Introduction to enzymes (8 L) Nature of enzymes - protein and non- protein (ribozyme); co-enzymes, cofactor & prosthetic group; apoenzyme; holoenzyme; ribozymes & isoenzymes; multienzyme complex, specificity of enzymes; classification of enzymes.	08	15
	1.2: Features of enzyme catalysis Fischer's lock and key hypothesis; Koshland's induced fit hypothesis; factors affecting the rate of reactions (time, enzyme concentration, substrate concentration, pH and temperature)	07	
MODULE 2: Enzyme Kinetics and Inhibition	<p>2.1: Enzyme kinetics 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</p> <p>2.2: Enzyme inhibition</p>	08	15

	Reversible inhibition (competitive, uncompetitive, non-competitive, mixed and suicide, end product); mechanism-based inhibitors - antibiotics as inhibitors; types of irreversible inhibition; allosteric inhibition	07	
MODULE 3: Mechanism of enzymes, Purification & applications of enzymes	3.1: Mechanisms of enzyme action and regulation Mechanism of action of chymotrypsin; regulation of enzyme activity and its importance - aspartate transcarbamoylase	04	15
	3.2: Enzyme purification Purification of enzymes: salt precipitation; dialysis; molecular exclusion chromatography; PAGE; Molecular weight determination by SDS-PAGE	06	
	3.3: Applications of enzymes Application of enzymes in diagnostics (SGPT, SGOT, creatine kinase, alkaline and acid phosphatases); enzyme immunoassay (HRPO); applications of enzymes in industry – detergents, leather, food	05	

BCH.E-17: ENZYMOLOGY (PRACTICAL)

SR. NO.	PRACTICAL	NO. OF PRACTICALS
1.	Preparation of buffers and solutions for the study of enzyme activity	01
2.	Effect of pH on enzyme activity	02
3.	Effect of temperature on enzyme activity	02
4.	Effect of substrate concentration and determination of K_m and V_{max}	02
5.	Partial purification of an enzyme from a suitable source, ammonium sulphate precipitation, dialysis	03
6.	Assay of enzyme activity and specific activity	01
7.	Native-PAGE	03
8.	Zymogram	01
	Total	15

REFERENCES for BCH.E-17 (Latest Editions)

Mandatory Reading

- Malcolm, D. and Edwin C. Webb. Enzymes. Academic Press Inc., Publishers, New York

Supplementary Reading

- Nelson, D. L. and Cox, M. M. Lehninger's Principles of Biochemistry. Worth Publishers, New York, USA.
- Stryer, L., Berg, J., Tymoczko, J. and Gatto, G. Biochemistry. W. H. Freeman and Co., New York, USA.
- Murray, R. K., Granner, D. K., Mayes, P. A. and Rodwell, V. W. Harper's Illustrated Biochemistry. McGraw-Hill Companies.
- Jain, J. L., Jain, S. and Jain, N. Fundamentals of Biochemistry. S. Chand and Company, Ltd., New Delhi.
- Harvey, R.A. and Ferrier, D.R. Lippincott's Illustrated Reviews, Biochemistry. Lippincott Williams and Wilkins.
- Voet, D. and Voet, J. G. Biochemistry. John Wiley & Sons, Inc, USA.

Web References

- <https://www.khanacademy.org/test-prep/mcat/biomolecules/enzyme-structure-and-function/a/enzyme-structure-and-function>
- <https://www.khanacademy.org/test-prep/mcat/biomolecules/enzyme-kinetics/v/an-introduction-to-enzyme-kinetics>
- <https://www.ncbi.nlm.nih.gov/pmc/articles/PMC5956270/>
- http://web.sungshin.ac.kr/~spark/class/enzchem/EnzChem_ch02.pdf
- <https://www.chem.wisc.edu/deptfiles/genchem/netorial/modules/biomolecules/modules/enzymes/enzyme3.htm>
- https://www.creative-enzymes.com/resource/enzyme-definition-and-classification_18.html
- <https://www.youtube.com/watch?v=OY1WsqlcUdo>
- https://www.youtube.com/watch?v=Z2ZN_9nF11E

ELECTIVE COURSE: FUNDAMENTALS OF MICROBIOLOGY

COURSE CODE:	BCH.E-18
MARKS:	100 (75 – Theory; 25 – Practical)
CREDITS:	4 (03 – Theory; 01 – Practical)
CONTACT HOURS:	Theory: 45 Hours (03 Lectures per week) Practical: 30 Hours (01 Practical per week)
COURSE OUTCOMES:	<p>On the successful completion of the course, students will be able to:</p> <p>CLO1: Comprehend the scope and importance of Microbiology, classification schemes, cultivation, preservation, and maintenance of the microbial cultures.</p> <p>CLO2: Discriminate between various groups of microorganisms using staining techniques.</p> <p>CLO3: Compare, analyze and apply concepts of the principle and working of various types of microscopes.</p> <p>CLO4: Adhere to strict laboratory safety measures to be followed in a microbiology laboratory.</p> <p>CLO5: Acquire basic skills in aseptic techniques and acquaint with various sterilization techniques.</p>

BCH.E-18: FUNDAMENTALS OF MICROBIOLOGY (THEORY)

MODULE	TOPICS	CONTACT HOURS	TOTAL HOURS
MODULE 1: History & Development of Microbiology; Ultrastructure of a bacterial cell, growth curve – types, characteristics	1.1: History and Scope of Microbiology Contributions of Anton von Leeuwenhoek, Louis Pasteur, Robert Koch, Joseph Lister, Alexander Fleming, Paul Ehrlich, Elie Metchnikoff, Edward Jenner in the fields of microbiology and immunology. Basics of Binomial Nomenclature; Classification systems of Whittaker (five Kingdom) and Carl Woese (three Domain).	05	15

	<p>Tree of Life.</p> <p>1.2: Basics of Microscopy Principle, design and working of light microscope (Bright-field, Dark-field, Phase-contrast, Fluorescence). Preparation of samples.</p> <p>1.3: Bacterial cell organization, reproduction and growth curve Bacterial cell: Organization and ultrastructure; Gram characteristics. Reproduction in bacteria - Binary fission Bacterial growth curve- characteristics of growth phases; diauxic growth curve</p>	<p>03</p> <p>07</p>	
<p>MODULE 2: Methods of cultivating and preserving bacteria</p>	<p>2.1: Cultivation of microorganisms Sterilization: Principle and methods. Types of culture media: Synthetic/defined, complex, solid, liquid, enrichment, selective, differential. Cultivation of microorganisms: Aerobic and anaerobic, Broth cultures, agar plate, pour plate. Determination of viable count: MPN, Serial dilution, spread plating, pour plating, determination of colony forming units (cfu) and calculation of viable count. Isolation of pure cultures: Streak plate; colony characteristics</p> <p>2.2: Maintenance and preservation of microbial cultures Slant and stab cultures, periodic transfer, storage in sterile soil, overlaying with mineral oil, glycerol stocks, preservation in liquid nitrogen, lyophilization</p>	<p>10</p> <p>05</p>	<p>15</p>

MODULE 3: Fungi and Viruses	3.1: Fungi General characteristics of fungi: habitat, nutritional requirements, cell ultra-structure, thallus organization, cell wall structure. Reproduction: sexual and asexual reproduction. Mycotoxins.	08	15
	3.2: Viruses Structure and classification: Bacterial, plant and animal viruses. Bacteriophage multiplication (lytic and lysogenic)	07	

BCH.E-18: FUNDAMENTALS OF MICROBIOLOGY (PRACTICAL)

SR. NO.	PRACTICAL	NO. OF PRACTICALS
1.	Introduction to microbiology laboratory equipments: Autoclave, Millipore filters and assembly, incubators, hot air oven, Laminar air flow, Biosafety cabinet, microscope, pH meter.	01
2.	Preparation and sterilization of glass wares	01
3.	Preparation and sterilization of liquid and solid culture media.	01
4.	Preparation of media agar plates, butts and slants.	01
5.	Determination of viable count (soil and water sample): Serial dilution, spread plating, quantification of colony forming units (cfu) and calculation of viable count.	03
6.	Isolation of pure cultures: Streak plate (T-streak, quadrant, radiant); colony characteristics	01
7.	Gram staining and cell morphology.	01
8.	Demonstration of coliphage in water sample.	02
9.	Isolation and staining of Fungi (Rhizopus, Mucor, Aspergillus, Penicillium) by lactophenol cotton blue.	02
10.	Decontamination and disposal of cultures	01
	Total	15

REFERENCES for BCH.E-18 (Latest Editions)

Mandatory Reading

- Pelczar, M. J., Chan E, C.S., and Krieg, N.R. Microbiology. McGraw Hill Education.
- Willey, J. M., Sherwood, L., Woolverton, C. J. and Prescott, L. M. Prescott, Harley, and Klein's microbiology. New York, McGraw-Hill Higher Education.

Supplementary Reading

- Atlas, R.M., Anantnaryan, R. and Paniker, C.K.J. Textbook of Microbiology, The OrientBlackswan.
- Madigan, M. T., Martinko. J. M. and Parker J. Brock's Biology of Microorganisms, PrenticeHall College Div.
- Stanier, R.Y. General Microbiology, Cambridge University.

Web References

- <https://openstax.org/details/books/microbiology>
- <https://vlab.amrita.edu/?sub=3&brch=73&sim=1105&cnt=1>
- http://textbookofbacteriology.net/growth_3.html
- <https://www.khanacademy.org/science/biology/bacteria-archaea/prokaryote-structure/v/bacteria>

SEMESTER III

<u>ELECTIVE COURSE: NUTRITIONAL BIOCHEMISTRY</u>	
COURSE CODE:	BCH.E-6
MARKS:	100 (75 – Theory; 25 – Practical)
CREDITS:	4 (03 – Theory; 01 – Practical)
CONTACT HOURS:	Theory: 45 Hours (03 Lectures per week) Practical: 30 Hours (01 Practical per week)
COURSE OUTCOMES:	On the successful completion of the course, students will be able to: CO1: Explain the various sources of food and RDA CO2: Apply theoretical and practical knowledge of antioxidants in various food samples. CO3: Correlate various nutritional disorders and the importance of diet CO4: Describe and design diet plans for different age groups.

