Fergusson College (Autonomous)

Pune

Learning Outcomes -Based Curriculum

for

M. Sc. I - Biochemistry

With effect from June 2019

Programme Structure

Year	Course Code	Course Title	Course	Credits
Semester I				
M.Sc Part I Semester I	CHB4101	Biomolecules	Tcore-1	4
	CHB4102	Genetics and Cell Biology	Tcore-2	4
	CHB4103	Biophysical Techniques	Tcore-3	4
	CHB4104	Enzymology and Plant Biochemistry	Tcore-4	4
	CHB4105	Biochemistry Practical - I	Pcore-1	4
	CHB4106	Biochemistry Practical - II	Pcore-2	4
				24
Semester II				
Year	**Course Code**	**Course Title**	**Course**	**Credits**
M.Sc. Part I Semester II	CHB4201	Microbiology and Fermentation technology	Tcore-1	4
	CHB4202	Metabolism	Tcore-2	4
	CHB4203	Molecular Biology	Tcore-3	4
	CHB4204	Physiological Biochemistry	Tcore-4	4
	CHB4207	Biochemistry Practical - III	Pcore-1	4
	CHB4208	Biochemistry Practical - IV	Pcore-2	4
				24

Semester III				
Year	**Course Code**	**Course Title**		**Credits**
M.Sc. Part II Semester III	CHB5301	Genetic Engineering and Animal cell culture	Tcore-1	4
	CHB5302	Immunology and Toxicology	Tcore-2	4
	CHB5303	Neurochemistry and Endocrinology	Tcore-3	4
	Electives Courses/MOOCS/General Elective (any One)			
	CHB5304	Biostatistics, Bioinformatics and Advance Biophysical techniques	Dcore-1	4
	CHB5305	Nutraceuticals and Pharmaceuticals	Ecore-1/M	4
	CHB5306	Molecular Oncology	Ecore-2/M	4
	CHB5307	Biochemistry Practical - V (Molecular Biology and Immunology)	Pcore-1	4
	CHB5308	Biochemistry Practical - VI (Bioinformatics, Computer Skills and Statistical Analysis)	Pcore-2	4
				24
Semester IV				
Year	**Course Code**	**Course Title**		**Credits**
M.Sc. Part II Semester IV	CHB5407	Biochemistry Practical (Project)	Pcore-1	8
				8

Programme learning outcomes

PO1	Biochemistry master's students will be able to demonstrate an understanding of fundamentalbiochemical principles, metabolic pathways and the regulation of biochemical processes.
PO2	They will gain proficiency in basic laboratory techniques in biochemistry and be able to apply scientific method to the processes of experimentation
PO3	Students will gain an ability to design and carry out experiments and to interpret experimental data.
PO4	Students will be able to develop in-depth understanding of the area of biochemistry to choose for the research purpose
PO5	They will demonstrate excellent critical thinking and problem solving abilities.
PO6	They will develop an ability to present their work through written, oral and visual presentations.
PO7	Students will learn construction of project thesis and able to defend their project result to other students and faculty.
PO8	They willgain the hands on knowledge of various techniques useful in biochemistry which can help them to stand with a skilful job at various industries and research labs
PO9	Students get ready to apply informatics and statistics to explore biological data for experimental and research purpose.
PO10	They acquire communication skill, team work strength and leadership qualities through various activities during their course work

Course Code: CHB4101
Biomolecules
Credits: 4

Course Outcomes	Suggested Pedagogical Processes
The student will be able to understand of all the classification of biomolecules and their biochemical functions	Flow Charts
The student will be able to understand the structures of biomolecules	Models and charts
The students will be able to correlate the reactions of aminoacids that are basis for identification tests and biochemical pathways	Board and demonstration of reactions
The student will be able to understand the properties of biomolecules that help to sustain life	Animated videos and power point presentations
The student will be able to understand characterisation of biomoelcules in research.	Research papers and Interactive discussions

Unit No.	Title of Unit and Contents
1.	Carbohydrates: 1.1. Introduction, Biological Significance, Classification with examples. Basic structures of Monosaccharides- Cyclisation of sugars according to Fischer and Haworth formula. Anomers and Epimers. 1.2. Structures of complex carbohydrates- Disaccharides (Homo and Hetero), Oligosaccharides and Polysaccharides (Homo and Hetero). 1.3. Concept of reducing and nonreducing sugars, Mutarotation and inversion. General reactions of sugars with Phenylhydrazine, Acids, Bases, Oxidisng agents and Reducing agents and its significance. 1.4. Derivatives of Sugars- Deoxy sugars, Phosphorylated sugars, Sulfated sugars, Amino sugars, Acetylated sugars, and Sugar acids, Sugar alcohols and its significance.
2.	Lipids: 2.1. Introduction, Biological Significance, Classification with examples. Basic structures of major lipid subclasses- Types of fatty acids, Waxes, Glycerophospholipids (Ester linked and Ether linked), Shingophospholipids, Nonphospholipids, Steroids. Essential and non essential fatty acids. 2.2. Blood group substance. Lipoproteins- Chylomicrons, VLDL, LDL and HDL. 2.3. General chemical reactions of lipids- Hydrolysis, Saponification, Emulsification, Oxidation. Saponification Number, Acid number, Iodine number, Reichert Meissel number, Polensky number. Hydrolytic and Oxidative rancidity of lipids. 2.4. Amphipathic lipids-Formation of micelles, monolayers, bilayer, liposomes. 2.5. Membrane structure and composition: Fluid Mosaic model, Significance of biological membranes. Molecular Constituents, percentage composition of plant, animal and microbial membranes, membrane permeability asymmetry and fluidity of membrane, rotation, flip flop

