ST. PHILOMENA'S COLLEGE (Autonomous), MYSURU-570 015

Subject: BIOCHEMISTRY
REVISED SYLLABUS FOR B.Sc., UNDER SEMESTER SCHEME
From The Academic Year2016-17 Onwards

The Scheme of Teaching & Examination

Semester	Title of the Paper	Code No	Teaching Hours / Week			Examination			
			Theory	Practical	Credits	Duration	Theory/ Practical Max. Marks	I A Max Marks	Total
I	Paper-I Principles of Biochemistry	16MA 210	3	-	3	3	60	10	100
	Practical Paper-I Principles of Biochemistry	16MA212	-	3	1.5	3	20	10	
II	Paper-II Bio-molecules-I	16MB210	3	-	3	3	60	10	100
	Practical Paper-II Bio-molecules-I	16MB212	-	3	1.5	3	20	10	
III	Paper-III Biomolecules-II & Biochemical techniques	16MC210	3	-	3	3	60	10	100
	Practical Paper-III Biomolecules-II &Biochemical techniques	16MC212	-	3	1.5	3	20	10	
IV	Paper-IV Enzymology & Metabolism-I	16MD210	3	-	3	3	60	10	100
	Practical Paper-IV Colorimetric Estimations	16MD212	-	3	1.5	3	20	10	
V	Paper-V Metabolism II & Human Physiology	16ME210	3	-	3	3	80	20	300
	Practical Paper-V Enzyme Assays	16ME214	-	2	1	3	40	10	
	Paper-VI Molecular Biology & Genetic Engineering	16ME212	3	-	3	3	80	20	
	Practical Paper-VI Biophysical and Biochemical Experiments	16ME216	-	2	1	3	40	10	
VI	Paper-VII Nutrition	16MF210	3	-	3	3	80	20	300
	Practical Paper-VII Nutrition	16MF 214	-	2	1	3	40	10	
	Paper-VIII Clinical Biochemistry and Immunology	16MF212	3	-	3	3	80	20	
	Practical Paper-VIII Clinical Biochemistry and Immunology	16MF 216	-	2	1	3	40	10	
					22		800	200	1000

FIRST SEMESTER
BIOCHEMISTRY PAPER-I
Title: PRINCIPLES OF BIOCHEMISTRY
CLASS DURATION – 03 HOURS PER WEEK48 Hours
Marks-Theory - 60 + Internal Assessment -10= 70

SUBJECT DESCRIPTION: Bio-organic chemistryemphasizesoncombined aspect of studying biological processes using chemical methods. Bio-inorganic chemistry emphasizes on the properties, biological role and importance of inorganic elements in biological systems. Biophysical chemistry combines the aspects of chemistry, biology and physics.

GOAL: To enable the students to learn the basic concept of bio organic, bio-inorganic and bio-physical chemistry.

OBJECTIVE: On successful completion of the course the students should have the basic knowledge about the basic concepts of Bio-organic, Bio-inorganic and Bio-physical chemistry and their application in various fields.

PART-A

BIO-ORGANIC

1. **Concept of Biochemistry:**
   Definition and scope of biochemistry. Important discoveries in biochemistry. An outline of elements and major organic compounds in living system. **2hrs**

2. **Hydroxy acids and dicarboxylic acids:**
   Structure, properties & biological importance of
   a) Hydroxy acids: Lactic acid (Action of heat, oxidation), tartaric acid, citric acid (Action of heat, salt formation) &isocitric acid.
   b) Dicarboxylic acid: Succinic acid, maleic acid &fumaric acid. **4hrs**
   c) Ketoacids: - Pyruvic acid, α - ketoglutaric acid &oxaloacetic acid.

3. **Heterocyclic compounds:** **4hrs**
   Occurrence, structural formula and biological importance of the following and their derivatives -Furan, pyrrole, thiophene, pyridine, pyran, thiazole, pyrimidine, purine, indole, imidazole, quinoline and isoquinoline.

4. **Steroids:** **4 hrs.**
   Basic ring system in steroids, structure & biological importance of cholesterol, ergosterol, estrediol, testosterone, progesterone, cortisol, cortisone. Biological importance of bile acids [mono, di &tricholic acids] and ecdysone.

5. **Phytochemicals:**
   a) **Terpenes:**Isoprene rule, classification, structure, occurrence and importance of: **4 hrs.**
      1. Monoterpenes-limonene and importance of menthol and camphor.
      2. Sesquiterpenes- Juvenile hormone-I and importance of abscisin-II,
      3. Diterpenes-phytol,
      4. Triterpenes- lanosterol,
      5. Tetraterpenes-lycopene,
      6. Polyprenols- importance of dolichol.

   b) **Flavanoids**:Quercetin, capsaicin &curcumin: occurrence & biological importance. **2 hrs.**

c) **Alkaloids:**Definition, classification based on their composition with examples, structure & the physiological action of LSD, morphine, caffeine, nicotine. Biological importance of reserpine, piperine, quinine, cocaine, theobromine and atropine. Synthesis of nicotine and atropine. **4 hrs.**

PART-B

BIO-PHYSICAL

1. **Concentration units:**Mole, mole fraction, molarity, equivalent weight, normality, molality (problems to be worked out), dilution factors. **1 hr.**
2. **Water:**Essentiality to life. Water as a biological fluid. Special properties of water. Hypo, hyper and isotonic solutions. Effects of osmotic pressure on living cells. **2 hrs.**
3. **Acids, bases and buffers:**Lewis concept of acids & bases. Ionic product of water. pH scale, buffers, Henderson-Hasselbalch equation, buffer capacity, preparation of acidic and basic buffer solutions. Theory of acid-base indicators, choice of indicators **3 hrs.**
4. **Electrochemistry:**Electrodes (Hydrogen Electrode & calomel electrode), Quinhydrone electrode, Glass electrode. Conductometric titrations [Strong acid against strong base, weak acid (amino acid) against NaOH]. Determination of pKa values of weak Electrodes (Hydrogen electrode & calomel electrode), quinhydrone electrode, glass electrode. Conductometric titrations [Strong acid against strong base, weak acid (amino acid) against NaOH]. Determination of pKa values of weak acid by potentiometric titration. **3 hrs.**
5. **Photochemistry:**Laws of photochemistry, quantum efficiency, light absorption, Beer-Lambert's law. Spectrophotometer, colorimeter-principle and applications, Fluorescence, phosphorescence, chemiluminescence, bioluminescence (Elementary treatment). **3 hrs.**

