Annexure 9.4

Avinashilingam Institute for Home Science and Higher Education for Women
(Deemed to be University under Category A by MHRD, Estd. u/s 3 of UGC Act 1956)
Re-accredited with A+ Grade by NAAC. Recognised by UGC Under Section 12 B
Coimbatore - 641 043, Tamil Nadu, India

Department of Biochemistry, Biotechnology and Bioinformatics

B.Sc. Biochemistry & Biotechnology

Programme Outcomes (PO):

On successful completion of the B.Sc. Biochemistry and Biotechnology program, students will be able to

1. Demonstrate fundamental knowledge of basic concepts and principles of biochemistry and biotechnology
2. Understand complex biological mechanisms using biotechnological aspects
3. Acquire skills to utilize appropriate modern techniques, tools, resources, equipments and software in compliance with standard operating procedures and safety aspects
4. Apply acquired knowledge and skills in areas related to biochemistry and biotechnology for global sustainability
5. Employ research-based knowledge and skills to identify problems, design and carry out experiments, analyse and interpret data to develop innovative solutions in social and environmental contexts
6. Develop entrepreneurship skills, manage the workflow and financial aspects of bioscience business and innovative ideas to need-based products
7. Practice professional ethics in academia, industry and research environments
8. Adapt to diverse working environmentswith competenceand contribute productively as individuals and as team members
9. Build interpersonal skills for effective communication through all available means
10. Demonstrate independent thinking and integrate knowledge from other disciplines into the context of biosciences for addressing societal issues
11. Acquire and use appropriate currently available learning resources to improve knowledge base and practice lifelong learning

Programme Specific Outcomes (PSO):

The B.Sc. Biochemistry and Biotechnology programme will enable the students to

1. Gain comprehensive fundamental knowledge in Biochemistry and Biotechnology to achieve a holistic expertise
2. Inculcate critical thinking and analytical skills to solve real time research problems in life sciences
3. Find opportunities for higher studies in reputed academic and research institutions and establish them in their workplace environments

Scheme of instruction and Examinations

(For students admitted from 2021-2022 &onwards)

Part	Subject Code	Number of papers and components	Hours of Instructions / Week		Scheme of Examination				
			Theory	Practical	Duration of Exam	CIA	CE	Total	Credit
		First Semester							
I	21BLT001 21BLH001 21BLF001	Tamil/Illakayam –I – Illakanam – Illakyavaralaru Hindi/Prose and non-detailed text French	5	-	3	50	50	100	4
III		**Core Course – I**							
	21BBCC01	Chemistry of Biomolecules	5	-	3	50	50	100	3
	21BBCC02	Practicals – I Analytical Biochemistry – Qualitative Analysis	-	3	3	50	50	100	2
		Core Course – I							
	21BBTC01	Introduction to Biotechnology and Cell Biology	5	-	3	50	50	100	3
	21BBTC02	Microbiology	4		3	50	50	100	3
		Discipline Specific Elective (DSE) Course							
	21BBCI01	**DSE – I** Chemistry theory for Biochemistry and Biotechnology	4	-	3	50	50	100	3
	21BBCI02	Chemistry practical for Biochemistry and Biotechnology	-	3	3	50	50	100	2
		Games	-	1	-	-	-	-	-
		Second semester							
I	21BLE002	English – Language II – Literature	5	-	3	50	50	100	4
III		**Core Course – I**							
	21BBCC03	Techniques in Biochemistry	5	-	3	50	50	100	4
	21BBCC04	Chemistry of Proteins	4	-	3	50	50	100	3
		Core Course – II							
	21BBTC03	Biophysics	4	-	3	50	50	100	3
	21BBTC04	Practicals – I Techniques in Biotechnology	-	4	3	50	50	100	2
		Discipline Specific Elective (DSE) Course							
	21BBCI03	**DSE – II** Physics for Biochemistry (Physics)	4	-	3	50	50	100	3
	21BBCI04	Physics – Practicals for	-	3	3	50	50	100	2

Part	Subject Code	Number of papers and components	Hours of Instructions / Week		Scheme of Examination				
			Theory	Practical	Duration of Exam	CIA	CE	Total	Credit
		Biochemistry (Physics)							
		Games	-	1	-	-	-	-	-
		Third Semester							
III		**Core Course – I**							
	21BBCC05	Intermediary Metabolism – I	4	-	3	50	50	100	3
	21BBCC06	Human Physiology	4	-	3	50	50	100	3
	21BBCC07	Practicals II – Enzymes	-	5	6	50	50	100	3
		Core Course – II							
	21BBTC05	Environmental Biotechnology	4	-	3	50	50	100	3
	21BBTC06	Genetics	4	-	3	50	50	100	3
	21BBTC07	Enzymes and Enzyme Technology	4	-	3	50	50	100	3
		Discipline Specific Elective (DSE) Course							
	21BBCI05	**DSE – III** Computer Applications in Biosciences	2	3	3	50	50	100	4
		Fourth Semester							
III		**Core Course – I**							
	21BBCC08	Intermediary Metabolism -II	4	-	3	50	50	100	3
	21BBCC09	Plant Biochemistry	4	-	3	50	50	100	3
	21BBCC10	Drug Biochemistry	4	-	3	50	50	100	3
		Core Course – II							
	21BBTC08	Immunology	4	-	3	50	50	100	3
	21BBTC09	Microbial Biotechnology	4	-	3	50	50	100	3
	21BBTC10	Practicals II – Microbial Techniques	-	6	6	50	50	100	3
		Discipline Specific Elective (DSE) Course							
	21BBCI06	**DSE – IV** Mathematics for Biological Sciences (Mathematics)	4	-	3	50	50	100	3
		Fifth Semester							
III		**Core Course – I**							
	21BBCC11	Clinical Biochemistry	4	-	3	50	50	100	3
	21BBCC12	Molecular Biology	4	-	3	50	50	100	3
	21BBCC13	Practicals III – Clinical Biochemistry	-	5	3	50	50	100	2

Part	Subject Code	Number of papers and components	Hours of Instructions / Week		Scheme of Examination				
			Theory	Practical	Duration of Exam	CIA	CE	Total	Credit
		Core Course – II							
	21BBTC11	Plant Biotechnology	3	-	3	50	50	100	3
	21BBTC12	rDNA technology and Nanobiotechnology	4	-	3	50	50	100	3
	21BBTC13	Practicals III – Methods in Molecular Biology and Plant Tissue Culture	-	5	6	50	50	100	3
	21BBTC14	Antioxidants in Health and Diseases- **Self study Course**	1	-	3	100	-	100	4
	21BBTC15	Biochemistry and Biotechnology - **Computer Based Test**	-	-	1	-	100	100	2
	21BBCC14	Training*	-	-	-	100	-	100	6
		Generic Elective Course	2	-	-	100		100	2
Sixth Semester									
III		**Core Course – I**							
	21BBCC15	Molecular Physiology	5	-	3	50	50	100	3
	21BBCC16	Nutritional Biochemistry	5	-	3	50	50	100	3
	21BBCC17	Practicals IV – Clinical Biochemistry and Food analysis	-	5	6	50	50	100	3
		Core Course – II							
	21BBTC16	Computational Biology	5	-	3	50	50	100	3
	21BBTC17	Animal Cell Culture and Animal Biotechnology	5	-	3	50	50	100	3
	21BBTC18	Bioentrepreneurship Development & Project Work	-	5	Viva	100	-	100	2
			Total Credits						**132**

Part IV Components

S.No	Components	Subject Code	Semester	No of Credits
I	**A. Ability Enhancement Courses**			
	Environmental Studies	21BAES01	I	4
	Fundamentals of Research	21BAFU01	II	2
	Communication Skills	21BSCS01	V	2
	Soft Skills	21BSSS01	VI	2
II	**Skill Enhancement Course (SEC)**			
a.	**Value Added Course**		III	2
b.	**Co - Curricular Course**		IV	2
	B. Extra - Curricular Course			
	NCC/ **NSS/** **Sports/**	**21BXNC01-06** **21BXNS01-06** **21BXSP01-06**	**1-6**	24 Credits* 6 Credits 6 Credits
			Total Credits	**20**

#For NCC Students alone 38 credits for Part IV Components

For the first four semesters there will be a minimum of two core courses/ semester.

*Training for a period of 30 days during summer vacation (6 credits)

Total Credits to earn the degree

1. Parts I, II & III Components - 132
2. Part IV Components - 20

Total Credits - 152

Other Courses offered by the Department

Discipline Specific Electives

For B.Sc. Physician Assistant	21BPAI02	Clinical Biochemistry	II Semester
For B.Sc. Physician Assistant	21BPAI03	Microbiology	III Semester
For B.Sc. FSN and B.Sc. Chemistry	21BFNI03/21BCHI03	Chemistry and Metabolism of Biomolecules – Theory	III Semester
For B.Sc. FSN and B.Sc. Chemistry	21BFNI04/21BCHI04	Chemistry and Metabolism of Biomolecules –Practicals	III Semester

- **Generic Elective Course** - **21BBCO01** - Biochemical Parameters in Health and Diseases
- **Value Added Course** - **21BBCV01** - Herbal Home Remedies
- **Co-curricular course** - **21BSCBC1** - Certificate course in Computational Biology

Chemistry of Biomolecules

Semester I
21BBCC01

Hours of Instruction /week: 5
No. of Credits: 3

Objectives:

1. To learn about the structure and function of organic molecules in living system
2. To know about the physical and chemical properties of biomolecules for understanding their biological importance
3. To impart knowledge on the complexity of cell structure

Unit 1 Carbohydrates **15**

Introduction and classification of carbohydrates, structure and reactions of monosaccharides; structure and biological importance of glycosides, amino sugars and deoxy sugars.
Structure and biological importance of sucrose, maltose, isomaltose, lactose, cellobiose and raffinose.
Structure and biological importance of storage polysaccharides (starch, glycogen and inulin) and structural polysaccharides (cellulose, chitin and pectin).

Unit 2 Lipids **15**

Definition and classification of lipids based on backbone structure - chemistry and characterization of simple lipids- triacylglycerol - classification, structure and chemistry of phospholipids and non-phosphorylated lipids – sulpholipids - Eicosanoids.

Unit 3 Complex polysaccharides and complex lipids **15**

Structure and biological importance of glycosaminoglycans - blood group polysaccharides -bacterial cell wall polysaccharides - peptidoglycans, teichoic acid and lipopolysaccharides.
Chemistry of biologically important steroids - cholesterol, mycosterol, phytosterol and bile acids. Brief account of lipoproteins.
Terpenes - structure of mono-, di-, tri- and tetraterpenes
Structure of fat- and water- soluble vitamins.

Unit 4 Nucleic acids **15**

Structure of bases, nucleosides and nucleotides. Biologically important nucleotides.
Deoxyribonucleic acid – base composition, structure and forms, denaturation and renaturation of DNA helix.
Ribonucleic acid – base composition, classes -structure of major ribonucleic acid mRNA, tRNA and rRNA.

Unit 5 Amino acids **15**

Structure and classification of standard amino acids - rare amino acids and non- protein amino acids - physical and electrochemical properties -reactions of amino acids - due to amino groups, carboxyl groups and R groups - colour reactions of amino acids. Brief introduction to peptides and proteins.

Total Hours: 75

Text Books:

1. ***Berg, J.M.,Tymoczko, J.L. and Stryer, L.*(2015)*Biochemistry***, Eigth Edition, W.H. Freeman and Company, NewYork.
2. ***Boyer, R.F.* (2010) *Biochemistry – Laboratory Modern theory and technique,*** Second Edition, Prentice HallPublishers,UK.
3. ***Nelson, D.L. and Cox, M.M.* (2021) *Lehninger Principles of Biochemistry***, Eighth Edition, W.H. Freeman and Company, New York.

Reference Books:

1. ***Cambell, M.K. and Farrell, S.O.*** (2018) ***Biochemistry,*** Eight Edition, Cangage Learning
2. ***Voet, D., Voet, J.G. and Pratt, C.W.*(2013)*Fundamentals of Biochemistry – Life at the Molecular level***, Fouth Edition, John Wiley & Sons. Inc, New York.
3. ***Murray, R.K., Bender, D.A., Bootham, K.M., Kennlley, P.J., Rodwell, V.W. and Weil, P.A.* (2012) *Harpers Illustrated Biochemistry,*** Twenty ninth Edition, Tata McGraw Hill Companies' Publication, New Delhi.

Course Outcomes:

At the end of the course students will be able to

1. Understand the fundamental knowledge and basic concepts and principles of biochemistry and biotechnology.
2. Assessabout the structure and function of biomolecules in living system
3. Understand the physical and chemical properties of biomolecules.
4. To impart knowledge on the structure and biologically important complex biomolecules.
5. To study the nature, physical and electrochemical properties of amino acids.

Mapping of COs with POs & PSOs

CO/PO	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11	PSO 1	PSO 2	PSO 3
CO 1	H	H	M	H								H	M	
CO 2	H	H	M	H								H	M	M
CO 3	H	H	M									H	M	H
CO 4	H	H	M									H	M	
CO 5	H	H	M							H		H	M	M

CO – Course Outcomes; PO – Programme Outcomes: PSO- Programme Specific Outcomes

H - High; M - Medium; L - Low

Practicals-I Analytical Biochemistry – Qualitative Analysis

Semester I
21BBCC02 **Hours of Instruction /week: 3**
Objectives: **No. of Credits: 2**

1. To acquire basic lab skills, concepts and use of scientific method
2. To understand the basic principle and methodology for the qualitative analysis of biomolecules
3. To learn the basic techniques involved in the biochemical methods for the isolation and analysis of biological molecules

Unit 1 Reactions of monosaccharides **9**
Pentose, Glucose, Fructose, Galactose and Mannose

Unit 2 Reactions of disaccharides and polysaccharides **9**
Sucrose, Maltose, Lactose, Starch, Dextrin and Glycogen

Unit 3 Reactions of proteins and amino acid **9**
Reactions of amino acids Tyrosine, Tryptophan, Histidine, Arginine, Cysteine and Methionine

Unit 4 Group experiment I **9**
Characterization of fats – acid number, iodine number, saponification number and RM number

Unit 5 Group experiment II **9**
Color reactions of cholesterol
Preparation of starch
Extraction of total lipids by Soxhlet apparatus

Total Hours: 45

References:

1. ***Murray, R.K., Bender, D.A., Botham, K.M., Kennlley, P.J., Rodwell, V.W. and Weil, P.A.*(2012)*Harpers Illustrated Biochemistry,*** Twenty ninth Edition, Tata McGraw Hill Companies' Publication, New Delhi.
2. ***Wilson, W. and Walker, J.* (2002) *Practical Biochemistry***, Fifth Edition, Cambridge University Press, UK.
3. ***Sadasivam, S. and Manickam, A.*** (2005) ***Biochemical Methods***, Second edition, New Age International Pvt. Ltd.
4. ***Jayaraman, J.***(2011)***Laboratory Manual in Biochemistry,*** New Age International Pvt. Ltd.
5. ***Murray, R.K., Bender, D.A., Botham, K.M., Kennlley, P.J., Rodwell, V.W. and Weil, P.A.*(2012)*Harpers Illustrated Biochemistry,*** Twenty ninth Edition, Tata McGraw Hill Companies' Publication, New Delhi.
6. ***Wilson, W. and Walker, J.* (2002) *Practical Biochemistry***, Fifth Edition, Cambridge University Press, UK.

7. ***Sadasivam, S. and Manickam, A.*** (2005) ***Biochemical Methods***, Second edition, New Age International Pvt. Ltd.
8. ***Jayaraman, J.***(2011)***Laboratory Manual in Biochemistry***, New Age International Pvt. Ltd.

Course Outcomes:

At the end of the course, students will be able to

1. Understand the basic laboratory equipments and appreciate their use in biochemistry experiments
2. Analyze and identify the various carbohydrates by means of biochemical reactions
3. Analyze and identify the various amino acids by means of biochemical reactions
4. Characterize fats by various chemical methods
5. Isolate starch and identify cholesterol in samples by colour reactions

Mapping of COs with POs & PSOs

CO / PO	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11	PSO 1	PSO 2	PSO 3
CO 1	H	L	M		M			M	L			H	M	H
CO 2	H	L	M		M			M	L				M	
CO 3	H	L	L		M			M	L			H	M	M
CO 4	H	L	L		M			M	L			H		M
CO 5	H	L	L		M			M	L			H	M	

CO – Course Outcomes; PO – Programme Outcomes; PSO- Programme Specific Outcomes

H - High; M - Medium; L - Low

Introduction to Biotechnology and Cell Biology

Semester I
21BBTC01

Hours of Instruction /week: 5
No. of Credits: 3

Objectives:

1. To understand the origin of biotechnology and the difference between ancient and modern biotechnology
2. To build strong basics of cellular architecture, its components and their organization
3. To inculcate the knowledge of the varied functions of cells, their interactions and development

Unit 1 Introduction **15**

Timeline of Biotechnology - History and industrial development of Biotechnology – Green, yellow, white, blue and other colors of Biotechnology

Cell as the basic unit of living systems – the cell theory – pre-cellular evolution – Stanley Miller's experiment to understand the artificial creation of cells

Broad classification of cell types - mycoplasma, bacteria, eukaryotic microbes, plant and animal cells (general discussion of cell architecture)

Detailed classification of cell types within an organism – cell, tissue, organ and organism as different levels of organization of otherwise genetically similar cells

Unit 2 Structure and functions of cell organelles **15**

Ultrastructure of cell membrane, cytosol, Golgi bodies, endoplasmic reticulum (rough and smooth), ribosomes, mitochondria, chloroplasts, lysosomes, peroxisomes, glyoxisomes, nucleus (nuclear membrane, nucleoplasm, nucleolus, chromatin)

Unit 3 Cell division and interactions **15**

Cell division - mitosis and meiosis. Cell cycle – stages of interphase and M-phase – cell synchrony and its applications (regulatory aspects not needed)

Cell-cell interactions - Metabolic cooperation, electrical coupling, contact inhibition, autocrine, paracrine and endocrine signaling (discussion on individual hormones not needed)

Ecological amplitude of cells in high altitude, sediments, arctic, hot springs, arid, brackish and freshwater environments

Unit 4 Cell locomotion

Cytoskeletal elements - Microtubules, microfilaments (actin and myosin), intermediary filaments - cell locomotion (amoeboid, flagellar and ciliary) – muscle and nerve cells as terminally differentiated cells – muscle cells – general structure of skeletal and smooth muscles – microfilament organization in skeletal and smooth muscles – sliding filament mechanism of contraction (energy aspects and regulation not needed) – nerve cells – general structure of a neuron – synapses – types (electrical and chemical) (mechanism and regulation of nerve impulse generation and transmission not needed) **15**

Unit 5 Cell differentiation, senescence and death **15**

Cell differentiation in plants: Fertilization, initial divisions, seed formation, germination, primordial layer formation, organogenesis (only sources of organs from each layer)
Cell differentiation in animals: fertilization, implantation, blastula formation, gastrulation, primordial germ layers, organogenesis (only sources of organs from each layer)
Cell senescence: Biochemical changes during senescence – role of telomere and telomerase.
Cell death – necrosis and programmed cell death (apoptosis, paraptosis and autophagy)

Total Hours : 75

Textbooks:

1. ***Karp, G.* (2013)*Cell and Molecular Biology - Concepts and Experiments***, Seventh Edition, John Wiley and Sons, Inc, New York.
2. ***Verma, P.S. and Agarwal, V.K.* (2010) *Cell Biology, Genetics, Molecular Biology, Evolution and Ecology***, Ninth Edition, S. Chand and Co. Ltd, New Delhi.
3. ***Cooper, G.M. and Hausman, R.E.*(2013)*The Cell – A Molecular approach***, Seventh Edition,Sinauer Associates Inc, US.
4. **Islam Aminul, (2018), Essentials of Cell Biology,** Books and Allied

Reference Books:

1. ***Nelson, D.L. and Cox, M.M.*(2021).*Lehninger Principles of Biochemistry,*** Eighth Editon, W.H. Freeman and Company, New York.
2. ***Berg, J.M., Tymoczko, J.L. and Stryer, L.*(2012).*Biochemistry,*** Seventh Edition, W.H. Freeman & Company, New York.
3. ***Lodish, H., Berk, A., Matsudair, P., Kaiser, C.A., Krieger, M., Scott, P.M., Bretscher, A., Ploegh, H. and Matsuaira, P.* (2014)*Molecular Cell Biology***, Seventh Edition, W.H Freeman and Company, New York.