	movement, lateral diffusion of phospholipids. Protein lipid interaction and factors affecting properties of membranes
3.	Nucleic Acids: 3.1. Structure of Nitrogenous bases- Purines and Pyrimidines, Nucleosides, Nucleotides and Polynucleotides. 3.2. The central Dogma, DNA as genetic material 3.3. Structure of DNA. Features of denaturation and renaturation of DNA 3.4. Structure and types of RNA.
4.	Amino acids: 4.1. Introduction, Biological Significance, Classification with examples based on R group, Polarity, optical activity. Essential and Non essential amino acids, Standard and Nonstandard amino acids. 4.2. Zwitter ions and Isoelectric pH, Titration curve of amino acids. 4.3. General reactions of Amino acids with Ninhydrin, Sanger's, Dansyl chloride, Dabsyl chloride reagents. Deamination, Transamination and decarboxylation of amino acids. UV spectra of amino acids. 4.4. Peptide bond formation. Solid phase synthesis of peptides.
5.	Proteins: 5.1. Classification on the basis of composition, biological role and shape. 5.2. Structural levels of protein: Primary structure – End group analysis of N and C terminus, Breaking of polypeptides to small peptides using enzymes and chemical reagents, Amino acid sequencing by Edmann degradation. 5.3. Secondary structure-alpha-helix, beta pleated structure, super secondary structure. 5.4. Tertiary Structure- Forces stabilizing the structure. 5.5. Quaternary structure – Hemoglobin. Denaturation and Renaturation of proteins. 5.6. Ramachandran plot and prediction of protein structure.
6.	Vitamins and Co-enzymes: 6.1. Classification- Water-soluble and Fat-soluble vitamins. 6.2. Structure, Coenzyme forms of B- complex vitamins, Source, dietary requirements. 6.3. Biochemical functions, deficiency conditions.
7.	Transport of Biomolecules across membranes: 7.1. ATPases and its types (Sodium- Potassium pump, ABC, P type, V type ATPases).Sodium, proton Potassium and chloride dependent processes. 7.2. Ion transport: Types, proteins involved in ion transport, ionophores (antibiotics: Gramicidin and Valinomycin) 7.3. Drug transport: Role of liposome in drug transport, cellular permeability, some examples of drugs, role in cell signaling

Learning Resources

1. Principles of Biochemistry, Lehninger CRS publication
2. Biochemistry, L. Stryer
3. Biochemistry Voet&Voet
4. Problem Approaches in Biochemistry. Wood and Hood
5. Physiological chemistry- Hawk

Course Code: CHB4102
Genetics and Cell Biology
Credits: 4

Course Outcomes	**Suggested Pedagogical Processes**
Students will understand the fundamental principles of genetics and able to describe Mendel's Laws and its extensions. They will be able to understand common genetic terms used frequently.	Classroom teaching, problem solving, PowerPoint presentations
They will be able to apply the principles of genetics to produce a family pedigree from a family history, and to distinguish patterns of inheritance for single gene disorders linked to autosomes or sex chromosomes.	Classroom teaching, Flow Charts, problem solving
Students will understand about the effect of mutations and reasons behind genetic disorders. They will also know how sex determination happens in various species.	Research papers and Interactive discussions
They will understand how genes work together in biological processes and understand how a complementation test allow to determine if two mutations are located in the same gene	Classroom teaching, powerpoint presentations, animated videos.
They will get familiarize with major experiments and discoveries that influenced the development of modern genetics.	Research papers and Interactive discussions Animated videos and power point presentations
Students will understand how genetic exchange takes place in microbes	Classoom teaching, powerpoint presentations.
The student will be able to understand the compartmentation of the cell into cell organelles, the functional aspects of the cell organelles.	Power point presentation, Models and charts
Structure and properties of cell membrane and different types of transport mechanism across cell membrane.	Animated videos and power point presentations

Unit No.	**Title of Unit and Contents**
	Genetics
1.	Concept of gene: 1.1. Evolution of gene : Beadle and Tatum's one gene one enzyme concept, one gene one polypeptide concept, **1.2.** Allele, multiple alleles, pseudoalleles, multiple gene, **1.3.** Fine structure of gene : Cistron, Recon and Muton, Eg. rII locus in T4 phage, **1.4.** Complementation test.
2.	Mendelian genetics: **1.5.** Mendel's History, Genetic terminology, Genotype, Phenotypes 2.2. Mendel's Laws –Dominance, Segregation and Independent assortment with examples
3.	Extension of Mendelian principles:

	3.1. Co-dominance, incomplete dominance 3.2. Gene interactions : epitasis, pleiotropy, penetrance and expressivity
4.	4.1. Chromosomal Sex determination, 4.2. sex limited and sex influenced characters
5.	Extra chromosomal inheritance: **5.1.** Inheritance of mitochondrial and chloroplast genes with examples **5.2.** Maternal inheritance, nucleocytoplasmic inheritance
6.	Molecules of Heredity: 6.1. DNA as genetic material, The central Dogma. Semi conservative mechanism of DNA replication. 6.2. Features of denaturation and renaturation of DNA, cot curve analysis,
7.	Mutation: 7.1.Types of mutations, causes and detection, 7.2. Germinal vs. somatic mutation, chromosomal and genetic mutations 7.3. Human teratogenesis
8.	Mutant types: 8.1. Auxotrophs, prototrophs, lethal, conditional mutants 8.2. Mutant isolation and selection method
9.	Microbial genetics: 9.3. Types of plasmids, Fertility factor, Hfr 9.4. Methods of genetic transfers –transformation, and conjugation in bacteria. Life cycle of bacteriophages, lytic and lysogeny, transduction types: specialized, generalized. 9.5. Mapping genes by interrupted mating technique 9.6. Tetrad analysis.
10.	Genetic Code: Biochemical and genetic analysis of the genetic code.
	Cell Biology
11.	Brief Introduction about cell: 11.1. Cell theory, Cell classification, cell variability, size, shape and complexity, function
12.	Animal cell and Plant cell: 12.1. Animal cell: Morphology and functions of sub cellular components: Nucleus, chromatin and chromosomes, plasma membrane, ribosomes, endoplasmic reticulum, lysosomes, peroxisomes, Golgi apparatus, mitochondria, cytoskeleton 12.2. Plant cell: cell wall, chloroplast, glyoxysomes, dictyosomes, vacuoles, xylem, phloem and plant cell epidermis 12.3. Sub-cellular fractionation: Differential and density gradient centrifugation, marker enzymes.
13.	Cell division and cell cycle: 13.1. Mitosis: events of different phases and its significance 13.2. Meiosis -Types, process and its significance, comparison of mitosis and meiosis, cell cycle check points.
14.	Cell junction and mechanism of transport across cell: 14.1. Anchoring junctions, communicating junctions, tight junctions, gap

	junctions. 14.4. Extracellular matrix and role of collagen, elastin and fibronectin. Plasmodesmata. 14.5. Principles and mechanism of osmo-regulation, diffusion, passive, active and facilitated transport, features of uniport, symport and antiport transport systems, role of proteins in the process like exocytosis, endocytosis-phagocytosis and pinocytosis, receptor mediated endocytosis (cholesterol transport), and ATP, ADP- exchanger.
15.	Germ cells and Stem cells: 15.1. Gametogenesis, fertilization and organogenesis: zygote formation, cleavage, blastula formation, embryonic fields, gastrulation and formation of germ layers in animals. 15.2. Stem cells: Types

