Deccan Education Society's

FERGUSSON COLLEGE, PUNE - 411004

AUTONOMOUS COLLEGE

Two Years
M. Sc. Degree Course in Chemistry
(Biochemistry)

SYLLABUS
First Year M. Sc.
[Biochemistry]

Semester - I

[Academic year 2016-2017]

Deccan Education Society's

FERGUSSON COLLEGE, PUNE – 411004

Department of Chemistry

[Autonomous College]

Two Years M. Sc. Degree Course in Chemistry

[Implemented from Academic Year 2016-2017]

M. Sc. Part I Biochemistry Course Structure under CBCS (Autonomy)

Course Structure:

Term / Semester	Name of the Paper	Title of Paper	Theory Credits	No. of Lectures / Practicals
Semester I	CHB4101	Biomolecules	4	60
	CHB4102	Enzymology	4	60
	CHB4103	Cell Biology and Membrane Biochemistry	4	60
	CHB4104	Biophysical Techniques	4	60
	CHB4105	Practical Course in Analytical Biochemistry	4	15 Practicals
	CHB4106	Practical Course in Enzymology and Biophysical Techniques	4	15 Practicals
	CHB4107	Self-Learning Course - I Modern Approaches in Bioanalysis and Bioassays	1	15
Semester I : Credits			**25**	

Term / Semester	Name of the Paper	Title of Paper	Theory Credits	No. of Lectures / Practicals
Semester II	CHB4201	Metabolic Pathways	4	60
	CHB4202	Microbiology and Fermentation Technology	4	60
	CHB4203	Biostatistics, Research Methodology and Bioinformatics	4	60
	CHB4204	Genetics	4	60
	CHB4205	Practical Course in Microbiology and Immunology	4	15 Practicals
	CHB4206	Practical Course in Bioinformatics, Computer Skills and Statistical Analysis	4	15 Practicals
	CHB4207	Self-Learning Course - II Introduction on Quality Control Laboratory (QC/ GLP)	1	15
Semester II : Credits			**25**	

Deccan Education Society's

Fergusson College (Autonomous), Pune – 411004

Faculty of Science

Extra Credits for Post Graduate Courses

M. Sc. Course in Biochemistry

Semester	Course Code	Title of the Course	No. of Credits
I	XHR0001	Human Rights - I	1
	XCS0002	Introduction to Cyber Security - I / Information Security - I	1
	XSD0003	Skill Development - I	1
II	XHR0004	Human Rights - II	1
	XCS0005	Introduction to Cyber Security - II / Information Security - II	1
	XSD0006	Skill Development - II	1

Semester I
CHB4101: BIOMOLECULES
SECTION I (2 Credits, 30 L)

1. **Molecular logic of life:** **(3 L)**

Composition of living matter, Macromolecules and their monomeric subunits, Types of bonds within Biomolecules. Structural and Stereoisomerism of Biomolecules, Concept of Chirality, Enantiomers, Diastereoisomers. Water as universal solvent. Henderson and Hasselbach equation, significance of K_a , pK_a, Biological Buffers.

Objectives:

1. Students will learn the elements present in biomolecules and the different monomers and polymers.
2. They will understand the role of water in synthesis and breakdown of polymers.
3. Students will know about major complex biomolecules found in living cells and the basis for grouping of biomolecules.
4. For each group of biomolecules students will learn the name of its generic monomer (simple unit) and polymer (complex structure) and their functions.

2. **Carbohydrates:** **(12 L)**

Introduction, Biological Significance, Classification with examples. Basic structures of Monosaccharides- Cyclisation of sugars according to Fischer and Haworth formula. Anomers and Epimers. Structures of complex carbohydrates- Disaccharides (Homo and Hetero), Oligosaccharides and Polysaccharides (Homo and Hetero). 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.

Derivatives of Sugars- Deoxy sugars, Phosphorylated sugars, Sulfated sugars, Amino sugars, Acetylated sugars, and Sugar acids, Sugar alcohols and its significance.

Glycoconjugates- Glycoproteins and Glycolipids. Overview of Separation techniques and qualitative analysis of carbohydrates in laboratory.

Objectives:

1. Students will be able to identify structures of various carbohydrates and the difference between simple sugars and complex carbohydrates.
2. Students will learn the reactions and properties of carbohydrates and significance of derived sugars.
3. Importance of glycoconjugates in biological systems
4. Overview of various biochemical techniques and analytical procedures used in laboratories.

3. Lipids: **(12 L)**

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. Blood group substance. Lipoproteins- Chylomicrons, VLDL, LDL and HDL. 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. Amphipathic lipids-Formation of micelles, monolayers, bilayer, liposomes. Overview of separation techniques and qualitative analysis of lipids in laboratory.

Objectives:

1. Students will be able to identify structures of various lipids and the difference between simple and complex lipids.
2. Reactions and properties of lipids
3. Behaviour of amphipathic lipids in water
4. Importance of lipoproteins, blood group substance.
5. Overview of various biochemical techniques and analytical procedures used in laboratories

4. Nucleic Acids: (3 L)

Introduction, Types- DNA and RNA, Biological significance, Structure of Nitrogenous bases- Purines and Pyrimidines, Nucleosides, Nucleotides and Polynucleotides.

Objectives:

1. Students will learn the Structures of Nitrogenous bases, Nucleosides, Nucleotides and Phosphodiester linkages seen in Poly Nucleotides
2. DNA and RNA – Difference, formation and their significance.