PART-C

BIO-INORGANIC

1. **Phosphorous, Sulphur and Selenium:**Importance of phosphorus &sulphur compounds in the biological system, effect of sulphur compounds on environmental pollution, role of selenium in biological system. **2 hrs.**
2. **Biochemical Toxicology:**Toxicity of lead, mercury, cadmium, flouride and arsenic-source, entry into biological system and toxic effects. Toxicity studies: LD_{50}& ED_{50} **3 hrs.**
3. **Porphyrins:**Porphyrin nucleus – structure. Structure and the biological role of metal ions in important metalloporphyrins-Hb, cytochromes, chlorophyll & vit-B_{12}. **3 hrs.**
4. **Radiation chemistry:**Introduction, Natural and artificial radioactivity. Characteristics of radioactive elements, units of radioactivity, disintegration constant, half-life, detection of radioactivity by scintillation counter and advantages. Uses of radioisotopes in biological system – ^{3}H, ^{14}C, ^{131}I, ^{60}CO and ^{32}P. Biological effects of radiations. Radiation hazards. Safety measurements in handling radio isotopes. **4 hrs.**

Reference Books:

1. Text book of Inorganic Chemistry by J.D Lee
2. Text book of Inorganic Chemistry by Puri& Sharma
3. Text book of Physical Chemistry. By Puri& Sharma
4. Text book of Physical Chemistry by S.Glasstone
5. Text book of Physical Biochemistry-David Friefelder
6. Text book of Organic Chemistry by Puri& Sharma

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PRACTICAL-I

Title: PRINCIPLES OF BIOCHEMISTRY

Practical Duration -03 Hours per week Examination-03 Hours

MARKS=30.

Practical Proper-20 marks. Internal Assessment - Record-05+ Class Test-05=10 marks

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Note: Analytical / electronic balance for weighing can be used.

1. Calculation and preparation of molar solutions.
2. Calculation and preparation of normal solutions.
3. Calibration of volumetric glassware (Burette and Pipette).
4. Preparation of standard Oxalic acid solution. Standardization of NaOH solution and estimation of H_2SO_4 in the given solution. (Phenolphthalein).
5. Preparation of standard Sodium carbonate solution, standardization of HCI (Methyl orange) and estimation of NaOH in the given solution (methyl orange or phenolphthalein).
6. Preparation of $ZnSO_4$ solution. Standardization of EDTA solution and estimation of total hardness of water using Eriochrome black- T indicator.
7. Preparation of standard oxalic acid solution. Standardization of NaOH solution and estimation of acidity in vinegar.
8. Preparation of standard potassium biphthalate solution, standardization of NaOH solution and estimation of free and total acidity in gastric juice.
9. Preparation of standard Potassium dichromate and estimation of ferrous/ferric mixture using diphenylamine indicator (Demonstration).
10. Preparation of standard Oxalic acid solution. Standardization of $KMnO_4$ solution and estimation of calcium in milk.
11. Preparation of standard potassium biphthalate solution, standardization of sodium hydroxide solution and estimation of hydrochloric acid present in the given solution.
12. Preparation of standard potassium biphthalate solution, standardization of sodium hydroxide solution and estimation of alkalinity of antacids.

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SECOND SEMESTER
Biochemistry Paper-II
Title: BIOMOLECULES -I
CLASS DURATION – 03 HOURS PER WEEK48 Hours
MARKS-Theory - 60 + Internal Assessment -10= 70

SUBJECT DESCRIPTION: This course involves the study of bio-molecules their structure, properties and biological importance.

GOAL: To enable the students to learn the basic concept in biomolecules.

OBJECTIVES: On successful completion of the course the students should have the basic knowledge about biomolecules, their classification, structure and brief knowledge on qualitative analysis of bio-molecules.

PART A

CARBOHYDRATES

1. **Carbohydrates:**Classification, biological importance **8 hrs.**
   Monosaccharides:Configuration relationship of D-aldoses, D-ketoses. Reactions of glucose and fructose- oxidation, reduction, reducing properties, formation of glycosides, acylation, methylation, condensation - phenyl hydrazine, addition – HCN. Interconversion of aldoses and ketoses by chemical method. Ascending and descending the series by chemical methods. Stereochemistry of monosaccharides, (+) and (-), D and L, epimers, anomers, enantiomers and diastereomers.
   Glucose: Elucidation of open chain structure, configuration and ring structure of glucose and mutarotation. Open and Haworth structures of galactose, mannose, ribose and fructose. Structure and biological importance of amino sugars, deoxy sugars, sugar acids, neuraminic and muramic acid. **8 hrs.**
   Disaccharides: Establishment of structures of sucrose and lactose. Structure of isomaltose, cellobiose, trehalose and maltose and importance of trehalose.
   Polysaccharides: Classification with examples. Partial structure, occurrence and importance of starch, glycogen, inulin, cellulose, chitin, and pectin.
   Glycosaminoglycans: Occurrence, importance and the structure of the repeating units of heparin, hyaluronic acid, and chondroitin sulphate. Bacterial cell wall polysaccharides- Teichoic acid and peptidoglycans, Blood group oligosaccharides.
   Chemical basis of the qualitative tests: Molisch, iodine, Benedicts, Fehling's, picric acid, Barfoed's, Bial's, Seliwanoff's, osazone tests. **8 hrs.**

PART-B

LIPIDS

1 **Lipids:**Definition, classification and biological role,
   Fatty acids: Saturated [C4-C24] and unsaturated fatty acids: Nomenclature, structure & occurrence. Physical properties and chemical reactions: esterification and rancidity. **8 hrs.**
   Essential fatty acids: (ω-3 & ω-6 fatty acids): structure, occurrence & biological importance

Tri-acylglycerols: simple and mixed glycerides with examples, Saponification, hydrolysis,Definition & significance of saponification value, iodine value, acid value and per-oxide value. **8 hrs.**

Waxes: Composition, importance with examples

Phosphoglycerides: Structure of lecithin, cephalins, phosphotidyl inositol, plasmalogens, and cardiolipins. biological role of phosphoglycerides.