Course Outcomes:

The students will be able to

1. Know the history, development of biotechnology and classify cell types within an organism at all levels of differentiation
2. Understand the structure and functions of cell organelles
3. Illustrate the different stages of cell division and cell-cell interactions
4. Establish the role of cytoskeletal elements in cell locomotion
5. Distinguish cellular differentiation in plants and animals and interpret the different modes of cell death

Mapping of COs with POs & PSOs

CO / PO	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11	PSO 1	PSO 2	PSO 3
CO 1	H	H		M	L	L							M	H
CO 2	H	H		M	L	L						H	M	
CO 3	H	H		M	L	L						H	M	H
CO 4	H	H		M	L	L						H		M
CO 5	H	H		M	L	L						H	M	

CO – Course Outcomes; PO – Programme Outcomes; PSO- Programme Specific Outcomes
H - High; M - Medium; L - Low

Microbiology

Semester I **Hours of Instruction /week: 4**

21BBTC02 **No. of Credits: 3**

Objectives:

1. To understand the discovery of microorganisms, their classification and structures
2. To know the methods in microbiology and sterilization techniques
3. To give an idea about the various diseases caused by pathogenic microorganisms

Unit 1 Scope and history of microbiology **12**

Discovery of microorganisms - spontaneous generation controversy – germ theory of disease - microbial effects on organic and inorganic matter

Microscopy - light microscopy- dark field, phase contrast, fluorescence microscopy, electron microscopy-SEM, TEM.

Unit 2 Classification and Structure of microorganisms **12**

Microbial taxonomy, Structure of bacterial cells- capsule, flagella, fimbriae or pili; Cell wall-chemical composition and characteristics of Gram positive and Gram-negative bacteria. Classification and morphology of fungi, algae, protozoa and viruses.

Unit 3 Methods in microbiology **12**

Staining- principle and types

Microbial growth – Growth curve. Culture media– types, preparation and characteristics; Methods of isolation of pure culture. Culture cultivation and preservation.

Unit 4 Control of microorganisms **12**

Sterilization and Disinfection.

Physical methods- dry and moist heat, Pasteurization, Tyndalization, radiation, ultrasonication, filtration.

Chemical methods – phenols, alcohols, halogens, heavy metals, quaternary ammonium compounds, aldehydes, sterilizing gases. Mechanism of action of antimicrobial agents

Unit 5 Medical microbiology **12**

Bacterial diseases – tuberculosis, diptheria, cholera, typhoid, leprosy; Viral diseases – Dengue fever, measles, mumps, rubella, AIDS, hepatitis B, COVID-19; Fungal diseases – mycosis, candidiasis; Protozoan diseases – malaria, sleeping sickness. Antimicrobial agents. Antibiotics and antibiotic resistance (brief account).

Total Hours : 60

Textbooks:

1. ***Talaro, K.P. and Talar, A.* (2012). *Foundations in Microbiology***, Eight Edition, The McGraw Hill Publishing Company, New York.
2. ***Prescott, L.M., Harley, J.P. and Klein, D.A.* (2010). *Microbiology***, Eight Edition, The McGraw Hill Publishing Company, New York.
3. ***Pelczar, M.J., Chan, E.C. and Krieg, N.R.* (2006). *Microbiology***, Sixth Edition, Tata McGraw Hill Publishing Company, New Delhi.
4. **SastryApurba S, Bhatt Sandhya, (2019), Essentials of Medical Microbiology**, 2nd Ed., Jay Pee Brothers Medical Publishers Ltd.

Reference Books:

1. ***Sumbali, G. and Mehrotra, R.S.*(2009). *Principles of Microbiology***, Tata McGraw-Hill Publication, New Delhi.
2. ***Casida, J.R.* (2009).*Industrial Microbiology***, Fifth Edition, New Age International Publishers, New York.
3. ***Tortora, J.G., Funke, K.B. and Case, L.C.* (2006).*Microbiology – An Introduction***, Eleventh Edition, Beryamin-Cummings Publishing Company, New York.

Course Outcomes :

At the end of the course, the students will

1. Appreciate the principle of various microscopes and their utility in Microbiology
2. Gain an insight into the classification of microorganisms and their ultra structure
3. Acquire the theoretical knowledge for the various methods used in microbiology.
4. Understand the methods used in the control of microorganisms
5. Understand how microorganisms cause various diseases.

Mapping of COs with POs & PSOs

CO / PO	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11	PSO 1	PSO 2	PSO 3
CO 1	H	H	H	L						L		H	M	M
CO 2	H	H	H	L						L			M	M
CO 3	H	H	H	L						L		H		
CO 4	H	H	H	L						L			H	H
CO 5	H	H	L	L						L		H	H	H

CO – Course Outcomes; PO – Programme Outcomes; PSO- Programme Specific Outcomes
H - High; M - Medium; L - Low

Techniques in Biochemistry

Semester II **Hours of Instruction /week: 5**

21BBCC03 **No of Credits: 4**

Objectives:

1. To impart knowledge on the concepts related to the characterization of biomolecules.
2. To enable students to understand the basic principles and applications of biochemical techniques
3. To provide a strong theoretical base for employability of students in industries and research

Unit 1 Buffers and Centrifugation techniques **15**

Definition, derivation of Henderson- Hasselback equation and its application. Buffer systems of body fluids and pH maintenance. Determination of pH by hydrogen electrode and glass electrode.
Introduction, basic principles of sedimentation, desktop centrifuges, and large capacity refrigerated centrifuges – analytical and preparative ultracentrifugation. Applications of ultracentrifuge-separation of cell organelles. Basic principles of density gradient centrifugation.

Unit 2 Chromatography I **15**

Definition, principles and types of chromatography
Paper chromatography – separation of amino acids by ascending chromatography.
Thin layer chromatography - principle and separation of phospholipids.
Adsorption chromatography - principle and separation of carotenoids.
Ion exchange chromatography- principle and different types of resins, separation of amino acids

Unit 3 Chromatography II **15**

Affinity chromatography – Principle and separation of an enzyme.
Gas chromatography - principle and separation of fatty acids.
Gel filtration - principle, estimation of molecular size and molecular weight of a bio macromolecule.
HPLC – Elementary concepts only

Unit 4 Electrophoresis **15**

Principles and types of electrophoresis – Agarose gel electrophoresis
Separation of serum proteins by paper electrophoresis
Polyacrylamide gel electrophoresis, Immunoelectrophoresis, Elementary concepts of Isoelectric focusing

Unit 5 Spectrophotometry and isotopes **15**

Principle, Beer and Lamberts Law, description of the instrument and technique. Absorption spectrophotometry - Principle and applications, description of the instrument – Colorimetry, UV-Visible and atomic absorption spectroscopy. Fluorimetry - Principles and description of the instrument.
Definition, Important stable and radioactive isotopes used in biochemical research. Use of radioactive isotopes in clinical diagnosis and therapy. Principle of radio-immuno assay. Radiation hazards and precautions to be taken in handling radioactive isotopes. Measurement of radioactivity

by scintillation counters.Autoradiography.

Total Hours : 75

Text Books:

1. ***Wilson, K. and Walker, J.*(2018) *Practical Biochemistry – Principles and Techniques,*** Eigth Edition, Cambridge University Press, India
2. ***Sharma, B.K.* (2014).*Instrumental Methods of Chemical Analysis***,Krishnaprakashan Media (P) Ltd, New Delhi.
3. ***Upadhyay, U and Upadhyay, N. (2010)*** Biophysical Chemistry principles and Techniques.Himalaya Publ. 2010.
4. ***Sabari Ghosal, AvasthiAnupama Sharma, (2018) Fundamentals of Bioanalytical Techniques and Instrumentation.*** *2nd Ed., PHI Learning.*

Reference Books:

1. ***Subramanian, M.A.* (2006) *Biophysics, Principles and Techniques***, MJP Publishers, Chennai, Tamil Nadu.
2. ***Plummer, D.* (2004) *An Introduction to Practical Biochemistry***, Fifth Edition, Tata McGraw Hill Publishing Co. Ltd, New Delhi.
3. ***Katoch, R*(2011)*Analytical Techniques in Biochemistry and Molecular Biology***, Springer Science

Course Outcomes:

At the end of the course students will be able to

1. Understand the theoretical basis for the practical experiments.
2. Recognize the importance of buffer systems in pH maintenance.
3. Appreciate the principle, operation, and applications of various techniques for analyzing biomolecules.
4. Design suitable techniques for the separation of biomolecules
5. Interpret the results of analytical techniques.

Mapping of COs with POs & PSOs

CO / PO	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11	PSO 1	PSO 2	PSO 3
CO 1	H	H	H	L							L		M	H
CO 2	H	H	H	L							L	H	M	
CO 3	H	H	H	L							L	H	M	M
CO 4	H	H	H	L							L	H	H	
CO 5	H	H	H	L							L		M	H

CO – Course Outcomes; PO – Programme Outcomes

H - High; M - Medium; L - Low ; PSO- Programme Specific Outcomes

Chemistry of Proteins

Semester II **Hours of Instruction /week: 4**
21BBCC04 **No. of Credits: 3**

Objectives:

1. To understand the hierarchical organization of protein structure.
2. To understand the classification and properties proteins.
3. To learn the methods of isolation, purification and sequence analysis of proteins

Unit 1 Amino acid sequence in proteins **12**

Determination of amino acid composition
N- terminal and C- terminal amino acids – determination of amino acid sequence of proteins by chemical and enzymatic methods

Unit 2 Peptides **12**

The peptide bond- formation and its conformation
Structure of biologically active small peptides- glutathione, oxytocin and vasopressin
Chemical synthesis of peptides- in solution and solid phase - Forces involved in protein conformation

Unit 3 Classification and properties of proteins **12**

Classification based on solubility and functions, acid-baseproperties and color reactions of proteins- denaturation and coagulation.

Unit 4 Structure and conformation of proteins **12**

Primary, secondary, supersecondary (brief account) tertiary and quaternary structure
Structure of proteins citing insulin, collagen and hemoglobin as examples.

Unit 5 Proteins Extraction and Characterization **12**

Isolation and extraction
Separation and purification of proteins based on molecular size, solubility differences, electric charge, selective absorption and ligand specificity.
Characterization and criteria of purity -Estimation of proteins

Total Hours : 60

Text Books:

1. ***Berg, J.M., Tymoczko, J.L. and Stryer, L.* (2012).*Biochemistry***, Seventh Edition, W.H. Freeman and Company, New York.
2. ***Gupta, P.K.* (2012). *Biotechnology and Genomics***, First Edition, Sixth reprint, Rastogi Publications, Meerut.
3. ***Dubey, R.C.* (2010). *A Text Book of Biotechnology***, Fifth Edition, S. Chand and Company, Ltd., New Delhi.

Reference Books:

1. ***Nelson, D.L. and Cox, M.M.* (2013).*Lehninger Principles of Biochemistry***, Sixth Edition, W.H. Freeman and Company, New York
2. ***Voet, D., Voet, J.G., and Pratt, C.W.* (2013).*Fundamentals of Biochemistry – Life at the Molecular level***, Fourth Edition, John Wiley & Sons. Inc, New York.
3. ***Ratledge, C. and Kristiansen, B.* (2003).*Basic Biochemistry***, Second Edition, Cambridge University Press, New York.

Course Outcomes:

At the end of the course students will be able to

1. Appreciate the hierarchical organization of protein structure
2. Understand the classification, properties and functions of proteins.
3. Relate the structural complexity of proteins with their biological activity
4. Apply the appropriate techniques for purification and characterization of proteins
5. Analyse the amino acid sequence of proteins and relate the same to the functions of proteins

Mapping of COs with POs & PSOs

CO / PO	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11	PO 12	PSO 1	PSO 2	PSO 3
CO 1	H	H	L						L				H	H	H
CO 2	H	H	L						L					M	
CO 3	H	H	L	M	L	L			L				H	M	
CO 4	H	H	H	M	M	L			L				M	H	M
CO 5	H	H	H	H	H	M			L				H	M	M

CO – Course Outcomes; PO – Programme Outcomes; PSO- Programme Specific Outcomes

H - High; M - Medium; L - Low

Biophysics

Semester II **Hours of Instruction /week: 4**
21BBTC03 **No. of Credits: 3**

Objectives:

- To comprehend the basic concepts of regulation of body temperature and nerve action potential.
- To understand the basic principles and applications of instruments used to analyze the structure of biomolecules
- To understand the designing and functioning of modern biomedical equipment.

Unit 1 Bioenergetics **12**

Energetics of the living body – basic concepts of thermodynamics, bioenergetics, role of ATP as energy currency of the cell, forms of energy, metabolic rate and factors affecting, BMR, body temperature – regulation, limits to temperature, heat dissipation and conservation, abnormalities of body temperature regulation

Unit 2 Light perception strategies **12**

Light perception strategies in humans - receptor and neuronal functions of retina, photochemistry of vision, regulation of retinal sensitivity, errors of refraction and correction of vision faults

Unit 3 Membrane potential and hearing perception **12**

Electrical properties of biological compartments – basic physics of membrane potential, resting potential, nerve action potential, propagation of nerve potential.
Generation and reception of sonic vibrations - physical aspects of hearing, hearing abnormalities, hearing aids – mechanism of working and types

Unit 4 Techniques for molecular structure determination **12**

Basic concept, principle and application of spectroscopic techniques in structure –infrared, fluorescence, Raman spectra, X-ray crystallography, mass spectroscopy and NMR.

Unit 5 Imaging techniques **12**

Methods of imaging intact biological structures – Ultrasound scan, MRI, Electrocardiogram, Electroencephalogram, CAT scan, PET scan, X- ray

Total Hours : **60**

Text Books:

1. **Guyton, A.C. and Hall, J.E. (2020). Textbook of Medical Physiology**, 14th Edition, Saunders Company Publishers, New York.
2. ***Khandpur, R.S.* (2014) *Biomedical Handbook of Biomedical Instrumentation***, Third Edition, McGraw Hill Publishing Company, New York.
3. ***Wilson, W. and Walker, J.* (2018) *Practical Biochemistry – Principles and Techniques***, Eigth Edition, Cambridge University Press, UK.

4. ***Upadhyay, U and Upadhyay, N. (2010) Biophysical Chemistry principles and Techniques.*** Himalaya Publ.

Reference Books:

1. ***Cromwell, L., Welbel, F.J. and Pfeiffer, E.A.*** **(2010)** ***Biomedical Instrumentation and Measurement***, Narosa Publishing House, Second Edition, New Delhi.
2. ***Srivastava, P.K.*** **(2005)** ***Elementary Biophysics - An Introduction***, Narosa Publishing House, New Delhi.
3. ***Chatwal, G.R. and Anand, S.K.*** **(2011)** ***Instrumental Methods of Chemical Analysis***, Himalaya Publishing House, Chennai.