SECTION II (2 Credits, 30 L)

1. Amino acids: (10 L)

Introduction, Biological Significance, Classification with examples based on R group, Polarity, optical activity. Essential and Non essential amino acids, Standard and Nonstandard amino acids. Zwitter ions and Isoelctric pH, Titration curve of amino acids. General rteactions of Amino acids with Ninhydrin, Sanger's, Dansyl chloride, Dabsyl chloride reagents. Deamination, Transamination and decarboxylation of amino acids. UV spectra of amino acids. Peptide bond formation. Solid phase synthesis of peptides.

Objectives

1. Recognize the structure of amino acids and the peptide bond that connects di-, tri, and polypeptides.
2. Differentiate between essential and Non Essential Amino acids, Standard and Non standard Amino acids
3. Acid Base Properties of amino acids
4. Reactions of Amino acids and their significance.

2. Proteins: (12 L)

Classification on the basis of composition, biological role and shape.

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. Secondary structure-alpha-helix, beta pleated structure, super secondary structure. Tertiary Structure- Forces stabilizing the structure. Quaternary structure - Hemoglobin. Denaturation and Renaturation of proteins. Ramachandran plot and prediction of protein structure. Precipation of proteins, Dialysis and overview of separation techniques of proteins in laboratory.

Objectives

1. Types and functions of proteins.
2. Hierarchy of Protein structure
3. N, C terminus determination, Edmann's reaction and its significance
4. Features of secondary structures.

5. Recognize the importance of the three dimensional shape of a protein for its function.
6. Factors that stabilize the conformation of a protein.
7. Effect of various denaturing agents on protein.
8. Interpretation of Ramachandran Plot.
9. Principle behind various Biophysical methodologies that indicate the stepwise progress of Protein Purification.

3. Vitamins and Co-enzymes: (8 L)

Classification- Water-soluble and Fat-soluble vitamins. Structure, Coenzyme forms of B-complex vitamins, Source, dietary requirements, Biochemical functions, deficiency conditions. Overview of estimations of vitamins in laboratory.

Objectives:

1. The students will know about different types of vitamins and their functions.
2. Identify food sources and state the recommended intake of each of the fat-soluble vitamins.
3. Describe the signs and symptoms of vitamin deficiencies and toxicities.
4. Different types of coenzymes and their metabolic functions.

References::

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

CHB4102: ENZYMOLOGY
SECTION I (2 Credits, 30 L)

1. Classification and features of enzymes: (**4 L)**

History, Nomenclature and classification, 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, colloidal nature, thermolabile nature. Concept of Isoenzymes, conjugated enzymes- holoenzyme apoenzyme, prosthetic groups: Cofactors coenzymes, multi-enzymes.

Objectives

1. Students will know the experimental and accidental finding of enzymes, their components, meaning and composition of cofactor and coenzymes, their nomenclature, classes depending on the reactions and basic properties.
2. Students will learn the term Cofactors, coenzymes, holoenzyme and apoenzyme isoenzyme and multienzyme system with its types, examples and role in biological reactions

2. Enzyme turnover: **(8 L)**

Kinetics of enzyme turnover, measurement of enzyme turnover, Ks and Kd, correlation between the rates of enzyme turnover and structure and function of enzymes, mechanism of enzyme degradation, significance of enzyme turnover.

Objectives:

1. Enzyme turn over that is life span of an enzyme in the cell will be learned through kinetic reactions and their degradation pathways.
2. Students will learn Mechanism of enzyme action
3. Reaction constants
4. Degradation pathways of enzyme

3. Enzymes kinetics: **(8 L)**

Factors affecting enzyme activity-pH, temperature, substrate, product and enzyme concentrations, activators and enzyme inhibition –reversible and irreversible types One-substrate reactions, two substrate reactions, theory, order analysis, pre-steady state kinetics-MM equation, LB equation significance of Km, Hill equation, Adair equation. stopped flow technique, relaxation methods.

Objectives:

1. Students are expected to learn order of enzymatic reaction (first, second)
2. Determination of the rate of the reaction (MM equation) and various techniques to study it. Students will also learn factors affecting rate of reactions (Inhibitors, pH, temp)

4. Mechanism of enzymes action : **(10 L)**

Theoretical background, 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.

Objectives:

1. Learn to study the methods to find rate of reaction
2. Various methods for it.

SECTION II (2 Credits, 30 L)

1. Experimental approach to Enzyme mechanics: **(10 L)**

Kinetics studies, detection of intermediates, X-ray crystallographic studies, chemical modification of amino acid side chain and affinity labeling. Examples of chymotrypsin, triose-phosphate isomerases, Lysozymes and Ribonuclease.

Objectives:

1. X-ray crystallography method to detect rate of enzymatic reaction.
2. Chemical composition of few enzyme their structure and reactions.

2. Regulation of Enzyme activity and Enzyme models: **(12 L)**

Control of activities of single enzyme: Inhibitor molecules, substrate availability or cofactor and changes in covalent structure of enzyme, lysozomal degradation, ubiquitation and other cellular processes of enzyme degradation. Allosteric regulation, Zymogen activation, phosphorylation and dephosphorylation of enzymes involved in biochemical pathways. Ligand binding and induced changes, theoretical models, MWC – KNF models and their usefulness.

Objectives:

1. Will learn various models (theoretical) of enzyme working and usefulness.
2. Allosteric behavior and co-operative behavior

4. Isolation and Purification: **(8 L)**

Industrially useful enzymes their isolation and purification techniques, Immobilization of enzymes and its applications.