Learning Resources

1. Genetics by Monoroe W. Strickberger,1990 (3rd Ed.) Macmillan Pub
2. iGenetics: A Molecular Approach by peter J.Russell
3. Biochemistry, L Stryer, 3rd/4th/5th ed, 1989 , Freeman and Co. NY
4. Principles of Biochemistry –Lehninger
5. Molecular Biology of the Gene- Watson Benjamin / Cummings Publ. Company (1987).
6. Introduction to Genetics: A Molecular Approach; T A Brown, Garland Science (2011).
7. Human Molecular Genetics; Peter Sudbery, (2002) Printice Hall
8. Molecular Biology of The Cell, fifth addition– Bruce Alberts, Garland Science
9. Cell and Molecular Biology – DeRobertis and Saunders (1980).
10. The Cell- A molecular approach by Geoffrey M. Cooper
11. Cell Biology – C.J. Avers, Addision Wesley Co. (1986).
12. Molecular biology by Lodish and Baltimore

Course Code CHB4103
Biophysical Techniques
Credits: 4

Course Outcomes	Suggested Pedagogical Processes
Students will learn about various membranes, their properties and appropriate uses. They will understand the concept of dialysis and reverse dialysis techniques, lyophilization techniques along with their application.	Classroom lectures, demonstration of filteration and dialysis, reverse dialysis techniques
Students will be familiarized with the theory of chromatographic separation process and they will be able to apply theoretical knowledge in optimization of chromatographic separation.	Classroom lectures, tutorials, videos, powerpoint presentations and demonstration of analytical techniques
They will be able to assess the suitability of chromatographic techniques for solving specific bio-analytical problems and critically apply the knowledge for biomolecules separation	Classroom teaching, problem solving, hands on experience, cooperative-based learning, presentations
At the end of this course student must be able to illustrate the working principles underlying protein and nucleic acid electrophoresis techniques and their application in biochemistry.	Lectures-board and powerpoints, Hands-on experiences of electrophoresis. Problem-based method
Students will learn concepts, fundamentals and types of centrifugation technique.	Classroom lectures, hands-on experience
Students will learn about how to measure radioactivity, instrument used for detecting and measuring ionizing radiations and use of autoradiography.	Classroom lectures, tutorials, discussions
Students will understand the concept of spectrophotometer, relevant terms of uv-visible spectroscopy and outline of uv spectroscopy device.	Classroom lectures, hands-on experience, problem solving
They will get familiarized with application of AAS and ICP	Classroom lectures, discussions

Unit No.	Title of Unit and Contents
1.	Membrane filtration and dialysis: **1.1.** Nitrocellulose, fibre glass, Polycarbonate filters **1.2.** Dialysis, reverse dialysis, glass fibre dialysis. **1.3.** Freeze drying and lyophilization
2.	Chromatography theory and practice: 2.1. Introduction, Partition and Adsorption principle 2.2. Brief introduction of Paper chromatography and Thin layer chromatography 2.3. Column chromatography-parameters employed in column chromatography, retention, resolution, physical basis of peak broadening plate height equation, capacity factors, peak symmetry, standard systems of chromatography and its components, stationary phase, elution. 2.4. Ion exchange chromatography-principle, method, major matrices,

	examples of cation and anion exchangers, applications. 2.5. Gel chromatography- principle, method, matrix and fractionation range, application. 2.6.Affinity chromatography-principle, method, affinity ligands, immobilization of ligands, activation of matrices, coupling affinity ligands, metal affinity chromatography, hydroxyl apatite chromatography, covalent chromatography, hydrophobic interaction chromatography. 2.7. HPLC -Instrumentation, method, Separate modes: normal and reverse, detectors. Introduction: Fast protein liquid chromatography (FPLC), 2.8. GC –instrumentation, principle, procedure, applications.
3.	Electrophoretic techniques: 3.1. General principles, Support media – agarose, paper, cellulse-acetate electrophoresis, polyacrylamide gels. 3.2. Electrophoresis of proteins – SDS-PAGE, native PAGE, disc PAGE, gradient PAGE, Capillary electrophoresis, 3.2. Isoelectric focussing, 2-D gel electrophoresis, Western blotting 3.3. Staining techniques – Coomassie and Silver staining,. Electrophoresis of 3.4. Nucleic acids- Agarose gel electrophoresis, DNA sequencing gels
4.	Spectroscopy: 4.1. UV and visible spectrophotometry- Principle, instrumentation and applications 4.2. Atomic Absorption Spectroscopy (AAS), Inductively coupled Plasma Atomic Emission Spectrometry (ICP-AES or IES)
5.	Sedimentation: **5.1.** Theory, Preparatory and analytical ultracentrifuges, Density gradient centrifugation. **5.2.** Factors affecting sedimentation velocity, sedimentation coefficient, measurement of S, Zonal centrifugation, DNA analysis **5.3.** Determination of molecular weight by sedimentation, diffusion and sedimentation equilibrium methods. **5.4.** Applications of sedimentation techniques with examples
6.	Viscosity: 6.1. Theory, effect of macromolecules on the viscosity of solutions 6.2. Flow time measurement, relative viscosity
7.	Isotope Tracer Techniques: 7.1. Types of radiations, types of decay, rate of radioactive decay, half life, units of radioactivity 7.2. Detection and measurement of radioactivity, GM counter –design and application, Scintillation counters, types, advantages and limitations, background noise quenching, Radiation dosimetry, Cerenkov counting
8.	Autoradiography: Principle, method and applications
9.	X-Ray Diffraction: Principle and applications