Sphingolipids : Ceramides, structure and importance of sphingomyelin.

Glycosphingolipids : Structure and importance of cerebrosides (galactocerebroside and glucocerebroside), gangliosides (GM_1, GM_2, GM_3).

Eicosanoids: Structure of PGE_1, PGE_2, $PGF_{1\alpha}$ and $PGF_{2\alpha}$. Biological roles of thromboxanes, leukotrienes and prostaglandins. **8 hrs.**

Plasma lipoproteins: Types and functions, composition and structure of lipoprotein.

Biological Membrane: Amphipathic lipids, membrane bilayers, micelles, liposomes and its uses.

Fluid Mosaic model – structure, composition & functions of the plasma membrane.

Reference Books:

1. Text book of Biochemistry-West & Todd
2. Text book of Biochemistry-A. Lehninger
3. Chemistry of natural products-Chatwal
4. Text book of Biochemistry-O.P. Agarwal
5. Text book of Biochemistry-Jain
6. Hand book of Biochemistry-Sathynarayana
7. Illustrated biochemistry- Harper

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PRACTICAL-II
Bio-Molecules-I
Practical Duration -03 Hours per week Examination-03 Hours
MARKS=30.
Practical Proper-20 marks Internal Assessment - Record-05+ Class Test-05=10 marks

1. Qualitative analysis of monosaccharides(glucose, fructose).
2. Qualitative analysis of disaccharides & polysaccharides (lactose, maltose, sucrose & starch).
3. Acid hydrolysis of starch.
4. Determination of acid value of oil or fat.
5. Determination of saponification value of oil or fat.
6. Determination of iodine value of oil or fat.
7. Determination of per-oxide value of oil or fat.
8. Extraction and confirmation of caffeine from tea leaves.
9. Extraction and estimation of lactose from milk.
10. Extraction of starch from potatoes.
11. Demonstration of extraction of Lycopene from Biological source.
12. Demonstration of extraction of oil from oil seeds.

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THIRD SEMESTER
Biochemistry Paper-III
Title: BIOMOLECULES-II AND BIO-CHEMICAL TECHNIQUES
CLASS DURATION – 03 HOURS PER WEEK 48 Hours
MARKS-Theory - 60 + Internal Assessment -10= 70

SUBJECT DESCRIPTION: This course emphasizes on various bio-molecules and significance, principles, instrumentation, working and application of the instruments commonly used in the laboratories.

GOALS: To enable the students to learn the basic functions, structures and biological importance of lifeless chemical compounds along with functioning components of the various instruments.

OBJECTIVES: On successful completion of the course the students should have understood the significance of the complex bio-molecules, polysaccharides, lipids, proteins, nucleic acids, vitamins and minerals and also would have learnt the principles and applications of the instruments.

1. **Amino acids & Peptides:** **8 hrs.**

Structure and classification of amino acids based on polarity. D and L notation, zwitterionic properties, pKa values, Reactions of the amino groups with HNO_2, $LiAlH_4$, phenylisothiocyante, dansyl chloride, 1-fluro 2,4-dinitro benzene. Reaction of carboxyl group with hydrazine. Any one method (Gabriel's) of chemical synthesis of amino acids.

Peptide bond-formation and characteristics. Structure and biological importance of glutathione. Biological importance of valinomycin, leu-enkephalin and endorphins, Chemical synthesis of di-peptides by carbobenzoxy method.

2. **Proteins:** **8 hrs.**

Classification of proteins based on solubility, structure and functions with examples.

Color reactions of proteins- Biuret, xanthoproteic, Millon's, Hopkins-Cole, Sakaguchi and lead acetate tests.

Structural organization of proteins:

Primary Structure of proteins, steps involved in protein sequencing, amino acid composition, methods of determining N and C-terminal amino acids, sequencing by Edman's degradation method.

Secondary Structure - α-Helix. β-sheets, β -bends.

Tertiary structure: forces stabilizing the structure, structure of myoglobin.

Quaternary structure: 3D structure of hemoglobin.

Denaturation and renaturation of proteins, Anfinsen's experiment.

3. **Nucleic acids:** **8 hrs.**

a) Isolation of DNA and RNA from plant and animal sources. Structure of purines and pyrimidines; nucleosides and nucleotides. Biological importance of nucleotides that are not found in nucleic acids.
b) DNA: Chargaff's rule. Watson and Crick model of DNA. A, B and Z forms. Melting of DNA (Tm).
c) RNA: Composition, types (mRNA, tRNA and rRNA), secondary structures of

tRNA - clover leaf model.
Chemical reactions of RNA and DNA with acid and alkali, colour reactions of DNA and RNA.