Objectives:

1. Learn principle behind enzyme isolation
2. Various purification techniques

References:

1. Fundamentals of Enzymology by Price and Stevens
2. Enzymology by Dixon and Webb
3. Enzymes by Palmer

CHB4103: CELL BIOLOGY AND MEMBRANE BIOCHEMISTRY
SECTION I (2 Credits, 30 L)
Cell Biology

1. **Brief Introduction about cell:** **(2 L)**
   Cell theory, Cell classification, cell variability, size, shape and complexity, function.

2. **Animal cell** : **(12 L)**
   Morphology and functions of sub cellular components: Nucleus, chromatin and chromosomes, plasma membrane, ribosomes, endoplasmic reticulum, lysosomes, peroxisomes, Golgi apparatus, mitochondria, cytoskeleton, sub-cellular fractionation: Differential and density gradient centrifugation, marker enzymes.

3. **Cell junction**: **(4 L)**
   Anchoring junctions, communicating junctions, tight junctions, gap junctions.
   Extracellular matrix and role of collagen, elastin and fibronectin.

4. **Cell division and cell cycle:** **(3 L)**
   Mitosis: events of different phases and its significance, Meiosis -Types, process and its significance, comparison of mitosis and meiosis.

5. **Plant cell**: **(3 L)**
   Morphology and functions of Cell wall, chloroplast, glyoxysomes, dictyosomes, vacuoles, xylem, phloem and plant cell epidermis, Plasmodesmata

6. **Bacteria and Fungi:** **(2 L)**
   Cell structure, classification and biological importance.

7. **Germ cells:** **(3 L)**
   Gametogenesis, fertilization and organogenesis: zygote formation, cleavage, blastula formation, embryonic fields, gastrulation and formation of germ layers in animals,

8. **Stem cells** - Types, Applications. **(1 L)**

Objectives

1. To understand the structures and purposes of basic components of prokaryotic and eukaryotic cells, especially macromolecules, membranes, and organelles.
2. To understand the cellular components underlying mitotic meiotic cell division.
3. To apply the knowledge of cell biology to selected examples of changes or losses in cell function. These can include responses to environmental or physiological changes, or alterations of cell function brought about by mutation.
4. To study different plant cell, animal cell its different cell components, cell division etc.
5. Understand the stem cells

SECTION II (2 Credits, 30 L)
Membrane Biochemistry

1. **Biological membrane:** **(8 L)**
   Significance of biological membranes. Membrane models: biological and physical model. 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. Cell to cell interactions. Protein lipid interaction and factors affecting properties of membranes.

2. **Membrane transport:** **(8 L)**
   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.

3. **Special molecules of Transport:** **(6 L)**
   ATPases and its types (Sodium- Potassium pump, ABC, P type, V type ATPases).
   Sodium, proton Potassium and chloride dependent processes. Phosphotransferase system, Group translocation, specialized mechanism for transport of macromolecules (Virus membrane assembly and ribosome).

4. **Ion transport:** ` **(3 L)**
   Types, proteins involved in ion transport, ionophores (antibiotics: Gramicidin and Valinomycin)

5. **Drug transport:** **(3 L)**
   Role of liposome in drug transport, cellular permeability, some examples of drugs, role in cell signaling

6. Techniques: Freeze fracture, pinch-off **(2 L)**

Objectives

1. To understand about the structure, composition of various cell membranes, models of membranes
2. To understand different transport system in cells.
3. To understand drug transport and role of different cells in transport.
4. To study different techniques to study cells.

References:

1. Molecular Biology of The Cell, fifth addition– Bruce Alberts, Garland Science
2. Cell and Molecular Biology – DeRobertis and Saunders (1980).
3. The Cell- A molecular approach by Geoffrey M. Cooper
4. Cell Biology – C.J. Avers, Addision Wesley Co. (1986).
5. Molecular biology by Lodish and Baltimore

CHB4104: BIOPHYSICAL TECHNIQUES
SECTION I (2 Credits, 30 L)

1. UV and visible Spectophotometry: **(2 L)**
Principle, instrumentation and applications.

Objectives

1. Students will understand the concept of spectrophotometer, relevant terms of uv-visible spectroscopy and outline of uv spectroscopy device.
2. Students will understand the basic principle-laws, importance of absorption maxima, finding extinction coefficient, application of uv-vis spectroscopy and techniques in practice.

2. Membrane filtration and dialysis: **(3 L)**
Nitrocellulose, fibre glass, Polycarbonate filters, Dialysis, reverse dialysis, glass fibre dialysis. Freeze drying and lyophilization.

Objectives

1. Students will understand the principles and goals of filtration using various membranes.
2. It will help students in understading use and advantage of membrane filtration techniques.
3. Students will also learn principle and procedure of dialysis and reverse dialysis techniques, concept of freeze drying and lyophilization techniques along with their application.

3. Chromatography theory and practice: **(15 L)**
Introduction, Partition and Adsorption principle, Techniques- Brief introduction of Paper chromatography, TLC, 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. Modes of Chromatography: Ion exchange-principle, method, major matrices, examples of cation and anion exchangers, applications. Gel chromatography- principle, method, matrix and fractionation range, application. 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. HPLC -Instrumentation, method, Separate modes: normal and reverse, detectors. Introduction:Fast protein liquid chromatography (FPLC), GLC – instrumentation, principle, procedure, applications.

Objectives

1. Students will understand the terms chromatography, adsorption chromatography, partition chromatography, column chromatography, TLC, paper chromatography, different phases involved in separation etc.
2. They will understand how these chromatographic techniques can be used for separation of different molecules.
3. Students will understand the basic requirements for performing any of the above type of chromatography. They will learn about principles, method, application of mentioned types of chromatography techniques and will to judge when to apply which type of technique for better results.
4. Students will acquire the skill to perform the experiment based on above types of chromatographic technique, identify the components based on their Rf value etc.