Learning Resources

1. Physical biochemistry by D. Freifelder II edition.
2. Biochemical techniques by Wilson and Walker.
3. Biophysical techniques by Upadhyay, Upadhyay and Nath.
4. Biochemical calculation by I.H. Segal IInd Edition

Course Code: CHB4104
Enzymology and Plant Biochemistry
Credits: 4

Course Outcomes	**Suggested Pedagogical Processes**
Students will learn basics of enzymology and will be familiar with important terms of enzymology	Classroom teaching, problem solving, PowerPoint presentations
They will know classes, nomenclature and important properties of Enzymes	Classroom teaching, Flow Charts, problem solving
Basis of enzymatic reactions, their types and mechanism	Research papers and Interactive discussions
Experimental approach to enzyme action	Classroom teaching, powerpoint presentations, animated videos.
Enzyme degradation control of their activity	Research papers and Interactive discussions Animated videos and power point presentations
Regulation of enzyme activity and turnover	Classroom teaching, powerpoint presentations.
Isolation, purification and applications of enzymes	Power point presentation
They will learn the major principles of plant physiology and the crucial processes behind it (e.g. photosynthesis, water and nutrient transport, key regulatory hormones).	

Unit No.	**Title of Unit and Contents**
	Enzymology
1.	Classification and features of enzymes 1.1. History, Nomenclature and classification, 1.2. Remarkable properties- High catalytic power, features of active site, enzyme substrate complex formation: lock and key hypothesis, induced fit and substrate strain theory, enzyme specificity, regulation. 1.3. Concept of Isoenzymes, conjugated enzymes- holoenzyme, apoenzyme, prosthetic groups: Cofactors coenzymes, multi-enzymes.
2.	Mechanism of enzymes action 2.1. Theoretical background of enzymatic reactions 2.2. Factors leading to rate enhancement of enzyme catalyzed reactions, acid-base catalysis, proximity and orientation effects, covalent catalysis, strain or distortion and change in environment, site directed mutagenesis.
3.	Isolation and Purification of Enzymes 3.1. Industrially useful enzymes (Amylase, Invertase, pepsin) their isolation and purification techniques, 3.2. Immobilization of enzymes and its applications
4.	Experimental approach to Enzyme mechanics 4.1. Kinetics studies

	4.2. Detection of intermediates 4.3. X-ray crystallographic studies 4.4. Chemical modification of amino acid side chain and Affinity labeling, 4.6. Examples of enzymes chymotrypsin, Pyruvate dehydrogenase complex, ATP synthase, Ribonuclease.
5.	Enzymes kinetics 5.1. Factors affecting enzyme activity- 5.1.1.pH 5.1.2.Temperature 5.1.3 Substrate, product and enzyme concentrations 5.1.4.Activators and enzyme inhibition –reversible and irreversible 5.2. One-substrate reactions, two substrate reactions, 5.3 pre-steady state kinetics-MM equation, LB equation, significance of Km stopped flow technique, relaxation methods.
6.	Regulation of Enzyme activity and Enzyme turnover 6.1.Allosteric regulation, Zymogen activation, phosphorylation and dephosphorylation of enzymes involved in biochemical pathways. 6.2. Ligand binding and induced changes, theoretical models, MWC – KNF models and their usefulness. 6.3. Control of activities of single enzyme: Inhibitor molecules, substrate availability or cofactor and changes in covalent structure of enzyme, 6.4. Mechanism of enzyme degradation: lysozomal degradation, ubiquitation and other cellular processes of enzyme degradation. 6.5. Enyme turnover, Ks and Kd, correlation between the rates of enzyme turnover and structure and function of enzymes, significance of enzyme turnover.
7.	Applications 7.4. Clinical aspects and applications of enzymes, Enzymes in food analysis and processing
	Plant Biochemistry
8.	Seed germination: 8.1. Biochemistry and physiology of seed germination and dormancy. 8.2. Energy production in plant cells and its control. Metabolism of sucrose and starch.
9.	Mineral nutrition: 9.1. Micro and macro elements, requirement, role, excess and deficiency disorders
10.	Photosynthesis: 10.1. Chloroplasts, photosystem, mechanism CO2 fixation,C3 and C4 pathways, CAM
11.	Nitrogen metabolism: 11.1. Nitrogen cycle, nitrogen fixation, assimilation of nitrate and ammonium ions, nitrogen transformation during development
12.	Plant hormones : **12.1.** Types and role in plant growth and development. Auxins, gibberellins, cytokinins, ethylenes, abscisic acid, hormones in senescence and

	abscission.
13.	Secondary metabolites: 13.1. Active principles in medicinal plants, Definition types, phenolics, flavanoids, lignins, terpenoids alkaloids, Gum, Pectins, 13.2. Pathways : shikkimic acid, mavelonate. Phytochemistry of the medicinally importance plants.
14.	Stress physiology: 14.1. Response of plants to biotic (pathogen and insects) and abiotic (water, temperature and salt) stresses.
15.	Introduction to Plant diseases: 15.1. Pest types, symptoms, treatment, pesticides.
16.	PCC Techniques: 15.3. Callus and cell suspension culture, Micropropogation, Conditioning of tissue culture. 15.4. Somatic cell hybridization, Haploid (anther) culture, Embryo culture, Protoplast fusion, Somatic embryogenesis, Somaclonal variations, Cybrids and Allopheny.