Course Outcomes:

At the end of the course students will be able to

1. Understand the concept of bioenergetics and mechanism of body temperature regulation
2. Grasp the mechanism of Light absorption strategies
3. Comprehend the mechanism of membrane potential and hearing perception
4. Appreciate the various spectroscopic methods used to study the bimolecular structure
5. Understand the designing and functioning of modern imaging techniques

Mapping of COs with POs & PSOs

CO / PO	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11	PO 12	PSO 1	PSO 2	PSO 3
CO 1	H	M		M		L							H	M	H
CO 2	H	M		M		L							H		
CO 3	H	M		M		L							H	M	H
CO 4	H	M	M	M	M	L									
CO 5	H	M	M	H	M	M	L		L				H	M	H

CO – Course Outcomes; PO – Programme Outcomes; PSO- Programme Specific Outcomes

H - High; M - Medium; L - Low

Practicals - I Techniques in Biotechnology

Semester II **Hours of Instruction /week: 4**

21BBTC04 **No. of Credits: 2**

Objectives:

1. To develop laboratory skills in handling biological samples
2. To get hands on experience in various techniques in biotechnology and immunotechniques

Unit 1 Individual Experiments **12**

Biometric observations in plants

1. Germination Percentage
2. Root Length
3. Shoot length
4. Fresh Weight
5. Dry Weight
6. Moisture Content
7. Vigour index
8. Nodule number

Unit 2 *Spectrophotometric techniques* **12**

1. Estimation of total proteins
2. Estimation of phosphorus
3. Estimation of iron

Unit 3 *Titrimetric analysis* **12**

1. Estimation of ascorbic acid
2. Estimation of calcium

Group Experiments/Demonstrations

Unit 4 *Separation techniques* **12**

1. Chromatography: Gel filtration, ion exchange
2. Electrophoresis: PAGE (Poly acrylamide gel electrophoresis)

Unit 5 *Immunotechniques* **12**

1. Blood grouping
2. Immuno diffusion
3. Immuno electrophoresis

Total Hours : 60

Course Outcomes

At the end of the course students will be able to

1. Understand thefundamental knowledge and basic concepts and principles of biochemistry and biotechnology.
2. Analyse some of the biometric observations in plants
3. Estimate the concentration of compounds by using various techniques.
4. Observe the results and recording the data.
5. Examine the blood sample and identification of blood groups.

Mapping of COs with POs & PSOs

CO/PO	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11	PSO 1	PSO 2	PSO 3
CO 1	H	H	M					H	H			H	M	H
CO 2	H	H	M	H			M	L			H	M	M	
CO 3	H	H	M	H			L		L		M	H	M	
CO 4	H	H	M	H	M		H	M	M		M	M	M	H
CO 5	H	H	M	H	M			H		H		H	M	H

CO – Course Outcomes; PO – Programme Outcomes

H - High; M - Medium; L - Low

Intermediary Metabolism – I

Semester III **Hours of Instruction /week: 4**
21BBCC05 **No. of. Credit: 3**

Objectives:

1. To understand the fate of dietary constituents after digestion and absorption
2. To enable the students to understand the metabolic pathway and metabolic disorders in order to apply in clinical diagnosis
3. To facilitate the students in gaining employability in nutrition and health sciences

Unit1 **12 hrs**

Introduction to metabolism - Anabolism, catabolism

Metabolism of Carbohydrates and metabolic disorders - Glycolysis, metabolism of fructose, galactose and mannose, TCA Cycle, Glyoxalate cycle, hyperglycemia, hypoglycemia, hereditary fructose intolerance (HFI) and galactosemia.

Unit 2 **12 hrs**

Glycogen metabolism and metabolic disorders - Glycogenesis, Glycogenolysis, Gluconeogenesis, Hexose mono phosphate shunt and Glucuronic acid pathway, Glycogen storage disorders type I to IX.

Unit 3 **12 hrs**

Metabolism of Lipidsand metabolic disorders - Fatty acid oxidation- oxidation of even carbon and odd carbon fatty acids and unsaturated fatty acids, α-oxidation and ω-oxidation, MTPD, MCADD, LCHADD, and VLCADD.

Unit 4 **12hrs**

Fatty acid synthesis - synthesis of saturated and unsaturated fatty acids, synthesis of essential fatty acids, chain elongation.

Unit 5 **12 hrs**

Metabolism of Protein and metabolic disorders - General breakdown of protein, deamination, transamination, decarboxylation and urea cycle and its disorders (ornithine transcarbamylase deficiency and citrullinemia).

Total 60 hrs

Text Books:

1. *Bery, J.M., Tymoezko, J.L. and Stryer, L.* (2019), *Biochemistry*, 9th Edition, W.H.Freeman and Company, New York.
2. *Ramadevi, K.* (2016). AmbikaShanmugam's Fundamentals of Biochemistry for Medical Students, 8th Edition.
3. *Jain, J.L and Jain, S* (2016), *Fundamentals of Biochemistry*, Revised Edition, S. Chand & Company, New Delhi.

Reference Books:

1. *Donald Voet, Judith G. Voet, Charlotte W. Pratt* (2016), Fundamentals of Biochemistry: Life at the

Molecular Level, 5th Edition, Wiley Publications.
2. *Murray, K.R., Granner, K.D., Mayes, P.A. and Rodwell, W.V.* (2018), *Harper's Biochemistry*, 31st Edition, Appleton & Lange Stamford, Connecticut.
3. *Nelson, D.L and Cox, M.M* (2021), *Lehninger Principles of Biochemistry*, 8th Edition, Worth Publishers, New York.

Course Outcomes:

1. Students will be able to **understand** the fate of dietary constituents after digestion and absorption.
2. Students will be able to **recognize** the role of biomolecules in intermediary metabolism
3. Students will be able to **explain** how diet regulates major human metabolic pathways.
4. Students will be able to **correlate** the metabolism of biomolecules and their specialized products.
5. Students will be able to **relate** the role distinct metabolic pathways and their disorders.

Mapping of COs with POs & PSOs

CO / PO	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11	PSO 1	PSO 2	PSO 3
CO 1	H	L	L	M	M					H		H	M	L
CO 2	H									M		H	M	
CO 3	H			L						M		H	M	
CO 4	H			L	L	L				L		H	M	
CO 5	H	L	L							M		H	M	

CO- Course Outcomes; PO- Programme Outcomes; PSO- Programme Specific Outcomes
H: High M: Medium L: Low

Human Physiology

Semester III **Hours of Instruction /week: 4**
21BBCC06 **No. of Credits: 3**

Objectives:

1. To acquire basic knowledge of the various physiological systems and organs in the human body
2. To learn the complex mechanisms of the various systems in the human body
3. To assist the students to obtain employability in healthcare industry

Unit 1 Digestive and Excretory system **12hrs**

Functional anatomy of digestive tract, functions of salivary gland, stomach, small intestine, large intestine, liver and pancreas. Digestion and absorption of carbohydrates, proteins and lipids
Structure of kidney, mechanism of urine formation. Role of kidney in maintaining acid-base balance. Micturition

Unit 2 Cardiovascular system **12hrs**

Blood- properties, composition and functions of blood and blood elements, erythropoiesis, blood groups, blood transfusion, blood coagulation.
Heart- Structure and functions of heart, cardiac output, blood pressure and blood circulation-systemic and pulmonary. Factors affecting blood pressure. Cardiac cycle and electrocardiogram

Unit 3 Respiratory system **12hrs**

Functional anatomy of respiratory system, mechanics of respiration, diffusion of gases - mechanism of respiration, regulation of respiration, hypoxia

Unit 4 Muscular system **12hrs**

Classification – structure of skeletal and smooth muscles. Mechanism of muscle contraction and relaxation. Disorders of skeletal muscles
Nervous system- divisions, structure and functions of brain, spinal cord and neuron, transmission of nerve impulse. Autonomic nervous system. Cerebrospinal fluid and its functions

Unit 5 Reproductive system **12hrs**

Development of gonads and genitalia, testis and spermatogenesis, female reproductive system-oogenesis, physiological changes and hormones during menstruation, pregnancy, parturition and lactation

Total 60hrs

Text Books:

1. Guyton, A.C. and Hall, J.E. (2020). Textbook of Medical Physiology, 14th Edition, Saunders Company Publishers, New York.
2. Sembulingam, K. and Sembulingam, P. (2019). Essentials of Medical Physiology, 8th Edition, J.P. Medical Publishers (P) Ltd, New Delhi.
3. Tortora, G.J. and Bryan H. Derrickson. (2017). Tortora's Principles of Anatomy and Physiology, 15th Edition, John Wiley & Sons, New York.

Reference Books:

1. Chandramouli, R. (2010). Textbook of Physiology, Third Edition, Jaypee Brothers Medical Publishers (P) Ltd. New Delhi.
2. Fox, S. (2018).Human Physiology, 15th Edition, WCB McGraw- Hill Publications, New York.
3. Davies, A., Blackely, A.G.H. and Kidd, C. (2001). Human Physiology, Churchill Livingstone, Toranto, Harcourt Publishers Ltd, New York.

Course Outcomes:

At the end of the course, the student will able to

1. Understand the concepts of digestive and excretory system in the human body
2. Analyse the physiological functions of cardiovascular system
3. The complex mechanisms of respiratory system
4. Integrated system physiology of muscular system
5. Explain the concept of reproductive system

Mapping of COs with POs & PSOs

CO / PO	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11	PS O 1	PS O 2	PS O 3
CO 1	H	H	M	M	M	M	M	H	H			H	M	M
CO 2	H	H	M	M	M	M	H	M	L			H	M	H
CO 3	H	H	M	M	M	M	L	M	M	H	H	H	M	M
CO 4	H	H	M	M	M	M	H	H		H	M	H	M	M
CO 5	H	H	M	M	M	M	H	H				H	M	H

CO- Course Outcomes; PO- Programme Outcomes; PSO- Programme Specific Outcomes

H: High M: Medium L: Low

Practicals – II Enzymes

Semester III **Hours of Instruction /week: 5**
21BBCC07 **No. of Credits: 3**

Objectives:

1. To enable students to understand the methods of isolation and purification of enzymes
2. To understand the factors affecting enzyme activity
3. To facilitate employability in industries associated with mass production of commercial enzymes

Unit 1 **15 hrs**

Titration curve of an amino acid
Formol titration
Ammonium sulphate precipitation of protein and dialysis
Isolation of Enzymes – acid phosphatase (Potato) and Catalase (Chow Chow)

Unit 2 **15 hrs**

Effect of pH on the activity of catalase
Effect of temperature on the activity of catalase

Unit 3 **15 hrs**

Effect of enzyme concentration on the activity of catalase
Effect of substrate concentration on the activity of catalase

Unit 4 **15 hrs**

Effect of pH on the activity of acid phosphatase
Effect of temperature on the activity of acid phosphatase

Unit 5 **15 hrs**

Effect of enzyme concentration on the activity of acid phosphatase
Effect of substrate concentration on the activity of acid phosphatase

Total **75 hrs**

Reference Books:

1. Sadasivam, S. and Manickam, A. (2005) Biochemical Methods, Second edition, New Age International Pvt. Ltd.
2. Jayaraman, J.(2011)Laboratory Manual in Biochemistry, New Age International Pvt. Ltd.
3. Palmer, T. (2018). Enzyme Biochemistry, Biotechnology and Clinical Chemistry,ChaukhambaAuriyantaliya publisher

Course Outcomes:

At the end of the course, students will be able to

1. Identify the sources of enzymes.
2. Analyse the techniques to extract the enzymes.
3. Understand the influence of Enzyme concentration, Substrate concentration, pH and Temperature on the activity of enzymatic reactions.
4. Learn the kinetics of enzyme catalyzed reactions.
5. Learn the purification of enzyme using ammonium sulfate precipitation and dialysis.

Mapping of COs with POs & PSOs

CO / PO	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11	PSO 1	PSO 2	PSO 3
CO 1	M		L				M						L	
CO 2	H		L	M	M		M				M		M	M
CO 3	H		H	H	M		M				M		M	
CO 4	M		L	L	M		M				M		M	M
CO 5	H		H	H	M		M				M		H	M

CO – Course Outcomes;PO – Programme Outcomes;PSO – Programme Specific Outcomes;
H: High M: Medium L: Low

Environmental Biotechnology

Semester III **Hours of Instruction /week: 4**
21BBTC05 **No. of Credits: 3**

Objectives:

1. To understand the sources of energy and need for conservation of natural resources
2. To understand the methodologies available for wastewater treatment and to apply for societal challenges in waste management
3. To equip the students to become employer in sustainable energy industry and government sectors

Unit 1 Energy sources **12 hrs**

Renewable and non-renewable resources - fossil fuels, conventional fuels and their environmental impacts – firewood, plant, coal, gas and animal waste – solar energy converters, conservation of energy.

Unit 2 Biomass energy **12 hrs**

Hydrocarbons from plant sources- plant based petroleum industry, biogas production, photobiological process of hydrogen production, production of ethanol from fermentable substrates.
Cellulose degradation for combustible fuel

Unit 3 Bioremediation **12 hrs**

In situ, intrinsic and *ex situ* – bioremediation of dyes, heavy metals, xenobiotics, bioremediation using genetically engineered microbes (GEM), bioleaching – direct and indirect methods. Biomining – Enrichment of ores by microorganisms

Unit 4 Biofertilizers and Biopesticides **12 hrs**

Bacterial inoculants- Nitrogen biofertilizers and phosphate biofertilizers- Green manuring- Azolla, Mycorrhizaland Bacteria (*Pseudomonas, Bacillus*) as biofertilizers. Biopesticides- *Bacillus thuriengenesis.* Biodegradable plastics. Biofilms.

Unit 5 Wastewater treatment **12 hrs**

Physical, chemical and biological methods for wastewater treatment. Activated sludge, oxidation ponds. Anaerobic processes. C.O.D. and BOD. Treatment schemes for municipal waste and industrial effluents.

Total **60 hrs**

Text Books:

1. Dubey, R.C. (2010). A Textbook of Biotechnology, S. Chand and Company Ltd, New Delhi.
2. Das, H.K (2018) A Textbook of Biotechnology,8th edition, Wiley publisher
3. Gwendo, B., Ben, L., Singh and Theodore, L. (2005) Hand book of Environment, Management and Technology. John Wiley and Sons, New York, USA

Reference Books:

1. Wang, L.K. (2010). Environmental Biotechnology, First Edition, A Product of Human Press.
2. Fisher, M.R. (2018) Environmental Biology, Open Oregon Education Resources, USA.
3. De, A.K. (2020) Environmental Chemistry 7th edition. New Age International Publishers, New Delhi, India

Course Outcomes:

At the end of the course students will be able to

1. Comprehend the various biotechnological approaches to environmental management.
2. Learn the strategies for obtaining energy from various natural sources and for energy conservation.
3. Understand the concept of bioremediation to handle environmental toxins.
4. Recognize the importance of biofertilisers and bio pesticides
5. Analyze the harmful effects of waste water disposal to the environment and the biotechnological solutions.

Mapping of COs with POs & PSOs

CO / PO	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11	PSO 1	PSO 2	PS O3
CO 1	H	M	L		L							M	L	M
CO 2	H	H	L	L	M	H		M		L	M	M	M	M
CO 3	H	L	H	L	M	M			H		M	M	M	M
CO 4	H	L	L	M	M	H			H	M	M	M	M	M
CO 5	H	L	H	H	L		M				M	M	H	M

CO – Course Outcomes;PO – Programme Outcomes;PSO – Programme Specific Outcomes
H: High M: Medium L: Low

Genetics

Semester III **Hours of Instruction /week: 4**
21BBTC06 **No. of Credits: 3**

Objectives:

1. To make students understand the basics of Mendelian genetics, linkage and chromosome mapping
2. To provide students with a comprehensive understanding of cytogenetics, quantitative genetics and its influence on phenotypes.
3. To help students to understand the importance of population and developmental genetics in Biotechnological research and to become employer in biotechnology and medical industries

Unit 1 Classical Mendelian Genetics **12 hrs**

Mendelian principles and laws of heredity – monohybrid, dihybrid cross, test cross
And back cross, Multiple alleles, Sex chromosomes, sex influenced and sex-limited traits

Unit 2 Genetic Linkage, Chromosome Mapping and recombination

Linkage and crossing over
Two factor and three factor linkage analysis **12 hrs**
Genetic Recombination in bacteria - Transformation, Transduction and Conjugation
Mapping of the chromosome
Chromosomal determination of sex, sex linked inheritance
Dosage compensation and X chromosome inactivation

Unit 3 Cytogenetics **12 hrs**

Structure of chromosomes, Polytene and lamp brush chromosomes. Karyotyping
Banding pattern of chromosomes
Variations in chromosome number and structure – ploidies, deletion, duplication, inversion and translocation
Chromosomal aberrations in humans – non-disjunction

Unit 4 Quantitative Genetics **12 hrs**

Variations in the concept of dominance, penetrance, and expressivity
Polygenetic inheritance in beans
Inheritance in human beings – skin colour and IQ
Genetic analysis: Complementation test in gene identification
Traits determined by genes: pleiotropy and epistasis: genome imprinting

Unit 5 Population Genetics and Developmental Genetics **12 hrs**

Gene frequency and gene pool
Hardy Weinberg Equilibrium
Genetic control of development in *Drosophila melanogaster*

Total 60hrs

Text Books:

1. Pierce, B.A. (2020) Genetics: A Conceptual Approach, Seventh Edition, W.H Freemanand Company Publishing, New York.
2. Klug, W., Michael Cummings, M., Charlotte Spencer, C., Michael Palladino, M. and Killian, D. (2020)Concepts of Genetics, 12th Edition, Pearson Higher Education & Professional Group.
3. Hartwell, L., Goldberg, M., Fischer, J. and Hood, L.(2020) Genetics: From Genes to Genomes,7th Edition, McGraw-Hill Education.
4. Gardner, E.J., Simmons, M.J. and Snustad, D.P. (2015) Principles of Genetics, Seventh Edition, Wiley Publication, India.

Reference Books:

1. Daniel L. Hartl,and Elizabeth W. Jones(2019) Genetics: Analysis of Genes and Genomes, Ninth Edition, Jones and Bartlett Publishers, Inc.
2. Jorde, L., Carey, J. andBamshad, M. (2019) Medical Genetics. Elsevier
3. Wolpert, L., Arias, A.M., Tickle, C., Wolpert, T. and Crosland, C.(2015) Principles of Development, 5th Edition. OxfordUniversity press.