PART-B
BIO-CHEMICAL TECHNIQUES

1. **Isolation of proteins**: methods of purification – dialysis, salting in & salting out, pH precipitation and solvent precipitation. Criteria of purity of proteins. **2 hrs.**
2. **Chromatography:** Principles, procedures and applications of **12 hrs.**
    1) Paper chromatography- Ascending, descending, circular and 2D chromatography.
    2) Column chromatography-Adsorption, gel-filtration, ion-exchange and affinity chromatography, HPLC and GLC
    3) Thin layer chromatography.
3. **Electrophoresis** **4 hrs.**
Principles, procedures and applications of
Electrophoresis - Paper and gel electrophoresis (agarose, SDS – PAGE).
4. **Centrifugation:** **4 hrs.**
Principle and procedure of differential and density gradient centrifugation. Ultra centrifuge- construction and applications.
5. **Spectroscopy:** **2 hrs.**
Principles & applications of UV-visible, IR, fluorescence, NMR and CD spectra

Reference Books:

1. Text book of Biochemistry-West & Todd
2. Text book of Biochemistry-A. Lehninger
3. Text book of Biochemistry-O.P. Agarwal
4. Text book of Biochemistry-Jain
5. Hand book of Biochemistry-Sathynarayana
6. Illustrated biochemistry- Harper
7. A Guide to principles and techniques of practical biochemistry – K.Wilson & K.Goulding
8. Principles and techniques of practical biochemistry - Bryan L.Williams and Keith Wilson
9. Text book of Practical Biochemistry –Shawney

PRACTICAL-III

Biomolecules –II & Biochemical Techniques

Practical Duration -03 Hours per week Examination-03 Hours

MARKS=30.

Practical Proper-20 marks Internal Assessment - Record-05+ Class Test-05=10 marks

PART – A

PROTEINS

- Precipitation reactions of proteins (albumin).
- Color reactions of proteins (albumin, casein, gelatin).
- Qualitative analysis of amino acids (arginine, tryptophan, tyrosine, cysteine & phenylalanine).
- Extraction of casein from milk.
- Determination of the activity of urease from horse gram.
- Demonstration of the activity of phosphatase from potatoes.

PART-B

BIOCHEMICAL TECHNIQUES

- Identification of amino acid by circular paper chromatography.
- Ascending paper chromatography of amino acids.
- Separation of plant pigments by column chromatography using silica Gel-G.
- Demonstration on polyacrylamide gel electrophoresis [PAGE] of proteins.
- Demonstration of separation of lipids by TLC.
- Demonstration of two dimensional chromatography of amino acids.

FOURTH SEMESTER
Biochemistry Paper-IV
Title: ENZYMOLOGY & METABOLISM-I
CLASS DURATION – 03 HOURS PER WEEK 48 Hours
MARKS-Theory - 60 + Internal Assessment -10= 70

SUBJECT DESCRIPTION: Enzymes are protein catalyst that regulates the rates at which physiological process takes place. Consequently, defects in enzyme function frequently cause diseases. Hence, sound knowledge about enzymes is essential for life science students.

GOALS: To enable the students to learn about the different types of enzymes and its isolation and purification which will pave the ways in which the students can enter in research field. And also to learn about the basic functions, principles and concepts of metabolism.

OBJECTIVES: On successful completion of the course the students will acquire knowledge about Techniques of isolation & purification of the enzyme and Provides much information related to carbohydrate and fat metabolism that takes place in our body.

Part-A

ENZYMOLOGY

1. **Enzymes:** **6 hrs.**

General characteristics, definition with examples of holoenzyme, apoenzyme, co-factors coenzymes, metallo enzymes, abzymes and RNA as enzyme. Isolation and purification of enzymes.
Classification of enzymes based on IUB with examples, units of enzyme activity, Specific activity, enzyme specificity, concept of active site.
Theories of enzyme catalysis: Lock and key model, Koshland's induced fit theory.
Mechanism of enzyme action: General acid base catalysis, covalent catalysis.

2. **Enzyme kinetics:** **4 hrs.**

Factors affecting rate of enzyme catalyzed reactions**.** Effect of substrate concentration, pH, temperature. Michaelis - Menten equation (derivation not required). Lineweaver- Burk (L-B) plot. Determination of Km &Vmax from L-B plot and their significance. Turn over number.
Enzyme inhibition:
Competitive, non- competitive and uncompetitive inhibition with suitable examples Graphical representation by L-B plot, Effect of inhibitor on Km &Vmax using LB **4 hrs.**
plot. Irreversible inhibition-suicide inhibition.
Allosteric enzymes –Characteristics with ATCase as example.
Iso enzymes – Properties –LDH as an example.
Multienzyme complex - Pyruvate dehydrogenase complex,
Multi-functional enzymes - Definition, characteristics with an example. **4 hrs.**
Applications of enzymes: Industrial & medical applications.

Part-B
METABOLISM – I

1. **Bioenergetics:** **2 hrs.**

Concept of free energy. Endergonic and exergonic reactions. Coupled reactions.
High energy compounds – Structure of ATP and its free energy change during hydrolysis, examples of other high energy compounds.

2. **Biological oxidation:** **3 hrs.**

Electron transport chain: electron transport complexes (Complex I, II, III and IV).
Oxidative & substrate level phosphorylation with examples, uncouplers and inhibitors of respiration: Rotenone, antimycin-A, cyanide and 2,4 DNP, P/O ratio. Formation of ATP (Outlines of Mitchell's hypothesis) binding change mechanism (Boyer model).
Photophosphorylation,

3. **Metabolism:** **1 hr.**

Anabolism and catabolism, compartmentalization of metabolic pathways.

4. **Metabolism of Carbohydrates:** **4 hrs.**

Reactions and energetics of glycolysis, fermentation, entry of fructose, galactose, mannose and lactose into glycolytic pathway. Fates of pyruvate - conversion of pyruvate to lactate, alcohol and acetylCoA. Reactions and energetics of TCA cycle. Cori cycle.

Gluconeogenesis. Regulatory steps of glycolysis and TCA cycle, futile cycle**.** **4 hrs**.
Amphibolic and integrating roles of TCA cycle. Anaplerotic reactions.
Pentose phosphate pathway and its significance. **4 hrs.**
Glycogen metabolism: Glycogenolysis, glycogenesis & regulation. Synthesis of starch and lactose.
Regulation of blood glucose.

