Syllabus

BIOCHEMISTRY

Admitted Batch 2008 -2009

(UG courses)

May 2008

A.P. State Council of Higher Education

SUBJECT COMMITTEE

1. Prof. D. Siva Prasad — Coordinator
   Department of Biochemistry,
   Andhra University, Visakhapatnam.

2. Prof. M S K Prasad
   Department of Biochemistry,
   Kakatiya University, Warangal.

3. Prof. K. Thyagaraju
   Department of Biochemistry,
   Sri Venkateswara University, Tirupati.

4. Prof. B. Sashidhar Rao
   Department of Biochemistry,
   Osmania University, Hyderabad.

5. Prof. P.V.V. Satyanarayana,
   Department of Biochemistry,
   Acharya Nagarjuna University,
   Nagarjuna Nagar, Guntur Dist.

6. Prof. D. Sarala Kumari
   Department of Biochemistry,
   Sri Krishnadevaraya University, Anantapur.

7. Dr. G. Sudhakar Reddy
   Govt. Degree College,
   Piler, Chittoor Dist.

8. Dr. G. Seshagiri Rao
   Department of Biochemistry,
   Andhra University, Visakhapatnam.

9. Prof. S. Sanjeevi Rao
   Department of Biochemistry,
   Andhra Medical College, Visakhapatnam.

10. Prof. P. V. Subba Rao
    General Manager,
    Divis Laboratories Ltd. Phippada, Annavaram P,
    Visakhapatnam Dist.

B.Sc. Courses (Structure)

First year:

S.no.	Subject	Hrs per week
1.	English language including communication skills	6
2.	Second language	4
3.	Core1-I	4
4.	Core2-I	4
5.	Core3-I	4
6.	Core1-lab I	3
7.	Core2-lab I	3
8.	Core3-lab I	3
9.	Foundation course	3
10.	Computer skills	2
	Total	**36**

Second year:

S.no.	Subject	Hrs per week
1.	English language including communication skills	6
2.	Second language	4
3.	Core1-II	4
4.	Core2-II	4
5.	Core3-II	4
6.	Core1-lab II	3
7.	Core2-lab II	3
8.	Core3-lab II	3
9.	Environmental studies	4
10.	Computer skills	2
	Total	**37**

Third year:

S.no.	Subject	Hrs per week
1.	Core1-III	3
2.	Core1-IV	3
3.	Core2-III	3
4.	Core2-IV	3
5.	Core3-III	3
6.	Core3-IV	3
7.	Core1-lab III	3
8.	Core1-lab IV	3
9.	Core2-lab III	3
10.	Core2-lab IV	3
11.	Core3-lab III	3
12.	Core3-lab IV	3
13.	Foundation course	3
	Total	**39**

A.P.State Council of Higher Education, Hyderabad
Biochemistry
Course Structure, Scheme of Instruction and Examination

Year	Theory / Practical Paper No.	Title	Work load / Hours per Week	Exam Duration Hours	Marks
I	Theory Paper I	Biomolecules and Enzymology	4	3	100
	Practicals Paper I	Qualitative Analysis and Enzymology	3	3	50
II	Theory Paper II	Metabolism and Biochemical Techniques	4	3	100
	Practicals Paper II	Quantitative Analysis and Biochemical Techniques	3	3	50
III	Theory Paper III	Physiology, Clinical Biochemistry and Immunology	3	3	100
	Theory Paper IV	Microbiology and Molecular Biology	3	3	100
	Practicals Paper III	Nutritional and Clinical Biochemistry	3	3	50
	Practicals Paper IV	Microbiology and Molecular Biology	3	3	50

Note: <u>Foundation Course</u>:

(i) 1st Year: Mathematics for Biology Students / Biology for Mathematics Students

(ii) 2nd Year: Environmental Studies.

(iii) 3rd Year: Computational Science (Biostatistics, Bioinformatics).