Learning Resources

1. Fundamentals of Enzymology by Price and Stevens
2. Enzymology by Dixon and Webb
3. Enzymes by Palmer
4. Enzymes and food processing- GG Birch, N Blackbrough (1981)
5. Introduction to food sciences and technology –GF Stewart and MA Amerine (1973) Academic Press
6. The Cell; Geoffery Cooper and Robert E; 5 Ed (HausmanSinauer Associates 2009)
7. Plant physiology, Salisbury and Ross (2007) CBS publishers and distributors.
8. Plant Physiology- Devlin
9. Plant Biochemistry- Dey
10. Introduction to Plant Biochemistry- T.W. Goodwin and E.L. Mercer

Practical Course Code: CHB4105
Biochemistry Practical - I
(Any Twelve Experiments)
Credits: 4

Exp. No.	Experiment Title
1.	Isolation of Starch and characterization
2.	Isolation of milk casein by Isoelectric pH precipitation
3.	Isolation of Egg albumin and globulin
4.	Isolation of Cholesterol and lecithin from egg
5.	Identification of carbohydrate mixture with suitable tests
6.	Specific reactions for Carbohydrate
7.	Detection of amino acids from mixture (qualitatively and quantatively)
8.	Estimation of vitamin C
9.	Estimation of protein by Biuret method
10.	Estimation of protein by Lowry method
11.	Estimation of DNA/RNA by DPA method
12.	Estimation of protein by Bradford method
13.	Estimation of sugar by PSA method
14.	Estimation of sugar by DNSA method
15.	Extraction of fatty acid and Fat acid number, saponification and Iodine value
16.	Estimation of chlorophylls from leaf
17.	Estimation of any of the B vitamin
18.	Detection of phytochemicals from plants
19.	Estimation of amino acid by ninhydrine method
20.	Determination on alpha amino nitrogen of amino acid.
21.	Estimation of inorganic phosphorus by Fiske-Subbarow method

Practical Course Code: CHB4106
Biochemistry Practical - II
(Any Twelve Experiments)
Credits: 4

Exp. No.	Experiment Title
	Enzymology
1.	Extraction, Isolation and detection of common enzyme (invertase/amylase/peroxidase/catalase)
2.	Assay of Enzyme activity and Specific activity
3.	To asses effect of substrate concentration (Vmax and Km) on enzyme activity.
4.	Effect of different parameters (temperature, pH, enzyme concentration) on enzyme activity
5.	To asses effect of activator and inhibitor on enzyme activity
6.	Effect of enzyme immobilization on its activity
7.	Enzyme isolation and purification (Any natural source).
	Biophysical Techniques
1.	Introduction to techniques: Use of pipettes (standardization), Concept of pH, preparation of buffer of desired pH and molarity and measurement of pH.
2.	pH metry: Acid base titration curves. Measurement of pKa of amino acids.
3.	Ion exchange chromatography/ Gel filtration chromatography
4.	Paper Chromatography/Thin layer chromatography
5.	Electrophoresis: Agarose/ 1D- PAGE
6.	UV and Visible Spectrophotometry: Absorption spectra, Verification of Lamberts-Beer's Law, absorption spectrum of proteins /amino acids/molecules
7.	Dialysis, reverse dialysis and membrane filtration
8.	Density gradient Centrifugation
9.	Estimation of micronutrients from food by Flame photometer (any two elements from Ca,K, Na etc)
10.	Demonstration of sophisticated analytical instrument working (GC/ GCMS/ LCMS/XRD / SEM)

Microbiology and Fermentation technology
Credits: 4

Course Outcomes	Suggested Pedagogical Processes
Student will study different types of microscopes, characteristics of various microorganisms and their structures.	Classroom teaching, discussion
Composition of various media and optimum condition for their growth. Effect of various physical and chemical agents on growth of microorganism	Classroom teaching, power point presentation
Types of plant and animal viruses and their characteristics and role of microorganism in nitrogen metabolism	Power point presentation, Classroom teaching, animated videos
The student will be able to understand of all the different microorganism, sterilization processes, cultivation of microorganism and their pathogenecity	Classroom teaching, discussion
Fermenters, design of fermenters	Classroom teaching with examples
Students will learn different types of fermentation process, strain improvement methods and isolation of industrial important microorganisms.	Classroom teaching, animated videos
Different recovery process of the final product formed	Power point presentation
Application of fermentation.	Models and working, videos

Unit No.	Title of Unit and Contents
	Microbiology
1.	**Microscopy:** **1.1.** Introduction : Visualization of cells and sub cellular components by light microscopy, resolving powers of different microscopes, microscopy of living cells **1.2.** Phase contrast microscopy: principle, working and applications **1.3.** Fluorescence microscopy: principle, working and applications **1.4.** Techniques: specimen preparation Freeze Itching, Freeze fracture, pinch-off.
2.	**2.1.** Classification of microorganisms: system of classification, Identifying characters for classification, classification based on different requirements (eg. Nutrition, temperature, oxygen etc.) **2.2.** Characterization methods **2.3.** Cell structure and components,
3.	**Cultivation of bacteria:** **3.1.** Types of growth media (natural, synthetic, complex, enriched, selective-definition with example) **3.2.** Ppure culture methods (streak plate, spread plate, pour plate, stab culture, slant culture)**,** pure culture characteristics **3.3.** Nutrition, physiology and growth of microbial cells, reproduction and

	growth, synchronous growth, continuous culture of microorganisms
4.	**Agents for growth control** **4.1.** Control of growth by physicals and chemicals agents **4.2.** Mutations by growth control agents and mutant characterization
5.	**Host microbe interactions** **5.1.** Terminology, events of infection, effect of enzyme and other factors **5.2.** Endotoxins, exotoxins, capsular material. **5.3.** Tissue affinity, resistance and immunity.
6.	**Microbial membrane transport:** **6.1.** Phosphotransferase system, Group translocation **6.2.** Specialized mechanism for transport of macromolecules (Virus membrane assembly and ribosome).
7.	**Viruses:** **7.1.** Viruses of bacteria, plant and animal cells: Structure, classification and life cycle **7.2.** Mycoplasma and viriods, diseases
8.	**Role of Microbes** 9.1. Food spoilage and microbial food toxin
9.	**Nitrogen fixation:** **10.1.** Nitrogen cycle in nature, symbiotic and non symbiotic nitrogen fixation **10.2.** Nitrogenase system, nitrate reductase
	Fermentation Technology
10.	**Introduction to fermentation**: **10.1.** Sterilization and its importance, maintenance of aseptic conditions **10.2.** Design of fermenters, fermentation types, aeration and agitation
11.	**Fermentation types:** **11.1.** Methods and parameters of cultivation of microorganisms, media for industrial fermentation
12.	**Characteristics and Techniques**: **12.1.** Characterization of industrial microorganisms, strain improvement, use of auxotrophic mutants
13.	**Product purification and treatment:** **13.1.** Downstream processing, recovery and purification of fermentation products, effluent treatment
14.	**Applications:** **14.1.** Fuels from microbes, microbial polymers and microbial steroid bio transformations
15.	**Products from microorganisms**: **15.1.** Enzymes (Amylases, Proteases, Pectinases), Primary metabolites (Glu, vit B12), Antibiotics (Penicillin), Pigments (Carotenoids), Sweeteners, Beverages (wine, Beer)