4. Electrophoretic techniques: **(10 L)**

General principles, Support media - agarose, paper, cellulse-acetate electrophoresis, polyacrylamide gels. Electrophoresis of proteins – SDS-PAGE, native PAGE, disc PAGE, gradient PAGE, Capillary electrophoresis, Isoelectric focussing, 2-D gel electrophoresis. Staining techniques – Coomassie and Silver staining, Western blotting. Electrophoresis of Nucleic acids- Agarose gel electrophoresis, DNA sequencing gels

Objectives

1. Students will understand the basic concept of electrophoresis techniques and its different types. They will understand how gel electrophoresis is able to separate molecules.
2. Students will acquire knowledge about methods involved in different types of electrophoresis techniques and uses and advantages of the same.

SECTION II (2 Credits, 30 L)

1. **Sedimentation:** **(12 L)**

Theory, Preparatory and analytical ultracentrifuges, Density gradient centrifugation. Factors affecting sedimentation velocity, sedimentation coefficient, measurement of S, Zonal centrifugation, DNA analysis, Determination of molecular weight by sedimentation, diffusion and sedimentation equilibrium methods. Applications of sedimentation techniques with examples.

Objectives

1. Students will learn concepts and fundamentals of centrifugation. They will learn about different types of centrifugation techniques, Ultracentrifugation techniques in biology.
2. Students will acquire the knowledge about the various use of centrifugal techniques

2. Viscosity: **(2 L)**

Theory, effect of macromolecules on the viscosity of solutions, flow time measurement, relative viscosity.

Objectives

1. Students will learn about concept of velocity.
2. They will learn how viscosity affects fluids and how other parameters of a molecule in turn contribute towards viscosity.

3. Isotope Tracer Technique: **(10 L)**

Types of radiations, types of decay, rate of radioactive decay, half life, units of radioactivity, Detection and measurement of radioactivity, GM counter –design and application, Scintillation counters, types, advantages and limitations, background noise quenching, Radiation dosimetry, Cerenkov counting.

Objectives

1. Students will learn about different types of radiations, how to measure radioactivity.
2. They will learn about the ins used for detecting and measuring ionizing radiations.

4. Autoradiography **(2 L)**

5. Atomic Absorption Spectroscopy **(2 L)**

6. X-Ray diffraction studies **(2 L)**

Objectives

1. Students will learn about the principle, methodology biological application of autoradiography
2. Students will acquire the knowledge of AAS technique, its principle, instrumentation and application in biological field.
3. Students will learn x-ray diffraction concepts and fundamentals, phenomenon of diffraction, Bragg's Law etc.

References::

1. Physical biochemistry by D. Freifelder II edition
2. Biochemical techniques by Wilson and Walker.
3. Biophysical techniques by Upadhyay, Upadhyay and Nath.

CHB4105: Practical Course in Analytical Biochemistry

1. Isolation of Starch and characterization.
2. Isolation of milk casein by IpH 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
8. Estimation of vitamin C
9. Estimation of protein by Biuret
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

References:

1. Practical Biochemistry: Principles and techniques: K. Wilson and J. Walker.
2. Practical Biochemistry by David Plummer
3. Introductory Practical Biochemistry by S.K. Sawhney and R.Singh
4. Practical Biochemistry Sadasivam and Manickam

CHB4106: Practical Course in Enzymology and Biophysical Techniques

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. To asses effect of pH on enzyme activity
5. To asses temperature stability of the enzyme
6. To asses effect of activator on enzyme activity
7. To asses effect of inhibitor on enzyme activity
8. Effect of enzyme immobilization on its activity

Biophysical Techniques

1. 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 / Paper / 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

References::

1. An introduction to practical Biochemistry - David T. Plummer, Tata McGraw Hill Co. Ltd., Bombay
2. Introductory Practical Biochemistry (2001). Ed. S.K. Sawhney and Randhir Singh.
3. Practical Biochemistry Sadasivam and Manickam.
4. Practical Biochemistry, Principles and Techniques (1995). Ed. Keith Wilson and John Walker
5. Practical Biochemistry - David Palmer

CHB4107: Self-Learning Course - I

Modern Approaches in Bioanalysis and Bioassays (1 Credit, 15 L)

1. **Spectrofluorimetry:**
   Analysis of various biomolecules like carbohydrates, proteins, Lipids, Vitamins and Nucleic acids

Objectives:

1. Different spectroscopic methods to analyze biomolecules
2. Sample preparation according to analysis

2. **Biomolecule separation methods:**
   Isoelectric Focusing**,** 2-Dimensional electrophoresis, Microchip electrophoresis, Western, Southern and Northern blotting

Objectives:

1. Principle of the method
2. Applications

3. **Lab Safety Measures:** Chemical, Biological, electrical and mechanical, general laboratory hazards

Objectives:

1. Safe handling of the chemicals
2. Safe handling of the instruments
3. General laboratory safety measures

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AUTONOMOUS COLLEGE

Two Years
M. Sc. Degree Course in Chemistry
(Biochemistry)

SYLLABUS
First Year M. Sc.
[Biochemistry]

Semester - II

[Academic year 2016-2017]

Semester II
CHB4201: METABOLIC PATHWAYS

1. Introduction of Metabolism and Bioenergetics: (2 L)

Anabolism, catabolism, precursors of metabolism and its significance. Basic laws of thermodynamics, standard free energy, enthalpy, entropy, high energy compounds, structure and significance of ATP.