5. **Metabolism of Lipids:** **6 hrs.**

Outlines ofα, β & ω modes of oxidation.
Beta oxidation of even number saturated fatty acid and carnitine shuttle.
Energetics of β-oxidation.
Biosynthesis of even number saturated fatty acids.
Metabolism of ketone bodies- formation, utilization and ketosis.

6. **Cholesterol Metabolism**: **6 hrs.**

Biosynthesis and degradation of cholesterol. Production of primary and secondary bile acids, bile salts and its importance. Regulation of cholesterol biosynthesis.
Outline of the metabolism of lipoproteins: Chylomicrons, VLDL, LDL & HDL
Reverse transport of cholesterol.

Reference Books:

1. Principles of Biochemistry by Lehninger

2. Harper's Biochemistry by Murray, K. Robert.

3. Text book of Biochemistry by Voet and Voet.

4. Text book of Biochemistry by Garrett and Grisham

5. Essentials of Biochemistry by Sathyanarayan.

6. Text book of Biochemistry by Strayer.

7. Text book of Biochemistry by Baldwin Review of Physiological chemistry by Harper.

8. Text book of Biochemistry by Suttie.

9. Outline of biochemistry by Conn &Stumpf.

10. Trevor Palmer, 3rd edition, 1991. Understanding enzymes. Ellis-Horwood Limited.

11. Enzymes – Dixon and Webb. Publisher Academic Press, 1964. Digitized 22nd Jan 2010.

12. Enzyme Technology – Chaplin &Bucke. Publisher Cambridge University Press, 1990.

13. Alan Welshman, 2nd edition, Handbook of enzyme biotechnology.

PRACTICAL-IV
Colorimetric estimation
Practical Duration -03 Hours per week Examination-03 Hours
MARKS=30.
Practical Proper- 20 marks Internal Assessment - Record-05+ Class Test-05=10 marks

Colorimetric estimation of

1.Glucose by DNS method

2.Protein by Biuret method.

3.Protein by Lowry's method.

4.Keto acid by DNPH method.

5.Urea by DAMO method.

6.Creatinine by Jaffe's method.

7.Inorganic Phosphorous by Fiske and Subbrao/Ascorbic molybdate method.

8.Iron by Wong's method.

9.Cholesterol by Zak’s method.

10. Glucose by Folin-Wu's method.

11. Glucose by anthrone method.

12. Aminoacid by ninhydrin method.

FIFTH SEMESTER
Biochemistry Paper-V
Title: METABOLISM–II AND HUMAN PHYSIOLOGY
CLASS DURATION – 03 HOURS PER WEEK 48 Hours
MARKS-Theory - 80 + Internal Assessment -20= 100

SUBJECT DESCRIPTION:This course emphasizes the students to understand the metabolism of amino acids, proteins and nucleic acids and also to study of the functioning of the normal body, and is responsible for describing how various systems of the human body work.

GOALS: This course Provides knowledge base and understanding of the physiological processes underlying health and disease in the major organ systems of the body, i.e., cardiovascular, respiratory, renal, gastrointestinaland endocrine systems.

OBJECTIVES:This course would have made the student's ability to explain physiological processes in detail and understanding of the metabolic fates of amino acids, proteins and nucleic acids.

PART- A

METABOLISM –II

1. **Metabolismof Amino acids:** **6 hrs.**
   General mechanism of amino acid metabolism: Deamination-oxidative and non – oxidative deamination, transamination, decarboxylation (biologically important amines) and desulphuration. Catabolism of carbon skeleton of amino acids, glycogenic and ketogenic amino acids. Urea cycle and its significance. Synthesis and catabolism of alanine, phenylalanine and cysteine.
2. **Metabolism of peptides and porphyrins** **8 hrs.**
   Biosynthesis of creatine, polyamines and glutathione
   Heme –synthesis and degradation.
3. **Metabolism of proteins:**
   Protein turnover, structural features influencing the protein degradation: PEST sequence,N-end rule. ATP dependent and ATP independent mechanism of protein degradation, synthesis of glycoproteins: N-linked and O-linked glycoproteins.
4. **Metabolism of Nucleic acids:** **10 hrs.**
   Pathways of degradation of nucleic acids in cells, action of nucleases-DNase I and II, RNase and phosphodiesterases. Catabolism of purines and pyrimidines, uric acid formation and inhibition, salvage pathways. De novo biosynthetic pathways of purine and pyrimidine nucleotides. Conversion of ribonucleotides to deoxy ribonucleotides.
   Inhibitors of nucleotide biosynthesis-methotrexate, and 5-fluorouracil.

PART –B
HUMAN PHYSIOLOGY

1. **Nervous system:** **4 hrs.**
   Neurons -Types, generalized structure of multipolar neuron. Neuromuscular junction. Resting membrane potential, action potential, transmission of nerve impulse along an axon and across the synapse. Neurotransmitters-Excitory and

Inhibitory with examples. Inhibitors of neuro transmission and their importance.

2. **Muscle:** **3 hrs.**
Types of muscles and their structure. Ultrastructure of skeletal muscle. Contractile and regulatory proteins of skeletal muscle. Sliding filament model of skeletal muscle contraction.

3. **Bone:** **3 hrs.**
Composition and structure of long bone (internal and external structure), growth (mechanism of growth) and remodeling of long bone. Factors affecting growth.

4. **Renal system:** **2 hrs.**
Structure of the nephron, formation of urine - Glomerular filtration, tubular reabsorption (sodium, urea, water and glucose) and secretions.