Biochemistry
Course Structure

First Year	Marks
Theory – Paper-I: Biomolecules and Enzymology	**100**
Unit-I : Carbohydrates and Lipids	
Unit-II : Amino acids, Peptides and Proteins	
Unit-III : Nucleic acids and Porphyrins	
Unit-IV : Enzymology	
Practicals – Paper-I: Qualitative Analysis and Enzymology	**50**

Second Year	Marks
Theory – Paper-II: Metabolism and Biochemical Techniques	**100**
Unit-I : Bioenergetics and Biological Oxidations	
Unit-II : Carbohydrate and Lipid Metabolism	
Unit-III : Metabolism of Nitrogen Compounds	
Unit-IV : Biochemical Techniques	
Practicals – Paper-II: Quantitative Analysis and Biochemical Techniques	**50**

Third Year	Marks
Theory – Paper-III: Physiology, Clinical Biochemistry and Immunology	**100**
Unit-I : Physiology	
Unit-II : Nutritional Biochemistry	
Unit-III : Clinical Biochemistry	
Unit-IV : Immunology	
Theory – Paper-IV: Microbiology and Molecular Biology	**100**
Unit-I : Microbiology	
Unit-II : DNA Replication and Transcription	
Unit-III : Protein Synthesis and Regulation of Gene Expression	
Unit-IV : Recombinant-DNA Technology	
Practicals – Paper-III: Nutritional and Clinical Biochemistry	**50**
Practicals – Paper-IV: Microbiology and Molecular Biology	**50**

Note: <u>Foundation Course:</u>

(i) **1st Year**: Mathematics for Biology Students / Biology for Mathematics Students
(ii) **2nd Year**: Environmental Studies.
(iii) **3rd Year**: Computational Science (Biostatistics, Bioinformatics).

ANDHRA UNIVERSITY

BIO-CHEMISTRY SYLLABUS ADMITTED BATCH 2008-09

1st Year Theory – Paper-I : Biomolecules and Enzymology

120 hrs
(4 hrs/week)

Unit – I : Carbohydrates and Lipids **30 hours**

Water as a biological solvent and its role in biological processes.

Carbohydrates: Classification, monosaccharides, D and L designation, open chain and cyclic structures, epimers and anomers,mutarotation, reactions of carbohydrates (due to functional groups - hydroxyl , aldehyde and ketone). Amino sugars, Glycosides. Structure and biological importance of disaccharides (sucrose, lactose, maltose, isomaltose, trehalose), trisaccharides (raffinose, melezitose), structural polysaccharides (cellulose, chitin, pectin) and storage polysaccharides (starch, inulin, glycogen). Glycosaminoglycans, Bacterial cell wall polysaccharides. Outlines of glycoproteins, glycolipids and blood group substances.

Lipids: Classification, saturated and unsaturated fatty acids, structure and properties of fats and oils (acid, saponificition and iodine values, rancidity). General properties and structures of phospholipids, sphingolipids and cholesterol. Prostaglandins- structure and biological role of PGD_2,PGE_2 and $PGF_{2\alpha}$. Lipoproteins: Types and functions

Biomembranes: Behavior of amphipathic lipids in water- formation of micelles, bilayers, vesicles, liposomes. Membrane composition and organization – Fluid mosaic model.

Unit-II : Amino Acids, Peptides and Proteins **30 hours**

*p*H, Buffers, Henderson- Hasselbalch equation.

Amino Acids: Classification, structure, stereochemistry, chemical reactions of amino acids due to carbonyl and amino groups. Titration curve of glycine and p*K* values. Essential and non-essential amino acids, non-protein amino acids. Peptide bond - nature and conformation. Naturally occurring peptides – glutathione, enkephalin.

Proteins: Classification based on solubility, shape and function. Determination of amino acid composition of proteins. General properties of proteins, denaturation and renaturation of proteins. Structural organization of proteins- primary, secondary, tertiary and quaternary structures (Eg. Hemoglobin and Myoglobin), forces stabilizing the structure of protein. Outlines of protein sequencing.