Course Outcomes:

Students will be able to

1. Explain the key concepts of Classical mendelian genetics its deviations and relationship between genotype and phenotype
2. Comprehend the relationship between linkage and chromosome mapping, and its influence on phenotype
3. Relate the structural variations of chromosomes to phenotype
4. Differentiate chromosomal structure by simple banding techniques
5. Explain the key concepts of population genetics, hardy Weinberg equilibrium, and factors influencing evolution

Mapping of COs with POs & PSOs

CO/PO	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11	PSO 1	PSO 2	PSO3
CO 1		M		H	M		M		M			M	L	
CO 2	M	H	H	M	H	M	H	M	H	M	M	M	M	
CO 3	M		H	H	M	H	M	M	H	M	M	M	M	M
CO 4	M		H		H	M	H	M	H	M	M	M	M	M
CO 5		H		H	M	H				H		M	H	M

CO – Course Outcomes; PO – Programme Outcomes; PSO – Programme Specific Outcomes; H - High; M - Medium; L - Low

Enzymes and Enzyme Technology

Semester III **Hours of Instruction /week: 4**
21BBTC07 **No. of Credits: 3**

Objectives:

1. To understand enzyme classification, structure and mechanisms of catalysis
2. To understand enzyme kinetic and role in metabolic regulation
3. To hone the students to understand the importance of enzymes in pharmaceutical and biotechnology industries

Unit 1 Introduction **12hrs**

Definition and history of enzymes

Classification and nomenclature of enzymes- brief account of classification of enzymes by IUB system

Enzyme kinetics- Michaelis-Menten equation, Line Weaver Burk plot, Hanes plot, Hofsteeplot.Effect of pH, temperature and enzyme concentration on the rate of enzyme reaction

Enzyme inhibitors - competitive, non-competitive and un-competitiveinhibition - allosteric enzymes and isoenzymes (kinetics not required)

Unit 2 Mechanism of enzyme action **12hrs**

Mechanisms of catalysis - acid base catalysis, electrostatic catalysis, proximity and orientation effect

Mechanism of action of lysozyme and chymotrypsin

Unit 3 Measurement of enzymatic reactions **12hrs**

Titrimetric, colorimetric, spectrophotometric, manometric and enzyme coupled reaction, enzyme units, turnover number, katal

Vitamins and trace elements in the function of enzymes

12hrs

Unit 4 Enzyme – Substrate complex formation and regulation

Active site- theories proposed – lock and key hypothesis and induced fit hypothesis

Enzyme specificity

Enzyme mediated regulation of metabolism - enzyme compartmentalization; feedback inhibition, reversible covalent modification of regulatory enzymes- multiple cascade system

Unit 5 Enzyme engineering

Immobilization of enzymes – methods of immobilization. **12 hrs**

Rationale of enzyme engineering - basic assumptions of protein engineering - site directed mutagenesis. Key biocatalyst properties that are altered through protein engineering.

Enzyme electrodes, Enzyme Biosensors

Applications of enzymes in industry – food processing, textiles, detergents and leather industries. Medical diagnosis (ELISA), therapy (thrombolytic agents and digestive aids).

Total 60hrs

Text Books

1. *Berg, J.M., Tymoczko, J.L. and Stryer, L.* (2019) *Biochemistry*, Ninth Edition, W.H. Freeman and Company, New York.
2. AnushaBhaskar and V.G.Vidhya. (2009). Enzyme Technology, MJP Publishers, Chennai, India.
3. *Nelson, D.L. and Cox, M.M.* (2020) *Lehninger Principles of Biochemistry*, Eighth Edition, W.H. Freeman and Company, New York.
4. *Mathur V.K.* (2019) Industrial applications of enzyme engineering and technology, Oxford Book Company

Reference Books:

1. *Palmer, T. and Bonner, P. (2008)Enzymes: Biochemistry, Biotechnology, Clinical Chemistry,*Second Edition, Woodhead Publishing, New York
2. *Voet, D., Voet, J.G., and Pratt, C.W.* (2016) *Fundamentals of Biochemistry – Life at the Molecular level*, Fifth Edition, John Wiley and Sons. Inc, New York.
3. *Copeland, R. A. (2008) Enzymes: A Practical Introduction to Structure, Mechanism and Data Analysis,*Wiley-YCH Publisher

Course Outcomes:

At the end of the course, students will be able to

1. To acquire fundamental knowledge on enzymes and their importance in biological reactions.
2. Understanding the enzyme kinetics and themechanism of action of enzymes.
3. Acquire theoretical knowledge on various methods of measurement of enzymatic reactions.
4. Appreciate the role of enzyme in regulation of metabolism
5. Understanding the role of enzymes in clinical diagnosis and industries.

Mapping of COs with POs & PSOs

CO / PO	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11	PSO 1	PSO 2	PSO 3
CO 1	H	H	M	L					M		L	H	M	
CO 2	H	H	M	L			M		M			H	M	
CO 3	H	H	M	L			M		M	M		H	M	L
CO 4	H	M	H	L		L	M			M		H	M	
CO 5	H	M	H	L	M	L			L	M		H	M	

CO – Course Outcomes; PO – Programme Outcomes; PSO- Programme Specific Outcome;
H - High; M - Medium; L - Low

Computer Applications in Biosciences

Semester III **Hours of Instruction /week: T+P: 2+3**
21BBCI05 **No. of Credit: 4**

Objectives:

1. To impart basic knowledge on computers and its fundamentals
2. To gain knowledge on Internet and networks and develop conceptual understanding of MS-Officce
3. To explore the digital technologies with the basics of computer applications

Unit 1 Introduction to Computers **6 hrs**

Introduction, characteristics of computers, classification of computers: micro, mini, mainframe, super computers. Components of computers: central processing unit, input unit, output unit, storageunit.
Operating System:
Functions and classification of operating system, Types: DOS, LINUX, UNIX, MS Windows, iOS and Chrome OS

Unit 2 Operating System – MS windows **6 hrs**

Working with MS windows - My Documents, My Computer, Recycle Bin: Open, Close, Resize, Minimize, Move and Customize Windows, Start Menu, Search programs and files: move, copy, save, name, rename, delete and backup files and folders. Windows help and support.

Unit 3 Networks and Internet **6 hrs**

Computer networks: LAN, WAN, MAN. Internet - search engines, browser, website, URL, web server, getting connected to the internet, TCP/IP, ISP, modem, types of internet connection. Internet applications: e mail, www, FTP, telnet, video conferencing, newsgroups.

Unit 4 MS Word and Power Point **6 hrs**

MS word - create a document, format and organize text, word with graphics - picture, objects, chart etc. Tabs and tables, applying special text, paragraph, and document formats.
MS Power point: getting started, formatting a presentation, presenting data using graphics, tables, charts, and animation.

Unit 5 MS Excel and Access **6 hrs**

MS Excel - creating and enhancing a worksheet, construct formulas and functions, charts, Manage multiple worksheets in a workbook - using excel functions and tables.
MS Access - creating a table, navigating a table, queries. Creating forms and reports.

Total **30 hrs**

Practical

Unit 1 **9 hrs**
Operating systems: DOS, WINDOWS

Unit 2 **9 hrs**
Working with MS Windows

Unit 3 **9 hrs**
Internet browsing, Search Engines, search strategies, working with E-mail

Unit 4 **9 hrs**
MS Word and PowerPoint

Unit 5 **9 hrs**
MS Excel and Access

Total : 45 hrs

Text Books:

1. *David, C., Orr, J. A. and Vaz, R.F.* (2009). *Introduction to Information Technology,* Pearson Education Asia, India.
2. *Rajaraman, V (2018)* Introduction to Information Technology, third editon, PHI publisher
3. *Karp, D.A., O'Reilly, T., Mott, T. and Cobbett, R.* (2005).*Windows XP in a Nutshell: A Desktop Quick Reference,*Orielly Publishers, USA.
4. *Bansal, S.K.*(2002).*Fundamentals of Information Technology,* APH Publishing, New Delhi.

Reference Books:

1. *Peterson, L.L. and Davie, S.B.*(2012). *Computer Networks – A Systems Approach*, 5th Edition, Morgan Kaufmann, San Francisco.
2. *Bott, E. and Leonhard, W.* (2006).*Using Microsoft Office 2007,* 1st edition, Que Publishing.
3. *Jeffloate, J.*(2007).*Multimedia in practice, Technology and Applications*, Dorling Kindersley (India) Pvt. Ltd..

Course Outcomes:

At the end of the course, students will be able to

1. Understand the types and functioning of computers
2. Apply in creation of folder, copying, renaming, deleting, searching, creating shortcuts, backup files using MS Windows.
3. Understand the components in data communication, compare and contrast types of networking and apply in maintenance applications of networking
4. Create their own documents and presentations using MS Word and Power Point
5. Create their own worksheet and creation of functions in Excel. Students will be able to create database tables, queries, forms and reports using Access

Mapping of COs with POs & PSOs

CO / PO	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11	PSO 1	PSO 2	PSO 3
CO 1	H	L	H	L							L	H	M	
CO 2	H	H	H	L		M						H	M	
CO 3	H	H	M	L	L							H	M	
CO 4	H	H	H	L	M	M				M		H	M	
CO 5	H	H	H	L	M	M			L	M		H	M	

CO – Course Outcomes; PO – Programme Outcomes; PSO- Programme Specific Outcome;
H - High; M - Medium; L – Low

Intermediary Metabolism II

Semester - IV
21BBCC08

Hours of Instruction /week:4
No. of Credits: 3

Objectives:

1. To enable students to understand the fate of dietary constituents after digestion and absorption
2. To understand the basic metabolic pathways
3. To enable students to understand the interrelationship between major food stuffs

Unit 1 **12hrs**

Lipid Metabolism - Biosynthesis and degradation of triglycerides and phospholipids (Lecithin, cephalin, sphingomyelin) and glyco lipids (cerebrosides, sulfatides, globosides and gangliosides).

Unit 2 **12hrs**

Cholesterol Metabolism - Biosynthesis of Cholesterol and its regulation
Breakdown of cholesterol – synthesis of progesterone, corticosterone, aldosterone, testosterone , estrogens, bile acids and vitamin D_3

Unit 3 **12hrs**

Metabolism of amino acids- glycine, phenylalanine and tyrosine.
Metabolism of Nucleic acids - Biosynthesis of purine and pyrimidine nucleotides. Salvage pathway Degradation of purine and pyrimidine nucleotides

Unit 4 **12hrs**

Integration of metabolism– interconversion of major food stuffs. Metabolic profile of the liver, adipose tissue and brain. Altered metabolism in starvation.

Unit 5 **12hrs**

Respiratory Chain - Electron transport chain, oxidative phosphorylation, High and low energy phosphates.
Methods of investigating intermediary metabolism- *In vivo* studies – Analysis of excretion, respiratory exchange, removal of organs and perfusion studies
In vitro studies – Tissue slice techniques, homogenates and isotopic tracer studies

Total 60hrs

Text Book:

1. *Bery, J.M., Tymoezko, J.L. and Stryer, L.* (2015), *Biochemistry*, 8th Ed, W.H.Freeman and Company, New York.
2. *Nelson, D.L. and Cox, M.M.*(2021). *Lehninger Principles of Biochemistry*,8th Editon, W.H. Freeman and Company, New York.
3. *Boyer, R.F.* (2010) *Biochemistry – Laboratory Modern theory and technique,* Second Edition, Prentice Hall Publishers, UK

Reference Books:

1. *Donald Voet, Judith G. Voet, Charlotte W. Pratt* (2016), Fundamentals of Biochemistry: Life at the Molecular Level, 5th Edition, Wiley Publications.
2. *West, E.S., Todd, W.R., Mason, H.S. and Van Brugge, T.J.* (2001), 4th Ed, *The textbook of Biochemistry*, Macmillan Company, London.
3. *Rodwell, V.*W., Bender, D., Botham, K.M., Kennelly, P.J. and Neil, P.A. (2015) *Harpers Illustrated Biochemistry,* thirtieth Edition, Tata McGraw Hill Companies' Publication, New Delhi.

Course Outcomes:

Students will be able to

1. Understand the fate of dietary constituents after digestion and absorption.
2. Recognize the role of vitamins and mineral in intermediary metabolism
3. Learn how amino acids and nucleic acids are metabolized, highlighting the role of few intermediates of their metabolism
4. Understand the relationship between the properties of biomolecules and their metabolic profile in different organs.
5. Relate the role distinct metabolic pathways used by cells to harvest the energy.

Mapping of COs with POs & PSOs

CO / PO	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11	PS O 1	PS O 2	PS O 3
CO 1	H	L	L	M	M					H		H	M	L
CO 2	H						M			M		H	M	
CO 3	H			L			M		M	M		H	M	
CO 4	H	L		L	L		M		M	L		H	M	
CO 5	H	L	L						M	M		H	M	

CO – Course Outcomes; PO – Programme Outcomes; PSO- Programme Specific Outcome;
H - High; M - Medium; L – Low

Plant Biochemistry

Semester IV
21BBCC09

Hours of Instruction /week: 4
No. of Credits: 3

Objectives:

1. To provide students with fundamental knowledge of biochemical pathways taking place in plants
2. To provide an insight into biochemical mechanisms of stress management in plants
3. To provide knowledge on plant hormones and its mechanism of action

Unit 1 Photosynthesis **12hrs**

Introduction and importance of photosynthesis, photosynthetic apparatus, light harvesting complexes, reaction centers for photosynthesis, mechanism of photosynthesis, light and dark reactions, cyclic and non-cyclic photophosphorylation

Unit 2 Respiration and photorespiration **12hrs**

Citric acid cycle, plant mitochondrial electron transport and ATP synthesis, photorespiratory pathway

Unit 3 Transpiration and photo assimilation **12hrs**

Uptake, transport and translocation of water, ions, solutes and macromolecules from soil, through cells, across membranes, through xylem and phloem; transpiration; mechanisms of loading and unloading of photo assimilates

Unit 4 Stress physiology and secondary metabolites **12 hrs**

Responses of plants to biotic (pests and pathogens) and abiotic (water, temperature and salt); Biosynthesis of terpenes, phenols and nitrogenous compounds and their role

Unit 5 Plant hormones **12hrs**

Biosynthesis, storage, breakdown and transport, physiological effects and mechanism of action

Total : 60hrs

Text Books:

1. Srivastava, H.S. and Shankar, N. (2018) Plant physiology and Biochemistry, 7th Edition,RastogiPublications,Meerut.
2. Pandey, S.N. and Sinha, B.K. (2008) Plant Physiology, 4 th Edition, VIKAS publishing House Pvt Ltd, NewDelhi.
3. Buchanan, B., Gruissem, W. and Jones, R (2015) Biochemistry and Molecular Biology of Plants, 2nd Edition,Wiley-Blackwell Publishers, USA..
4. Das Susheela M, BharadwajAbha, (2019), Plant Physiology, Wisom Press

Reference Books:

1. Heldt, H. and Piechulla, B. (2021) Plant Biochemistry, Ffth Edition, Academic Press, USA.
2. Kumar, A. (2021) Plant Physiology - Fundamentals and Applications, Second edition, Agrobios, India.

3. Taiz, L., Zeiger, E., Møller I.M. and Murphy A. (2018) Plant Physiology and Development, Sixth Edition, Oxford University Press.

Course Outcomes:

At the end of the course, students will

1. Understand the basic concepts of photosynthesis
2. Explain the role of respiration and photorespiration
3. Discuss the importance of transpiration and photo assimilation biofuels.
4. Describe about stress physiology and secondary metabolites
5. Infer the different types of plant hormones.

Mapping of COs with POs & PSOs

CO/PO	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11	PSO1	PSO2	PSO3
CO 1	H	M		M								H	M	L
CO 2	H			M	L							H	M	
CO 3	H			M	L							H	M	
CO 4	H		M		L							H	M	
CO 5	H	M	M									H	M	L

CO – Course Outcomes; PO – Programme Outcomes; PSO- Programme Specific Outcome;
H - High; M - Medium; L - Low

Drug Biochemistry

Semester IV
21BBCC10

Hours of Instruction /week: 4
No. of Credits: 3

Objectives:

1. To make the students to understand the fundamentals in pharmacology
2. To make the students to understand the mechanism of action of drugs
3. To make the students to understand the pharmacokinetic and dynamics properties of drugs and to facilitate employability in pharma industries

Unit 1 Introduction and classification of drugs **12Hrs**

Introduction to basic terms in pharmacology. Classification of drugs – on the basis of drug action, pharmacological effect and molecular targetsThe nature and source of drugs - plant, animal and microbial. Routes of drug administration. Alternative medicine: herbals and nutraceuticals. Cell based recombinant DNA therapy.

Unit 2 Drug therapeutics **12Hrs**

Biochemical mode of action of antibiotics: penicillin and chloramphenicol. Antibacterial, antiviral drugs. Drugs for metabolic disorder- anti diabetic, cardiovascular, hypertensive drugs. Cancer chemotherapy. Biochemical mechanism of drug resistance.

Unit 3 Metabolism of drugs **12Hrs**

Biotransformation - synthetic and non-synthetic reactions: Oxidation, reduction, hydrolysis and conjugation reactions (Phase I and Phase II reactions).Drug metabolizing enzymes. Role of cytochrome p450. Non microsomal reactions of drug metabolism. Drug overload and poisoning.

Unit 4 Mechanism of action of drugs **12Hrs**

Principles of drug action. Drug and receptor interactions. Non-receptor mechanisms. Factors modifying the drug responses – Combined effects of drugs. Drug metabolising Enzymes. Drug synergism and antagonism.

Unit 5 Pharmacokinetics and pharmacogenomics **12Hrs**

Absorption, Transport across membrane. Distribution and bioavailability of drugs. Dose response curve ED50 and LD 50. Importance of drug protein interaction. Excretion of drugs. Adverse drug reactions. Personalized medicine and pharmacogenomics.

Total 60 hours

Text Books:

1. Satoskar, R.S. and Bhandarkar, S.D. (2020).Pharmolocology and Pharmacotherapeutics, 26thEdition, Vol. I and II, Popular Prakasam Pvt. Ltd, Mumbai.
2. Tripathi, K.D. (2021).Essentials of Medical Pharmacology, 8thEdition, Jay Pee Brothers Medical Publishers, New Delhi.
3. James M. Ritter and Lionel D. Leweis(2008). The text Book of Clinical pharmacology and therapeutics, 5thEditionGreat Britain Publishers. London

Reference Books:

1. Mycek, M.J., Harvey, R.A. and Champe, P.C. (2010).Pharmacology, Fifth Edition, Lippincotts Illustrated reviews, Lippincott Williams & Wilkins publishers, North America.