Objectives

1. Overview of Biosynthesis and Biodegradation of molecules and their significance
2. Laws of Thermodynamics and their importance in governing Biochemical pathways
3. High energy compounds and their significance
4. ATP as Energy currency of the cell

2. Carbohydrate metabolism: (12 L)

Glycolysis, Gluconeogenesis, Pentose Phosphate Pathway, feeder pathways of glycolysis, fates of pyruvate under aerobic and anaerobic conditions. TCA/Kreb's cycle, Glyoxylate cycle. Cori's cycle. Pasture effect.

Carbohydrate biosynthesis: Biosynthesis of starch, sucrose, cellulose, Glycogen. Reaction intermediates, enzymes, energetics & regulation of all the pathways.

Inborn errors of carbohydrate metabolism.

Objectives

1. Overview of carbohydrate metabolic pathways
2. Enzymes that catalyse the formation of intermediates
3. Energetic of pathways
4. Rate limiting steps
5. Features of the pathways
6. Regulation of the pathways
7. Defective enzymes and Inborn errors.

3. Lipid Metabolism: (12 L)

Fatty acid catabolism: Beta oxidation of saturated and unsaturated fatty acids, odd and even number fatty acids.

Lipid biosynthesis: Biosynthesis of fatty acids, fatty acid synthase complex, Triacylglycerol, Phospholipids, Ketogenesis, cholesterol biosynthesis.

Reaction intermediates, enzymes, energetic & regulation of all the pathways.

Inborn errors of lipid metabolism

Objectives

1. Overview of Lipid degradation and biosynthesis
2. Enzymes that catalyze the formation of intermediates
3. Features of the pathways
4. Energetics and Regulation of the pathways
5. Defective enzymes and Inborn errors.

4. Biological oxidation: (4 L)

Structure of mitochondria, features of electron carriers, Electron transport chain in mitochondria and oxidative phosphorylation - chemiosmotic hypothesis. ATP synthase complex and its mechanism. Inhibitors and uncouplers of ETC and OP

Objectives

1. Arrangement of electron carriers on mitochondrial membrane.
2. Features of electron transport system, proton gradient, proton motive force
3. Chemiosmotic hypothesis
4. Inhibitors and Uncouplers

1. Amino acid Metabolism: (18 L)

Amino acid degradation: Amino acid oxidation and production of Urea, Significance of Transamination, oxidative deamination, Decarboxylation reactions of amino acids. Degradation of amino acids leading to formation of Pyruvate, Acetyl CoA, α Keto glutarate, Succinyl CoA, Oxalo acetate.

Amino acid biosynthesis: Synthesis of Glutamate, Glutamine, Proline, Arginine, from α keto glutarate. Synthesis of Serine, Glycine, Cystine, from 3 Phospho glutarate .Synthesis of amino acid using oxaloacetate and pyruvate as precursors. Synthesis of Aromatic Amino acids.

Reaction intermediates, enzymes & regulation of all the pathways.

Inborn errors of amino acid metabolism.

Objectives

1. Overview of Amino acid degradation and biosynthesis
2. Enzymes that catalyse the formation of intermediates
3. Features of the pathways
4. Regulation of the pathways
5. Understanding about diseases related to error in amino acid metabolism

2. Specialized Molecule derived from Amino acids: (4 L)

Creatine, Glutathione, Porphyrins, Biological Amines, Nitric oxide. Gamma glutamyl cycle.

Objectives

1. Overview of specialized products derived from amino acids
2. Enzymes that catalyze the formation of intermediates
3. Features of the pathways
4. Significance of specialized products of amino acids

3. Nucleotide metabolism : (8 L)

Degradation of Purines and Pyrimidines.

Denovo and salvage pathways of Purine and Pyrimidine biosynthesis.

Reaction intermediates, enzymes & regulation of pathways

Inborn errors of Nucleotide metabolism

Objectives

1. Overview of Nucleic acid metabolism
2. Enzymes that catalyse the formation of intermediates
3. Features of the pathways
4. Regulation of the pathways

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

CHB4202: MICROBIOLOGY AND FERMENTATION TECHNOLOGY
SECTION I (2 Credits, 30 L)
Microbiology

1. Microscopy: Theory, phase contrast microscopy and fluorescence microscopy**.** **(2 L)**

2. Characterization and classification of microorganisms, cell structure and components **(2 L)**

3. Pure cultures and their characteristics **(2 L)**

4. Cultivation of Bacteria, nutrition, physiology and growth of microbial cells, reproduction and growth, synchronous growth, continuous culture of microorganisms **(4 L)**

5. Mutations and control of microbial growth by physicals and chemicals agents and mutant characterization. **(4 L)**

6. Host microbe interactions, endotoxins, exotoxins, capsular material. Effect of enzyme and other factors. Tissue affinity, resistance and immunity. **(6 L)**

7. Viruses of bacteria, plant and animal cells: Structure, classification and life cycle, mycoplasma and viriods, diseases **(5 L)**

8. Nitrogen fixation: Historical background, nitrogen cycle in nature, symbiotic nitrogen fixation, nitrogenase system, nitrate reductase **(5 L)**

Objectives:

1. To study different types of microscopes and their working principles.
2. Types and characteristics of various microorganisms and their structures.
3. Composition of various media and optimum condition for their growth.
4. Effect of various physical and chemical agents on growth of microorganism
5. Pathogenesis of microorganism and its toxicity
6. Types of plant and animal viruses and their characteristics
7. Role of microorganism in nitrogen metabolism