Unit-III : Nucleic Acids and Porphyrins **25 hours**

Nature of nucleic acids. Structure of purines and pyrimidines, nucleosides, nucleotides. Stability and formation of phosphodiester linkages. Effect of acids, alkali and nucleases on DNA and RNA. Structure of Nucleic acids- Watson-Crick DNA double helix structure, introduction to circular DNA, super coiling, helix to random coil transition, denaturation of nucleic acids-

hyperchromic effect, *T*m-values and their significance. Reassociation kinetics, cot curves and their significance. Types of RNA and DNA .

Prophyrins: Structure, properties and functions of heme, chlorophylls and cytochromes.

Unit-IV : Enzymes **35 hours**

Introduction to biocatalysis, differences between chemical and biological catalysis. Nomenclature and classification of enzymes. Enzyme specificity. Active site. Principles of energy of activation, transition state. Interaction between enzyme and substrate- lock and key, induced fit models. Definition of holo-enzyme, apo-enzyme , coenzyme, cofactor. Fundamentals of enzyme assay, enzyme units.

Factors affecting the catalysis- substrate concentration, *p*H, temperature. Michaelis - Menten equation for uni-substrate reaction (derivation not necessary), significance of K_M and V_{max}. Enzyme inhibition- irreversible and reversible, types of reversible inhibitions- competitive and non-competitive.

Outline of mechanism of enzyme action- acid-base catalysis, covalent catalysis, electrostatic catalysis, and metal ion catalysis. Regulation of enzyme activity- allosterism and cooperatitvity, ATCase as an allosteric enzyme, covalent modulation- covalent phosphorylation of phosphorylase, zymogen activation- activation of trypsinogen and chymotrypsinogen. Isoenzymes (LDH). Multienzyme complxes (PDH). Ribozyme .

1st Year Practicals – Paper-I: Qualitative Analysis and Enzymology

90 hrs
(3 hrs/week)

Introduction to Good Laboratory Practice (GLP). Principles of Laboratory Hygiene and Safety.

List of experiments:

1. Preparation of buffers (acidic, neutral and alkaline) and determination of *p*H.
2. Qualitative identification of carbohydrates- glucose, fructose, ribose/xylose, maltose, sucrose, lactose, starch/glycogen.
3. Qualitative identification of amino acids – histidine, tyrosine, tryptophan, cysteine, arginine.
4. Qualitative identification of lipids- solubility, saponification, acrolein test, Salkowski test, Lieberman-Burchard test.
5. Preparation of Osazones and their identification.
6. Absorption maxima of colored substances- *p*-Nitrophenol, Methyl orange.
7. Absorption spectra of protein-BSA, nucleic acids- Calf thymus DNA.
8. Titration curve of glycine and determination of *p*K and *p*I values.
9. Assay of amylase
10. Assay of urease
11. Assay of catalase.
12. Assay of phosphatase
13. Determination of optimum temperature for amylase.
14. Determination of optimum *p*H for phosphatase.

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BIO-CHEMISTRY SYLLABUS ACADEMIC YEAR 2009-10
2nd Year Theory – Paper-II: Metabolism and Biochemical Techniques 120 hrs (4 hrs/week)

Unit- I : Bioenergetics and Biological Oxidations 30 hours

Energy transformations in the living system, Free energy concept. Exergonic and endergonic reactions. High energy compounds. Phosphate group transfer potential. Substrate level phosphorylation.

Biological oxidations: Definition, enzymes involved- oxidases, dehydrogenases and oxygenases. Redox reactions. Redox couplers. Reduction potential ($\mathcal{E}$, $\mathcal{E}_o$, $\mathcal{E}'_o$). Standard reduction potential ($\mathcal{E}'_o$) of some biochemically important half reactions.

Ultra structure of mitochondria. Electron transport chain and carriers involved. Oxidative phosphorylation, theories of oxidative phosphorylation- Mitchell's chemiosmotic theory.
F_o F_1- ATPase. Inhibitors of respiratory chain and oxidative phosphorylation, uncouplers. Formation of reactive oxygen species and their disposal through enzymatic reactions.
Ultra structure of chloroplast, Cyclic and non-cyclic photophosphorylation.