BCH.E-6: NUTRITIONAL BIOCHEMISTRY (THEORY)

MODULE	TOPICS	CONTACT HOURS	TOTAL HOURS
<p align="center">MODULE 1: Nutrition & Energy Metabolism, Dietary Carbohydrates and Dietary Lipids</p>	<p>1.1: Nutrition and Energy Metabolism Introduction, role of nutrients, unit of energy; Biological oxidation of foodstuff, calorific value 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), Water metabolism, electrolyte imbalance; dehydration, Probiotics and prebiotics: sources and significance in the diet</p> <p>1.2: Dietary Carbohydrates Food sources, RDA, hormonal regulation of blood glucose, Diabetes: types and nutrition intake, Glycemic Index, Fiber; food sources, significance, Problems associated with carbohydrate intake.</p> <p>1.3: Dietary Lipids Food sources, RDA, significance of: MUFA, PUFA, Saturated fatty acids, Omega fatty acids, TGs, Cholesterol, Lipoproteins, Phospholipids, deficiency and disorders related to dietary lipids.</p>	<p align="center">07</p> <p align="center">03</p> <p align="center">05</p>	<p align="center">15</p>
<p align="center">MODULE 2: Dietary Proteins, Vitamins and Mineral metabolism</p>	<p>2.1: Dietary proteins Essential and non-essential amino acids, Food source, Protein malnutrition, Nitrogen balance Supplements – risk of imbalance and toxicity of amino acids.</p> <p>2.2: Vitamins Fat soluble vitamins: Types and sources, physiological role, deficiency disorders, toxicity. Water soluble vitamins: Types and sources, physiological role, deficiency disorders, toxicity.</p> <p>2.3: Mineral Metabolism</p>	<p align="center">04</p> <p align="center">06</p> <p align="center">05</p>	<p align="center">15</p>

	<p>Macronutrients – calcium, magnesium, sodium, potassium, phosphorus, sulphur and chlorine; physiological role, deficiency disorders and toxicity.</p> <p>Trace elements – essential and non-essential - physiological role, deficiency disorders and toxicity.</p>		
<p>MODULE 3: Food Allergens and Diet Plans</p>	<p>3.1: Food allergens</p> <p>Food allergens: gluten, milk and milk products, nuts, soy products, fish and shellfish. PEM – Marasmus and Kwashiorkar and Bulimia.</p> <p>3.2: Diet Plans</p> <p>Atkin’s Diet, Keto Diet, Paleo Diet, Vegetarian and Veganism, Intermittent fasting and its effects on health.</p> <p>Diet plans for different age groups.</p>	<p>05</p> <p>10</p>	<p>15</p>

BCH.E-6: NUTRITIONAL BIOCHEMISTRY (PRACTICAL)

SR. NO.	PRACTICAL	NO. OF PRACTICALS
1.	Preparation of Probiotics, microscopy and sensory evaluation	02
2.	Assessment of Vitamin constituents in various foods: Lycopene, - β carotene	06
3.	Assessment of Nutritional Disorders: Anaemia, Hyperglycemia	02
4.	Formulating a Diet Plan: Diabetes, Sports Persons, Pregnancy	05
	Total	15

REFERENCES for BCH.E-6

Mandatory Reading

- Gibson, R. Principles of Nutritional Assessment. Oxford University Press.

Supplementary Reading

- Frazier, W.C and Westhoff, D.C. Food Microbiology. McGraw Hill Education (India) Private Limited: New Delhi
- Tiwari, R.P., Hoondal, G.S. and Tewari, R. Laboratory Techniques in Microbiology and Biotechnology, Abhishek Publications Chandigarh (India).
- Murray, R.K., Granner, D.K., Mayes, P.A. and Rodwell, V.W. Harper's Illustrated Biochemistry, Twenty-Sixth Edition Lange Medical Publications. New York
- Williams, M.H., Anderson, D.E. and Rawson, E.S. Nutrition for health, fitness and sport; McGraw Hill international edition.

Web References

- <http://www.biologydiscussion.com/nutrition/nutritional-characteristics-of-a-substance-protein-value/44329>
- <https://www.khanacademy.org/science/high-school-biology/hs-biology-foundations/hs-biological-macromolecules/v/introduction-to-vitamins-and-minerals>
- <https://www.khanacademy.org/test-prep/mcat/biomolecules/enzyme-structure-and-function/v/cofactors-coenzymes-and-vitamins>
- <https://www.khanacademy.org/science/health-and-medicine/gastrointestinal-system-diseases/celiac-disease/v/what-is-gluten>
- <https://www.khanacademy.org/test-prep/mcat/biological-sciences-practice/biological-sciences-practice-tut/e/the-underlying-mechanism-of-milk-allergies->

<u>CORE COURSE: IMMUNOLOGY</u>	
COURSE CODE:	BCH-IV.C-6A
MARKS:	100 (75 – Theory; 25 – Practical)
CREDITS:	4 (03 – Theory; 01 – Practical)
CONTACT HOURS:	Theory: 45 Hours (03 Lectures per week) Practical: 30 Hours (01 Practical per week)
COURSE OUTCOMES:	On the successful completion of the course, students will be able to: CLO1: Comprehend the scope of the history of immunological studies CLO2: Gain knowledge of the structure and function of the cells and organs of immune systems CLO3: Describe the mechanisms of Ag-Ab reaction, hypersensitivity reactions and importance of the complement system CLO4: Recognize the importance of Monoclonal Ab and various immunodeficiency diseases CLO5: Describe the working principle of various techniques involved in Immunology

BCH-IV.C-6A: IMMUNOLOGY (THEORY)

MODULE	TOPICS	CONTACT HOURS	TOTAL HOURS
MODULE 1: Introduction to the immune system and the cells and organs involved	1.1: The immune system Introduction to the immune system - historical perspective; 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	08	15
	1.2: Cells and Organs of the Immune system Cells (myeloid and lymphoid lineage); immune-reactive cells (macrophages, granulocytes, NK Cells); primary lymphoid organs (bone marrow and thymus); secondary lymphoid organs; (spleen, lymph nodes, GALT and MALT).	07	
	2.1: B and T cells B-cells & T-cells – structure; function and significance; maturation, activation of B-cells and T-cells	04	

<p style="text-align: center;">MODULE 2: B & T cells, Antigen-antibody interactions and the Complement system</p>	<p>2.2: Antigen-Antibody Interactions Introduction to antigens and antibodies; structure, types, classes, properties and variants (e.g. immunogens, antigens, haptens, adjuvants); paratope and epitope; antigen – antibody interaction; forces involved in antigen-antibody reaction; concept of affinity, avidity, precipitation, agglutination reactions; immunoelectrophoresis, applications in diagnostics. RIA, ELISA.</p>	<p>08</p>	<p>15</p>
	<p>2.3: The complement system The complement system; functions, components and activation pathways (classical, alternate & lectin)</p>	<p>03</p>	

MODULE 3: MHC & Hypersensitivity, Vaccines & Monoclonal antibodies and Autoimmunity	3.1: MHC and Autoimmunity 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;	05	15
	Introduction to autoimmunity with examples; introduction to immunodeficiency types with examples	05	
	3.2: Hypersensitivity Introduction and types of hypersensitivity	05	
	3.3: Vaccine and Monoclonal Antibodies Introduction to vaccines and types of vaccines; Polyclonal & Monoclonal antibodies (hybridoma technology)	05	

BCH-IV.C-6A: IMMUNOLOGY (PRACTICAL)

SR. NO.	PRACTICAL	NO. OF PRACTICALS
1.	Study of lymphoid organs and cells of the Immune System	01
2.	Total count of WBC & RBCs using hemocytometer	02
3.	Differential count of WBC	01
4.	Blood grouping & Rh factor	01
5.	Preparation of serum	01
6.	Single Radial Immuno-diffusion	02
7.	Ouchterlony's double diffusion method and antibody titer calculation	02
8.	Immuno-electrophoresis	01
9.	ELISA (Demonstration)	02
10	Serological tests involving precipitations (Pregnancy &Widal)	02
	Total	15

REFERENCES for BCH-IV.C-6

Mandatory Reading

- Richard, A. G., Thomas, J. K. & Barbara A. O., (2018). Kuby Immunology, (7th Edition). W. H. Freeman & Company, New York.

Supplementary Reading

- Punt J., Stranford S., Jones P, Owen, J. A. (2018). Kuby Immunology, (8th Edition). W. H. Freeman & Company, New York.
- Arora, M.P. (2006). Cell Biology, Immunology and Environmental Biology, Himalaya Publishing House.
- Rao, C. V. (2011). Immunology (5th Edition), Narosa Publishing House Pvt. Ltd.
- Roitt, I., Brostoff, J. & Male, D.K. (2012). Immunology, (8th Edition). Elsevier Health, UK

Web References

- <https://www.khanacademy.org/test-prep/nclex-rn/rn-immune-system>
- <https://www.youtube.com/watch?v=yDAGxVxY-L8>
- <https://www.frontiersin.org/articles/10.3389/fimmu.2017.00292/full>
- <https://www.ncbi.nlm.nih.gov/books/NBK459471/>
- <https://www.immunology.org/public-information/bitesized-immunology/immune-dysfunction/autoimmunity-introduction>
- <https://www.youtube.com/watch?v=2-57bqFSJ1E>

SEMESTER IV

<u>ELECTIVE COURSE: HUMAN PHYSIOLOGY</u>	
COURSE CODE:	BCH.E-5
MARKS:	100 (75 – Theory; 25 – Practical)
CREDITS:	4 (03 – Theory; 01 – Practical)
CONTACT HOURS:	Theory: 45 Hours (03 Lectures per week) Practical: 30 Hours (01 Practical per week)
COURSE OUTCOMES:	On the successful completion of the course, the students will be able to: CO1: Describe the various chromosomal theories and Mendelian genetics. CO2: Understand and analyze the pedigree chart and inheritance pattern in a family CO3: Correlate various genetic disorders to chromosomal mutations CO4: Explain the various sex-determining mechanisms in animals

BCH.E-5: HUMAN PHYSIOLOGY (THEORY)