Learning Resources

1. Microbiology, M.S. Pelczar, R.D. Reid, E.C.S. Chan, McGraw Hill, NewYork (1986).
2. General Microbiology (Vth Edition), R.Y. Stanier, Prentice Hall (1986)
3. Biology of Microorganisms by Brocks
4. Introductory Microbiology, F.C. Ross, Charles Merril Publication (1983).
5. Principles of Fermentation technology, PF Stanbury, A Whitaker, SJ Hall (2008)
6. Molecular biology and biotechnology- edited by JM Walker and FB Gingold, Royal society of chemistry (1988)
7. Industrial Microbiology – Casida
8. General Microbiology Stainer R.Y. et al (1987) 5th Ed., Macmillan Press Ltd. London

9. Biotechnology by B.D. Singh

Course Code: CHB4202
Title of the Paper: Metabolism
Credits: 4

Course Outcomes	Suggested Pedagogical Processes
Overview of carbohydrate metabolic pathways	Board Teaching, Charts, Models
Enzymes that catalyze the formation of intermediates	Board teaching
Rate limiting steps and Regulation of the pathways	Interactive animations
Features of the pathways	Group Discussions
Defective enzymes and Inborn errors	Power point presentations
Energetic of pathways	Tables and charts

Unit No.	Title of Unit and Contents
1.	**Introduction of Metabolism and Bioenergetics:** **1.1.** Anabolism, catabolism, precursors of metabolism and its significance. **1.2.** Basic laws of thermodynamics, standard free energy, enthalpy, entropy **1.3.** high energy compounds, structure and significance of ATP
2.	**Carbohydrate metabolism:** **2.1. Carbohydrate Catabolism :** Glycolysis, Gluconeogenesis, Pentose Phosphate Pathway, feeder pathways of glycolysis, fates of pyruvate under aerobic and anaerobic conditions. TCA/Kreb's cycle, Glyoxylate cycle, Uronic acid pathway, Cori's cycle. Pasture effect. **2.2. Carbohydrate biosynthesis:** Biosynthesis of starch, sucrose, cellulose, Glycogen. Reaction intermediates, enzymes, energetics & regulation of all the pathways. **2.3.** Inborn errors of carbohydrate metabolism.
3.	**Lipid Metabolism:** **3.1.Fatty acid catabolism**: Beta oxidation of saturated and unsaturated fatty acids, odd and even number fatty acids. Reaction intermediates, enzymes, energetic & regulation of all the pathways. **3.2.Lipid biosynthesis:** Biosynthesis of fatty acids, fatty acid synthase complex, Triacylglycerol,Phospholipids, Ketogenesis, cholesterol biosynthesis. Reaction intermediates, enzymes, energetic & regulation of all the pathways. **3.3.**Inborn errors of lipid metabolism
4.	**Biological oxidation:** **4.1.** Structure of mitochondria, features of electron carriers, Electron transport chain in mitochondria and oxidative phosphorylation- chemiosmotic hypothesis. **4.2.** ATP synthase complex and its mechanism. **4.3.** Inhibitors and uncouplers of ETC and OP
5.	**Amino acid Metabolism:**

	5.1. Amino acid degradation: Amino acid oxidation and production of Urea. Reaction intermediates, enzymes & regulation of all the pathways. Significance of Transamination, oxidative deamination, Decarboxylation reactions of amino acids. **5.2.** Degradation of amino acids leading to formation of Pyruvate, Acetyl CoA, α Keto glutarate, Succinyl CoA, Oxalo acetate. Reaction intermediates, enzymes & regulation of all the pathways. **5.3. Amino acid biosynthesis:** Synthesis of Glutamate, Glutamine, Proline, Arginine, from α ketoglutarate. Reaction intermediates, enzymes & regulation of all the pathways. **5.4.** Synthesis of Serine, Glycine, Cystine, from 3 Phospho glutarate **5.5.** Synthesis of amino acid using oxaloacetate and pyruvate as precursors **5.6.** Synthesis of Aromatic Amino acids. **5.7.** Inborn errors of amino acid metabolism.
6.	**Specialized Molecule derived from Amino acids:** **6.1.** Creatine, Glutathione, Porphyrins, Biological Amines, Nitric oxide. Gamma glutamyl cycle.
7.	**Nucleotide metabolism :** **7.1. Degradation** of Purines and Pyrimidines. Reaction intermediates, enzymes & regulation of pathway **7.2**. Denovo and salvage pathways of Purine and Pyrimidine biosynthesis. Reaction intermediates, enzymes & regulation of pathway **7.3.** Inborn errors of Nucleotide metabolism

References

1. Biochemistry – Lehninger.
2. Metabolic Pathways - Greenberg.
3. Biochemistry – G. Zubay, Addision Wesley Publ. (1983).
4. Biochemistry – Stryer (1988) 3rd Edition W.H. Freeman and Co.
5. Harper's Biochemistry