Unit- II : Carbohydrate and Lipid Metabolism 30 hours

Concept of anabolism and catabolism. Glycolytic pathway, energy yield. Fate of pyruvate- formation of lactate and ethanol, Pasteur effect. Citric acid cycle, regulation, energy yield, amphipathic role. Anaplerotic reactions. Glycogenolysis and glycogenesis. Pentose phosphate pathway. Gluconeogenesis. Photosytnthesis- Light and Dark reactions, Calvin cycle, C_4 Pathway.

Catabolism of fatty acids (β- oxidation) with even and odd number of carbon atoms, Ketogenesis, *de novo* synthesis of fatty acids, elongation of fatty acids in mitochondria and microsomes, Biosynthesis and degradation of triacylglycerol and lecithin. Biosynthesis of cholesterol.

Unit-III : Metabolism of Nitrogen Compounds 30 hours

General reactions of amino acid metabolism- transamination, decarboxylation and deamination, Urea cycle and regulation, Catabolism of carbon skeleton of amino acids- glycogenic and ketogenic amino acids. Metabolism of glycine, serine, aspartic acid, methionine, phenylalanine and leucine. Biosynthesis of creatine. Inborn errors of aromatic and branched chain amino acid metabolism.

Biosynthesis and regulation of purine and pyrimidine nucleotides, *de novo* and salvage pathways. Catabolism of purines and pyrimidines. Biosynthesis of deoxyribonucleotides- ribonucleotide reductase and thymidylate synthase and their significance. Disorders of nucleotide metabolism- Gout, Lesch- Nyhan syndrome.

Biosynthesis and degradation of heme.

Unit-IV : Biochemical Techniques **30 hours**

Methods of tissue homogenization: (Potter-Elvejham, mechnical blender, sonicator and enzymatic).

Principle and applications of centrifugation techniques- differential, density gradient. Ultra-centrifugation- preparative and analytical..
Principle and applications of chromatographic techniques- paper, thin layer, gel filtration, ion-exchange and affinity chromatography. Elementary treatment of an enzyme purification.

Electrophoresis- principles and applications of paper, polyacrylamide (native and SDS) and agarose gel electrophoresis.

Colorimetry and Spectrophotometry- Laws of light absorption- Beer-Lambert law. UV and visible absorption spectra, molar extinction coefficient, biochemical applications of spectrophotometer. Principle of fluorimetry.

Tracer techniques: Radio isotopes, units of radio activity, half life, β and γ- emitters, use of radioactive isotopes in biology.

2nd Year Practical – Paper-II: Quantitative Analysis and Biochemical Techniques

90 hrs
(3 hrs/week)

List of Experiments:

1. Estimation of amino acid by ninhydrin method.
2. Estimation of protein by Biuret method.
3. Estimation of protein by Lowry method.
4. Estimation of glucose by DNS method.
5. Estimation of glucose by Benedict's titrimetric method.
6. Estimation of total carbohydrates by anthrone method.
7. Isolation of egg albumin from egg white.
8. Isolation of cholesterol from egg yolk.
9. Isolation of starch from potatoes.
10. Isolation of casein from milk.
11. Separation of amino acids by paper chromatography.
12. Determination of exchange capacity of resin by titrimetry.
13. Separation of serum proteins by paper electrophoresis.
14. Separation of plant pigments by TLC.

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BIO-CHEMISTRY SYLLABUS FOR THE ACADEMIC YEAR 2010-11
3rd Year Theory – Paper-III: Physiology, Clinical Biochemistry and Immunology

90 hrs
(3 hrs/week)

Unit- I : Physiology **24 hours**

Digestion and absorption of carbohydrates, lipids and proteins. Composition of blood and coagulation of blood. Hemoglobin and transport of gases in blood (oxygen and CO_2).

Heart- structure of the heart, cardiac cycle, cardiac factors controlling blood pressure.

Muscle- kinds of muscles, structure of myofibril, organization of contractile proteins and mechanism of muscle contraction.