5. **Endocrine system:** **10 hrs.**
Endocrine organs, classification of hormones. Hierarchy, interplay and dynamic balance and regulation of hormone secretions. Functions of the hormones of hypothalamus, pituitary (GH, ACTH, TSH, FSH, LH, oxytocin and ADH) adrenal (aldosterone, cortisol & cortisone), thyroid (T_3 & T_4), pancreas (insulin and glucagon) and gonads (testosterone, estradiol and progesterone).
General mechanism of peptide and steroid hormone action. Concept of second messengers. Eg: cAMP, DAG and IP_3.
Endocrine disorders-Diabetes mellitus. .

6. **Liver:** **2 hrs.**
Structure of the liver lobule, functions – metabolic & storage, role in removal of following substances: ethanol, ammonia, bilirubin and drugs.

Reference Books:

1. Text book of Biochemistry-West & Todd
2. Text book of Biochemistry-A. Lehninger
3. Text book of Biochemistry-O.P. Agarwal
4. Text book of Biochemistry-Jain
5. Hand book of Biochemistry-Sathynarayana
6. Illustrated biochemistry- Harper

PRACTICAL-V
Enzyme Assays
Practical Duration -02Hours per week Examination-02 Hours
MARKS=50.
Practical Proper- 40 marks Internal Assessment - Record-05+ Class Test-05=10 marks

I. Salivary amylase/Acid phosphatase/Invertase:

- Determination of specific activity by DNS method.
- Determination of optimum pH.
- Determination of Km and Vmax.
- Determination of optimum time.
- Determination of optimum temperature.
- Effect of activators/inhibitors on enzyme activity

II. Report:

- Visit to scientific/research institute – Tour report.

FIFTH SEMESTER
Biochemistry Paper-VI
Title: MOLECULAR BIOLOGY & GENETIC ENGINEERING
CLASS DURATION – 03 HOURS PER WEEK 48 Hours
MARKS-Theory - 80 + Internal Assessment -20= 100

SUBJECT DESCRIPTION: This course emphasisthe mechanism of synthesis of DNA, RNA and proteins, gene regulation and gene mutation. Techniques used in molecular biology Along with the basis of gene cloning, vectors, genetic engineering techniques.

GOALS: This course enable the students to learn about the synthesis and functions of molecules that make up living organisms, their mutation and identification of mutants with a sound knowledge on cloning methods, techniques and applications of genetic engineering.

OBJECTIVES: On successful completion of the course the student should have understood the synthesis of genetic material, RNA and proteins along with gene repair mechanism &gene mutation in molecular biology; basics, vectors, methods of gene cloning Techniques and application of gene technology.

Part-A

MOLECULAR BIOLOGY

1. **Introduction**: **3 hrs.**
   Nucleic acids as genetic information carriers, experimental evidences ex: bacterial genetic transformation, Hershey Chase experiment. Central dogma of molecular biology and its modification.
2. **Replication of DNA:** **5 hrs.**
   DNA replication in prokaryotes- conservative, semi conservative and dispersive types. Mechanism of semi conservative replication. DNA polymerases, other enzymes and protein factors involved in replication. Meselson and Stahl experiment. Mechanism of replication in prokaryotes.
3. **Prokaryotic RNA Synthesis:** **5 hrs.**
   Role of RNA polymerase. Initiation, elongation and termination, reverse transcription-replication of HIV virus.
4. **Genetic code:** General features, wobble hypothesis. **1 hr.**
5. **Prokaryotic Protein biosynthesis:** **5 hrs.**
   Activation of Amino acids, amino acyl tRNA synthesis. Initiation, elongation and termination of protein synthesis. Inhibitors of protein synthesis. Post translational modifications.

6. **Mutations:** **4 hrs.**
Concept of mutation and mutagens – effect of HNO_2, alkylating agents, intercalating agents and UV-radiation. Concept of missense, nonsense, point mutation and frameshift mutation.

7. **Repair of DNA:** **3 hrs.**
DNA damage and their repair. Types of damages repair by direct reversal of damage, excision repair, recombination repair, SOS repair.

8. **Concept of gene:** **4 hrs.**
   (1) Gene expression in prokaryotes - concept of Lac operon and trp operon.
   (2) Functional units in a typical eukaryotic gene-promoter, introns and exons.

9. Historical development, aim and scope of genetic engineering. **1 hr.**

10. **Outline of techniques of genetic engineering.** **10hrs.**
Isolation of DNA, cutting of DNA by restriction endonucleases –Types, staggered cut and blunt end. Separation of fragments by agarose gel electrophoresis. Vectors- plasmid (pBR322), bacteriophage, viruses, cosmids, phagemid and plant vectors. Insertion of foreign DNA into vectors- Use of linkers and adapters. Homopolymer tailing. Transfection of vectors into host cells. cDNA. Principle of polymerase chain reaction and applications.

11. **Blotting techniques:** **4 hrs.**
Principle and procedure of Southern, northern and western blotting. Dot blot. DNA finger printing.

12. **Applications of Genetic engineering** **3 hrs.**
   (1) Transgenic plants, transgenic animals and gene therapy.
   (2) Human genome project.

Reference Books:

1**.** Biochemistry of Nucleic acids-Adam et al

2. Text book of Molecular Biology -David Friefelder

3. Text book Molecular Biology of gene-James and Watson

PRACTICAL-VI
Biophysical and Biochemical Experiments
Practical Duration -02Hours per week Examination-02 Hours
MARKS=50.
Practical Proper- 40 marks Internal Assessment - Record-05+ Class Test-05=10 marks

1. Conductometric titration of strong acid against strong base.
2. Conductometric titration of amino acid against strong base.
3. Preparation of acidic and basic buffers and determination of pH using pH meter.
4. Determination of pKa value of amino acid by using pH meter.
5. Determination of pKa value of acetic acid by using potentiometer.
6. Determination of molar extinction coefficient.
7. Determination of UV spectra of proteins and nucleic acid.
8. Extraction of DNA from natural source.
9. Estimation of DNA by diphenylamine method.
10. Demonstration of estimation of RNA by orcinol method.