Course Outcomes:

At the end of the course, the student will be able

1. Understand basics terms in pharmacology, classification, sources and routes of administration of drugs.
2. Acquire knowledge about the therapeutic effects of drugs.
3. Interpret the metabolism of the drugs
4. Highlight the principles of drug action
5. Analyze the pharmacokinetics and pharmacogenomics of drugs

Mapping of COs with POs & PSOs

CO / PO	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11	PSO1	PSO2	PSO3
CO 1	H			M	M							H	M	
CO 2	H			M	M							H	M	
CO 3	H			M	H							H	M	
CO 4	H			M	H							H	H	
CO 5	H			M	H							H	M	

CO – Course Outcomes; PO – Programme Outcomes; PSO- Programme Specific Outcome;
H - High; M - Medium; L - Low

Immunology

Semester IV
21BBTC08

Hours of Instruction /week: 4
No. of Credits: 3

Objectives:

1. To expose students to the basic principles of immunology
2. To use these principles to understand how the immune system combats infections
3. To study the interaction of the various components of the immune system and acquire Immunization practices and Transplantation

Unit 1 Lymphoid organs and cells, immunity and immune Response **12 Hrs**

Organs and cells of the immune system - organs - primary and secondary lymphoid organs. Cells - lymphoid and myeloid lineages. Differentiation and maturation of B-cells and T-cells.

Immunity and immune response – innate and acquired immunities: Humoral and cell – mediated immunities. Primary and secondary immune responses. Phagocytosis, inflammation, NK activity, ADCC, fever, chemical defences

Unit 2Antigens, antibodies and complement **12 Hrs**

Antigens - types of antigens and their features. Requirement for antigenicity.Antigen processing and presentation. TCRs and BCRs. Antibodies - general structure of immunoglobulins (IgG). Classes of immunoglobulins, their properties and functions

Complement – Outlines of classical and alternative pathways, intermediates formed and biological functions

Unit 3 Disorders of the Immune System **12 Hrs**

Hypersensitivity – elementary concepts of hypersensitivities – Types I-IV

Autoimmunity – basic concepts, causes and types of auto immune diseases. Organ specific and systemic autoimmune diseases with special reference to Hashimoto's thyroiditis and Systemic Lupus Erythematosus. Add a note on HIV cycle.

Unit 4 Immunization practices and Transplantation **12 Hrs**

Immunization procedures - active and passive immunization. Vaccines – killed, attenuated, toxoids, recombinant, DNA, synthetic peptide vaccines and mRNA Vaccines. General principles involved in the production of monoclonal and polyclonal antibodies. Transplantation types. General organisation of MHC genes. Class I, II and III molecules.

Unit 5 Immunotechniques **12 Hrs**

Immunotechniques – Features of antigen–antibody interactions. Precipitation reactions – immunodiffusion, immunoelectrophoresis.Agglutination reactions – blood grouping, haemagglutination.Assays with tagged antigen/antibody – RIA, ELISA, immunoblotting, immunofluorescence.Separation of lymphocytes.

Total **60 Hrs**

Text Books:

1. Tizard, I.R. (2005). Immunology – An Introduction, Fourth Edition, Saunders College Publishing, New York.
2. Rao, C.V. (2006). An Introduction to Immunology, Second Edition, Narosa Publishing House, Delhi, Chennai, Mumbai, Kolkata.
3. Roitt, I.,Brostoff, J. and Male, D. (2017). Essential Immunology, 13thEdition, Wiley Blackwell Publishers, New York.

Reference Books:

1. Owen, J., Punt, J. and Stranford, S. (2019) Immunology, 8thEdition, W.H. Freeman and Company Publishers, New York.
2. Prescott, L.M., Harley, J.P. and Klein, D.A. (2020) Microbiology, 11thEdition, The McGraw Hill Companies Publishers, New York.
3. Sawhney, S.K. and Singh, R. (2014) Introductory Practical Biochemistry, Second Edition,Narosa Publishing House, New Delhi.

Course Outcomes:

At the end of the course, students will

1. Gain an insight on the various cells and organs involved in the immune system.
2. Understand the molecular mechanisms of antigen-antibody interactions.
3. Appreciate the molecular mechanisms behind the immune response evoked after infection by various pathogens
4. Comprehend the Immunization and Transplantation practices
5. Learn the theoretical basis for the various immunological techniques.

Mapping of COs with POs & PSOs

CO / PO	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11	PSO 1	PSO 2	PSO 3
CO 1	H	H	M	M	H	M						H	M	
CO 2	H	H	H	M	M	H						H	H	
CO 3	H	H	M	H	M	M						H	M	
CO 4	H	H	H	M	H	M						H	H	
CO 5	H	M	H	M	H	M						H	M	

CO – Course Outcomes; PO – Programme Outcomes; PSO- Programme Specific Outcome;
H - High; M - Medium; L - Low

Microbial Biotechnology

Semester IV **Hours of Instruction /week: 4**
21BBTC09 **No. of Credits: 3**

Objectives:

1. To discuss the significant role of microorganisms in the production of industrially important compounds
2. To understand the basic principle and procedures in fermentation process with examples
3. To equip the student to acquire the knowledge required to increase the employability and entrepreneur in the field of food biotechnology industries

Unit 1 Isolation and screening of industrially important microbes **12hrs**

Improvement of strains for increased yield and other desirable characteristics using conventional and modern technologies- significance of auxotrophic mutants- replica plating technique

Unit 2 Basic principles of fermentations **12hrs**

Batch, fed-batch and continuous fermentation- types of fermenters – design and operation – air-lift, continuous stirred tank reactor, bubble column, packed tower bioreactor; media formulation, sterilization, aeration, agitation and downstream processing.

Unit 3 Food and dairy technology **12hrs**

Factors influencing microbial growth in food. Composition and spoilage of food. Control of microorganisms by retarding growth- low temperature, drying, heat, radiation. Types of food preservation .canning and packing. Basic principles of food fermentation. Fermented foods- yoghurt, cheese, bread., Probiotics

Unit 4 Beverage technology **12hrs**

Alcoholic beverages (beer, wine) – non alcoholic beverages (tea, coffee)

Production of antibiotics (penicillin), organic acids (vinegar), enzymes (amylase), polysaccharides (xanthane)

Unit 5 Microbial products **12hrs**

Primary and secondary metabolites, mushroom cultivation, SCP production, Baker's yeast production. Traditional Fermented therapeutics

Total 60hrs

Text Books:

1. Kango, N. (2010) Textbook of Microbiology, I.K. International Publishing House, New Delhi.
2. Talaro, K.P. and Chess, B. (2017)Foundations in Microbiology, 10thEdition, McGraw Hill Publishing Company, New York.
3. Casida, L.E.J.R. (2019) Industrial Microbiology, II Ed., New Age International Private Limited

Reference Books:

1. Gupta, P.K. (2017) Biotechnology and Genomics, First Edition, Seventh Reprint, Rastogi Publication, Meerut.
2. Willey J, Sandman K, Wood D. (2019) Prescott's Microbiology, 11thEdition, The McGraw Hill Companies Publishers, New York.
3. Patel, AH (2021) Industrial Microbiology 2ndEd, Laxmi Publications Pvt Ltd

Course Outcomes:
At the end of the course the students will be able to

1. Isolate and screen industrially important microbes
2. Acquire knowledge on basic principles of fermentation
3. Understand the role of microbes in food and dairy technology
4. Gain knowledge of production of beverages using biotechnological approaches
5. Appreciate the economic importance of microbial products

Mapping of COs with POs and PSOs

CO / PO	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11	PSO 1	PSO 2	PSO 3
CO 1	H	H	M	M	M	M						H	M	
CO 2	H	H	M	M	M	M						H	M	
CO 3	H	H	M	M	M	M						H	M	
CO 4	H	H	M	M	M	M						H	M	
CO 5	H	H	M	M	M	M						H	M	

CO – Course Outcomes; PO – Programme Outcomes; PSO- Programme Specific Outcome;
H - High; M - Medium; L - Low

Practicals-II Microbial Techniques

Semester IV **Hours of Instruction /week: 6**

21BBTC10 **No. of Credits: 3**

Objectives:

1. To learn the various sterilization techniques and to maintain aseptic conditions
2. To acquire skills in various microbiology techniques
3. To equip the students to obtain basic skills in attaining employability in diagnostic laboratories, food and dairy industries

Unit 1 **18hrs**

Orientation and safety in the microbiology laboratory-Sterilization techniques
Microscopy- cell counting and average cell size determination
Smear preparation and staining techniques- simple staining, Gram staining, negative staining, flagellar staining

Unit 2 **18hrs**

Plating techniques – spread plate, pour plate and streak plate methods
Enumeration of bacteria from soil, water and air

Unit 3 **18hrs**

Isolation of microorganisms from urine and sputum
Isolation of bacteriophage from sewage sample

Unit 4 **18hrs**

Microbial growth determination
Bacteriological examination of water (MPN)
Antibiotic sensitivity test

Unit 5 **18hrs**

Identification of bacteria by biochemical tests
Demonstration of wine, arista and asva production

Total : 90hrs

References:

1. *Cappuccino, J. and Sherman, N.*(2013) *Microbiology: A Laboratory Manual,*Tenth Edition, Benjiamin Cummings Publishers, USA.
2. *Dubey, R.C. and Maheswari, D.K.* (2010)*Microbiology,* Third Edition, S.Chand and Company Publishers, New Delhi.
3. Ayurvedic Pharmacopoeia of India, https://pcimh.gov.in/show_content.php?lang=1&level=1&ls_id=56&lid=54

Course Outcomes:

At the end of the course the students will be able to

1. Acquire skills in Sterilization and culturing techniques in microbiology
2. Isolate the microorganisms from various sources and analysis of microbial growth
3. Identify the microorganisms by different staining techniques and by biochemical tests
4. Analysis of bacterial contamination of water

5. Determine the antibiotic resistance of microbes

Mapping COs with POs & PSOs

CO / PO	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11	PSO 1	PSO 2	PSO 3
CO 1	H		H	M	H			M		M	M	M	M	M
CO 2	H	M	M	M	M			M		H	M		M	M
CO 3	M	H	H	M	H			M		H	M		H	H
CO 4	H	H	M	M	M	H	M			H	M		H	H
CO 5	H	H	H	M	M	M	M			H	M		H	H

CO – Course Outcomes; PO – Programme Outcomes; PSO- Programme Specific Outcome;
H - High; M - Medium; L - Low

Mathematics for Biological Sciences

Semester IV
21BBCI06

Hours of instruction per week: 4
No of Credits: 3

Objectives:

1. To understand the basic concepts of Differential Calculus
2. To learn fundamental for applications
3. To grasp the fundamentals of Statistics

Unit 1 Sets, Relations Functions and Matrices **12hrs**

Sets, Relations Functions and Matrices: Sets - Types of sets - set operations - Relations - Functions - Types of functions - Binary operation - Counting principle - Permutations and combinations - Eigen values

Unit 2 Solution of Algebraic and Transcendental Equations

The Bisection method - The Iteration method - Newton-Raphson Method - System of simultaneous linear equations - Gauss elimination method. **12hrs**

Unit 3 Differentiation and Partial Differentiation

Logarithmic differentiation - Differentiation of one function with respect to another - Differentiation of functions in parametric form - Differentiation of implicit functions - Successive partial derivatives - Function of function rule - Total Differential coefficient - Implicit functions - Homogeneous functions. **12hrs**

Unit 4 Integration and Ordinary Differential Equations

Bernoulli's formula - Evaluation of integrals using Bernoulli's formula - Variable separable - Homogeneous equations - Linear equations.

Unit 5 Measures of central tendency and Measures of Dispersion **12hrs**

Mean - Median - Mode - Relationship between mean - median and mode - Range - Mean deviation - Quartile deviation - Standard deviation - Coefficient of variation.

Total **60hrs**

Text Books:

1. *U. Rizwan (2002). "Mathematical Foundation"*,SCITECH publications Pvt., Ltd., Chennai. (Unit I)
2. *S. Narayanan, R. HanumanthaRao, T. K. ManicavachagomPillayand*P. *Kandaswamy (2008). "Ancillary Mathematics for Allied Mathematics Course of B.Sc Physics, Chemistry and Computer science major, Volume –I"*,S. Viswanathan (Printers and Publishers) Pvt., Ltd., Chennai. (Unit I)
3. *S. S. Sastry (2009). "Introduction Methods of Numerical Analysis"*, Prentice- Hall of India Private., New Delhi. (Unit II)

Reference Books:

1. *S. Narayanan and T. K. ManicavachagomPillay (2009). "Calculus Volume I Differential Calculus"*, S. Viswanathan (Printers and Publishers), Pvt., Ltd., Chennai. (Unit III)

2. *S. Narayanan, R. HanumanthaRao, T. K. ManicavachagomPillay and P. Kandaswamy (2008). "Ancillary Mathematics for Allied Mathematics Course of B.Sc Physics, Chemistry and Computer science major, Volume –II"*,S. Viswanathan (Printers and Publishers) Pvt., Ltd., Chennai. (Unit IV)
3. *K. SenthamaraiKannan and D. Venkatesan (2006). "Introduction to Statistical Methods"*,SCITECH Publications Pvt., Ltd. (Unit V)

Course Outcomes:

On completion of the course, the students will be able to

1. Demonstrate the various types of sets, functions and relations.
2. Find solutions for algebraic, transcendental equations
3. Apply differential equation techniques in scientific field
4. Use the integration-by-parts formula to solve integration problems
5. Calculate various measures of central tendency required to analyze research project.

Mapping of COs with POs & PSOs

CO / PO	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11	PSO 1	PSO 2	PSO 3
CO 1				M	M	M			M	H	M		M	M
CO 2		M	M	M	M	M	M	M	M	H	M		M	M
CO 3	M	M	M	M	M	M	M	M	M	H	M		M	M
CO 4	M	M	M	M	M		M	M		H	M		M	M
CO 5	M			M	M					H	M		M	M

CO – Course Outcomes; PO – Programme Outcomes; PSO- Programme Specific Outcome;
H - High; M - Medium; L - Low

Clinical Biochemistry

Semester V **Hours of Instruction /week: 4**

21BBCC11 **No. of Credits: 3**

Objectives:

1. To understand the biochemical aspects of diseases.
2. To acquire theoretical basis for conducting tests for organ functions
3. To equip the students to obtain basic skills in attaining employability in clinical laboratories

Unit 1 Kidney functions and disorders **12 hrs**

Tests that measure GFR- urea and creatinine clearance, tests measuring secretion and tubular functions. Abnormal constituents of urine.

Diagnosis and screening for renal disease. Types of renal failure, uremia, glomerular diseases–nephritis and nephrosis

Analysis of Urinary calculi:

Elementary principles of dialysis (artificial kidney)

Unit 2 Liver function tests and carbohydrate metabolic disorders **12 hrs**

Metabolism of bilirubin. Excretory, detoxification and metabolic liver function tests Plasma enzymes in liver disease.

Liver diseases- cirrhosis, hepatitis and types of jaundice.

Blood glucose regulation, diabetes mellitus – types, metabolic changes and complications, Glucose tolerance test, HbA1C, ketosis

Glycogen storage diseases

Unit 3 Abnormalities of lipid metabolism and Electrolyte Imbalance **12 hrs**

Plasma lipids and lipoproteins - hypo and hyper lipoproteinemia, fatty liver, atherosclerosis, sphingolipidosis.

Hypertension and its complications

Electrolyte Imbalance - hyper and hyponaterimia, hypo and hyperkalemia.

Unit 4 Variations of plasma proteins, inherited disorders and blood coagulation **12 hrs**

Plasma proteins and their variations in diseases.

Inborn errors of metabolism - phenyl ketonuria, albinism, alkaptonuria, cystinosis, maple syrup urine disease, gout.

Blood coagulation, bleeding time, clotting time, prothrombin time.

Unit 5 Clinical Enzymology and hormonal imbalance **12 hrs**

Clinical significance of phosphatases, γ-glutamyltransferase, amylase, lactate dehydrogenase, transaminases and creatine phosphokinase.

Hormonal Imbalance – Causes, symptoms and treatment of protein, steroid and thyroid hormones

Total 60 hrs

Text Books:

1. Chatterjea, M.N. (2011).Text Book of Medical Biochemistry,Eight Edition, Jaypee Brothers Medical Publishers, New Delhi.
2. Chawla, R.(2020).Practical Clinical Biochemistry - Methods and Interpretations,5thEdition, Jaypee Brothers Medical Publishers, New Delhi.
3. Bhagavan, N.V. (2004).Medical Biochemistry, Fourth Edition, Academic Press, Calfornia.

Reference Books:

1. Voet, D., Voet, J.G., and Pratt, C.W. (2018).Fundamentals of Biochemistry – Life at the Molecular Level, 5thEdition, John Wiley & Sons. Inc, New York.
2. Murray, R.K., Bender, D.A., Bootham, K.M., Kennlley, P.J., Rodwell, V.W. and Weil, P.A. (2021).Harpers Illustrated Biochemistry, 31stEdition, Tata McGraw Hill Companies Publication, New Delhi.
3. Burtis, C.A. and Bruns, D.E.(2007).Fundamentals of Clinical Chemistry,Sixth Edition, W.B Saunders Co, Philadelphia, London, Toronto.

Course Outcomes:

At the end of the course, students will

1. Understand and evaluate the kidney function tests and renal diseases
2. Diagnose the appropriate tests to assess liver function and carbohydrate metabolic defects
3. Interpret the abnormalities of plasma lipids and their metabolic disorders
4. Analyse the biochemical basis of plasma proteins, inherited disorders and blood coagulation
5. Comprehend the clinical significance of enzymes and electrolyte imbalance

Mapping of COs with POs & PSOs

CO / PO	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11	PSO 1	PSO 2	PSO 3
CO 1			M	M	H	M		M		M		H	M	
CO 2	H	M	M	M	H	M	M	M	M	M	M	H	M	
CO 3	H	M	M	M	H	M	M	M	M	M	M	H	M	M
CO 4	H	M		M	H	M	M	M	M			H	M	M
CO 5	H			M	H	M	M	M	M			H	M	M

CO – Course Outcomes; PO – Programme Outcomes; ; PSO- Programme Specific Outcome; H - High; M - Medium; L - Low

Molecular Biology

Semester V
21BBCC12

Hours of Instruction /week: 4
No. of Credits: 3

Objectives:

1. To comprehend the hierarchical organization of genomes.
2. To gain an insight into the flow of genetic information from DNA through RNA to protein.
3. To learn about regulation of gene expression, DNA damage, repair and recombination.