Endocrinology- organization of endocrine system. Classification of hormones. Outlines of chemistry, physiological role and disorders of hormones of pancreas, thyroid, parathyroid, gonads, placenta, adrenals, pituitary and hypothalamus. Introduction of gastrointestinal hormones. Mechanism of hormonal action- signal transduction pathways for adrenaline, glucocorticoids and insulin.

Unit- II : Nutrition **21 hours**

Balanced diet. Calorific values of foods and their determination by bomb calorimeter. BMR and factors affecting it. Specific dynamic action of foods. Energy requirements and recommended dietary allowance (RDA) for children, adults, pregnant and lactating women. Sources of complete and incomplete proteins. Biological value of proteins. Role of essential fatty acids in human nutrition. Malnutrition- Kwashiorkar, Marasmus and PEM.

Vitamins- sources, structure, biochemical roles, deficiency disorders of water and fat soluble vitamins. Introduction to neutraceutical and functional foods. Bulk and trace elements-Ca, Mg, Fe, I, Cu, Mo, Zn, Se and F. Obesity and starvation.

Unit- III : Clinical Biochemistry **23 hours**

Plasma proteins in health and disease. Disorders of blood coagulation (haemophilia). Types of anemias, haemoglobinopathies-sickle cell anemia and thalassemias.

Structure and functions of the liver. Liver diseases-jaundice, hepatitis, cirrhosis. Liver function tests- conjugated and total bilurubin in serum, albumin: globulin ratio, hippuric acid and bromsulphthalein tests. Serum enzymes in liver diseases- SGPT, GGT and alkaline phosphatase.

Kidneys-structure of nephron, urine formation, normal and abnormal constituents of urine. Biological buffers. Role of kidneys in maintaining acid-base and electrolyte balance in the body. Renal function tests- creatinine and urea clearance tests, phenol red test.
Disorders of carbohydrate metabolism- hypoglycemia, hyperglycemia, glycosuria, renal threshold value. *Diabetes mellitus*-classification, glucose tolerance test (GTT), diabetic ketoacidosis.
Disorders of lipid metabolism- plasma lipoproteins, lipoproteinemias, fatty liver, hyper cholesterolemia, atherosclerosis.
Biochemical tests for the diagnosis of heart diseases- HDL/LDL cholesterol, SGOT, LDH, CK, C-reactive protein, cardiac troponins.

Unit- IV : Immunology **22 hours**

Organization of immune system. Organs and cells of immune system. Innate and acquired immunity. Cell mediated and humoral immunity (T- and B- cells). Classification of immunoglobulins, structure of IgG. Epitopes / antigenic determinants. Concept of haptens. Adjuvants. Theories of antibody formation- clonal selection theory. Monoclonal antibodies.

Antigen-antibody reactions- agglutination, immunoprecipitation, immunodiffusion. Blood group antigens. Immunodiagnostics-RIA, ELISA. Vaccines and their classification. Traditional vaccines-live and attenuated, toxoids. Modern vaccines- recombinant and peptide vaccines. Outlines of hypersensitivity reactions. Fundamentals of graft rejection and MHC proteins.

3rd Year – Practical -III: Nutritional and Clinical Biochemistry

90 hrs
(3 hrs/week)

List of Experiments:

1. Estimation of calcium by titrimetry
2. Estimation of iron in apple juice by phenanthroline method.
3. Estimation of sodium by flame photometry.
4. Estimation of vitamin C by 2, 6 -dichlorophenol indophenol method.
5. Isolation of total lipids by gravimetric method.
6. Determination of iodine value of an oil.
7. Determination of acid value of an oil.
8. Estimation of hemoglobin in blood.
9. Total count - RBC and WBC. Differential count.
10. Determination of blood group and Rh typing.
11. Visualization of antigen antibody reactions (Ouchterlony technique).
12. Urine analysis for albumin, sugars and ketone bodies.
13. Estimation of urinary creatinine.
14. Estimation of blood urea.
15. Estimation of serum total cholesterol.
16. . Determination of serum alkaline phosphatase activity.
17. Determination of SGOT and SGPT activity

ANDHRA UNIVERSITY
BIO-CHEMISTRY SYLLABUS ACADEMIC YEAR 2010-11
3rd Year Theory – Paper-IV: Microbiology and Molecular Biology **90 hrs** **(3 hrs/week)**

Unit- I : Microbiology **24 hours**

Introduction to brief history of microbiology. Classification of microorganisms- prokaryotic and eukaryotic microorganisms. Isolation and cultivation of bacteria. Selective media and enriched media. Bacterial growth curve and kinetics of growth. Batch, continuous and synchronous cultures. Gram's staining- Gram positive and Gram negative bacteria, motility and sporulation.