SECTION II (2 Credits, 30 L)
Fermentation Technology

1. Introduction to fermentation: Fermentation, types, Fermenters, design of fermenters, maintenance of aseptic conditions, aeration and agitation **(6 L)**

Objectives

1. Meaning of fermentation, types.
2. Various types of fermentor and its working

2. Methods and parameters of cultivation of microorganisms, media for industrial fermentation. **(4 L)**

Objectives

1. Types and selection of microorganisms.
2. Media preparation and optimization

3. Characteristics of industrial microorganisms, strain improvement, use of auxotrophic mutants **(4 L)**

Objectives

1. Selection of industrially important microorganisms.
2. What are auxotrophs and their importance

4. Downstream processing, recovery and purification of fermentation products, effluent treatment. **(6 L)**

Objectives

1. Meaning of downstream processing.
2. Different methods (centrifugation, filtration etc.) for purification of products
3. How to treat effluents
4. Applications of fermentation technology, Manufacturing by fermentative process: beer, Citric acid, Glutamic acid, lipase, Penicillin, L-asparginase

5. Fuels from microbes, microbial polymers and microbial steroid bio transformations. (**4 L)**

6. Products from microorganisms – enzymes (Amylases, Proteases, Pectinases), Primary metabolites (Glu, vit B12), Antibiotics (Penicillin), Pigments (Carotenoids), Sweeteners, Beverages (wine, Beer) **(6 L)**

Objectives

1. Applications of fermentation (Pharma and food industries)
2. Applications of microorganisms in various other industries

References::

1. Microbiology, M.S. Pelczar, R.D. Reid, E.C.S. Chan, McGraw Hill, NewYork (1986).
2. General Microbiology (5^{th} 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

CHB4203: BIOSTATISTICS, RESEARCH METHODOLOGY AND BIOINFORMATICS
SECTION I (2 Credits, 30 L)
Biostatistics and Research Methodology

Biostatistics **(22 L)**

1. Principles and practice of statistical methods in biological research, samples and populations, Basic statistics-average, statistics of dispersion, coefficient of variation, confidence limits, Probability distribution, normal, binomial and Poisson distribution

Objectives:

1. Need of Statistics in biochemistry and research
2. Various techniques to handle the biological data and apply statistic on it

2. Mean variants, standard deviations and standard error, correlation and regression, Null hypothesis, use of t-test to validate analytical methods- unpaired, paired, one-sample, two-sample tests with examples, test of statistical significance, student's t-test, f-test, standard error of mean, analysis of variance (ANOVA), latest software (GraphPad, SPSS), introduction of software, exercise on biochemical problems.

Objectives:

1. Need of Statistics in biochemistry and research
2. Various techniques to handle the biological data and apply statistic on it

Research Methodology **(8 L)**

Meaning of Research - Importance and purpose, Ethics and scientific research; guidelines for use of human and animals in research. Formulation of hypothesis; Identification and Formation of research problem, designing a research work.

Objectives:

1. Students will learn different areas of research
2. Importance of scientific journals, its types
3. How to search research paper/articles etc
4. What is meaning of impact factor, h-index etc.
5. Meaning of research hypothesis, designing solutions to research problems and research work etc.

SECTION II (2 Credits, 30 L)
Bioinformatics

1. Bioinformatics: Introduction and definition, History and Scope, Applications of Bioinformatics in various fields. **(2 L)**

Objectives:

1. Need of bioinformatics in biochemistry and research and its scope
2. Various techniques to handle the biological data and apply programming on it

2. Databases: Nucleic acid sequence data bases (NCBI, EMBL, DDBJ), Protein sequence data base-SWISS-PORT, TrEMBL, PIR, Uniprot. Open Access Bibliographic Resources and Literature Databases (PubMed, MEDLINE, PubMed Central PLOS, BMC, Metabolic Pathway databases (KEGG, MetaCyc, EcoCyc). **(5 L)**

Objectives:

1. Use of bioinformatics in proteomics and genomics
2. Handle the data to find out sequencing of biological samples
3. New product in biological reactions
4. How to search the literature

3. Sequence Analysis various file formats for bio-molecular sequences: **(8 L)**

1. GenBank, FASTA, GCG, MSF, BRF-PIR etc. Allignments local, global, pairwise & multiple sequences; anlaysis phylogenetics - CLUSTAL, PHYLIP & UPGAMAS. Gene finding and gene scan.
2. Database Searches: Basic concepts of sequence similarity, identity and homology, definitions of homologues, orthologues, paralogues.
3. Scoring matrices: Basic concept of a scoring matrix, Matrices for nucleic acid and proteins sequences, PAM and BLOSUM series, principles based on which these matrices are derived. Keyword-based Entrez and SRS, Sequence-based: BLAST and FASTA.

Objectives:

1. Biomolecules sequencing programme
2. Survey of Gen bank
3. Phylogenetic tree analysis
4. Principle behind all database
5. Prosite, Pfamo Structure: CATH, SCOP, DSSP, PDB Goodies, Extraction of knowledge from databases on Immunology, Plant, animal &infectious diseases: search new databases & servers using NAR Database & Web server Issue.