SIXTH SEMESTER
Biochemistry Paper-VII
Title: NUTRITION
CLASS DURATION – 03 HOURS PER WEEK 48 Hours
MARKS-Theory - 80 + Internal Assessment -20= 100

SUBJECT DESCRIPTION: This course emphasizes the students to know about nutritional requirement of cell and organisms that are necessary to support life and privilege of healthy diet in preventing common health problems.

GOALS: This course enable the students to improve their health status by understanding the strong relationship between nutrition and health and also improve their food choices and eating habits to prevent nutrition-related health problems.

OBJECTIVES: This course would have made the students to increase their knowledgeon healthy food choices using safe food handling practices, preparation and storage practices and to improve their skill in selection of healthy foods.

1. **Introduction:**
   Concept of Nutrition, calorific value of foods and its determination (Bomb calorimeter), different components of energy expenditure, measurement of energy expenditure by direct and indirect calorimetric method. Energy expenditure at rest and work, respiratory quotient, basal metabolic rate (BMR), determination of BMR by indirect calorimetric method, factors affecting BMR. Specific dynamic action of foods.
   Proximate analysis of food samples: **8hrs.**
   Moisture, fiber, ash, proteins, carbohydrates, fats and their importance

2. **Carbohydrates:**
   Dietary sources of carbohydrates, dietary fibers (types, beneficial & adverse effects) and protein sparing action. Glycemic index, importance with examples, lactose intolerance.
3. **Proteins:**
   Dietary sources of proteins, nutritional classification, nutritive value of proteins-PER and biological value (BV). Essential amino acids. Nitrogen balance, **8 hrs.** mutual Supplementation of proteins. Malnutrition-kwashiorkor and marasmus.
4. **Fats:**
   Dietary sources of fats, visible and invisible fat, trans fats, omega fatty acids and their biological importance, role of DHA and EPA. Effects of fried foods.
5. **Vitamins:**
   Dietary sources, requirements, deficiency symptoms and biological role of water soluble vitamins-thiamine, riboflavin, niacin, pantothenic acid, pyridoxine, **8 hrs.** biotin, folic acid, vitamin-B_{12} and vitamin-C.
   Fat soluble vitamins-A, D, E and K, hypo and hypervitaminosis.

6. **Minerals:**
Dietary sources, physiological functions, deficiency disorders, absorption and excretion. **8 hrs.**
Macronutrients-Ca, P, Na, Cl, Mg and K
Micronutrients-Fe, Zn, Cu, I_2, F, Se, Cr, Mn.

7. **Balanced diet**:
Composition of balanced diet for infants, children, pregnancy and lactating women, old age.

8. **Water Metabolism:**
Absorption, requirement, distribution of water in body fluid compartments. Factors influencing water metabolism, functions of water, deficiency and water intoxication in human body. **8 hrs.**

9. **Antinutritional Factors:**
Sources and harmful effects of anti vitamins (example:- avidin, dicoumarol), natural toxicants (example:- Lathyrussativus) and adultrants (Butter yellow, lead chromate & malachite green)

10. **Digestion and absorption:**
GIT: secretion, composition and functions of saliva, gastric, bile, pancreatic and intestinal juices. Gastro intestinal hormones and its effects.
Absorption and transport of carbohydrates, proteins and fats.

11. **Nutraceuticals:** **8 hrs.**
Introduction, functional foods and pre and pro-biotics in health and disease prevention.

Reference Books:

1. Text book of nutrition by Swaminathan
2. Fundamentals of Foods, Nutrition and Diet Therapy bySumati R. Mudambi& M.V. Rajagopal

PRACTICAL-VI

Nutrition

Practical Duration -02Hours per week Examination-02 Hours

MARKS=50.

Practical Proper- 40 marks Internal Assessment - Record-05+ Class Test-05=10 marks

1. Determination of moisture content of foods and detection of adulterants in food.
2. Extraction and estimation of calcium in ragi.
3. Proximate analysis of food samples- Moisture, fibre, protein fat and carbohydrate (by difference)
4. Estimation of reducing sugars (From jams and jellies) byFehling's method.
5. Extraction and estimation of vitamin – C in biological sample.
6. Extraction and estimation of iron from mustard.
7. Determination of saponification value of oil.
8. Determination of iodine/acid/peroxide value of oil or fat.
9. Estimation of amino acid by Sorensen's formal titration.
10. Determination of pH of the given sample of fruit juice. (Eg: lemon, papaya, apple, sugar cane, bejois juice etc).
11. Estimation of lactic acid in milk.

SIXTH SEMESTER
Biochemistry Paper-VIII
Title: CLINICAL BIOCHEMISTRYAND IMMUNOLOGY
CLASS DURATION – 03 HOURS PER WEEK 48 Hours
MARKS-Theory - 80 + Internal Assessment -20= 100

SUBJECT DESCRIPTION: This course emphasizes the students to study of the diagnostic importance of various metabolic disorders.Immunology presents a wide knowledge about all the aspects of immune system with respect to biomedical applications.

GOALS: This course Provides knowledge base and understanding of the clinical aspects of various metabolic disorders along with principles based on antigen and antibody interactions which help in the field of medicine and detection of diseases.

OBJECTIVES: This course would have made the student's ability to explain physiological processes in detail and on an appropriate level (knowledge, comprehension, application and analysis) with a sound knowledge about the significance of diagnostic bio chemistry. And also should have understood the detail aspects of immune cells, organs and their role in hypersensitivity reactions.