Industrial uses of *Aspergillus niger*, yeast and Spirulina.

Structure and composition of viruses. One-step growth and determination of plaque forming units (PFU). Isolation and cultivation of bacterial plaques. Lytic and lysogenic life cycle of λ phage. TMV, Retro viruses- HIV. Prions and Mycoplasma.

Unit- II : DNA Replication and Transcription **21 hours**

Organization of genome in prokaryotes and eukaryotes. Experimental evidences to prove nucleic acids as genetic material. Nature and structure of the gene. DNA replication- models of replication, Meselson-Stahl's experimental proof for semi-conservative model. DNA polymerases I, II and III of *E.coli*, helicase, topoisomerases, primase, ligase. Bidirectional replication model. Okazaki fragments, leading and lagging strands of DNA synthesis. Inhibitors of DNA replication.

Transcription - RNA synthesis, RNA polymerases of prokaryotes. Promoters, Initiation- sigma factors and their recognition sites. Elongation- role of core enzyme. Termination- rho dependent and rho independent. RNA polymerase I, II and III of eukaryotes.

Transcriptional events in eukaryotic m-RNA synthesis, post-transcriptional modifications of eukaryotic m-RNA. Inhibitors of RNA synthesis.

Unit- III : Protein Synthesis and Regulation of Gene Expression **21 hours**

Introduction to protein synthesis- Genetic code, structure of t-RNA, deciphering of genetic code, Nirenberg's and Khorana's experiments, wobble hypothesis, degeneracy of genetic code.

Protein synthesis- activation of amino acids (aminoacyl t-RNA synthetases). Ribosome structure. Initiation, elongation and termination of protein synthesis. Post- translational modifications- signal hypothesis. Inhibitors of protein synthesis.

Regulation of prokaryotic gene expression- induction and repression. Lac operon, catabolite repression. Tryptophan operon and attenuation.

Unit- IV : Recombinant DNA technology **24 hours**

Outlines of cloning strategies. DNA sequencing- Maxam Gilbert and Sanger's methods. Tools of r-DNA technology: Enzymes- Restriction endonucleases, ligase, phosphatases, reverse transcriptase, polynucleotide kinases, terminal transferase nucleases-S_1 and RNAase H.

Restriction mapping. Cloning vectors- Plasmids, Ti plasmids, Cosmids, λ phages, shuttle vectors, expression vectors. Host- *E.coli*, *Sacchromyces cereviciae, Agrobacterium tumifaciens.*

Construction of c-DNA and genomic libraries. Isolation and sequencing of cloned genes- colony hybridization, nucleic acid hybridization, hybrid released translation (HRT) and hybrid arrested and released translation (HART) using reporter genes [β- galactosidases, green fluorescent proteins (GFP)].

Polymerase chain reaction- principle and applications. Outlines of blotting techniques-Southern, Northern and Western.

Applications of gene cloning- production of insulin and human growth hormone, production of Bt cotton and edible vaccines.

Introduction to Bioinformatics- definitions of proteomics and genomics. Gene bank, NCBI, DDBJ, Swissprot, PDB. Sequence alignments- BLAST and FASTA.