4. **Structure Databases:** PDB, NDB, PubChem, Derived Databases Knowledge of the following databases with respect to: basic concept of derived databases, sources of primary data and basic principles of the method for deriving the secondary data, organization of data, contents and formats of database entries, identification of patterns in given sequences and interpretation of the same. **(5 L)**

Objectives:

1. Handling of data of structures of Biomolecules sequencing programme
2. Survey of Gen bank
3. Phylogenetic tree analysis

5. **Protein Prediction & Drug Discovery:** Physical properties, secondary structure, alpha & beta structure, motifs, tertiary structures, specialized structure and function. Molecular visualization - protein conformation and visualization tool (RASMOL). Drug discovery - role of bioinformatics in drug discovery, target discovery, lead discovery, microarray, docking and prediction of drug quality. Bioinformatics companies. **(6L)**

6. **Genomics and Proteomics:** Sequencing genomes – sequence assembly – genomeon the web – annotating and analyzing genome sequences. Proteomics – biochemical pathway databases – submitting sequence to the databases. **(4 L)**

Objectives:

1. Structures and properties of proteins
2. Understanding of drug discovery
3. Learn to find gene and protein sequence in database

References:

1. Fundamentals of Biostatistics by Khan and Khanum
2. Biostatistics-A foundation for Health Science, Daniel WW, John Wiley (1983).
3. Statistical Methods, Medhi J, Willey Eastern Limited, (1992).
4. Bioinformatics Databases, Tools and Algorithms: Orpita Bosu, Simminder Kaur Thukral
5. Bioinformatics Sequence and Genome Analysis: David Mount.
6. Introduction to Bioinformatics, 2001. AH Wood, T.K. Parry Smith DJ, Pearson Education Asia.
7. Bioinformatics: A practical guide to the analysis of genes and proteins – 2001 – AD Baxevanis & BFF Ouellette – Wiley Interscience – New York.
8. Bioinformatics: Methods and Protocols – 2000 – Stephen Misener & Stephen A. Krawetz, Humana Press, New Jersey.
9. Bioinformatics: Sequence, structure and databanks – 2000 – Des Higgins &Willie Taylor – Oxford University Press.

CHB4204: GENETICS
SECTION I (2 Credits, 30 L)

1. **Molecules of Heredity:** **(5 L)**
   Structure of DNA- A, B, C, D and Z forms of DNA, Nucleosome, DNA as genetic material, The central Dogma. Semi conservative mechanism of DNA replication. Features of denaturation and renaturation of DNA, structure and types of RNA.

Objectives

1. Students must learn to describe the primary structure of DNA and RNA: List the three components that make up a nucleotide and describe how nucleotides are joined together via 3',5'- phosphodiester bonds and list which groups are involved in the formation of these bonds.
2. They will learn experiments to prove DNA as genetic material in bacteria and virus.

2. Mutation: (**4 L)**
Types of mutations, causes and detection. germinal vs. somatic mutation. Chromosomal and genetic mutations, Human teratogenesis.

3. Auxotrophs, Prototrophs, Conditional mutants, mutant isolation and selection **(4 L)**

Objectives

1. Students must define genetic mutation, kind of mutations, types of structural changes in chromosomes, changes in chromosome number etc.
2. Classify the mutation according to size and quality, origin, direction etc.
3. Identify the type of mutation that is inherited.
4. Define teratogenesis and its know its causes.
5. Know types of mutants

4. Sex factors and Plasmids: Types of plasmids, Fertility factor, Hfr, Types of Cloning vectors: Plasmids, Phages, Cosmids **(4 L)**

Objectives:

1. Students will understand the types and importance of plasmids
2. Describe main features of F plasmid
3. Describe what Hfr strains are
4. Structure and function of phage and cosmids

5. Basis of Biochemical genetics: **(6 L)**
Evolution of gene concept - Definition of factors, alleles, multiple alleles, pseudoalleles, Beadle and Tatum's One gene one enzyme concept, One gene one polypeptide concept, Complementation test, Cistron, Recon and Muton, E.g. rII locus in T4 phage

Objectives:

1. Students will understand the history of gene and concepts of genes and experiments.
2. Characters of multiple alleles e.g. Human Blood Group
3. Understand what a test of complementation is and why it is performed.
4. Student will understand how can a complementation test allow you to determine if two mutations are located in the same gene

6. Microbial genetics: **(6 L)**
Methods of genetic transfers - transformation, and conjugation in bacteria. Life cycle of bacteriophages, lytic and lysogeny, transduction types: specialized, generalized. Mapping genes by interrupted mating technique.

Objectives:

1. Students will understand the role of recipient and donor cells and describe the natural competence and chemically induced competence in cells
2. Identify the roles of the proteins involved in DNA transformation
3. Students will learn the stages of conjugation and the role of the proteins. Describe the features of bacterial plasmids.
4. Explain the difference between conjugative, mobile and non mobile plasmids
5. Predict the outcomes of simple examples of conjugation experiments
6. Students will know the difference between lytic and lysogenic viruses of Bacteria
7. Explain how bacterial DNA is transferred from donor to recipient in transduction by a lysogenic phage.

SECTION II (2 Credits, 30 L)

1. Laws of Heredity: (7 L)

Genotype, Phenotypes, Mendelian principles - History, Laws with examples, Types of cross. Extensions of Mendelian principles: Codominance, Incomplete dominance, Multiple alleles, Epistatis

Objectives

1. Students will learn Mendel's law of inheritance.
2. Contrast dominant alleles with recessive alleles.
3. Define genotype and phenotype.
4. Describe how a Punnett square can be used to predict the results of a genetic cross.

2. Extranuclear inheritance **(3 L)**

Objectives:

1. Students will learn extranuclear inheritance in eukaryotes: maternal inheritance, extranuclear inheritance by cellular organelles: e.g chloroplast inheritance, mitochondria inheritance

3. Review of classical genetics: (7 L)

Work on Drosophila Melanogaster, Neurospora Crassa etc. Animal models in the study of Genetics, Linkage, Crossing over, Chromosomal sex determination.