MODULE	TOPICS	CONTACT HOURS	TOTAL HOURS
MODULE 1: General Physiology and Body Fluids	1.1: Introduction to General physiology Overview of cell structure, composition, tissues, organs and systems, Transport through cell membrane – Passive and Active transport, Homeostasis	06	15
	1.2: Body Fluids Body fluids: intracellular, extracellular and interstitial fluid, Plasma, Blood, Lymph: RBCs, WBCs, clotting cascade mechanism, Blood related disorders: anemia, hemophilia, polycythemia, thalassemia, acidosis	09	
MODULE 2: Organ Systems I	2.1: Skeletal and Muscular System Introduction to the skeletal system, types of bones, composition, functions of bones. Introduction to muscular system, types of muscles, structure of muscle, Physiology of muscle contraction: proteins involved, neuromuscular junction, role of acetylcholine. Disorders of skeletal muscle: Duchenne muscular dystrophy, Myasthenia gravis, Osteoporosis, arthritis – physiological and immunological.	05	15
	2.2: Digestive System Introduction, parts of digestive system, gastrointestinal hormones, digestion and absorption, peristaltic system. Accessory organs of digestive system, Disorders of GI tract: GERD, Gastritis, Celiac disease and Liver cirrhosis.	04	
	2.3: Respiratory and Cardiovascular system Introduction to respiratory system, functional anatomy of respiratory tract, lung volumes, Cardiovascular system: heart, blood vessels, divisions of circulation, Pacemaker, Cardiac cycle, ECG, Heart sounds, cardiovascular diseases: MI and Arrhythmia.	06	
MODULE 3: Organ Systems II	3.1: Excretory System Introduction, anatomy and functions of excretory system, Nephron, Renal circulation, Urine formation, Renal function tests, Renal disorders: Nephrosis, kidney stones.	05	15
	3.2: Nervous system Introduction, parts of brain, spinal cord, neuron and its associated functions, membrane potential, synapse, neurotransmitters, EEG, Disorders: Alzheimer's, Epilepsy and Meningitis.	05	

	3.3: Reproductive system Functional anatomy of male and female reproductive system, menstrual cycle, spermatogenesis and oogenesis, PCOS, uterine fibroids, prostatitis and erectile dysfunction.	05	
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BCH.E-5: HUMAN PHYSIOLOGY (PRACTICAL)

SR. NO.	PRACTICAL	NO. OF PRACTICALS
1.	Determination of clotting time	01
2.	Estimation of hemoglobin	01
3.	Observation of permanent slides – Transverse section of mammalian gonads, muscles, nerve cells	01
4.	Analysis of human blood pressure and pulse rate in man	01
5.	Determination of glucose and albumin in urine	02
6.	Determination of sugar in blood	01
7.	Determination of ESR and PCV	02
8.	Effect of different salt solutions on RBC's	01
9.	Liver function test	01
10.	Kidney function tests	01
11.	Progesterone estimation (kit based)	01
12.	Analysis of ECG	01

13.	Case studies	01
	Total	15

REFERENCES for BCH.E-5

Mandatory Reading

- Sembulingam K. and Sembulingam P. Essentials of Medical Physiology, Jaypee brothers medical publishers (P) Ltd, New Delhi.

Supplementary Reading

- Arora, M.P. Animal physiology, Himalaya publishing house, New Delhi.
- Verma, S.K., Tyagi, A.K. and Agarwal, B.B.L. Animal Physiology, S. Chand and Company.
- Guyton, A.C and Hall, J.E. Textbook of Medical Physiology, Reed Elseviers India Pvt. Ltd. New Delhi.
- Murray, R. K., Granner, D. K., Mayes, P. A. and Rodwell, V. W. Harper's Illustrated Biochemistry. McGraw-Hill Companies.
- Buja L. M. and Krueger G. R. F. Netter's Illustrated Human Pathology. Elsevier Inc., Philadelphia.
- Sadasivam, S. and Manickam A. Biochemical Methods, New Age International Publishers, New Delhi.

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- <https://www.khanacademy.org/science/high-school-biology/hs-human-body-systems/hs-body-structure-and-homeostasis/a/homeostasis>
- <https://www.khanacademy.org/science/high-school-biology/hs-human-body-systems/hs-the-digestive-and-excretory-systems/a/hs-the-digestive-and-excretory-systems-review>
- <https://www.khanacademy.org/science/high-school-biology/hs-human-body-systems/hs-the-circulatory-and-respiratory-systems/a/hs-the-respiratory-system-review>
- <https://www.khanacademy.org/science/high-school-biology/hs-human-body-systems/hs-the-circulatory-and-respiratory-systems/a/hs-the-circulatory-system-review>
- <https://www.khanacademy.org/science/biology/human-biology/neuron-nervous-system/a/the-membrane-potential>
- <https://www.khanacademy.org/science/high-school-biology/hs-human-body-systems/hs-the-reproductive-system/a/hs-the-reproductive-system-review>
- <https://openstax.org/details/books/biology-2e>

BCH.E-8: ADVANCED CELL BIOLOGY (THEORY)

MODULE	TOPICS	CONTACT HOURS	TOTAL HOURS
MODULE 1: Membrane Transport and potentials; Nerve impulses	1.1: Membrane Transport Composition and properties of cell membrane; structure of nuclear envelope; nuclear pore complex Transport across nuclear envelope -Simple diffusion and facilitated diffusion -Passive transport - glucose transporter, anion transporter -Primary active transporters - P type ATPases, V type ATPases, F type ATPases -Secondary active transporters – Na + glucose symporter -Ion channels: voltage-gated ion channels (Na + /K + voltage-gated channel)	12	15
	1.2: Membrane potentials and Nerve impulses Resting potential, Action potential, Propagation of action potentials, Neurotransmission	03	
MODULE 2: Cell Cycle and Programmed Cell Death	2.1: Cell Cycle and Programmed Cell Death Cell cycle; events of mitosis; cytokinesis; Events of meiosis; regulation of cell division; Apoptosis (extrinsic and intrinsic pathway)	15	15
MODULE 3: Cancer Biology and Tools used in Cell Biology	3.1: Cancer Biology Development and causes of cancer; genetic basis; oncogenes, tumor viruses	09	15
	3.2: Tools in Cell Biology Microscopy: Light microscope, Phase contrast microscope, Inverted microscope, Fluorescence microscope, Confocal microscope, Electron microscope Centrifugation: Differential and gradient centrifugation for sub-cellular fractionation	06	

BCH-IV.E-8: ADVANCED CELL BIOLOGY (PRACTICAL)

SR. NO.	PRACTICAL	NO. OF PRACTICALS
1.	Identification of different stages of mitosis (in onion root tip/WBC)	02
2.	Identification of different stages of meiosis (in flower buds)	01
3.	Study of cell viability by neutral red (viable cells) and trypan blue (non-viable cells)	01
4.	Identification and study of cancerous cells using permanent slides/ photomicrographs	02
5.	Study of plant, animal and human tumour viruses using photomicrographs	01
6.	Differential centrifugation for separation of cellular components	01
7.	Preparation of sucrose density gradient and purification of sub cellular organelles: visualization of nuclear fraction by acetocarmine stain and mitochondria by Janus green stain	05
8.	Study of electron micrographs of sub-cellular organelles	01
	Total	15

REFERENCES for BCH.E-8 (Latest editions)

Mandatory Reading

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

Supplementary Reading

- Nelson, D. L. & Cox, M.M. (2017). Lehninger's Principles of Biochemistry (7th Edition). Worth Publishers, New York, USA.
- Karp, G. & Harris, D. (2013). Cell and Molecular Biology – Concepts and Experiments (7th Edition), John Wiley & Sons Inc, New York.
- Robertis, E. D. P. & Robertis, E. M. F. (2017). Cell Biology and Molecular Biology (8th Edition). Saunders College.
- Watson, J.D., Hopkins, N.H. et al. (2008). Molecular Biology of the Gene, Garland Publishing (Taylor & Francis Group), New York & London.
- Verma P. S. & Agarwal V. K. (2005). Cell Biology, Genetics, Molecular Biology, Evolution, and Ecology (14th edition). S. Chand & Company Ltd., New Delhi

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- <https://www.khanacademy.org/science/biology/membranes-and-transport>
- [https://chem.libretexts.org/Bookshelves/Analytical_Chemistry/Supplemental_Modules_\(Analytical_Chemistry\)/Electrochemistry/Examples/Membrane_Potentials](https://chem.libretexts.org/Bookshelves/Analytical_Chemistry/Supplemental_Modules_(Analytical_Chemistry)/Electrochemistry/Examples/Membrane_Potentials)
- [https://bio.libretexts.org/Bookshelves/Genetics/Book%3A_Online_Open_Genetics_\(Nickle_and_Barrette-Ng\)/13%3A_Cancer_Genetics/13.2%3A_Cancer_Cell_Biology](https://bio.libretexts.org/Bookshelves/Genetics/Book%3A_Online_Open_Genetics_(Nickle_and_Barrette-Ng)/13%3A_Cancer_Genetics/13.2%3A_Cancer_Cell_Biology)
- [https://bio.libretexts.org/Bookshelves/Cell_and_Molecular_Biology/Book%3A_Cells_-_Molecules_and_Mechanisms_\(Wong\)/16%3A_Viruses%2C_Cancer%2C_and_the_Immune_System/16.3%3A_Cancer](https://bio.libretexts.org/Bookshelves/Cell_and_Molecular_Biology/Book%3A_Cells_-_Molecules_and_Mechanisms_(Wong)/16%3A_Viruses%2C_Cancer%2C_and_the_Immune_System/16.3%3A_Cancer)

SEMESTER V

<u>CORE COURSE: MOLECULAR BIOLOGY</u>	
COURSE CODE:	BCH-V.C-7
MARKS:	100 (75 – Theory; 25 – Practical)
CREDITS:	4 (03 – Theory; 01 – Practical)
CONTACT HOURS:	Theory: 45 Hours (03 Lectures per week) Practical: 30 Hours (01 Practical per week)
COURSE OUTCOMES:	On the successful completion of the course, the students will be able to: CO1: Comprehend the scope and significance of molecular biology by imbibing the principles of hereditary genetic transmission and interactions of gene with the environment. CO2: Compare and contrast DNA, RNA and Proteins. CO3: Describe the process of DNA replication and transcription. CO4: Apply the practical and theoretical knowledge of various molecular techniques.