3rd Year Practical – Paper-IV: Microbiology and Molecular Biology

90 hrs
(3 hrs/week)

List of Experiments:

1. Preparation of culture media and sterilization methods.
2. Isolation of pure cultures: (i) Streak plate method.
   (ii) Serial dilution method.
3. Gram staining.
4. Motility of bacteria by hanging drop method.
5. Bacterial growth curve.
6. Antibiotic sensitivity by paper disc method.
7. Isolation of DNA from onion/liver/coconut endosperm.
8. Isolation of plasmids.
9. Determination of purity of nucleic acids by UV-spectrophotometric method.
10. Estimation of DNA by diphenylamine method.
11. Estimation of RNA by orcinol method.
12. Electrophoresis of nucleic acids and visualization by methylene blue staining.
13. Restriction mapping: λ- DNA with any two restriction enzymes.
14. Sequence alignments of insulin/BSA with other proteins using BLAST and FASTA.

Recommended Books for UG Course (Biochemistry)

General Biochemistry

1. Lehninger's Principles of Biochemistry – Nelson.D.L. and Cox.M.M., Freeman & Co.
2. Biochemistry – Berg.J.M., Tymoczko.J.L. and Stryer.L., Freeman & Co.
3. Biochemistry – Voet.D and Voet., J.G., John Wiley & Sons .
4. Textbook of Biochemistry – West.E.S.,Todd.W.R,Mason.H.S..and. Bruggen, J.T.V., Oxford & IBH Publishers.
5. Principles of Biochemistry: General Aspects-Smith, E. L., Hill, R.L. Lehman, I. R. Lefkowitz, R.J. Handler, P., and White, A. McGraw-Hill
6. Outlines of Biochemistry – Conn.E.E.,Stumpf.P.K., Bruening, G and Doi.R.H., John Wiley & Sons .
7. Harper's Illustrated Biochemistry – Murray, R.K., Granner.D.K. & Rodwell,V.W., McGraw-Hill 8. Bichemistry-Lippincott's Illustrated Reviews. Champe, P.C. and Harvey, R. A. Lippincott
9. Fundamentals of Biochemistry –Jain, J.L., Jain, S., Jain, N. S. Chand & Co.
10. Biochemistry – Satyanarayana. U and Chakrapani. U, Books & Allied Pvt. Ltd.
11. Biochemistry – Rama Rao. A and Ratna Kumari. D, Kalyani Publishers.
12. Biochemistry- The Molecular Basis of Life – McKee. T and McKee, J. R, McGraw-Hill.

Enzymology

1. Fundamentals of Enzymology – Price.N.C.and Stevens.L., Oxford University Press.
2. Understanding Enzymes – Palmer.T., Ellis Harwood.
3. Enzymes – Biochemistry, Biotechnology, Clinical Chemistry – Palmer.T., Affiliated East-West Press

Biochemical Techniques

1. Principles and Techniques of Practical Biochemistry- Wilson, K. and Walker, J. Cambridge Press.
2. The Tools of Biochemistry- Cooper, T. G. John Wiley & Sons Press.
3. Physical Biochemistry- Friefelder, D. W.H. Freeman Press.
4. Analytical Biochemistry – Holme.D.J. and Peck.H., Longman.
5. Biophysical Chemistry: Principle and techniques- Upadhyay A, Upadhyay K and Nath. N. Himalaya Publishing House.
6. Experimental Biochemistry- Clark Jr. J.M and Switzer, R. L. Freeman & Co..

Physiology, Nutrition and Clinical Biochemistry:

1. Textbook of Biochemistry and Human Biology – Talwar, G.P. and Srivastava. L.M., Printice Hall of India
2. Review of Medical Physiology-Ganong. McGraw-Hill.
3. Human Physiology – Chatterjee.C.C, Medical Allied Agency
4. Textbook of Medical Physiology – Guyton.A.G and Hall.J.E., Saunders
5. William's Textbook of Endocrinology – Larsen, R. P. Korenberg, H. N. Melmed, S. and Polensky, K. S. Saunders
6. Mammalian Biochemistry- White, A. Handler, P. and Smith, E. L. McGraw-Hill.
7. Textbook of Human Nutrition- Bamji, Pralhad Rao and Reddy V. Oxford & IBH Publishers.
8. Foods: Facts & Principle- Shakuntala and Shadaksharaswamy. Wiley Ester Press.
9. Essentials of Food and Nutrition – Swaminathan.M. Bangalore Press.
10. Human Nutrition and Dietetics. Davidson, S. and Passmore, J. R. ELBS.
11. A Textbook of Biochemistry: Molecular and Clinical Aspects. Nagini, S. Scitech Publishers.
12. *Tietz* Fundamentals of Clinical Chemistry- Burtis, A. A. and Ashwood, E. R. Saunders-imprint Elsevier Pub.
13. Textbook of Biochemistry with Clinical Correlations – Devlin.T.M.,Wiley – Liss
14. Textbook of Medical Biochemistry – Chatterjea.M.N. and Shinde.R, Jaypee Brothers Medical Publishers.
15. Textbook of Medical Biochemistry- Ramakrishnan, S., Prasannan, K. G. and Rajan, R. Orient Longman