Unit 1 Genome organization **12 hrs**

The central dogma of molecular biology. Concept of gene and genome. Colinearity of the gene and polypeptide. Organisation of the E. coli chromosome. Mitochondrial and chloroplast genomes. Organisation of the eukaryotic genome- histones and nucleosomes, higher order chromatin structure.

Unit 2 DNA Replication **12 hrs**

DNA replication in bacteria (θ and rolling circle model)

Enzymes and proteins involved replication, steps (initiation, elongation, termination). Brief account of DNA damage and repair (photoreactivation, excision repair).

Unit 3 Transcription and Post-transcriptional processing **12 hrs**

Transcription: RNA polymerase, transcription signals, steps (initiation, elongation and termination). Post-transcriptional processing of mRNA, rRNA and tRNA. Reverse transcription. Inhibitors of transcription – miRNA, siRNA

Unit 4 Genetic code and Translation **12 hrs**

Genetic code- general features. Mutations – Point (transversion, transition), frame-shift.

Protein biosynthesis- amino acid activation, initiation, elongation, termination. Post-translational modifications. Inhibitors of protein synthesis. Brief account of protein degradation.

Unit 5 Gene expression and Recombination **12 hrs**

Definition of housekeeping genes, inducible genes, up/downregulation. Regulation of gene expression in prokaryotes with lac operon as model.

Brief account of homologous and site-specific recombination. Transposition: Structure and functions of insertion sequence (IS) elements, transposons and transposition events

Total 60 hrs

Text Books:

1. *Ajoy, P.*(2009) *Textbook of Cell and Molecular Biology*, Second Edition, Books and Allied Publication, Mumbai.
2. *Jeyanthi,G.P.* (2009) *Molecular biology*, MJP Publishers, Chennai.
3. *Ramamurthi, K.S.*(2009) *Gene flowandmolecular biology*, Alfa Publications, New Delhi.

Reference Books:

1. *Watson, J.D.* (2017) *Molecular Biology of the Gene*, Seventh Edition, Pearson Publisher
2. Cooper, G.M. and Hausman, R.E. (2013), The Cell – A molecular approach, 6th Edition, Sinauer Associates Inc.

Course Outcomes :

At the end of the course, the students will be able to

1. Understand the concept of gene, genome, and genome organization.
2. Appreciate the intricate molecular mechanisms of the various steps in replication, transcription and translation.
3. Distinguish the processing of RNA and proteins after synthesis.
4. Gain an insight into how gene expression is regulated.
5. Understand the mechanism of DNA damage, repair and recombination.

Mapping of COs with POs & PSOs

CO/PO	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11	PSO1	PSO2	PSO3
CO 1	H	H	M	H	L							H		
CO 2	M	M		M	M					M		M	H	H
CO 3	H	M		H	L	H						M	M	M
CO 4	M	H	M	M	M	H	L			L	L	H		H
CO 5	H		M	M		M		L		L				H

CO – Course Outcomes; PO – Programme Outcomes; ; PSO- Programme Specific Outcome; H - High; M - Medium; L - Low

Practicals III-Clinical Biochemistry

Semester V **Hours of Instruction /week: 5**
21BBCC13 **No. of Credits: 2**

Objectives:

1. To learn the procedures and precautions for collection and storage of biological samples
2. To analyse urine and blood samples for disease diagnosis
3. To provide students life-skills in hands-on mode so as to increase their employability in diagnostic laboratories

Unit 1 Collection of urine and blood samples **15hrs**

Random,12 hours, 24 hours
Preservatives for urine
Volume of urine
Collection of blood samples
Collection by fingertip and venipuncture
Whole blood, Serum, plasma, RBC

Unit 2 Routine analysis of urine (Qualitative) **15hrs**

Colour, appearance, pH, specific gravity, albumin, glucose, fructose, pentose, ketone bodies, blood, urinary deposits and bile salts-bilirubin

Unit 3 Urine analysis (Quantitative) **15hrs**

Titrable acidity, true acidity, organic acids

Unit 4 Calculi analysis **15hrs**

Appearance, systematic analysis for carbonate, oxalate, phosphate, urate, xanthine, magnesium, calcium, non-oxalate calcium, ammonium, cystine, cholesterol

Unit 5 Blood Analysis **15hrs**

Acid phosphatase, alkaline phosphatase, aspartate transaminase, alanine transaminase, total cholesterol and HDL cholesterol

Total 75hrs

Text Books:

1. *Chatterjea, M.N.* (2011).*Text Book of Medical Biochemistry,*Eight Edition, Jaypee Brothers Medical Publishers, New Delhi.
2. *Ajamani PS, (2018), Handbook of clinical laboratory techniques, 1st Ed., AITBS publishers.*
3. *Chawla, R.*(2008).*Practical Clinical Biochemistry - Methods and Interpretations,*Third Edition, Jaypee Brothers Medical Publishers, New Delhi.
4. *Bhagavan, N.V.* (2004).*Medical Biochemistry,* Fourth Edition, Academic Press, Calfornia.

Reference Books:

1. *Voet, D., Voet, J.G., and Pratt, C.W.* (2013).*Fundamentals of Biochemistry – Life at the Molecular Level,* Fourth Edition, John Wiley & Sons. Inc, New York.
2. *Murray, R.K., Bender, D.A., Botham, K.M., Kennlley, P.J., Rodwell, V.W. and Weil, P.A.* (2012).*Harpers Illustrated Biochemistry,* Twenty ninth Edition, Tata McGraw Hill Companies Publication, New Delhi.
3. *Burtis, C.A. and Bruns, D.E.*(2007).*Fundamentals of Clinical Chemistry,*Sixth Edition, W.B Saunders Co, Philadelphia, London, Toronto.

Course Outcomes:

At the end of the course, the students will able to

1. Acquire skills in collecting and preserving biological samples.
2. Analyze the normal and abnormal constituents of urine sample.
3. Explore the quantitative analysis of urine sample
4. Interpret the various types of urinary stones
5. Diagnose the disease condition using various markers enzymes

Mapping of COs with POs & PSOs

CO/PO	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11	PSO1	PSO2	PSO3
CO 1	H		H	M	M	M	M	M		M		H	H	
CO 2	H	M	H	M	M	M	M	M	M	M		H	H	M
CO 3	H	M	H	M	H	M	M	M	M	M		H	H	M
CO 4	H	M	H	M	H	M		M	M			H	H	M
CO 5	H		H	M	H	M		M				H	H	

CO – Course Outcomes; PO – Programme Outcomes; ; PSO- Programme Specific Outcome; H - High; M - Medium; L - Low

Plant Biotechnology

Semester V **Hours of Instruction /week: 3**
21BBTC11 **No. of Credits: 3**

Objectives:

1. To understand the organisation of the plant genome and techniques to analyse the plant genome.
2. To employ the concepts of plant tissue culture and genetic engineering for crop improvement.
3. To impart basic knowledge and skill required to gain research opportunities in Food and Cash Crops industries

Unit 1 Plant tissue culture

Laboratory organization, lab equipment and their working, various sterilization and preparation techniques **9hrs**
Tissue culture methods - terms and definitions, concept of totipotency, media components – macro, micro and growth regulators (auxin, cytokinin, gibberellins, ethylene and abscisic acid)

Unit 2 Embryogenesis and organogenesis **9hrs**

Introduction to the process of embryogenesis and organogenesis and their practical applications.
Clonal multiplication of elite species – micropropagation – auxillary bud, shoot tip and meristem culture; limitations
Haploids and their applications (ovary, ovule and anther culture)
Triploid production (endosperm culture)
Invitro pollination and fertilization, embryo culture, wide hybridization and embryo rescue

Unit 3 Commercialization of tissue culture technology **9hrs**

Concept of commercialization- need and design of a typical tissue culture laboratory and its management
Commercial production of plants using tissue culture– floriculture, horticulture, olericulture
Commercial production of secondary metabolites using cell cultures – use of bioreactors, immobilized cells, biotransformation, applications and limitations
Commercial production of forest trees, fruit trees – problems in propagating trees namely systemic contaminates, phenolic leaching, seasonal variation in response, genotypic recalcitrance
Artificial seeds, cryopreservation and *ex situ* conservation of germplasm

Unit 4 Plant transformation methods **9hrs**

Introduction to plant transformation and development of transgenic crops.
Plant transformation vectors – Agrobacterium biology, Ti plasmid vectors and T-DNA transfer
Physical methods of transformation – biolistics, electroporation, lipofection
Selection and propagation of transformants – selectable markers, reporter genes and promoters

Unit 5 Genetic improvement of plants through Transgenic Technology **9hrs**

Development of Virus resistance, pest resistance, and herbicide tolerance in plants by transgenic technology. Antisense RNA technology for delayed fruit ripening. Terminator technology (brief account)
CRISPR technology and Genome Editing .
Ethical issues in plant genetic engineering.

Total 45hrs

Text books:

1. *Malik ZainulAbdin, UshaKiran, Kamaluddin, Athar Ali, (2017). Plant Biotechnology: Principles and Applications, Springer.*
2. *Chawla, H.S.* (2010).*Introduction to Plant Biotechnology*, 3rdEdition, Oxford & IBH Publishing Company Pvt. Ltd., New Delhi, India.
3. *Bojwani, S.S. and Rhazdan, M.K.*(2003).*Plant Tissue Culture: Theory and Practice*, Elsevier Science Publishers, Mumbai.
4. Robert H. Smith, (2021). Plant Tissue Culture: Techniques and Experiments, Academic Press Publications

Reference Books:

1. *Glick, B.R., and Patten, C.L.*(2022)*Molecular Biotechnology: Principles and application of recombinant DNA technology*, 6thEdition, ASM Press, USA.
2. *Hopkins, E.G.*(2007)*Plant Biotechnology*, Chelsea House, Infobase Publishing, New York.
3. *Fossard, R.A.*(2006)*Commercial Micropropagation CD*, Agritech Publications, USA.

Course Outcomes:

At the end of the course, the students will

1. Interpret the concept of gene families and its role in plant breeding
2. Explain the steps involved in photosynthesis and its regulation.
3. Integrate genetic and physical maps of plants to create genome viewer tools
4. Criticise the advantages and disadvantages of genetically modified plants
5. Devise new methods for biotransformation of plants to produce useful metabolites

Mapping of COs with POs & PSOs

CO / PO	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11	PSO 1	PSO 2	PSO 3
CO 1	H	H	H	M	H	M						H	M	
CO 2	H	H	H	M	H	H						H	H	
CO 3	H	H	H	H	M	M						H	M	
CO 4	H	H	H	M	H	M						M	H	
CO 5	H	M	H	M	H	M						H	H	

CO – Course Outcomes; PO – Programme Outcomes; ; PSO- Programme Specific Outcome; H - High; M - Medium; L - Low

rDNA Technology and Nanobiotechnology

Semester V
21BBTC12

Hours of Instruction /week: 4
No. of Credits: 3

Objectives:

1. To understand the basics principles and applications of rDNA technology
2. To gain knowledge on the techniques and applications of rDNA technology
3. To train students in strategizing research methodologies through genetic engineering technique

Unit 1 Introduction to recombinant DNA technology **12hrs**

Basic principles of rDNA technology. Type II Restriction endonucleases-nomenclature, and types of cleavage. Cloning vectors- plasmids (pBR322) and phages (λ phage) vectors. Cosmids. Brief introduction to high-capacity cloning vectors (BACs and YACs). Cloning vectors for Yeast, plants (Agrobacterium). Viral vectors – SV40. Expression vectors.

12hrs

Unit 2 Gene transfer methods and rDNA screening

Transformation, preparation of competent cells and selection. calcium phosphate coprecipitation, electroporation, lipofection, viruses, biolistics, microinjection. Screening of recombinants: marker inactivation (antibiotic resistance, blue-white selection), colony hybridization, immunological screening.

12hrs

Unit 3 Cloning strategies and expression of cloned genes

Cloning strategies: Construction of genomic and cDNA libraries. Differences between genomic and cDNA libraries. Chromosome Walking, Chromosome Jumping, HRT and HART. Reporter genes – CAT, GFP, luciferase.

Expression of eukaryotic genes in bacteria with insulin as an example. Basic concept of fusion proteins.

12hrs

Unit 4 Techniques and Applications of rDNA technology

Isolation and purification of nucleic acids. Probe preparation. Blotting techniques. Basic principle and application of PCR – DNA Polymorphism – RFLP, RAPD and AFLP.

DNA sequencing and fingerprinting. DNA microarrays. Applications of rDNA in medicine, agriculture. The Human Genome Project- brief account of goals, results, ethical, legal and social issues. Biosafety regulations, bioethics, intellectual property rights and patenting issues.

12hrs

Unit 5 Nanobiotechnology

Introduction - nanotech - enabled products and possibilities - nano manufacturing- health and safety issues - biosensors of cellulose nano fibrils - tools for characterization of biosensors and nanometer scale - poly electrolyte multilayers for fiber engineer. Hemicellulose at interfaces - lignin, cellulose, chitin and nanoscience - as nanoscopic biomaterials- Bacterial cellulose and its polymeric nano composites - Bone tissue engineering

Total **60hrs**

Text Books:

1. *Brown, T.A.*(2020).*Gene cloning and DNA Analysis: An Introduction.* Eighth Edition, Wiley Publishers, USA.
2. *Lucia, L.A. and Rojas O.J.*(2009).*The Nanoscience and Technology of Renewable Biomaterials*, Wiley and Sons Publishers, New York.
3. *Primrose, S.B., Twyman, R.M. and Old, R.W.* (2013).*Principles of Gene Manipulation*, Seventh Edition, Blackwell Publishing Company, USA.

Reference Books:

1. *Griffiths, A.J.F., Wessler, S.R., Lewontin, R.C., Gelbart, W.M., Sazuki, D.T. and Miller, J.H.* (2010).*Introduction to Genetic Analysis*, Tenth Edition, W.H. Freeman and Company, New York.
2. *Freifelder, D.*(2006).*Molecular Biology*, Second Edition, Narosa Publishing House, New Delhi.
3. *Kreuzer, H. and Mausey, A.*(2001).*Recombinant DNA and Biotechnology – A Guide for Student*, Second Edition, ASM Press, Washington.
4. B. Singh, (2014). Recombinant DNA and Biotechnology

Course Outcomes:

At the end of the course students will

1. Understand the basic steps in a cloning experiment.
2. Acquire knowledge about how to isolate a DNA segment, clone it into a suitable vector, introduce into a host and identify the recombinant from nonrecombinants.
3. Know the theoretical basis for selection, screening, construction of libraries and expression of genes.
4. Learn the principles of various genetic engineering techniques as well as their applications.
5. Acquire a fundamental understanding of the basic principles of nanobiotechnology.

Mapping of COs with POs & PSOs

CO / PO	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11	PSO 1	PSO 2	PSO 3
CO 1	H		L	L		L	M					H		
CO 2	H		H	H	H	M	M				M	H	H	H
CO 3	H		H	H	H	M	M				M	H	H	M
CO 4	H		M	M	M	M	M				M	H	M	M
CO 5	H		H	H	M	M	M				M	H	M	

CO – Course Outcomes; PO – Programme Outcomes; ; PSO- Programme Specific Outcome; H - High; M - Medium; L - Low

Practicals III-Methods in Molecular Biology and Plant Tissue Culture

Semester V **Hours of Instruction /week: 5**

21BBTC13 **No. of Credits: 3**

Objectives:

1. To describe protocols for sample preparation to observe the stages of cell division, isolation and estimation procedures used to quantify biomolecules
2. To explain the methods and techniques involved in rDNA technology, Plant and Animal tissue culture
3. To imparts skills for employability, innovation in research and entrepreneurship in Plant Sciences and Biotechnology.

Unit 1 Cytological preparations **15hrs**

Fixation, dehydration and staining – embedding and sectioning – preparation of squash stain of onion root tip – observation of different stages of mitosis

Separation of cell components – separation of cell organelles by ultracentrifugation - Isolation and estimation of DNA- UV and diphenyl amine method. Isolation and estimation of RNA - orcinol method. Isolation and estimation of protein - Lowry's method

15hrs

Unit 2 Restriction digestion of Lambda DNA

Agarose gel electrophoresis, Restriction mapping

Southern blotting (demo)

Growth of bacterial cells

Preparation of competent cells, restriction and ligation of pBR322

Transformation of pBR322 plasmid

Plating and selection

Unit 3 Plant tissue culture **15hrs**

Initiating plant tissue culture-media preparation, surface sterilization-callus culture- Micropropagation

Unit 4 Animal cell culture **15hrs**

Culture of lymphocytes from blood samples

Preparation of media, filter sterilization, initiation of primary culture from chick embryo fibroblasts - checking for viability

Unit 5 Field visits **15hrs**

Visit to a commercial plant tissue culture laboratory – Demonstration / operation of large scale fermenters

Total 75hrs

Text Books:

1. *Mathur, S.* (2012).*Animal Cell and Tissue Culture*, Agrobios Publications, India.
2. *Freshney, R.I.*(2006).*Culture of Animal Cells – A Manual of Basic Technique*, Fifth Edition, A John Wiley and Sons Publication, New York.

3. *Masters, J.R.W.*(2000).*Animal Cell Culture – A Practical Approach*, Third Edition, Oxford University Press, London.