Objectives

1. Students will be introduced about the models used in genetic study.
2. Students will understand about kinds of linkage, linkage groups and significance.
3. They will learn about characteristics of crossing over, its types and significance.
4. Types of sex chromosomes, chromosomal mechanism of sex determination

4. Human genetics: (5 L)

Pedigree analysis, lod score, Specialized genetic systems of fungi: Tetrad analysis

Objectives

1. Students will learn to determine the type of Mendelian inheritance from a pedigree (autosomal, X-linked, dominant, recessive);
2. Describe features of patterns of inheritance seen in pedigrees
3. Identify the recurrence risk for individuals in pedigrees.
4. Describe Tetrad Types produced by meiosis

5. Genetic Code: Biochemical and genetic analysis of the genetic code**.** **(2 L)**

Objectives

1. Students will learn what is genetic code, its relevance, basis of genetic code and its properties
2. Deciphering the code, invitro codon assignment and its discovery.
3. Characteristics of code

6. Concept of Operon: **(4 L)**

Introduction, Examples of Lac operon with regulations, Trptophan operon

Objectives

1. Students will learn what is difference between prokaryotic and eukaryotic mRNA
2. Definition of Operon, Lac operon structure and working: behaviors in presence /absence of glucose and lactose
3. Positive and negative regulation of lac operon.
4. Tryptophan operon, structure and how trp operon is regulated, importance of secondary structure in its regulation

7. Transposons in Prokaryotes and Eukaryotes **(2 L)**

Objectives

1. Define the term "transposable element".
2. Mode of discovery of transposable elements, its characteristics
3. Types of transposable elements, examples of transposons

References:

1. Genetics by Monoroe W. Strickberger, 1990 (3rd Ed.) Macmillan Pub
2. Biochemistry-G Zubay, Addison Wesley, 1983
3. Biochemistry, L Stryer, 3rd/4th/5th ed, 1989, Freeman and Co. NY
4. Principles of Biochemistry - Lehninger
5. The Genetics of Bacterial viruses - William Hayes, PBS Publ. (1984).
6. Molecular Biology of the Gene - Watson Benjamin / Cummings Publ. Company (1987).
7. Introduction to Genetics: A Molecular Approach; T A Brown, Garland Science (2011).
8. Human Molecular Genetics; Peter Sudbery, (2002) Printice Hall
9. The Cell; Geoffery Cooper and Robert E; 5 Ed (Hausman Sinauer Associates 2009)

CHB4205: Practical Course in Microbiology and Immunology
Microbial Techniques

1. Media preparation, pour plate, spread plate and streak plate techniques
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 for the quality of milk
6. Methylene blue reduction test (MBRT) for quality of milk
7. Growth curve of *E. coli*
8. Total viable count determination (pours plate and spread plate).
9. Ultraviolet irradiation and survival curve
10. Immobilization of yeast cells
11. Microbial assay of vitamin and antibiotic

(1) Immunology

1. Immuno-electrophoresis - Rocket
2. Immuno diffusion techniques - Ocuterlony, radial
3. Agglutination & Precipitation

CHB4206: Practical Course in Bioinformatics, Computer Skills and Statistical Analysis

1. Study of Internet resources in Bioinformatics. e.g. NCBI, CGEB, EMBL.
2. Searches on MEDLINE, PubMed and CDROM bibliographic databases. Concept of boolean operators in searching
3. Introduction to sequence data bases. Protein sequence databank, NBRF-PIR, SWISSPROT, EMBL.Nucleic acid sequence databank – Gene bank, EMBL
4. Pair wise alignment- Needleman - Wunsch and Smith - Waterman algorithms
5. Multiple alignment- CLUSTALW & PRINTS
6. BLAST, FASTA programs for sequence database search
7. Genome data bank - study the features of human genome
8. Evaluation of protein structure by Swiss PDB viewer and by other molecular visualization tools
9. Calculation of phi - psi angles - Ramachandran plot
10. Homology modeling of a given protein sequence
11. Statistical analysis: Selection of data, R-square, SD & average, Annova
12. Use of Microsoft Word, Excel & Power point

References:

1. Fundamentals of Biostatistics by Khan and Khanum
2. Biostatistics - A foundation for Health Science, Daniel WW, John Wiley (1983).
3. Statistical Methods, Medhi J, Willey Eastern Limited, (1992).
4. Bioinformatics Databases, Tools and Algorithms: Orpita Bosu, Simminder Kaur Thukral
5. Bioinformatics Sequence and Genome Analysis: David Mount.
6. Introduction to bioinformatics, 2001. AH Wood, T. K. Parry Smith DJ, Pearson Education Asia.
7. Bioinformatics: A practical guide to the analysis of genes and proteins – 2001– AD Baxevanis & BFF Ouellette – Wiley Interscience – New York.
8. Bioinformatics: Methods and Protocols – 2000 – Stephen Misener & Stephen A. Krawetz, Humana Press, New Jersey.
9. Bioinformatics: Sequence, structure and databanks – 2000 – Des Higgins & Willie Taylor - Oxford University Press.

CHB4207: SELF-LEARNING COURSE - II
Introduction on Quality Control Laboratory (QC/ GLP) (1 Credit, 15 L)

1. Quality: Introduction
2. Quality Management
3. Documentation: SOPs, reports, forms and formats
3. Quality Assurance
4. Quality Control
5. Good Lab practice (GLP)

Objectives

1. Students will learn about Quality, how to maintain and manage the quality of a product.
2. They will understand how to work in a quality control lab and maintain documents and reports.
3. Students will know about the requirements and expectations of the international auditors in terms of QA and GLP from the R&D set-ups.