Immunology:

1. Immunology. Tizard, I. R. Thomson Press.
2. Kuby Immunology – Kindt.T.J., Goldsby.R.A. and Osborne.B.A., Freeman & Co.
3. Roitt's Essential Immunology – Roitt.I.M. and Delves.P.J., Blackwell Science.
4. Immune system- Parham. Garland Publishing.

Microbiology:

1. Introduction to Microbiology: A Case History Approach- Ingraham and Ingraham. Thomson Press.
2. Textbook of Microbiology – Ananthanarayan, R and Jayaram Paniker, C.K., Orient Longman.
3. Microbiology – Prescott.L.M.,Harley.J.P. & Klein.D.A, McGraw-Hill.
4. Microbiology: An Introduction- Tortora, G. J. Funke, B. R. and Case, C. L., Pearson-Benjamin-Cummings Co.
5. Microbiology – Pelczar Jr,.M.J., Chan.E.C.S. and Krieg.N.R., Tata McGraw-Hill.
6. Textbook of Microbiology- Dubey, R. C. and Maheshwari, D. K. S. Chand & Co.

Molecular Biology and Biotechnolgy:

1. Protein Biochemistry & Biotechnology- Walsh. John Wiley & Sons Press.
2. Molecular Biology of Cell- Alberts, B. Bray, D. Lewis, J. Raff, M. Roberts, K. and Watson, J. D. Garland Publishing.
3. Recombinant DNA and Biotechnology: A Guide for teachers- Helen and Massey. ASM Press.
4. Genes VIII – Lewin. B, Oxford University Press .
5. Molecular Biology- Freifelder. D. Naroasa Pub. House
6. Molecular Biology of the Gene- Watson. J.D., Baker, T.A, Bell, S.P.,Gann.A, Levine, M. and Losick.R, Pearson Education.
7. Molecular Biotechnology- Glick, B. R. and Pasternak, J. J. ASM Press
8. Principles of Gene Manipulation: An Introduction to GE- Old, R. V. and Primrose, S. B. Blackwell Sci. Pub.
9. A Textbook of Biotechnology-Dubey, R. C. S. Chand & Co.
10. Gene Biotechnology- Jogdand. Himalaya Pub. House.
11. Introduction to Biotechnology: An Agricultural Revolution-Herren. Thomson Press.
12. Molecular Cell Biology- Lodish, H., Berk, A., Matsudaira, P., Kaiser, C. A., Krieger, M. Scott M. P., Zipursky, S. L. and Darnell, J. Freeman & Co.

Bioinformatics

1. Instant Notes-Bioinformatics- Westhead *et al*., Viva Books (P), Ltd
2. Introduction to Bioinformatics- Attwood T K and Parry-Smith, D. J. Pearson Education.
3. Introduction to Bioinformatics- Lesk, A.M. Oxford University Press

Practical Biochemistry:

1. Experimental Biochemistry: *A Student companion*- Sashidhar Rao, B and Deshpande, V. IK International (P) Ltd. Pub.
2. Modern Experimental Biochemistry- Boyer. R. Pearson Education
3. Biochemical Methods –Sadasivam, S and Manickyam, A.- New Age International publishers
4. An Introduction to Practical Biochemistry- Plummer, D. T. Tata McGraw-Hill.
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