Course Outcomes:

At the end of the course students will be able to

1. Illustrate various experiments to observe the stages of cell division & examine the isolated genetic material from various sources
2. Compare the functions of restriction enzymes and analyse the restricted fragments
3. Discuss how the genes are cloned and selected
4. Distinguish the importance of various techniques involved in plant tissue culture
5. Appreciate the significance of the techniques in animal tissue culture

Mapping of COs with POs & PSOs

CO / PO	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11	PSO 1	PSO 2	PSO 3
CO 1	H	H	H	L							L	H	H	H
CO 2	H	H	H	L							L	H	H	H
CO 3	H	H	H	L							L	H	H	H
CO 4	H	H	H	L							L	H	H	H
CO 5	H	H	H	L							L	H	H	H

CO- Course Outcomes; PO- Program Outcomes; PSO- Program Specific Outcomes

H: High M: Medium L: Low

Antioxidants in Health and Diseases (Self Study)

Semester V **Hours of Instruction /week: 1**

21BBTC14 **No. of Credits: 4**

Objectives:

1. To have knowledge of what free radicals are, how they are generated and how they react
2. To understand what antioxidants are and the role of antioxidants in health and disease
3. To understand about the many interactions between oxidants and antioxidants, and how such substances may act as natural protectants and/or natural toxicants

Unit 1 Free radicals **3hrs**

Oxygen toxicity - derivatives – reactive oxygen species – reactive nitrogen species – reactive chlorine species – reactive sulphur species – sources

Unit 2 Types of free radicals **3hrs**

Chemistry of biologically important radicals – transition metals, hydroxyl radical, superoxide, peroxyl and alkoxyl, sulphur and nitric oxide – non-radicals – hydrogen peroxide, hypochlorous acid, singlet oxygen, peroxynitrite – formation of free radicals

Unit 3 Oxidative stress **3hrs**

Damage to cellular targets – consequences – oxidative stress in disease – cancer, diabetes mellitus, cardiovascular diseases, neurodegenerative diseases

Unit 4 Antioxidant defenses **3hrs**

Enzymic antioxidants – superoxide dismutase, catalase, peroxidase, glutathione S-transferase, other antioxidant defense enzymes – non-enzymic antioxidants – ascorbic acid, vitamin E, carotenoids, polyphenols, trace elements

Unit 5 Antioxidants in health and disease **3hrs**

Concept of health, disease and well being – health and oxidative stress – prevention of diseases – concept of health indicators. Antioxidants in health and diseases. Dietary antioxidants – herbal antioxidants – antioxidants in treatment of diseases

Total **15hrs**

Text Books:

1. *Satynarayana, U. and Chakrapani, U.* (2009).*Biochemistry*, Third Edition, Books and Allied (P) Ltd, Kolkata
2. *Halliwell, B. and Gutteridge, J.M.C.*(2008).*Free radicals in biology and Medicine*, Fourth Edition, Oxford University Press, London.
3. Zampelas, A. and Micha, R., (2015). *Antioxidants in health and disease*. Taylor & Francis

Reference Books:

1. *Murray, R.K., Bender, D.A., Bootham, K.M., Kennlley, P.J., Rodwell, V.W. and Weil, P.A.*(2012).*Harper's Illustrated Biochemistry*, Twenty ninth Edition, Tata McGraw Hill Companies Publication, New Delhi.
2. *Prasad, K.N.*(2010).*Micronutrients in Health and Disease*, CRC Press, USA.
3. Nabavi, S.M. and Silva, A.S. eds., 2022. *Antioxidants Effects in Health: The Bright and the Dark Side*. Academic Press.

Course Outcomes:

At the end of the course students will be able to

1. Understand the different types of free radicals
2. Explain oxidative stress associated diseases and disorders
3. Interpret the role of antioxidants in combating diseases
4. Understand the importance and types of antioxidant
5. Analyse the antioxidants in health and disease

Mapping of COs with POs & PSOs

CO / PO	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11	PSO 1	PSO 2	PSO 3
CO 1	H	H	M	M	M	M						H	M	
CO 2	H	M	M	H	M	M						H	M	
CO 3	H	H	M	H	M	M						H	M	
CO 4	H	M	M	M	M	M						H	M	
CO 5	H	H	M	M	M	M						H	M	

CO- Course Outcomes; PO- Program Outcomes; PSO- Program Specific Outcomes

H: High M: Medium L: Low

Molecular Physiology

Semester VI
21BBCC15

Hours of Instructions /week: 5
No. of Credit: 3

Objectives:

1. To impart knowledge on the functioning of all the organs of the body
2. To understand the principles underlying the interaction among the various organs
3. To study the cellular mechanisms involved in diseased conditions

Unit 1 Membrane transport **15hrs**

Membrane architecture - functions, structural features and chemical composition of membranes. Molecular models of plasma membranes.

Membrane transport – Transport of small molecules - passive transport – simple diffusion, facilitated diffusion, active transport - sodium- potassium pump, calcium pump, glucose and water transport across intestinal epithelial cells, bacterial lactose permease system. Transport of large molecules – exocytosis and endocytosis

Unit 2 Neurotransmission **15hrs**

Organisation of nerve cells. Propagation of nerve impulse along axon and synapse Role of neurotransmitters – acetylcholine, epinephrine, norepinephrine

Unit 3Molecular motors **15hrs**

Types of muscles and their functions. Structure of muscle cells – sarcomere. Thick and thin filaments. Muscle proteins – actin, myosin, troponin, tropomyosin, accessory proteins. Molecular events involved in muscle contraction and relaxation. Energy sources involved

Unit 4 Hormones **15hrs**

Introduction. Characteristic features. Classification. General mechanism of action of hormones. Intracellular messengers – cAMP, cGMP, phosphoinositide cascade and calcium. Specific hormones in signal transduction – signalling devices – endocrine, paracrine and autocrine signalling

Unit 5 Sensory transduction **15hrs**

Visual, olfactory, taste, auditory and touch transductions.

Total **75hrs**

Text Books:

1. *Peter J. Kennelly, Kathleen M. Botham, Owen McGuinness, Victor W. Rodwell, P. Anthony Weil.*(2022). *Harpers Illustrated Biochemistry,* thirty second Edition, Tata McGraw Hill Companies Publication, New Delhi.
2. *Devlin, T.M.*(2010).*Textbook of Biochemistry with Clinical Correlations,*SeventhEdition, John Wiley and Sons Inc Publications, New York.
3. *Lohar, P.S.*(2007).*Endocrinology Hormones and Human Health,*Second Edition, MJP Publishers, Chennai.

Reference Books:

1. *Karp, G.* (2013).*Cell and Molecular Biology,*Seventh Edition, John Willey and Sons Inc Publishers, New York.
2. *Owen, J., Punt, J. and Stranford, S.* (2012).*Immunology,* Seventh Edition, W.H. Freeman and Company Publishers, New York.
3. *Rastogi, S.C.*(2012).*Cell and Molecular biology,*Third Edition, New Age International Publishers, New Delhi.

Course Outcomes:

At the end of the course students will

1. Understand the membrane architecture, different models and various transport systems.
2. Explain the organization of nerve cells and neurotransmitters
3. Understand the role of molecular motors, types of muscles and muscle proteins.
4. Explore the hormonal system and how it regulates the activities of organs by signal molecules
5. Understand the concepts of sensory organs.

Mapping of COs with POs & PSOs

CO / PO	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11	PSO 1	PS O 2	PSO 3
CO 1	H	M					M			M	H	H	H	H
CO 2	H	M					M			M	H	H	H	H
CO 3	H	M					M			M	H	H		H
CO 4	H	M					M			M	H	H	M	H
CO 5	H	M					M			M	H	H	M	H

CO- Course Outcomes; PO- Program Outcomes; PSO- Program Specific Outcomes

H: High M: Medium L: Low

Nutritional Biochemistry

Semester VI **Hours of Instruction /week: 5**
21BBCC16 **No. of Credits: 3**

Objectives:

1. To impart the knowledge on historical overview of nutrition, essential nutrients for metabolism
2. To provide an overview of the major macro and micronutrients relevant to human health
3. To discuss the scientific rationale for defining nutritional requirements in healthy individuals and populations, with reference to specific conditions such as pregnancy, lactation, and older age

Unit 1 Introduction **15hrs**

Nutrition – concepts - role of nutrition in maintaining health, basic food groups - energy yielding, body building and protective foods. Basic concepts of energy expenditure, unit of energy – Kcal - energy requirements of different categories of people - RQ of foods - Body Mass Index (BMI) - Basal Metabolic Rate (BMR) – determination and factors influencing

Unit 2 Nutritional significance of dietary components **15hrs**

Physiological role and nutritional significance of carbohydrates, lipids, proteins, vitamins (water soluble and fat soluble) minerals and fiber. Dietary sources. Functions. Digestion, absorption and storage, metabolism of carbohydrates – lipids – proteins. Hypo and Hyper vitaminosis

Unit 3 Nutritive value of proteins **15hrs**

Essential amino acids, biological values of proteins (animal and plant proteins). Evaluation of proteins by nitrogen balance method-DC, BV, NPU of animal and plant proteins, single cell proteins, factors influencing protein requirements, effects of excess protein intake.

Unit 4 Protein calorie malnutrition **15hrs**

Protein malnutrition (Kwashiorkor) and under nutrition (marasmus) their preventive and curative measures – composition of balanced diet and RDA for infants, children, adolescent, adult male and female, pregnant, lactating women and geriatrics

Unit 5Nutrition and body defenses **15hrs**

Effect of drugs on food and nutrients, drug - nutrient interaction - nutritional therapy, food preparation and management. Role of diet and nutrition in the prevention and treatment of diseases – Diabetes mellitus, hypertension, infections, CVD, liver and kidney disorders

Total **75hrs**

Text Books:

1. Srilakshmi, B. (2018) Nutrition Science Revised Sixth Edition, New Age International Publishers, New Delhi.
2. Paul, S. (2014) A Textbook of Bio-nutrition – Curing Diseases through Diet, Revised First Edition, CBS Publishers and Distributors, New Delhi.
3. Swaminathan, M. (2004) Advanced Textbook of Food and Nutrition, Volume II, Second Edition, The Bangalore Printing and Publishing Co. Limited, India.

Reference Books:

1. Geissler, C. and Powers, H. (2010) Human Nutrition, Twelfth Edition, Churchill Livingstone, USA.
2. Brody, T. (2006) Nutritional Biochemistry, Second Edition, Academic Press, USA.
3. Eastwood, M. (2003) Principles of Human Nutrition, Second Edition, Wiley - Blackwell Science Ltd Publishers,

Course Outcomes:

At the end of the course students will be able to

1. Appreciate the role of nutrition in maintaining health and understand the parameters of nutritive value
2. Realize the biochemical and physiological functions of the nutrients and their integrated role.
3. Understand the various parameters to evaluate protein quality and assess the nutritive value of proteins.
4. Recognize the importance of RDA and the effects of nutritional deficiencies.
5. Evaluate the therapeutic role of key nutrients in maintaining health under various disease conditions.

Mapping of COs with POs & PSOs

CO / PO	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11	PSO 1	PSO 2	PSO 3
CO 1	H		M	M						H	H	H	H	H
CO 2	H		L	M						H	H	H	H	H
CO 3	H		M	M						H	H	H	H	H
CO 4	H		M	M						H	H	H	H	H
CO 5	H		M	M						H	H	H	H	H

CO- Course Outcomes; PO- Program Outcomes; PSO- Program Specific Outcomes

H: High M: Medium L: Low

Practicals IV-Clinical Biochemistry and Food Analysis

Semester VI **Hours of Instruction /week: 5**
21BBCC17 **No. of Credits: 3**

Objectives:

1. To learn important procedures in blood/serum analysis
2. To analyze the food sample for the presence of nutrients/ vitamins
3. To provide students life-skills in hands-on mode so as to increase their employability in diagnostic laboratories and food industries

Unit 1 *Blood Analysis (Whole Blood)* **15hrs**
Iron and Hemoglobin, urea, glucose

Unit 2 *Serum Analysis* **15hrs**
Creatine, creatinine, chloride, uric acid, phosphorus, calcium, total protein, albumin:globulin ratio
ELISA (Demo)

Unit 3*Urine Analysis* **15hrs**
Creatine, creatinine, chloride, uric acid, phosphorus, calcium

Unit 4 *Food Analysis* **15hrs**
Wheat flour/Bengal gram flour analysis for ash content, moisture content, crude fibre content, oxalate, phytate, calcium, iron, phosphorus

Unit 5 *Vitamins in food samples* **15hrs**
Ascorbic acid, riboflavin, thiamine

Total 75hrs

Text Books:

1. *Burtis, C.A. and Bruns, D.E.*(2007).*Fundamentals of Clinical Chemistry,*Sixth Edition, W.B Saunders Co, Philadelphia, London, Toronto.
2. *Chawla, R.* (2008). *Practical Clinical Biochemistry - Methods and Interpretations*, Third Edition, Jaypee Brothers Medical Publishers, New Delhi
3. Ajamani PS, (2018), Handbook of clinical laboratory techniques, 1st Ed., AITBS publishers

Course Outcomes:

At the end of the course students will be able to

1. Analyse the biomarkers from the whole blood sample
2. Quantify and Interpret the components from the serum sample
3. Evaluate the constituents present in the urine sample
4. Measure the nutritional composition from Wheat flour/Bengal gram flour
5. Estimate the level of vitamins in food samples

Mapping of COs with POs & PSOs

CO / PO	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11	PSO 1	PSO 2	PSO 3
CO 1	H		M	M	M	L						H	M	
CO 2	H		M	M	M	L						H	M	
CO 3	H		M	M	M	L						H	M	
CO 4	H		M	M	M	L						H	M	
CO 5	H		M	M	M	L						H	M	

CO- Course Outcomes; PO- Program Outcomes; PSO- Program Specific Outcomes

H: High M: Medium L: Low

Computational Biology

Semester VI **Hours of Instruction /week: 5**
21BBTC16 **No. of Credits: 3**

Objectives:

1. To expose students to the interdisciplinary computational biology course and its applications
2. To expose the students to various biological databases
3. To understand algorithms and tools in biological sequence analysis and to become biological data analyst

Unit 1 Introduction to bioinformatics **15hrs**

Definition, history, knowledge discovery and data mining; opportunities in Bioinformatics; Bioinformatics and pharmaceutical industry; problems faced in Bioinformatics area

Unit 2 Introduction to biological databases **15hrs**

Sequence and structure databases; nucleotide sequence databases – GenBank, EMBL, DDBJ – data retrieval tool – Entrez. Protein databases: Swiss-Prot / TrEMBL, PIR, structural databases –PDB, SCOP, CATH; specialized databases – KEGG, TIGR, Duke's databases

Unit 3 Sequence analysis **15hrs**

Pair wise alignment – dot plot, global and local alignment (details of algorithm not required); similarity searches - FASTA and BLAST.

Unit 4 Multiple sequence alignment and phylogenetic analysis **15hrs**

Progressive alignment method – Clustal; phylogenetic tree construction – PHYLIP.

Unit 5 Molecular visualization of biomolecules **15hrs**

3D structural analysis of biomolecules, obtaining atom co-ordinate files from databases; molecular visualization tools – RasMol.

Total **75hrs**

Text books:

1. *Attwood, T., Parry, D. and Phukan, S.*(2009)*Introduction to Bioinformatics*, Pearson Education, Asia, India.
2. *Kothekar, V. and Nandi, T.*(2007)*An Introduction to Bioinformatics*, Duckworth Press, Bioscience Publishers, New York.
3. *Xiong, J.* (2006).*Essential Bioinformatics*, Cambridge University Press, Australia.
4. BalakumarChandrasekaran, Dinesh Goyal, S. Balamurugan, Anand T. Krishnan, BoomiPandi, (2020). Computation in BioInformatics: Multidisciplinary Applications, Wiley Publishers

Reference Books:

1. *Baxevanis, A.D. and Ouellette, B.F.F.*(2009).*Bioinformatics – A Practical Guide to the Analysis of Genes and Proteins*, Third Edition, Wiley Publishers, New York.
2. *Lesk, A.M.*(2007).*Introduction to Bioinformatics*, Oxford University Press, London.
3. *Mount, D.W.*(2005).*Bioinformatics – Sequence and Genome Analysis*, Second Edition, CBS Publishers and Distributors, Chennai.

Course Outcomes:

At the end of the course students will be able to

1. Understand bioinformatics and its applications in pharmaceutical industry.
2. Familiar with biological databases, data storage and querying.
3. Understand algorithms and applying tools in sequence analysis.
4. Apply bioinformatics tools and interpret results
5. Design approaches for creating phylogenetic tree.

Mapping of COs with POs & PSOs

CO / PO	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11	PSO 1	PSO 2	PSO 3
CO 1	L	M	H	M	H	M	M	M	M		H	M		
CO 2	L	L	H	M	M		L		L		H	M	M	M
CO 3			M	M	M	L		M	L		H	M	M	M
CO 4			H	M	H	L				M	H		M	M
CO 5		L	H	M	M	M				M	M		M	

CO- Course Outcomes; PO- Program Outcomes; PSO- Program Specific Outcomes

H: High M: Medium L: Low

Animal Cell Culture and Animal Biotechnology

Semester VI **Hours of Instruction /week: 5**

21BBTC17 **No. of Credits: 3**

Objectives:

1. To explain the principles of aseptic techniques of culturing tissues under *invitro* conditions,
2. To develop understanding of techniques for cell line, cell strain development, maintenance
3. To apply the concepts of cell culture techniques for molecular pharming.

Unit 1 History and scope of cell culture **15hrs**

Requirements for animal tissue culture- Laboratory layout - cellular growth requirements-qualitative and physiological factors

Culture media- natural and defined - serum free media - Constituents of serum and its role. Importance of the growth factors in serum. Growth factors promoting proliferation of animal cells- EGF, FGF, PDGF, IL-I, IL- II, NGF and erythropoietin

Unit 2 Primary cultures **15hrs**

Anchorage dependence of growth - Non anchorage dependent cells. Secondary cultures- transformed animal cells. Established / continuous cell lines- commonly used cell lines- origin and characteristics- Propagation and maintenance of cell lines

Growth kinetics of cells in culture- types of tissue culture- cell culture, primary explant culture- slide / coverslip - single and double - flask culture and organ culture.3D cultures (elementary details)

Unit 3 Embryo culture **15hrs**

Whole embryo culture- transfection of animal cells- selectable markers-HAT selection- Antibiotic resistance

Somatic cell fusion- production of monoclonal antibodies- transplantation of cultured cells- cell differentiation

Unit 4 Metabolism of animal Cells **15hrs**

Metabolism of animal cells in culture - special secondary metabolite production - insulin, growth hormones, interferons, t-plasminogen activator and factor VIII

Expression of cloned proteins and production of vaccines in animal cells - tissue engineering

Unit 5 Embryo transfer **15hrs**

Artificial insemination. *In vitro* fertilization and Embryo transfer- super ovulation and embryo transfer in farm animals –Somatic cell cloning of Dolly - methods and utility - gene transfer methods - transgenic animals - molecular pharming

Bioreactors for large - scale culture of cells – monolayers - suspension culture- immobilized bioreactors

Total 75hrs

Text Books:

1. *Gupta. P.K.* (2012)*Biotechnology and Genomics*, First Edition,Sixth reprint, Rastogi Publication, Merut.
2. *Brown, T.A.*(2010)*Gene cloning- An Introduction*, Sixth Edition, Wiley Publishers, USA.
3. *Ranga, M.M.* (2008)*Animal Biotechnology*, Student Edition, SaraswatiPurohitPublications, Jodhpur.