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

MODULE	TOPICS	CONTACT HOURS	TOTAL HOURS
MODULE 1: Chemical Nature of Genetic Materials	1.1: Nucleic Acids, bonds, types of DNAs, DNA packaging and model organisms Structural components of nucleic acid: Sugar, Phosphate, Nucleosides and Nucleotides; Structure of DNA: Watson – Crick Model, Different forms of DNA (B, 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 Chargaff's experiments and Law	10	15
	05		

	<p>1.2: Chromosome</p> <p>Fundamental functions of DNA.</p> <p>Chromosomal DNA and its packaging in the chromatin fibre. Chromatin structure, structural features (Telomere, Centromere and Repetitive sequences) of chromosomes and their functions, prokaryotic chromosomes, plasmids.</p>		
<p>MODULE 2: DNA/RNA a genetic material and DNA Replication</p>	<p>2.1: DNA/RNA as genetic material</p> <p>DNA as genetic material: Griffith's transforming principle, and Avery, Hershey and Chase Experiment proving DNA as genetic material</p> <p>RNA as the genetic material of some viruses</p> <p>2.2: DNA Replication</p> <p>Experimental evidence for semi-conservative DNA replication in E.coli - Messelson and Stahl's experiment</p> <p>DNA template, Enzymes - DNA polymerases, ligase, DNA gyrase, Structure and function, Ancillary proteins associated with replication</p> <p>Mechanism of replication: Initiation, Elongation and Termination; Introduction to theta and rolling circle models</p> <p>DNA Proof reading.</p>	<p>08</p> <p>07</p>	<p>15</p>
<p>MODULE 3: DNA damage, repair and recombination</p>	<p>3.1: DNA Damage and its Repair</p> <p>Types of DNA damage (spontaneous and induced). AMES Test</p> <p>Mechanisms/pathways to repair DNA: Excision repair, mismatch repair, recombination repair in <i>E. coli</i> and SOS Repair. Role of <i>RecA</i> in DNA damage repair, Photoreactivation repair in <i>E.coli</i> involving photolyase.</p>	<p>08</p> <p>07</p>	<p>15</p>

	<p>3.2: Mechanisms of Genetic Recombination</p> <p>General and site specific recombination.</p> <p>Heteroduplex DNA formation (Homologous recombination).</p> <p>Synaptonemal Complex, Bacterial <i>RecBCD</i> system and its stimulation of chi sequences.</p> <p>Role of <i>RecA</i> protein, homologous recombination, Holliday junctions.</p>		
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BCH-V.C-7: MOLECULAR BIOLOGY (PRACTICAL)

SR. NO.	PRACTICAL	NO. OF PRACTICALS
1.	Isolation of genomic DNA from prokaryotes and eukaryotes	05
2.	Isolation of RNA from prokaryotes	02
3.	Agarose gel electrophoresis of genomic DNA and its elution	05
4.	Mutagenesis in <i>E.coli</i> cells – UV	03
	Total	15

REFERENCES

Mandatory Reading

- David, C., Nanette, P. and Michelle, M. Molecular Biology. Elsevier Academic Press.

Supplementary Reading

- Murray, R., Granner, D., Mayes, P. and Rodwell, V. Harper's Illustrated Biochemistry. Mc Graw Hill.
- Watson, J. D., Baker, T.A., Bell, S.P., Gann, A., Levine, M. and Losick, R.M. Molecular biology of the gene. Menlo Park, CA: Benjamin-Cummings.
- Alberts, B., Johnson, A., Lewis, J., Raff, M., Roberts, K. and Walter, P. Molecular biology of the cell. New York: Garland Science.
- Gardner, M. J., Simmons D.P. Snustad. Principles of Genetics. John Wiley & Sons.
- Dubey, R.C. Advanced Biotechnology. S. Chand Publishing.

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- <https://vlab.amrita.edu/?sub=3&amr;brch=73&amr;sim=1105&amr;cnt=1>.
- http://textbookofbacteriology.net/growth_3.html
- <https://openstax.org/details/books/biology-2e>
- [https://bio.libretexts.org/Bookshelves/Introductory_and_General_Biology/Book%3A_Concepts_in_Biology_\(OpenStax\)/9%3A_Molecular_Biology](https://bio.libretexts.org/Bookshelves/Introductory_and_General_Biology/Book%3A_Concepts_in_Biology_(OpenStax)/9%3A_Molecular_Biology)

SEMESTER V

<u>ELECTIVE COURSE: CONCEPTS IN GENETICS</u>	
COURSE CODE:	BCHE-9
MARKS:	100 (75 – Theory; 25 – Practical)
CREDITS:	4 (03 – Theory; 01 – Practical)
CONTACT HOURS:	Theory: 45 Hours (03 Lectures per week) Practical: 30 Hours (01 Practical per week)
COURSE OUTCOMES:	On the successful completion of the course, the students will be able to: CO1: Describe the various chromosomal theories and Mendelian genetics. CO2: Comprehend and analyze the pedigree chart and inheritance pattern in family CO3: Correlate various genetic disorders to chromosomal mutations CO4: Explain the various sex-determining mechanisms in animals

	<p>3.2: Population Genetics</p> <p>Hardy-Weinberg law, Factors affecting Hardy Weinberg theory, Predicting allele and Genotype frequencies and exceptions to Hardy-Weinberg principle, Speciation: types and examples.</p>		
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BCH.E-9: CONCEPTS IN GENETICS (PRACTICAL)

SR. NO.	PRACTICAL	NO. OF PRACTICALS
1.	Study of Mendelian traits in Human Population	03
2.	Pedigree analysis and problem solving	03
3.	Karyotype analysis of chromosomal abnormalities	03
4.	Smear technique to demonstrate sex chromatin in buccal epithelial cells (Barr bodies in sex determination)	02
5.	Problem solving on Mendel's laws and Hardy-Weinberg's law	03
6.	Bacterial Conjugation (kit-based)	01
	Total	15

REFERENCES for BCH.E-9

Mandatory Reading

- Tamarin, R.H. (2017). Principles of Genetics (7th 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.

Supplementary Reading

- Stryer, L; Berg, J; Tymoczko, J & Gatto, G. (2019). Biochemistry (9th Edition). W. H. Freeman and Co., New York, USA.
- Murray, R. K, Granner, D. K., Mayes, P. A. & Rodwell, V. W. (2018). Harper's Illustrated Biochemistry (31st Edition). McGraw-Hill Companies.

- Jain, J. L.; Jain S. & Jain N. (2016). Fundamentals of Biochemistry (7th Edition). S.Chand and Company, Ltd., New Delhi.
- Verma, P. S. and Agarwal, V. K. (2013). Cell Biology, Genetics, Molecular Biology, Evolution and Ecology, S. Chand and Company Pvt. Ltd.
- Harvey, R.A. & Ferrier, D.R. (2017). Lippincott's Illustrated Reviews, Biochemistry (7th Edition). Lippincott Williams and Wilkins.
- Voet, D. and Voet, J. G. Biochemistry. John Wiley & Sons, Inc, USA.
- Lewin B., Krebs J. E., Goldstein E. S. and Kilpatrick S. T. Genes XI. Jones & Bartlett Publishers

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- <http://www.biologydiscussion.com/mendel/mendel-study-on-genetics-mendelian-inheritance/38754>
- <https://www.khanacademy.org/science/high-school-biology/hs-classical-genetics/hs-pedigrees/v/pedigrees>
- <https://study.com/academy/lesson/hardy-weinberg-equilibrium-i-overview.html>
- <http://www.biologydiscussion.com/genetics/structural-change-in-the-structure-of-chromosomes/5261>
- <https://www.khanacademy.org/science/high-school-biology/hs-classical-genetics/hs-sex-linkage/a/x-inactivation>
- <https://www.khanacademy.org/science/biology/classical-genetics/chromosomal-basis-of-genetics/a/discovery-of-the-chromosomal-basis-of-inheritance>

SEMESTER V

<u>ELECTIVE COURSE: REGULATION OF GENE EXPRESSION</u>	
COURSE CODE:	BCH.E-10
MARKS:	100 (75 – Theory; 25 – Practical)
CREDITS:	4 (03 – Theory; 01 – Practical)
CONTACT HOURS:	Theory: 45 Hours (03 Lectures per week) Practical: 30 Hours (01 Practical per week)
COURSE OUTCOMES:	On the successful completion of the course, the students will be able to: CO1: Differentiate between the process of transcription in prokaryotes and eukaryotes CO2: Compare and contrast between translation that happens in prokaryotes and eukaryotes CO3: Explain how gene regulation takes place in prokaryotes CO4: Elaborate how gene regulation occurs in eukaryotes CO5: Understand how genes can be regulated for the production of (gene) products of interests

BCH.E-10: REGULATION OF GENE EXPRESSION (THEORY)

MODULE	TOPICS	CONTACT HOURS	TOTAL HOURS
MODULE 1: Transcription in Prokaryotes and Eukaryotes	1.1: Concept of Central Dogma	01	15
	1.1: Transcription in Prokaryotes Introduction to genetic code: Features of genetic code, wobble hypothesis Prokaryotes: RNA polymerases, Sigma factor, Bacterial promoters; RNA synthesis, Rho-dependent and Rho-independent termination; Inhibitors of transcription and applications as anti-microbial drugs	07	
	1.2: Transcription in Eukaryotes 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	07	
MODULE 2: Splicing, Translation, Gene regulation	2.1: RNA Splicing The spliceosome machinery, Group I and group II introns, Alternative splicing, Exon shuffling	03	15
	2.2: Translation in Prokaryotes and Eukaryotes 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 antimicrobial drugs	09	
	2.3: Introduction to gene regulation	03	
MODULE 3:	3.1: In Prokaryotes Concept of operon - structural and regulatory genes, Operator, promoter. Negative and positive regulation. Operon; Lactose operon, Tryptophan operon	07	15

Regulation of Gene Regulation in Prokaryotes and Eukaryotes	3.2: Regulation of Gene Expression in Eukaryotes Euchromatin and heterochromatin, 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	08	
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BCH.E-10: REGULATION OF GENE EXPRESSION (PRACTICAL)

SR. NO.	PRACTICAL	NO. OF PRACTICALS
1.	Isolation of RNA from prokaryotes and eukaryotes	03
2.	Northern Blotting and Western Blotting (Virtual laboratory)	02
3.	UV absorption spectra and direct spectrophotometric estimation of DNA and RNA	01
4.	PCR (Demonstration)	02
5.	Real-time PCR (Virtual laboratory)	01
6.	To study gene expression by induction of enzyme(s) from suitable sources and confirmation by qualitative/quantitative assay/electrophoresis	05
7.	DNA microarrays (Virtual laboratory)	01
	Total	15

REFERENCES

Mandatory Reading

- Nelson, D. L. & Cox, M.M. (2017). *Lehninger's Principles of Biochemistry* (7th Edition). Worth Publishers, New York, USA.

Supplementary Reading

- Stryer, L; Berg, J; Tymoczko, J & Gatto, G. (2019). *Biochemistry* (9th Edition). W. H. Freeman and Co., New York, USA.
- Murray, R. K, Granner, D. K., Mayes, P. A. & Rodwell, V. W. (2018). *Harper's Illustrated Biochemistry* (31st Edition). McGraw-Hill Companies.
- Jain, J. L.; Jain S. & Jain N. (2016). *Fundamentals of Biochemistry* (7th Edition). S.Chand and Company, Ltd., New Delhi.
- Verma, P. S. and Agarwal, V. K. (2013). *Cell Biology, Genetics, Molecular Biology, Evolution and Ecology*, S. Chand and Company Pvt. Ltd.
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- Voet, D. & Voet, J. G. (2004). *Biochemistry* (4th Edition). John Wiley & Sons, Inc, USA.