Course Code: CHB4203
Title of the Paper: Molecular Biology
Credits: 4

Course Outcomes	Suggested Pedagogical Processes
Students will be able to describe the general principles of gene organization in prokaryotes and eukaryotes	Classroom lectures, figures and diagrams
Students will be able to describe mechanisms of DNA replication and repair, RNA synthesis and processing, protein synthesis and modification. They will be able to distinguish and compare how replication, transcription and translation processes differ in prokaryotes and eukaryotes.	Classroom lectures, tutorials, videos, powerpoint presentations and research paper presentation
They will be able to explain which enzymes, protein factors and energy sources are needed for	Classroom teaching, problem solving, , cooperative-based learning,

each stage.	presentations, problem solving
They will be familiarized with mechanism of action and resistance to antibiotics at molecular level	Lectures-board and PowerPoint, group-discussions
They will be able to describe the mechanisms of protein transport to various sub cellular sites and process of protein degradation	Classroom lectures, interactive videos
Students will be able to describe how gene expression is regulated at the transcriptional and post-transcriptional level.	Classroom lectures, tutorials, video presentations
They will be able to read and understand scientific articles related to subject and gain a critical understanding of their contents. They will be able to give a spoken and written presentation of scientific topics and research results.	Research paper and review articles presentations, video lectures

Unit No.	**Title of Unit and Contents**
1.	**Molecular structure of Genes and Chromosomes :** **1.1.** Definition and organization of viral, prokaryotic and eukaryotic genomes, Structural organization of Eukaryotic chromosomes **1.2.** Structure of chromatin, nucleosome, Histones, chromatin organization, higher order organization.
2.	**DNA Replication:** **2.1.** Chemistry of DNA synthesis, Enzymes involved in DNA synthesis e.g. topoisomerase, helicase, Ligase, DNA polymerase – types, subunits **2.2.** Mechanism of Replication in Prokaryotes and Eukaryotes. Okazaki fragments, Origin of replication Replication fork. **2.3.** Inhibitors of DNA synthesis.
3.	**DNA Repair :** **3.1.** Repair of DNA damage – Direct reversal of DNA damage **3.2.** Replication errors and their repair – Mismatch Repair, Base Excision mechanism, Nucleotide Excision mechanism, **3.3.** Translesion DNA synthesis, SOS response **3.4.** Defective repair system and diseases, Ames test
4.	**Homologous Genetic Recombination:** **4.1.** Recombination pathways, Holliday model, DSB repair model **4.2** Homologous recombination protein machines: RecBCD, Rec A, Ruv AB, RuvC. **4.3** Mobile genetic elements.
5.	**Transcription:** **5.1.** Mechanism in prokaryotes: RNA polymerases - subunits, promoters, initiation, elongation and termination of transcription-Rho dependent and independent. **5.2.** Mechanism in Eukaryotes: RNA pol I, II, III, subunits, promoters for RNAP I, II, III, Transcription factors, Transcription process

	5.3. Inhibitors of transcription.
6.	**Post-transcriptional modification of RNA:** **6.1.** Types of RNA processing, 5' capping and 3' poly A tailing: mechanism and functions **6.2.** Chemistry of RNA splicing: Type of Introns, Types of Splicing pathways: The Spliceosome machinery, Self splicing, Alternative splicing **6.3.** RNA editing
7.	**Translation:** **7.1.** Features of Translation components: mRNAs – structure, ORF; tRNAs – structure, adaptor hypothesis; Aminocyl tRNAsynthetase – attachment of amino acids; Riobosome, Genetic code **7.2.** Mechanism in Prokaryotes and Eukaryotes: Intiation, Elongation, Termination **7.3.** Post translational modifications, Inhibitors of protein synthesis.
8.	**Protein Targeting and Degradation:** **8.1.** Signal hypothesis, signal sequences, glycosylation **8.2.** Targeting of protein to ER, mitochondria, chloroplast, lysosomes, Peroxisomes **8.3.** Protein degradation.
9.	**Regulation of Gene Expression:** **9.1.** Principles of Gene regulation: regulation of gene expression in Bacteria, phage lambda, DNA binding motifs, **9.2.** Gene regulation in Eukaryotes: chromatin remodeling: process, enzymes **9.3.** Introduction to epigenetic regulation.

Learning Resources

1. Biochemistry (III/IV/V/VI edition, 2008) L. Stryer, WH Freeman and Co.
2. Molecular biology of the gene (V edition, 2004) J D Watson, Person education Inc.
3. Molecular Cell Biology (7th edition.2013) by Harvey Lodish et al.
4. Molecular biology of the cell (2008) B. Alberts, Garland Pub. In., NY
5. Genes X (2010), B. Lewin, John Wiley and sons, NY.

Course Code: CHB4204
Title of the Paper: Physiological Biochemistry
Credits: 4

Learning Outcomes	**Suggested Pedagogical Processes**
Students will be able to describe the general principles of gene organization in prokaryotes and eukaryotes	Classroom lectures, figures and diagrams
Students will be able to describe mechanisms of DNA replication and repair, RNA synthesis and processing, protein synthesis and modification. They will be able to distinguish and compare how replication, transcription and translation processes differ in prokaryotes and eukaryotes.	Classroom lectures, tutorials, videos, powerpoint presentations and research paper presentation

They will be able to explain which enzymes, protein factors and energy sources are needed for each stage.	Classroom teaching, problem solving, ,cooperative-based learning, presentations, problem solving
They will be able to describe the mechanisms of protein transport to various sub cellular sites and process of protein degradation	Classroom lectures, interactive videos