Reference Books:

1. *Probnee. R.* (2007)*Animal cell biotechnology, Methods and Protocols*, Second Edition, Humana press, New Jersey.
2. *Freshney, R.I.*(2006)*Culture of Animal Cells – A manual of Basic Technique*, Fifth Edition, A John Wiley and Sons Publication, New York.
3. *Freshney, R.I.*(2005)*Animal Cell Culture-A Practical Approach*, Fourth Edition, IRL Press, New York.
4. Mohamed Al-Rubeai. (2014). AnimalCell Culture, Springer International Publishing.

Course Outcomes:

At the end of the course students will

1. Describe the requirements to initiate cell culture facility
2. Compare primary and secondary culture
3. Explore the in-depth knowledge in embryo culture
4. Comprehend the metabolism of animal cells
5. Devise the methods for embryo transfer

Mapping of COs with POs & PSOs

CO / PO	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11	PSO 1	PSO 2	PSO 3
CO 1	H	H	M	M	M	H		M	H			H	M	M
CO 2	H	H	M	M	M	H		M		M		H	M	M
CO 3	H	H	M	M	M	H		M		M		H	M	M
CO 4	H	H	M	M	M	H		M		M		H	M	M
CO 5	H	H	M	M	M	H		M	H			H	M	M

CO- Course Outcomes; PO- Program Outcomes; PSO- Program Specific Outcomes

H: High M: Medium L: Low

DSE –Biochemistry Theory/ Chemistry and metabolism of Biomolecules

Semester III **Hours of Instruction/week:4**

21BCHI04/21BFNI04 **No. of Credit: 3**

[For Chemistry and Food Science and Nutrition]

Objectives:

1. To understand the basics of biomolecules.
2. To learn the properties of biomolecules and their significant role in living systems.
3. To learn about the metabolism of biomolecules.

Unit 1*Carbohydrates and carbohydrate metabolism* **12 hrs**

Introduction and classification of carbohydrates, Reactions of monosaccharides, disaccharides and polysaccharides – structure and function of sucrose, maltose, lactose starch, glycogen and cellulose. Glycosaminoglycans and glycoproteins (elementary concepts only).

Metabolism of carbohydrates - Glycolysis, TCA cycle, electron transport chain, glycogenesis, glycogenolysis.

Unit 2 *Lipids and lipid metabolism* **12 hrs**

Definition and classification based on backbone structure. Fatty acids – saturated, unsaturated - essential fatty acids. Phospholipids – structure, occurrence, function of lecithin, cephalin and sphingomyelins. Glycolipids – cerebrosides, galactocerebrosides and gangliosides. Sterols – structure, occurrence and functions of cholesterol and bile acids.

β oxidation of fatty acids.

Unit 3 *Amino acids, proteins and protein metabolism* **12 hrs**

Structure and classification of amino acids. Reaction of proteins and amino acids, Classification of proteins, plasma proteins and immunoglobulins. Transamination, deamination and urea cycle (elementary concepts only)

Unit 4 *Nucleic acids and Nucleic acid metabolism* **12 hrs**

Bases, nucleotides, structure of DNA and types of RNA.

Metabolism of purine and pyrimidine nucleotides (degradation pathway only)

Unit 5 *Enzymes* **12 hrs**

Definition of enzymes, elementary idea of classification (IDBA). Factors influencing enzymes activity pH, temperature, enzyme concentration and substrate concentration. Enzymes of clinical importance: ALT, AST, LDH, CK.

Total hours 60 hrs

Text Books:

1. Jain J.L., Jain, S and Jain, N. (2005),Fundamentals of Biochemistry, 1st ed, S. Chand and Company Ltd, Ram Nagar, New Delhi.
2. Satyanarayana, U.(2009)Essential of Biochemistry,4th ed, Books and Allied Pvt. Ltd, New Delhi.
3. Khan, M.Y. and Khan, F. (2015) Principles of Enzyme Technology, PHI Learning.

Reference Books:

1. Nelson D. L. and Cox, M. M.(2013),Lehninger Principles of Biochemistry,6th Ed, W. H. Freeman and Company, New York.
2. Murray, R.K., Bender, D.A., Bootham, K.M., Kennlley, P.J., Rodwell, V.W. and Weil, P.A.(2012),Harper's Biochemistry, 29th Ed, Tata McGraw Hill Companies Publication, New Delhi.
3. Voet, D and Voet, G. (2012),Fundamentals of Biochemistry, John Wiley and Sons, New York.
4. Veer BalaRastogi, (2017). Zubay's Principles of Biochemistry, Medtech Publishers, India.

Course Outcomes:

After completing this course, the student will:

1. Understand the structure and metabolism of carbohydrates.
2. Relate the backbone structure and metabolism of lipids in living systems.
3. Comprehend the classification of amino acids and proteins and their metabolic aspects
4. Devise the composition and metabolism of nucleic acids.
5. Elaborate the classification, factors and clinical significance of enzymes

Mapping of COs with POs & PSOs

CO / PO	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11	PSO 1	PSO 2	PSO 3
CO 1	H			M	M			M				H		M
CO 2	H			M	M			M				H		M
CO 3	H			M	M			M				H		M
CO 4	H			M	M			M				H		M
CO 5	H			M	M			M				H		M

CO- Course Outcomes; PO- Program Outcomes; PSO- Program Specific Outcomes

H: High M: Medium L: Low

DSE –Biochemistry Practical/ Chemistry and metabolism of Biomolecules practical

Semester III **Hours of Instruction/week: 3**

21BCHI05/21BFNI05 **No. of Credit: 2**

[For Chemistry and Food Science and Nutrition]

Unit I *Carbohydrates* 12 hrs

Reactions of monosaccharides – glucose, fructose, galactose and mannose
Reactions of disaccharides and polysaccharides - sucrose, maltose, lactose starch and glycogen

Unit II *Amino acids* 6 hrs

Reactions of amino acids, tryptophan, tyrosine, and arginine

Unit III *Lipids* 6 hrs

Characterization of fats – saponification number, iodine number and acid number and Rm number (group experiment)

Unit IV *Chromatography* 3 hrs

Separation of amino acids by ascending paper chromatography

Unit V *Electrophoresis and Colorimetry*

Separation of protein by electrophoresis 18 hrs

Estimation of glucose, urea, uric acid, phosphorus and protein by biuret method

Total 45 hrs

Text Books:

1. Jain J.L., Jain, S and Jain, N. (2005), Fundamentals of Biochemistry, 1sted, S. Chand and Company Ltd, Ram Nagar, New Delhi.
2. Satyanarayana, U. (2009) Essential of Biochemistry, 4thed, Books and Allied Pvt. Ltd, New Delhi.
3. Deb, A. C. (2004), Comprehensible Viva and Practical Biochemistry, 2nded, New Central Book Agency Pvt. Ltd, India.

Reference Books:

1. Nelson D. L. and Cox, M. M. (2013), Lehninger Principles of Biochemistry, 6thed, W. H. Freeman and Company, New York.
2. Murray, R.K., Bender, D.A., Bootham, K.M., Kennlley, P.J., Rodwell, V.W. and Weil, P.A. (2012), Harper's Biochemistry, 29th Ed, Tata McGraw Hill Companies Publication, New Delhi.
3. Veer BalaRastogi, (2017). Zubay's Principles of Biochemistry, Medtech Publishers, India.

Course Outcomes:

After completing this course, the student will:

1. Acquire skills in identify the carbohydrates
2. Analyse the reactions of aminoacids
3. Characterise the properties of lipids
4. Identify amino acids by paper chromatography and electrophoresis
5. Estimate major biomolecules by colorimetrically

Mapping of COs with POs & PSOs

CO / PO	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11	PSO 1	PSO 2	PSO 3
CO 1	H			M	M			M				H		M
CO 2	H			M	M			M				H		M
CO 3	H			M	M			M				H		M
CO 4	H			M	M			M				H		M
CO 5	H			M	M			M				H		M

CO- Course Outcomes; PO- Program Outcomes; PSO- Program Specific Outcomes

H: High M: Medium L: Low

DSE - Clinical Biochemistry

Semester II
18BPAI02

Hours of Instruction/week:T+P: 4+3
No. of Credit: T+P: 3+2

[For Physician Assistant]

Objectives:

1. To understand and learn the collection of biological samples and preservation
2. To know about the clinical significance of abnormalities in metabolism of carbohydrate, protein and lipid.
3. To learn about the clinical importance of enzymes.

Unit 1 Specimen collection

Blood, urine, feces, cerebrospinal fluid and amniotic fluid.
Preservation of the specimens - anticoagulants and normal values of biochemical parameters. **12 hrs**

Unit 2 Abnormalities of carbohydrate metabolism

Diabetes mellitus - complications, types and metabolic changes, glucose tolerance test, glycosuria, ketone bodies, ketoacidosis and glycosylated hemoglobin. Fructose and lactose intolerance, galactosemia, lactiacidosis, alcoholism and glycogen storage disease. **12 hrs**

Unit 3 Abnormalities of Lipid Metabolism

Plasma lipids and lipo proteins, fatty liver, obesity, atherosclerosis, hyper and hypo lipoproteinemia. **12hrs**

Unit 4 Abnormalities of Protein Metabolism

Plasma proteins and their variations in diseases.
Inborn errors of metabolism - phenyl ketonuria, albinism, alkaptonuria, cystinosis, maple syrup urine disease, gout. **12 hrs**

Unit 5 Clinical Enzymology

Clinical significance of phosphatases, γ-glutamyltransferase, amylase, lactate dehydrogenase, transminases and creatine phosphokinase. **12 hrs**

Total hours 60

PRACTICAL

Unit 1 Collection of Urine samples **10 hrs**

Collection of random and 24 hour's urine samples and use of preservatives.

Unit 2 Collection of blood samples

Collection of blood samples, Collection by fingertip and venipuncture **10 hrs**

Whole blood, Serum, plasma, RBC

Unit 3 Routine analysis of urine (Qualitative) **10 hrs**

Colour, appearance, glucose, proteins, ketone bodies, blood, urinary deposits and bile salts-bilirubin

Unit 4 Urine analysis (Quantitative) **10 hrs**

Estimation of urea, uric acid, creatinine and calcium in urine.

Unit 5 Lipid Profile in Serum **5 hrs**

Estimation of total cholesterol, HDL, LDL, VLDL cholesterol and triglycerides by kit method.

Total hours **45**

Text Books:

1. *Chatterjee, M.N.* (2011). *Text Book of Medical Biochemistry,* Eight Edition, Jaypee Brothers Medical Publishers, New Delhi.
2. *Chawla, R.* (2008). *Practical Clinical Biochemistry - Methods and Interpretations,* Third Edition, Jaypee Brothers Medical Publishers, New Delhi.
3. *Bhagavan, N.V.* (2004). *Medical Biochemistry*, Fourth Edition, Academic Press, Calfornia.

References:

1. *Gaw, A., Murphy, M.J., Cowan, R.A., Rectly, D.S., Stewart, M.J. and Shepherd, J.* (2008), *Clinical Biochemistry*, 4thed,Churchill Livingstone, New Yor
2. *Gowenlock, A.H., Murray, J.R. and Lauchlan, D.M.* (2006), *Practical clinical Biochemistry,* 6thed, CBS Butterworth publishers, New Delhi.
3. *Nayak, B.* (2002), *Manipal Manual of Clinical Biochemistry*, 1sted, Jay Pee brothers, New Delhi.

Course Outcomes:

After completing this course, the student will:

1. Demonstrate the collection f biological samples and preservation methods
2. Gaintheknowledgefortheclinicalsignificanceofmetabolicdisorderofcarbohydrate
3. Understand the impact of various metabolic disorders of protein
4. Analyze the metabolic disorders of lipids and its impact
5. Know the importance of clinical enzymology

Mapping of COs with POs & PSOs

CO / PO	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11	PSO 1	PSO 2	PSO 3
CO 1	H	L	M											
CO 2		L	M			M	H	H	H		H	H	H	
CO 3	H	L	M			M	H	H	H		H	H	H	
CO 4	H	M	L			M	M	H	H		M	H	H	
CO 5	H	L	M			M	H	M	H		M	H	H	

CO- Course Outcomes; PO- Program Outcomes; PSO- Program Specific Outcomes

H: High M: Medium L: Low

DSE - Microbiology

Semester III **Hours of instruction/week:2+3**
21BPAI03 **No.ofcredits:2**

[For Physician Assistant]

Objectives:

1. To acquire knowledge on the various types of microorganisms which are responsible for several infectious diseases
2. Toenablethestudentstounderstandthemethodsofdisinfectionandsterilizationtocontrolandprevent hospital and community acquired infections.
3. To make the students to impart the significance of immune system for the prevention and treatment of diseases

Unit -I Introduction to Microbiology **10hrs**

History of microbiology, Koch'spostulates, Features of prokaryotes and eukaryotes, nomenclature and classification, Microbial Nutrition-common nutrient requirements ,Nutritional types of microorganisms, growth factors, Culture Media: Synthetic or defined media. Types of Media-Selective, differential and enrichmentmedia. Cultivation of organism, Concept of pure culture. Methods of pure culture of microorganisms – Spreadplate, streak plate and pour plate. Identification of microorganisms by staining techniques and biochemical tests. Principles and methods of microbial control: Sterilization – dry heat,moist heat and chemicals, Disinfections– physical, natural gases, chemicals used and preparation of lotions. Medical and surgical asepsis, cross – infection; control of spread of infection

Unit-II Bacteriology **10hrs**

Classification, morphology and cultural characteristics of bacteria,

Lab diagnosis, treatment and prevention of common bacterial infections. *Staphylococcus ,Streptococcus, Pneumococcus, Neisseria, Corynebacterium diphtheriae, Clostridia, Enterobacteriaceae-Shigella, Salmonella, Klebsiella, E.coli, Proteus, Vibriocholerae, Pseudomonas* and *Spirochetes*

Unit-III Mycology **10hrs**

Nature of fungi : basic structures and classification, Morphology and structure of fungi,Classification of fungi, Nutrition and cultivation of fungus, Superficial mycoses, Cutaneous and Subcutaneous mycosis, Systemic fungal infections with opportunistic mycosis. Candida, Cryptococcus, Dermatophytes, opportunistic fungi(Aspergillus, Zygomycetes and Penicillium Common laboratory methods for diagnosis of fungal infection,Serodiagnosis

Unit IV Parasitology and Virology 10hrs

Parasites: Biology of protozoa, Protozoan parasites causing human infection, Medicallyimportant helminthes – Ectoparasites

Virology: The nature and properties of viruses, Classification of viruses, Morphology, Laboratory Diagnosis of Viral Infection: Brief appraisal of pathogenicity of viruses ,Culture methods, Cytopathic effects, Inclusion bodies, Serological test (CFT, HAI, neutralisation), Bacteriophages, Retro viruses - HIV, Hepatitis virus, Pox virus Picronavirus – Polio, Orthomyxo virus - Influenza., Arbo virus - chikungunya, Dengue. Herpies and Adenovirus, Mumps, Measles and Rubella Virus Bacteriophage-structure ands ignificance.

Unit-V Immunology 10hrs

Immunity: General principles of innate and acquired immunity. Immune Response –Humoral immunity and cell mediated immunity. Antigen and Antibodies / Immunoglobulins– types and properties, Sub types of Immunoglobulins, Antigen/Antibody Reactions-Precipitation, Agglutination, Complement fixation test, Neutralization, Opsonization, Immune adherence, Immuno fluorescence, Immuno electron microscopic test, Vaccines-production, types of immunization, auto immune disorders

Practicals: 25hrs

1. Sterilization techniques
2. Staining techniques – simple staining, Gram staining, Negative staining, Flagellar staining, lactophenol cotton blue staining,
3. Plating techniques – spreadplate, pourplate, streakplate
4. Isolation of microorganisms from different sources
5. Antibiotic sensitivity test

Total75hrs

Textbooks:

1. Talaro, K.P. and Talar, A. (2012). Foundations in Microbiology, Eight Edition, The McGraw Hill Publishing Company, New York.
2. Prescott, L.M., Harley, J.P. and Klein, D.A. (2010). Microbiology, Eight Edition, The McGraw Hill Publishing Company, New York.
3. Roitt, I., Brostoff, J. and Male, D. (2017). Essential Immunology, 13thEdition, Wiley Blackwell Publishers, New York.

Reference Books:

1. Sumbali, G. and Mehrotra, R.S.(2009). Principles of Microbiology, Tata McGraw-Hill Publication, New Delhi.
2. Casida, J.R. (2009).Industrial Microbiology, Fifth Edition, New Age International Publishers, New York.
3. Owen, J., Punt, J. and Stranford, S. (2019) Immunology, Eighth Edition, W.H. Freeman and Company Publishers, New York.

Course Outcomes

Students will be able to

1. Applythemethodsofdisinfectionandsterilizationtocontrolandprevent hospital and community acquired infections.
2. Differentiate the various infections caused by bacteria
3. Compare the different mycological infections
4. Analyse the harmful effects of protozoa and viruses based on its structure
5. Discuss the importance of immunity and vaccines in diseases

Mapping of COs with POs & PSOs

CO / PO	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11	PSO 1	PSO 2	PSO 3
CO 1	H	L												
CO 2	H	L				M	H	H	H			H		
CO 3	H	L	M			M	H	H	H					
CO 4	H	M	L			M	M	H	H		M	H	H	
CO 5	H	L	M			M	H	M	H		M	H	H	

CO- Course Outcomes; PO - Program Outcomes; PSO- Program Specific Outcomes

H: High M: Medium L: Low