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- <https://courses.lumenlearning.com/suny-wmopen-biology1/chapter/regulation-of-gene-expression/>
- <https://www.khanacademy.org/science/biology/gene-regulation>
- <https://www.nature.com/scitable/topic/gene-expression-and-regulation-15/>
- [https://bio.libretexts.org/Bookshelves/Genetics/Book%3A_Working_with_Molecular_Genetics_\(Hardison\)/Unit_IV%3A_Regulation_of_Gene_Expression](https://bio.libretexts.org/Bookshelves/Genetics/Book%3A_Working_with_Molecular_Genetics_(Hardison)/Unit_IV%3A_Regulation_of_Gene_Expression)
- [https://bio.libretexts.org/Bookshelves/Human_Biology/Book%3A_Human_Biology_\(Wakim_and_Grewal\)/06%3A_DNA_and_Protein_Synthesis/6.07%3A_Regulation_of_Gene_Expression](https://bio.libretexts.org/Bookshelves/Human_Biology/Book%3A_Human_Biology_(Wakim_and_Grewal)/06%3A_DNA_and_Protein_Synthesis/6.07%3A_Regulation_of_Gene_Expression)

SEMESTER V

<u>ELECTIVE COURSE: INDUSTRIAL MICROBIOLOGY</u>	
COURSE CODE:	BCH.E-20
MARKS:	100 (75 – Theory; 25 – Practical)
CREDITS:	4 (03 – Theory; 01 – Practical)
CONTACT HOURS:	Theory: 45 Hours (03 Lectures per week) Practical: 30 Hours (01 Practical per week)
COURSE OUTCOMES:	On the successful completion of the course, the students will be able to: CO1: Handle the industrial-based equipment CO2: Isolate and maintain the microorganisms for biochemical production CO3: Handle the process for the production of various industrial biochemical products CO4: Lead and manage the processes of biochemical production of industrial importance.

BCH.E-20: INDUSTRIAL BIOCHEMISTRY (THEORY)

MODULE	TOPICS	CONTACT HOURS	TOTAL HOURS
MODULE 1: Introduction	<p>1.1: Introduction to Industrial Microbiology</p> <p>Overview of industrial fermentation technology, scope and applications.</p>	01	15
	<p>1.2: Industrial bioreactor</p> <p>Fermenters: Structure of an Ideal fermentor, Parts of the fermentor and their uses – Impellers, Spargers, Baffles, Headspace, Controls and Sensors (temperature, pH, antifoam)</p> <p>Types of reactors (definition, description, diagram and uses) - Bubble columns, Airlift, Fluidized bed, Packed bed, Tray bioreactors, Photo-bioreactors.</p> <p>Sterilization of bioreactors</p>	08	
	<p>1.3: Fermentation Media</p> <p>Characteristics of an ideal fermentation medium, types of media – crude and synthetic, composition of fermentation media. sterilization of media</p>	06	
MODULE 2: Fermentation, fermentors and Screening of microorganisms	<p>2.1: Types of fermentation and fermentors</p> <p>Submerged, Surface/Solid state, Batch, Fed-batch, Continuous.</p> <p>Lab scale, Pilot Scale and industrial scale fermentors</p>	07	15
	<p>2.2: Screening of microorganisms</p> <p>Characteristics of microorganisms, strain improvement, Screening procedures: Primary screening: Definition, Methods of primary screening – Crowded plate, Auxanography, Enrichment, Indicator dye</p>	08	

	Secondary screening: Definition and features, Example of secondary screening (giant colony method)		
MODULE 3: Fermentation Products	3.1: Fermentation products Physical and Chemical assays - Titration and gravimetric assay, Turbidity analysis and Cell determination, Spectrophotometric assay, chromatographic method Biological assays - Diffusion assays, Turbidometric and Growth assay	05	15
	3.2: Industrial production of economically important products Citric acid, Vinegar, Ethanol, SCP, Beer, Wine, Yogurt, Penicillin, Amylase, Steroids	10	

BCH.E-20: INDUSTRIAL BIOCHEMISTRY (PRACTICAL)

SR. NO.	PRACTICAL	NO. OF PRACTICALS
1.	Study and handling of a fermentor	02
2.	Media preparation for batch fermentation process	01
3.	A study on the phases of growth of microorganisms during fermentation	02
4.	Isolation of antibiotic producing bacteria – crowded plate technique and secondary screening using giant colony technique	03
5.	Production of wine (from fruit) using yeast	02
6.	Production of vinegar	02

7.	MIC of Penicillin for Gram positive bacteria (<i>S. aureus</i> or <i>Bacillus</i>)	01
8.	Production of amylase in solid state fermentation	02
	Total	15

REFERENCES

Mandatory Reading

- Stanbury P. F, Whitaker A. and Hall. (1997). Principles of fermentation technology, 2nd Edition, Aditya Books Pvt. Ltd, New Delhi.
- Casida L. E. (2009). Industrial Microbiology, New Age International (P) Ltd. New Delhi.

Supplementary Reading

- 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, 4th edition, AVI Publishing Co.
- Ratledge C. and Kristiansen B. (2001). Basic Biotechnology, 2nd edition. Cambridge university press.

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- <http://www.biologydiscussion.com/fermentation/fermentation-technology-meaning-methodology-types-and-procedure/17492>
- <https://study.com/academy/lesson/bacterial-fermentation-process-products.html>
- <https://study.com/academy/lesson/alcohol-fermentation-definition-equation-process.html>
- <http://www.biologydiscussion.com/biotechnology/bioprocess-technology/media-used-for-the-growth-of-microorganisms/10096>
- <http://www.biologydiscussion.com/industrial-microbiology-2/fermentation-industrial-microbiology-2/production-of-ethanol-microbiology/66072>

BCH.E-12: BIOINFORMATICS (THEORY)

MODULE	TOPICS	CONTACT HOURS	TOTAL HOURS
MODULE 1: Introduction to Bioinformatics; Information resources	<p>1.1: Introduction to Bioinformatics 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</p> <p>1.2: Information resources Introduction, Aim and objectives (NCBI, NLM, NIH, EBI and SRS)</p>	<p>10</p> <p>05</p>	15
MODULE 2: Types of Databases	<p>2.1: Types of Databases 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</p>	15	15
MODULE 3: Sequence Alignment tools & phylogeny; HGP	<p>3.1: Sequence Alignment Tools and Phylogeny 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</p> <p>3.2: Human Genome Project Introduction to Human Genome Project (HGP), Objectives, Ethical and social issues</p>	<p>10</p> <p>5</p>	15

BCH.E-12: BIOINFORMATICS (PRACTICAL)

SR. NO.	PRACTICAL	NO. OF PRACTICALS
1.	Usage of NCBI resources for biological databases – Protein or amino acid sequences – DNA or gene sequences	05
2.	Usage of NCBI resources for – Structure databases – Literature databases	03
3.	Database search and Pairwise sequence alignment using NCBI BLAST: BLASTp, BLASTn	02
4.	Multiple sequence alignment using Clustal-W	01
5.	Construction of phylogenetic tree using Clustal-W	01
6.	DNA sequence analysis to find restriction enzymes sites using NEB cutter	01
7.	Visualization of protein structures using Cn3D/ Rasmol	02
	Total	15

REFERENCES

Mandatory Reading

- Harisha, S. (2007). Fundamentals of Bioinformatics, I. K. International Publishing House, Mumbai.

Supplementary Reading

- 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.

SEMESTER VI

<u>CORE COURSE: CLINICAL BIOCHEMISTRY</u>	
COURSE CODE:	BCH-VI.C-8A
MARKS:	100 (75 – Theory; 25 – Practical)
CREDITS:	4 (03 – Theory; 01 – Practical)
CONTACT HOURS:	Theory: 45 Hours (03 Lectures per week) Practical: 30 Hours (01 Practical per week)
COURSE OUTCOMES:	On the successful completion of the course, students will be able to: CO1: Comprehend the concepts of assessing and analyzing the clinical samples. CO2: Comprehend the mechanism of metabolic disorders at the molecular level CO3: Perform and analyze the diagnostic tests. CO4: Implement the standard diagnostic procedure for clinical samples.

BCH-V.C-8A: CLINICAL BIOCHEMISTRY (THEORY)

MODULE	TOPICS	CONTACT HOURS	TOTAL HOURS
MODULE 1: Laboratory Analysis of clinical samples	<p>1.1: Blood, Serum and Urine Composition of Blood, Serum, Cerebrospinal Fluid and Urine. Collection, Preservation, Handling and Processing of clinical samples. Blood Bank</p>	02	15
	<p>1.2: Analysis of Blood, Serum, Urine and CSF Blood: Haemoglobin, Total cell and Differential cell (TC/DC) counts, Erythrocyte sedimentation Rate (ESR); Clotting time, Glucose tolerance test, Urea; Gases: Oxygen and Carbon dioxide levels; pH. Serum: Proteins, Albumin/Globulin Ratio; Bilirubin; Creatinine; Uric acid; Electrolytes. Urine: Colour, Odour, Sediment, Crystals, Glucose; Protein/Albumin CSF: Colour, pH, microscopic examination (lymphocytes), chemical examination (protein, glucose, calcium), microbiological examination.</p>	13	
MODULE 2: Congenital and Metabolic disorders	<p>2.1: Congenital disorders Disorders associated with: a. Carbohydrate metabolism- Glycogen storage diseases, Galactosemia. b. Protein metabolism – Phenylketonuria, Alkaptonuria. c. Lipid metabolism – Niemann – Pick disease, Tay- Sach’s disease.</p>	09	15
	<p>2.2: Chromosomal aberration: Down syndrome, Turner syndrome, Klinefelter syndrome</p> <p>2.3 : Metabolic disorders Carbohydrate – Diabetes mellitus Type I and Type II; Ketosis. Lipids – Dyslipidemia. Proteins – Albuminuria Blood – Anaemia: Haemolytic, Pernicious, Sickle Cell Anaemia, Iron deficiency. Heart – Hypertension, Atherosclerosis Liver – Wilson’s disease, Gaucher disease</p>	06	

	Kidney –Diabetes insipidus		
MODULE 3: Infectious diseases and Diagnostic Tests	3.1: Infectious diseases: Viral infection: Polio, Measles, Mumps, HIV, Influenza Bacterial infection: Diphtheria, Tuberculosis, Typhoid, Cholera. 3.2: General Diagnostic tests Blood: Total and differential blood count, Blood groups and Rh factor incompatibility. Liver disorders and Liver function tests: Bilirubin metabolism. Renal function tests: Glomerular filtration rate, Renal threshold and clearance values. Heart: Role of enzymes and other proteins in assessment of myocardial infarction.	15	15

BCH-VI.C-8A: CLINICAL BIOCHEMISTRY (PRACTICAL)

SR. NO.	PRACTICAL	NO. OF PRACTICALS
1.	Identification of blood collection tubes and preparation of blood, plasma and serum	01
2.	Sample collection and processing – blood and urine	01
3.	Blood staining	01
4.	Bleeding and Clotting time	01
5.	Erythrocyte Sedimentation Rate	01
6.	Glucose Tolerance Test	01
7.	PCV Test	01
8.	Physical & Chemical Examination of Urine	02

9.	Liver function test	03
10.	Renal function test	02
11.	Cholesterol test	01
	Total	15

REFERENCES

Mandatory Reading

- Pattabiraman R. N. Text book of Biochemistry, All India Publisher distribution.