Unit No.	Title of Unit and Contents
1.	**Blood components and blood clotting:** **1.1.** Blood composition, plasma proteins and their diseases. **1.2.** Clotting factors, mechanism of coagulation role of vitamin K in clotting process. Conditions that cause excessive bleeding in humans, **1.3.** Hematopoiesis, bone marrow stem cell.
2.	**Respiration** **2.1.** Mechanics and regulation of respiration, pulmonary and alveolar ventilation and its control, **2.2.** Physical principles of gaseous exchange a transport of respiratory gases, respiratory mechanism of acid-base balance, **2.3.** Regulation of acid-base balance: acid-base buffers. Nervous and chemical control of respiration. **2.4.** Hypoxia acclimatization, cyanosis, dyspnoea, asphyxia, abnormal respiration. Pulmonary function tests.
3.	**Digestion:** **3.1.** Anatomy of digestive system, **3.2.** Secretion, regulation of secretion, composition and functions of saliva, gastric, pancreatic and intestinal juices and bile. **3.3.** Gastro-intestinal hormones. **3.4.** Digestion, absorption and transport of carbohydrates, proteins, lipids, nucleic acids and vitamins. **3.5.** Malnutrition and malabsorbtion. Intestinal stem cells
4.	**Liver:** **4.1.** Liver – anatomy, physiological functions. **4.2.** Detoxification mechanisms. Liver function tests **4.3.** Liver disorders: - hepatitis, cirrhosis, Jaundice: etiology and symptoms. **4.4.** Liver stem cells
5.	**Kidney:** **5.1.**Anatomy, physiological functions, **5.2.**kidney function tests, diseases/disorder,
6.	**Reproduction:** **6.1.**Anatomy of male and female reproductive system. **6.2**.Functions of reproductive organs.
7.	**Muscles (Skeletal muscle, cardiac and smooth muscles):** **7.1.** Morphology, ultra structural organization, protein components of myofibrils- Actin , Myosin, Troponin, Tropomyosin , molecular organization of thick and thin filament **7.2.** Proteins in muscles other than muscle filaments, mechanism of muscle

	contraction, **7.3.** Metabolism of muscles. Contraction and relaxation cycle of muscle and regulation.
8.	**Cytoskeleton components, chemotaxis and cell motility:** **8.1.**Microfilaments (Actin and Myosin) **8.2.**Microtubules (cilia and flagella of eukaryotic Cells) **8.3.**Intermediate filaments, (molecular composition of cytoskeleton) **8.4.** Chemotaxis in prokaryotes and eukaryotes.
9.	**Nervous tissue:** **9.1.** Structure and various components of neuron, their types and functions 9.2. Creation and propagation of nerve impulse. Generation of action potential 9.3. Types of channels in neurons. cholinergic receptors, electroplaxes as a source of acetyl choline receptor and 9.4. Nerve poisons 9.5. Neuronal stem cells and transcription factor
10.	**Biochemistry of vision:** **10.1.**Structure of eye, lens, and retina, photoreceptor cells (rods and cones), **10.2.** Perception of light, primary events in visual excitation, cyclic GMP **10.3.** Role of various proteins of eye, generation of nerve impulse, colour vision. **10.4.** Visual stem cells.
11.	**Biochemistry of sense of taste, smell and hearing:** **11.1.** Structure of taste buds and olfactory cells, role of cells in perception of taste (various chemical groups) and smell. Olfactory stem cells. **11.2.**Structural components of ear, receptors of sound waves, perception of sound mechanism of body balance
12.	**Biochemistry of sense of touch:** **12.1.** Structural components of skin and touch receptors, types of touch receptors **12.2.**Epidermal stem cells

Learning Resources

1. Text book of physiology- Guyton
2. Principles of neural science Kandel ER, Schwartz JH, Elsevier, N.Holland, NY
3. Neurobiology, Shepherd GM , Oxford Univ. Press
4. Nerve and muscle excitation Junge D, Sinauerassoc, Sanderland, mass
5. Biochemistry , L Stryer, Freeman and Co, NY
6. Biochemistry, Zubay, Addison Wesley and Co
7. Biochemistry, L Stryer, Freeman and Co, NY
8. Biochemistry, Zubay, Addison Wesley and Co.
9. Textbook of Physiology, Guyton
10. Physiology, Berne and Levy
11. Harper's Biochemistry- 27th edition
12. Text book of Human Biochemistry- Ed. G. P. Talwar

Practical Course Code: CHB4207
Title of the Paper: Biochemistry Practical - III (Microbiology and Special Experiments)
Credits: 4

Exp. No.	Experiment Title
	Microbiology
1.	Media preparation, pour plate, spread plate and streak plate techniques and Total viable count determination
2.	Sterilization: Steam, Dry heat and filter and Preservation of bacterial culture
3.	Microscopic examination (motility, monochrome staining and gram staining).
4.	Detection of common enzyme (amylase, caseinase, catalase activity)
5.	Phosphatase test and Methylene blue reduction test (MBRT) for the quality of milk
6.	Growth curve analysis of *E. coli*
7.	Ultraviolet irradiation and survival curve
8.	Antibiotic Sensitivity Test
9.	Biological Oxygen Demand (BOD) and Chemical Oxygen Demand (COD)
	Special Experiments (any 6)
1	Extraction, isolation of sub-cellular organelles with respect to marker enzyme and its activity.
2.	Extraction of phytochemicals, screening (qualitative) and quantitative measurements
3.	Extraction of antioxidant from natural source and its activity.
4.	Identification of functional groups in a compounds using IR (Working and interpretation of IR)
5.	Activity of Acetyl choline esterase
6.	Extraction of protein from natural source and nitrogen estimation by Kjeldahl method
7.	Extraction of liposoluble pigments/ Extraction of protein and molecular weight determination
8.	Essential oil extraction and characterization

Practical Course Code: CHB4208
Title of the Paper: Biochemistry Practical - IV (Clinical Biochemistry and Cell Culture)
Credits: 4

Exp. No.	Experiment Title
	Clinical Biochemistry
1.	**Experiment for kidney function test**. A. Urine analysis. B. Serum Creatinine C. Urea estimation D. BUN
2.	**Experiment for liver function test.** A. SGOT B. SGPT C. ALP

	D. Albumin E. Proteins F. Bilirubin G. Cholesterol
3.	**Blood sugar estimation**. A. Glucose oxidase and peroxidise method B. Folin-Wu method C. Glucose tolerance test
4.	**Different enzymes studies** A. LDH and its isozymes B. serum amylase
	Cell culture
1.	Basics of cell culture: Acquaintance with cell culture laboratory, Culture place: culture cubical P1 to P4; Laminar flow system. Preparatory techniques: Washing of glassware, dry and steam sterilisation. Maintenance of aseptic conditions, Sterilization techniques, Media preparation: Filter sterilization, and media storage. Serum inactivation.
2.	Culturing and sub-culturing of animal cell lines and its maintenance
3.	Cell counting, viable cell count, trypsinization, cryopreservation and revival.
4.	Culturing and sub-culturing of callus in different media its characterization
5.	Chick embryo fibroblast culture