PART A

CLINICAL BIOCHEMISTRY

1. **Introduction:** **1 hr.**
   Clinical biochemistry: Definition, scope, collection & preservation of biological fluids.
2. **Urine:** **3 hrs.**
   Normal composition of urine – Volume, pH, colour and specific gravity.
   Chemical analysis and normal values of the constituents- urea, uric acid, creatinine, pigments and their clinical significance.
   Abnormal constituents - glucose, albumin, ketone bodies and bile pigments and their pathological significance.
3. **Body fluids:** Blood- volume, composition and functions. RBC, WBC and platelets: structure and functions. Total WBC count, differential count, erythrocyte count, platelet count, Hb%, blood grouping & ESR. C-reactive protein and subpopulation of blood cells. Mechanism of blood coagulation (outline) - intrinsic and extrinsic pathway. Blood brain barrier. Cerebrospinal fluids and lymph – composition and functions. **5 hrs.**
   Normal constituents of blood and their variation in pathological conditions- urea, uric acid, creatinine, glucose, bilirubin, total protein, albumin/globulin ratio.
   Lipid profile: cholesterol, triglycerides, lipoproteins: chylomicrons, VLDL, LDL and HDL.
   3 hrs.
4. **Clinical enzymes:** **2 hrs.**
   Alkaline phospatase, serum transaminases (SGPT & SGOT) and lactate dehydrogenase (LDH). Cardiac injury profile- CPK and LDH.

5. **Acid base balance:** **3 hrs.**

Maintenance of normal pH of the body fluids. Role of blood buffers. Biochemical events in transport of CO_2 and O_2 in blood. Role of lungs and kidney in acid base balance. Acidosis and alkalosis.

6. **Liver disorders:** **4 hrs.**

Cirrhosis, hepatitis, fatty liver and jaundice (pre, post and hepatic). Estimation of conjugated and total bilirubin in serum (Diazo method). Detection of bilirubin and bile salts in urine (Fouchet's test and Hay's test).

7. **Inborn errors of Metabolism:** **3 hrs.**

Glycogen storage disease (Von-gierke's disease), fructosuria, galactosemia, phenylketonuria, alkpatonuria, albinism, Lesch-Nyhan syndrome, Niemann-Pick disease.

PART B

IMMUNOLOGY

1. **Overview of the Immune system:** **7 hrs.**

Role of immunologically important organs and cells - bone marrow, thymus, spleen and lymphocytes.Innate and adaptive immunity. Passive and active immunity. cellular and humoral immunity:formation and functions of T & B Lymphocytes. Helper T-cells and killer T-cells. Macrophages and dendritic cells.

2. **Antigens:** **2 hrs.**

Definition, types, chemical nature and antigenicity. Epitopes, paratopes, haptens and adjuvants.

3. **Antibodies:** **4 hrs.**

Definition, types and structure of a typical immunoglobulin (IgG – Light chain, heavy chain, hyper variable region, constant domains, Fab and Fc). Polyclonal and monoclonal antibodies. Production and applications of monoclonal antibodies.

4. **Antigen –antibody reaction *in-vitro*:** **4 hrs.**

Formation of antigen-antibody complex. Agglutination and precipitation. Principle, procedure and applications of immunodiffusion, RIA, ELISA.

5. **Immunization:** **2 hrs.**

Vaccines and their preparations, primary and secondary immune response.

6. **Hypersensitivity:** **2hrs.**

Different types in brief, Immediate and delayed type of hypersensitivity.

7. **Immunological disorders:** **3 hrs.**

Autoimmune disorder- systemic lupus erythromatus and rheumatoid arthritis.
Immunodeficiency diseases- AIDS.

Reference Books:

1. Text book of clinical biochemistry by Ranashindhe
2. Text book of biochemistry by Denise R. Ferrier, Richard A. Harvey
3. Text book of biochemistry with clinical correlations by Thomas M. Devlin
4. Clinical Chemistry in diagnosis and treatment by Philip.D.Mayne
5. Biochemistry – A case oriented approach- Montgometry, Conway, Spector
6. Textbook of Immunology by Kuby.
7. Textbook of Immunology by Tortora

PRACTICAL-VIII
Clinical Biochemistry & Immunology
Practical Duration -02Hours per week Examination-02 Hours
MARKS=50.
Practical Proper- 40 marks Internal Assessment - Record-05+ Class Test-05=10 marks

Qualitative analysis of urine:

- Organic: urea, uric acid, creatinine and amino acid.

  Inorganic constituents: chlorides, sulfates, phosphates and ammonia

- Abnormal constituents -glucose, albumin, bile pigments, bile salts and ketone bodies.

Quantitative estimations:

- Titrable acidity and ammonia in urine.
- Creatinine in urine.
- Urea in blood.
- Blood glucose
- SGPT/SGOT.
- Alkaline phosphatase.
- Hemoglobin.
- Determination of antigen-antibody reaction by immunodiffusion technique.
- Assay of antigen concentration by radial immunodiffusion technique.
- Photographic demonstration of immunological important cells

Education tour V or VI Visit

1. Bangalore: IISE, JNCASR, NIMHANS, UAS-NCBS, Biocon.
2. Bombay: TIFR, cancer research institute,BARC,IIT
3. Hyderabad:CCMB,NIN,Reddy's lab,Indian Drug Research Lab
    - Internal crop research institute for semi and crops (ICRISAC)
4. University of Poona
    - National institute of virology
    - National chemical laboratory
    - National center for cell science
5. Goa: National institute of oceanography(NIO)
6. Cochin: sri chitratirunal institute of medical science
7. Kasaragod: coconut research institute
8. Trivandrum: Rajiv Gandhi institute of biological science
9. Mangalore: fisheries college
    - Manipal centre of higher education
    - Plant biotechnology lab- St. Aloysius college
    - Mangalore Chemical Fertilizers(MCF)
10. Hassan: coffee Estate,
11. Ooty: potato research station
12. Kannur: TATA tea process Centre, vaccine institute
13. Madras:IIT
    - Centre for Leather and Resin Institute
    - RSIC-Regional Sophisticated Instrumentation Centre
14. Other research institutes in other parts of the country may also be included in the visit.