Supplementary Reading

- 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.

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- George, F. Hoffmann., Johannes, Z., William, L. Nyhan. Inherited Metabolic Disorders: A clinical approach, Springer.
- Fernandes, J., Saudubray, J.M., van Den Berghe, G. Inborn Metabolic Diseases. Springer.

SEMESTER VI

<u>ELECTIVE COURSE: INTRODUCTION TO PHARMACOLOGY</u>	
COURSE CODE:	BCH.E-21
MARKS:	100 (75 – Theory; 25 – Practical)
CREDITS:	4 (03 – Theory; 01 – Practical)
CONTACT HOURS:	Theory: 45 Hours (03 Lectures per week) Practical: 30 Hours (01 Practical per week)
COURSE OUTCOMES:	On the successful completion of the course, the students will be able to: CO1: Explain the principles that govern pharmacology CO2: Describe pharmacodynamics and pharmacokinetics CO3: Recognize routes of administration for various drugs and their absorption CO4: Infer mechanism of action of drugs based on pathophysiology of the disease CO5: Apply this knowledge in understanding how commonly used drugs work

BCHE-21: INTRODUCTION TO PHARMACOLOGY (THEORY)

MODULE	TOPICS	CONTACT HOURS	TOTAL HOURS
<p align="center">MODULE 1: Principles of pharmacology, Pharmacodynamics and Pharmacokinetics</p>	<p>1.1: General Principles of Pharmacology Introduction to Pharmacology, Therapeutics; History – Traditional & Modern Medicine; Concepts of Pharmacology; Common terminologies used in pharmacology Nature of drugs; Sources of drugs, Scientific basis of use of drugs in humans Introduction to Pharmacopeia</p>	<p>05</p>	<p align="center">15</p>
	<p>1.2: Pharmacodynamics & Pharmacokinetics Introduction; Pharmacodynamics: - Transport across biological membranes; Absorption of drugs, Bioavailability Pharmacokinetics: - Biotransformation, Excretion, Prolongation of drug action Mechanism of drug action, Placebo effect Receptors & Signal Transduction; Agonists, Antagonism; Slow processes, Non-receptor mechanism Constant Rate infusion; Single bolus dose, Repeated (multiple) dosing</p>	<p>10</p>	
<p align="center">MODULE 2: Drug Absorption & Routes of Administration; Drug Development</p>	<p>2.1: Drug Formulation and its administration Bioavailability, Bioequivalence and generic vs. Proprietary prescribing; Prodrugs; routes of administration – Oral, Buccal & Sublingual, Rectal route, Skin, Lungs, Nose, Eye, Ear & Vagina, Intramuscular Injection, Subcutaneous injection, Intravenous injection, Intrathecal injection</p>	<p>10</p>	<p>15</p>

	<p>2.2: Drug Development Introduction to drug development, processes involved in drug development, Toxicity, Clinical trials</p>	<p>05</p>	
<p>MODULE 3: Types of drugs for different applications</p>	<p>3.1: Drugs for the Nervous and Musculoskeletal Systems (Include brief pathophysiology of diseases wherever necessary) Mechanism of drugs against Insomnia, Anxiety, Schizophrenia, Depressive illnesses, Parkinson's, Myasthenia gravis, Alzheimer's, Migraines. Anesthetics & Muscle relaxants, Analgesics Anti Inflammatory drugs</p> <p>3.2: Drugs for the Circulatory & Respiratory system (Include brief pathophysiology of diseases wherever necessary) Antihypertensive drugs, drugs used in ischaemic heart disease, Anticoagulants & antiplatelet drugs, drugs for heart failure Drugs used to treat asthma, bronchitis, cough</p> <p>3.3: Drugs for the Gastrointestine (Include brief pathophysiology of diseases wherever necessary) Drugs for peptic ulceration & Esophageal disorders Diarrhoea, Irritable bowel syndrome, Liver diseases, Drugs that modify appetite</p> <p>3.4: Antimicrobial drugs Antibacterial, Antiviral, Antifungal drugs</p>	<p>05</p> <p>05</p> <p>03</p> <p>02</p>	<p>15</p>

BCH.E-21: INTRODUCTION TO PHARMACOLOGY (PRACTICAL)

SR. NO.	PRACTICAL	NO. OF PRACTICALS
1.	Study of the efficiency of any antibacterial and antifungal against standard organisms using diffusion method	04
2.	MIC of a store-purchased antibiotic	02
3.	Determining shelf life of a drug - Case Study	02
4.	Estimating the quantity of active ingredient in store-bought Vitamins	02
5.	Sterility testing of IV fluids	03
6.	Study of dosage forms of drugs/antifungal (case study)	02
	Total	15

REFERENCES

Mandatory Reading

- Tripathi K. D. (2019). Essentials of Medical Pharmacology (8th Edition). Jaypee Brothers Medical Publishers (P) Ltd., London.

Supplementary Reading

- Ritter J. M., Lewis L. D., Mant T. GK., and Ferro A., (2008). A Textbook of Clinical Pharmacology and Therapeutics (5th Edition). Hachette Livre, U.K.
- Katzung B., (2017). Basic and Clinical Pharmacology (14th Edition). McGraw-Hill Education/Medical.
- Whalen K., (2018). Lippincott Illustrated Reviews: Pharmacology (Sangeeta Sharma & Thirumurthy Velpandian edition). Wolters Kluwer India Pvt. Ltd.

Web References:

- <https://www.ncbi.nlm.nih.gov/books/NBK12815/>
- <https://www.youtube.com/watch?v=tobx537kFaI>
- <https://www.ncbi.nlm.nih.gov/books/NBK507791/>
- <https://www.youtube.com/watch?v=NKV5iaUVBUI>

SEMESTER VI

<u>ELECTIVE COURSE: FOOD BIOCHEMISTRY</u>	
COURSE CODE:	BCH.E-22
MARKS:	100 (75 – Theory; 25 – Practical)
CREDITS:	4 (03 – Theory; 01 – Practical)
CONTACT HOURS:	Theory: 45 Hours (03 Lectures per week) Practical: 30 Hours (01 Practical per week)
COURSE OUTCOMES:	On the successful completion of the course, the student will be able to: CO1: Appreciate the importance of composition of food and its implications in food spoilage. CO2: Apply the knowledge to describe the changes occurring in food due to storage and handling. CO3: Comprehend and apply the concept of food preservation techniques. CO4: Evaluate and assess the quality of food.

BCH.E-22: FOOD BIOCHEMISTRY (THEORY)

MODULE	TOPICS	CONTACT HOURS	TOTAL HOURS
<p align="center">MODULE 1: Introduction to Food Biochemistry and spoilage</p>	<p>1.1: Introduction to Food biochemistry Definition and composition of food. Food as a substrate for microorganisms</p>	02	<p align="center">15</p>
	<p>1.2: Spoilage of food Intrinsic and Extrinsic factors - Hydrogen-ion concentration, moisture requirement, oxidation-reduction potential, nutrient content, inhibitory substances and biological structure. Enzymatic browning, Non – Enzymatic browning, Maillard reaction, Caramelization reaction, Ascorbic acid oxidation Classification of foods by ease of spoilage, Factors affecting kinds, numbers and growth of microorganisms in food, temperature, pressure Chemical changes caused by microorganisms</p>	13	
<p align="center">MODULE 2: Principles of Food Preservation</p>	<p>2.1: Principles of Food preservation Preservation by high temperature – Factors affecting heat resistance (Thermal Death Time), Determination of heat resistance (Thermal Death Time), Heat treatments employed in food processing, Chemistry of canning Preservation by low temperature – Temperature employed in low-temperature storage. Principle of freezing, freezing curve, changes occurring during freezing, types of freezing i.e. slow freezing, quick freezing, Introduction to thawing, Mechanism of changes during thawing and its effect on food.</p>	15	15

	<p>Preservation by drying – Methods of drying, Factors in the control of drying</p> <p>Preservation by radiation – kinds of ionizing radiations used in food irradiation, mechanism of action, uses of radiation processing in food industry, concept of cold sterilization.</p>		
<p>MODULE 3: Food Quality, New Product Development</p>	<p>3.1 : Food Quality</p> <p>Objectives, type of food panels, characteristics of panel members, layout of sensory evaluation laboratory, sensitivity tests, threshold value, paired comparison test, duotrio test, triangle test, hedonic scale, chemical dimension of basic tastes, Amoore’s classification of odorous compounds. Sherman and Szczniak classification of food texture.</p> <p>Sensory attributes of cheese, cream, butter, ghee, juices.</p> <p>Application of texture measurement in cereals, fruits and vegetables, dairy, meat and meat products.</p> <p>Dimensions of colour and attributes of colour; gloss etc. Perception of colour, Colour Measurement: Munsell colour system, CIE colour system, Hunter colour system, etc.</p> <p>Grading of Milk, MBRT, Resazurin (include more tests for other foods)</p> <p>FSSAI and other Regulatory Bodies</p> <p>3.2: Product Development</p> <p>Importance, Need of product development, Steps of product development, Product development tools, Reasons for failure</p>	<p>11</p> <p>04</p>	<p>15</p>

BCH.E-22: FOOD BIOCHEMISTRY (PRACTICAL)

SR. NO.	PRACTICAL	NO. OF PRACTICALS
1.	Screening and evaluation of fresh and spoiled fruits and vegetables	02
2.	Texture evaluation of various processed food sample	01
3.	Processing and sensory evaluation of milk and milk products (milk, flavoured milk, curd, cheese, condensed milk, khoya)	05
4.	TDT of an organism isolated from spoilt fruit	01
5.	Spoilage of bakery product (bread, biscuits)	01
6.	Estimation of salt content in butter	01
7.	Study quality characteristics of foods preserved by drying/ dehydration/ freezing.	02
8.	Visit to a food industry or food research institute and preparation of report	02
	Total	15

REFERENCES

Mandatory Reading

- Frazier, W. C. and Westhoff, D. C., Food Microbiology. TMH Publication, New Delhi.

Supplementary Reading

- Ramaswamy, H. and Marcott, M. Food Processing Principles and Applications. CRC Press.
- Ranganna, S. Handbook of Analysis and Quality Control for Fruits and Vegetable Products, TMH Education Pvt. Ltd.
- Potter, N.H. Food Science, CBS Publication, New Delhi.
- Owen, F. R. Food Chemistry, Marcell Dekker, New York.
- Gordon, F. W. New Product Development From Concept to Marketplace, CRC Press.
- Norman, D.W. and James, D. N. The technology of food preservation, Westport.
- Pomeranz, Y. and Meloan, C.E. Food Analysis – Theory and Practice, CBS Publishers and Distributors, New Delhi.

Web References:

- <https://www.youtube.com/watch?v=LUQxrnEFzB0>
- <https://www.slideshare.net/natrajdurgannavar/sensory-evaluation-of-food>
- <http://ecoursesonline.iasri.res.in/mod/page/view.php?id=6091>

SEMESTER VI

<u>ELECTIVE COURSE: GENETIC ENGINEERING AND BIOTECHNOLOGY</u>	
COURSE CODE:	BCH.E-11
MARKS:	100 (75 – Theory; 25 – Practical)
CREDITS:	4 (03 – Theory; 01 – Practical)
CONTACT HOURS:	Theory: 45 Hours (03 Lectures per week) Practical: 30 Hours (01 Practical per week)
COURSE OUTCOMES:	On the successful completion of the course, the student will be able to: CO1: Comprehend the concept of genetic engineering and its scope in biotechnology CO2: Identify the various tools that might be required for specific genetic manipulation experiments. CO3: Elucidate the principles of DNA and RNA isolation and transformation of bacteria CO4: Explain the processes governing DNA separation, amplification, and sequencing techniques CO5: Understand the applications of genetic engineering in biotechnology

BCH.E-11: GENETIC ENGINEERING AND BIOTECHNOLOGY (THEORY)

MODULE	TOPICS	CONTACT HOURS	TOTAL HOURS
MODULE 1: Introduction of Genetic Engineering & the basic Tools required for it	1.1: Introduction to Genetic Engineering and Biotechnology General features and mechanisms of genetic engineering, Concept of biotechnology, Applications and ethical issues of recombinant DNA technology, Gene cloning	03	15
	1.2: DNA Modifying enzymes and Vectors for Gene Cloning 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	12	
MODULE 2: Transformation methods and Blotting techniques for DNA & RNA	2.1: Transformation methods and identification of recombinants DNA insertion into vectors: Ligation, Use of linkers and Adaptors, Homopolymer tailing; Competence (transformation in bacteria): Microinjection, Lipofection, Electroporation, Macroinjection, Sonication, DNA co-precipitation, Ultrasonication, Laser induced Identification of Recombinants: Principle and importance of identification of recombinants: Antibiotic resistance (amp, tet	10	15

	<p>resistance), lacZ selection, Colony hybridization</p> <p>2.2: Blotting Techniques for DNA and RNA 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 radiolabeled P 32 , Autoradiography Northern blotting: Blotting of RNA from agarose gel onto nitrocellulose membrane, Hybridisation with radiolabeled probe, Autoradiography</p>	05	
MODULE 3:	<p>3.1: DNA Amplification and Sequencing 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</p> <p>3.2: Genomic and cDNA libraries Preparation of genomic library, cDNA library, Screening of Libraries</p> <p>3.3: Genetic Engineering in Biotechnology 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</p>	08 02 05	15

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

SR. NO.	PRACTICAL	NO. OF PRACTICALS
1.	Isolation of plasmid DNA by alkaline lysis and boiling prep method, and molecular weight determination by gel electrophoresis	04
2.	Restriction digestion of plasmid DNA and analysis by gel electrophoresis	02
3.	Preparation of competent cells in bacteria	02
4.	Transformation in bacteria using plasmid vector (pUC 18)	04
5.	Deciphering the DNA sequence from a sequencing gel photograph by Maxam and Gilbert's method and Sanger's method	02
6.	Blotting techniques (virtual laboratory)	01
	Total	15

REFERENCES for BCH.E-11

Mandatory Reading

- Singh, B. D. (2008). Biotechnology: Expanding Horizons, Kalyani Publishers.

Supplementary Reading

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

Web References:

- <https://www.khanacademy.org/science/high-school-biology/hs-molecular-genetics/hs-biotechnology/v/introduction-to-genetic-engineering>
- [https://bio.libretexts.org/Bookshelves/Microbiology/Book%3A_Microbiology_\(Brusli%20nd\)/18%3A_Genetic_Engineering](https://bio.libretexts.org/Bookshelves/Microbiology/Book%3A_Microbiology_(Brusli%20nd)/18%3A_Genetic_Engineering)
- [https://bio.libretexts.org/Bookshelves/Microbiology/Book%3A_Microbiology_\(Boundless\)/7%3A_Microbial_Genetics/7.23%3A_Genetic_Engineering_Products/7.23B%3A_Applications_of_Genetic_Engineering](https://bio.libretexts.org/Bookshelves/Microbiology/Book%3A_Microbiology_(Boundless)/7%3A_Microbial_Genetics/7.23%3A_Genetic_Engineering_Products/7.23B%3A_Applications_of_Genetic_Engineering)
- <https://www.slideshare.net/gnsk143/gene-transformation-methods>
- https://www.brainkart.com/article/Identification-of-Recombinants---Recombinant-DNA-Technology_21278/

SEMESTER VI

<u>ELECTIVE COURSE: ENVIRONMENTAL CHEMISTRY</u>	
COURSE CODE:	BCH.E-23
MARKS:	100 (75 – Theory; 25 – Practical)
CREDITS:	4 (03 – Theory; 01 – Practical)
CONTACT HOURS:	Theory: 45 Hours (03 Lectures per week) Practical: 30 Hours (01 Practical per week)
COURSE OUTCOMES:	On the successful completion of the course, the students will be able to: CO1: Explain about the biochemistry of environmental processes and ecology. CO2: Comprehend the basic knowledge of ecological concepts, various pollutants and its remediation. CO3: Apply the knowledge of principle and methodologies of composting and designing their own. CO4: Assess the quality of the air, water and soil.

BCH.E-23: ENVIRONMENTAL CHEMISTRY (THEORY)

MODULE	TOPICS	CONTACT HOURS	TOTAL HOURS
MODULE 1: Ecological Concepts and Pollutants	1.1: Basic ecological concept Biogeochemical cycles (C, N, O, P, S, Water), Food chain and food webs, Ecological pyramids; Productivity and eco-energetic (10% law) 1.2: Pollutants Pollutants of water, air and soil and their sources Eco-toxicology: concept of permissible limits, ED50 & LD50; acute and chronic exposures. Significance of dissolved oxygen, BOD, COD.	09 06	15
MODULE 2: Impact of environmental pollution and its control I	2.1: Pollution monitoring Bioindicators: Concept and examples (indicators of water quality; air pollution indicators) Tests for assessing Genetic damage: AMES Test Concept and applications of biosensors in pollution detection 2.2: Air Pollution Impacts of air pollution on human health, animals, plants and climate, Removal of gaseous contaminants: Bioscrubbers, Biotrickling filters and Biofilters/Biobeds 2.3: Water Pollution Impacts of water pollution on human health, animals	05 05 05	15

	Wastewater treatment: Activated sludge process, Rotating biological discs, Oxidation ponds, Trickling filters		
<p>MODULE 3: Impact of environmental pollution and its control II</p>	<p>3.1: Soil Pollution Hazardous and non-hazardous solid wastes</p>	01	15
	<p>3.2: Bioremediation Bioremediation: Definition, Mechanism of microbial bioremediation, Microbial desulphurization of coal (indirect mechanisms). Microbial processes – enzymatic transformations, co-metabolism, microbial adhesion, biofilms, production of extracellular polymers and emulsifiers. Phytoremediation Removal of metal pollutants through sedimentation, sorption, precipitation, speciation conversion Biodegradation of xenobiotics: Aromatic hydrocarbons (benzene) and alkanes Biosorption: Principle, Use of Fungi and Algae Genetically engineered microorganisms: Super Bug (Pseudomonas species) Concepts of Reuse, Recycle and Recovery.</p>	10	
	<p>3.3: Composting and Vermitechnology Principle concept and method</p>	03	
	<p>3.4: Hospital waste management</p>	01	

BCH.E-23: ENVIRONMENTAL CHEMISTRY (PRACTICAL)

SR. NO.	PRACTICAL	NO. OF PRACTICALS
1.	Water quality by MPN method for sewage water	02
2.	Routine analysis of potable water sample using Presumptive, Confirmatory and Confirmed tests for coliform	04
3.	Determination of Dissolved Oxygen concentration of water sample by Winkler's method	01
4.	Determination of Biological Oxygen Demand (BOD) of the water sample	01
5.	Determination of Chemical Oxygen Demand (COD) of the water sample	01
6.	Determination of Total Solids (TS) of the given water sample	01
7.	Isolation of xenobiotic degrading bacteria by selective enrichment	03
8.	Visit to an effluent treatment plant (report)	02
	Total	15

REFERENCES

Mandatory Reading

- Dara, S.S. A text book of Environmental Chemistry and Pollution Control. S. Chand Publishers

Supplementary Reading

- Khopkar, S. M. Environmental Pollution Analysis. John Wiley and Sons.
- Mitchell, R. and Cu, J. D. Environmental Microbiology. Wiley- Blackwell Publication
- Ramesh, K. V. Environmental Microbiology. MJP Publishers, India.
- Maier, R., Pepper, I. and Gerba, C. Environmental Microbiology. Academic Press.
- Moore J. W. and Moore, E. A., Environmental Chemistry. Elsevier.
- Jadhav, H.V. Elements of Environmental Chemistry: For Undergraduate Science Students of Indian University. Himalaya Publishing House.
- Satake, M., Sethi, S. and Eqbal, S.A. Environmental Chemistry. Discovery Publishing Pvt.Ltd,
- Salle, A.J. Fundamental Principles of Bacteriology. McGraw Hill.
- Frobisher, M. and Hinsdale, R.D. Fundamentals of Microbiology. Saunders.

Web References:

- <https://openoregon.pressbooks.pub/envirobiology/>

SEMESTER I

<u>GENERIC ELECTIVE COURSE:</u> <u>CONTEMPORARY NUTRITION</u>	
COURSE CODE:	BCH.GEC-1
MARKS:	100
CREDITS:	4
CONTACT HOURS:	Theory: 60
COURSE OUTCOMES:	On the successful completion of the course, students will be able to: CLO1: Understand and explain the fundamentals of nutrition. CLO2: Comprehend the concept of energy in metabolism. CLO3: Discuss the role of nutrition in health. CLO4: Describe and design diet plans for different age groups.

MODULE	TOPICS	CONTACT HOURS	TOTAL HOURS
MODULE 1: Nutrients	<p>1.1: Introduction: Nutrients, anti-nutrients, Recommended Dietary Allowance, National and International Regulatory Authorities (ICMR, NIN-NSI, FSSAI, IDA, EFSA, FDA)</p> <p>1.2: Classes of Nutrients, sources and function: Carbohydrates, Lipids, Proteins, Vitamins, Minerals</p> <p>1.3: Water: Role of water cellular physiology and electrolyte imbalance.</p>	<p>3</p> <p>8</p> <p>4</p>	15
MODULE 2: Energy and Nutritional Supplements	<p>2.1: Energy: Units of Energy, Physical and Physiological Energy values, Basal Metabolic Rate (BMR)</p> <p>2.2: Energy Malnutrition: PEU- Marasmus, Kwashiorkor, PEU in adults. Overnutrition- Obesity, Vitamin and Mineral toxicity Eating disorders- anorexia nervosa, bulimia nervosa, Binge eating syndrome, Night eating syndrome, Female Athlete Triad</p> <p>2.3: Nutritional Supplements: Protein supplements, Nutraceuticals, Pro- and Prebiotics</p> <p>2.4: Hidden Hunger: Vitamin and Iron deficiency</p>	<p>4</p> <p>6</p> <p>3</p> <p>2</p>	15
MODULE 3: Nutrition and Life Stages	<p>3.1: Nutrition for Infants and Children: Guidelines, allergies, diet plan</p> <p>3.2: Nutrition for Adolescents: Guidelines and concerns, diet plan</p> <p>3.3: Nutrition for Adults and Older Adults: Guidelines, supplements, alcohol abuse, Aging and Cancer, diet plan</p> <p>3.4: Nutrition during Pregnancy and Lactation: Guidelines and concerns, diet plan</p>	<p>2</p> <p>2</p> <p>4</p> <p>5</p>	15

	3.5: Nutrition for Fitness and Sports: Guidelines, calorie and fluid intake, ergogenic aids	2	
MODULE 4: Food Reactions and Diets	4.1: Food Reactions: Intolerance and Allergies. 4.2: Diets of the world: Atkins diet, Intermittent fasting, Ketogenic diet, Vegetarian diet, Vegan diet, Weight Watchers diet, Paleo diet, Mediterranean diet, Detox diet, Risks of diet plans and Fad diets.	4 11	15

REFERENCES

Mandatory Reading

- Wardlaw, G. M. and Smith A. M. Contemporary Nutrition, McGraw-Hill, New York

Supplementary Reading

- Voet, D. and Voet, J. G. Biochemistry John Wiley and Sons, Inc, USA.
- Gopalan, C. Nutritive Value of Indian Food, National Institute of Nutrition Hyderabad, India.
- Nutrient Requirements for Indians: Recommended Dietary Allowances and Estimated Average Requirements, ICMR, NIH, Ministry of Health and family Welfare, Government of India.
- Dietary Guidelines for Indians -A Manual by National Institute of Nutrition Hyderabad, India
- Mehra V. Nutritional Biochemistry, Sonali Publications, New Delhi, India
- Sharma D.C. and Sharma D. Nutritional Biochemistry, CBS Publishers, New Delhi, India
- WHO Study Group on Diet, Nutrition and Prevention of Noncommunicable Diseases & World Health Organization. (1990). Diet, nutrition and the prevention of chronic diseases: report of a WHO study group

Web References

- <https://www.coursera.org/learn/childnutrition>
- <https://www.coursera.org/learn/nutrition-pregnancy>
- <https://www.edx.org/course/introduction-to-food-health>

SEMESTER: II

<u>GEC COURSE: BIOCHEMICAL CORRELATION OF DISEASES</u>	
COURSE CODE:	GEC
MARKS:	100
CREDITS:	4
CONTACT HOURS:	Theory: 60 Hours
COURSE OUTCOMES:	On the successful completion of the course, the students will be able to: CLO1: Understand the mechanism of metabolic disorders at molecular level. CLO2: Identify management methods of lifestyle disorders. CLO3: Comprehend the concepts of pathogenesis of the diseases. CLO4: Conceptualize the principle and use of vaccines.

BIOCHEMICAL CORRELATION OF DISEASES

MODULE	TOPICS	CONTACT HOURS	TOTAL CONTACT HOURS
MODULE 1: Congenital and Nutritional diseases	1.1: Inborn errors of metabolism Alkaptonuria, Phenylketonuria, Glycogen and Lipid storage diseases, Clotting disorders	07	15
	1.2: Nutritional deficiency-based diseases Kwashiorkar, Marasmus, Beri-beri, Scurvy, Pellagra, Anaemia, Night blindness, Rickets, Osteomalacia, Osteoporosis, Wilson's disease	08	
MODULE 2: Lifestyle and hormonal disorders	2.1: Life style diseases Obesity, Cardiovascular diseases, Atherosclerosis, Diabetes mellitus-II. Inflammatory Bowel Disease (IBD).	07	15
	2.2: Hormonal Imbalances Outline of hormone action and imbalances leading to disease - precocious puberty, hyper and hypopituitarism. Hyper and hypothyroidism. PCOS	08	
MODULE 3: Autoimmune diseases and protein misfolding	3.1: Autoimmune diseases Concepts in immune recognition - self and non-self-discrimination, organ specific autoimmune diseases – Hashimoto's thyroiditis, Grave's disease, Myasthenia Gravis; Systemic diseases - SLE, rheumatoid arthritis; Diabetes Mellitus-I.	09	15
	3.2: Diseases caused due to misfolded proteins Alzheimer's, Huntington's disease, Transmissible Spongiform Encephalopathy (Kuru, CJD, Mad Cow Disease), Sickle cell anaemia, Thalessemia.	06	

			15
MODULE 4: Infectious diseases	4.1: Infectious diseases Viral infection (polio, influenza/Covid-19, Jaundice); Bacterial infections (tetanus, diphtheria, cholera); Protozoan (Plasmodium and Entamoeba histolytica) and parasitic infections (helminthiasis). Vaccines against diseases. General strategies in the design and development of vaccines.	15	

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REFERENCES

Mandatory Reading

- Ananthanarayan R. and Paniker C. K. J. (2009) Textbook of Microbiology. 8th edition, University Press Publication

Supplementary Reading

- Berg, J. M., Tymoczko, J. L. and Stryer, L., Biochemistry (2012) 7th ed., W.H Freeman and Company (New York)
- Murray, R. K, Granner, D. K, Mayes, P.A. and Rodwell, V.W. (2003), Harper's Illustrated Biochemistry, McGraw-Hill Companies.
- Roitt, I. M. and Delves, P. J. (2001). Roitt's essential immunology (10th ed.). Malden, MA: Blackwell Science.
- Ellen Strauss, James Strauss. (2007) Viruses and Human disease (2nd ed.). Academic Press Publications.

Web References

- George, F. Hoffmann., Johannes, Z., William, L. Nyhan. Inherited Metabolic Disorders: A clinical approach, Springer.

- Fernandes, J., Saudubray, J.M., van Den Berghe, G. Inborn Metabolic Diseases. Springer.

SEMESTER IV

<u>SKILL ENHANCEMENT COURSE:</u> <u>NUTRACEUTICAL PRODUCT DEVELOPMENT</u>	
COURSE CODE:	SEC
MARKS:	100
CREDITS:	4
CONTACT HOURS:	Theory: 15 Hours Practice hours: 45 Hours
COURSE OUTCOMES:	On the successful completion of the course, students will be able to: CLO1: Explain the concept of nutraceuticals and functional foods. CLO2: Extract and estimate bioactive compounds from plant and animal sources. CLO3: Discuss the trends in the nutraceutical industry and perform market research. CLO4: Understand the process of nutraceutical product development.

NUTRACEUTICAL PRODUCT DEVELOPMENT

MODULE	TOPICS	CONTACT HOURS	TOTAL HOURS
MODULE 1: Introduction to Nutraceuticals	<p>1.1: Nutraceuticals: Definition and Classification, dietary supplements, novel foods, post-biotics, fortified foods and functional foods.</p> <p>1.2: The Nutraceutical Industry: Indian and global scenario</p> <p>Activities based on module 1: Analysis of reports, market trends and projections, choosing topic for mini-project</p>	03 02 10	15
MODULE 2: Phyto-Nutraceuticals	<p>2.1: Plant Based Nutraceuticals Plant secondary metabolites, Concept of cosmeceuticals and aquaceuticals.</p> <p>2.2: Popular Phyto-nutraceuticals Glucosamine from ginseng, Omega-3 fatty acids from linseed, Epigallocatechin, gallate from green tea, lycopene, polysaccharides from seaweeds.</p> <p>Activities based on module 2: Extraction of phytochemicals, antioxidant assay</p>	02 02 11	15
MODULE 3: Animal Based Nutraceuticals	<p>3.1: Animal Based Nutraceuticals Chitin, chitosan, glucosamine, chondroitin sulphate and other polysaccharides, protein isolates and omega-3 fatty acids of animal origin and marine sources</p> <p>Activities based on module 3: Extraction of chitin and chitosan production from seafood waste and fungi</p>	04 11	15
MODULE 4: Product development	<p>4.1: Efficacy, Safety and Toxicity of nutraceuticals, Regulatory bodies, QC, QA, FSSAI</p> <p>4.2: Mini project: Case studies on product development (paediatric/geriatric/lactose</p>	02 13	15

	intolerant/supplements during pregnancy/protein supplements/diabetes)		
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REFERENCES

Mandatory Reading

- A.P. Sarkate, M.A. Patil and P.V. Agharde, (2021) Nutraceuticals and Human Health. Brillion Publishing. New Delhi, India.

Supplementary Reading

- Pathak Y. V. (2009) Handbook of Nutraceuticals Volume I- Ingredients, Formulations, and Applications CRC Press, Florida, USA
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Web References

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