

Contents

SECTION 1: CHEMICAL BASIS OF LIFE

| | |
|---|-----------|
| 1. Biochemical Perspective to Medicine | 3 |
| ➤ Historical Background of Biochemistry 3 ➤ Biomolecules 4 ➤ Study of Metabolic Processes 5 | |
| ➤ Stabilizing Forces in Molecules 5 ➤ Water: The Universal Solvent 6 ➤ Principles of Thermodynamics 7 | |
| ➤ Donnan Membrane Equilibrium 7 ➤ Osmosis 8 ➤ Dialysis 9 ➤ Equivalent Weight 10 | |
| ➤ Molecular Weight 11 | |
| 2. Subcellular Organelles and Cell Membranes | 13 |
| ➤ Subcellular Organelles 13 ➤ Plasma Membrane 17 ➤ Bacterial Cell Wall 19 | |
| ➤ Specialized Membrane Structures 19 ➤ Cytoskeleton 20 ➤ Transport Mechanisms 20 | |
| ➤ Transport of Large Molecules 24 | |
| 3. Amino Acids and Proteins | 30 |
| ➤ Classification of Amino Acids 30 ➤ Properties of Amino Acids 33 | |
| ➤ General Reactions of Amino Acids 35 ➤ Amino Acid Derivatives of Importance 36 | |
| ➤ Proteins and Peptide Bond Formation 36 ➤ Structure of Proteins (Organization of Proteins) 37 | |
| ➤ Structure-Function Relationship 41 ➤ Study of Protein Structure 41 | |
| ➤ Chemical Synthesis of Peptides 43 ➤ Physical Properties of Proteins 43 | |
| ➤ Precipitation Reactions of Proteins 43 ➤ Classification of Proteins 45 | |
| ➤ Quantitative Estimation of Proteins 46 ➤ Proteomics 47 | |
| 4. Enzymology: General Concepts, Enzyme Kinetics, Isoenzymes and Clinical Enzymology | 56 |
| ➤ Classification of Enzymes 56 ➤ Coenzymes 58 ➤ Metalloenzymes 59 ➤ Cofactors 60 | |
| ➤ Mode of Action of Enzymes 60 ➤ Active Site or Active Center of Enzyme 62 | |
| ➤ Thermodynamic Considerations 64 ➤ Enzyme Kinetics 65 | |
| ➤ Factors Influencing Enzyme Activity 65 ➤ Specificity of Enzymes 73 | |
| ➤ Ribozymes 73 ➤ Enzyme Assays and Units 73 ➤ Body Metabolism is Controlled by Enzymes 74 | |
| ➤ Drug Metabolism 74 ➤ Enzyme Engineering 74 ➤ Drug Designing 74 | |
| ➤ Processive Enzymes 74 ➤ Multienzyme Complexes 74 ➤ Isoenzymes 75 | |
| ➤ Clinical Enzymology 76 ➤ Related Topics 80 | |
| 5. Chemistry of Carbohydrates | 90 |
| ➤ Functions of Carbohydrates 90 ➤ Nomenclature 90 ➤ Stereoisomers 90 | |
| ➤ Reactions of Monosaccharides 92 ➤ Disaccharides 96 ➤ Polysaccharides 97 | |
| ➤ Common Sugar Substitutes 100 ➤ Dietary Fiber 100 ➤ Aquasomes 100 | |
| ➤ Glycome and Glycomics 100 | |

6. Chemistry of Lipids 104

- Classification of Lipids 104 ➤ Classification of Fatty Acids 104 ➤ Saturated Fatty Acids 105
- Unsaturated Fatty Acids 106 ➤ Polyunsaturated Fatty Acids 106 ➤ Trans Fatty Acids 106
- Properties of Fatty Acids 106 ➤ Triglycerides 107 ➤ Ghee 108 ➤ Rancidity of Fat 108
- Classification of Compound Lipids 108 ➤ Phosphatides 109 ➤ Liposomes 109
- Biomembranes 110 ➤ Lecithin 110 ➤ Phospholipases 110 ➤ Pulmonary Surfactants 110
- Acute Respiratory Syndrome 110 ➤ Neonatal Hyaline Membrane Disease 111 ➤ Cephalin 111
- Plasmalogens 111 ➤ Sphingolipids 112 ➤ Sphingolmyelins 112 ➤ Glycolipids 112
- Cerebrosides 112 ➤ Gangliosides 112 ➤ Sulpholipids 112 ➤ Related Topics 112

SECTION 2: GENERAL METABOLISM**7. Citric Acid Cycle, Biological Oxidation and Electron Transport Chain 119**

- Stages of Oxidation of Foodstuffs 119 ➤ Citric Acid Cycle 120 ➤ Redox Potentials 127
- Biological Oxidation 128 ➤ High Energy Compounds 130 ➤ Electron Transport Chain 131
- Mitochondrial Transport Systems 139 ➤ Diseases Associated with Mitochondria 139

8. Metabolic Pathways of Glucose 146

- Digestion of Carbohydrates 146 ➤ Absorption of Carbohydrates 146 ➤ Glucose Metabolism 148
- Cori's Cycle or Lactic Acid Cycle 155 ➤ Metabolic Fate of Pyruvate 156 ➤ Gluconeogenesis 158
- Glycogen Metabolism 162 ➤ Glycogen Storage Diseases 166
- Hexose Monophosphate Shunt Pathway 166 ➤ Glucuronic Acid Pathway 171
- Polyol Pathway of Glucose 172 ➤ Related Topics 172

9. Regulation of Blood Glucose, Insulin and Diabetes Mellitus 180

- Regulation of Blood Glucose 180 ➤ Reducing Substances in Urine 184 ➤ Insulin 186
- Hyperglycemic Hormones 190 ➤ Diabetes Mellitus 191 ➤ Obesity 194

10. Metabolic Pathways of Carbohydrates other than Glucose 207

- Fructose Metabolism 207 ➤ Galactose Metabolism 208 ➤ Metabolism of Alcohol 209
- Metabolism of Amino Sugars 212 ➤ Glycoproteins 212 ➤ Congenital Disorders of Glycosylation 214
- Mucopolysaccharidoses 214

11. Metabolism of Fatty Acids 220

- Digestion of Lipids 220 ➤ Absorption of Lipids 221 ➤ Beta-Oxidation of Fatty Acids 223
- Oxidation of Odd Chain Fatty Acids 227 ➤ Alpha Oxidation 227 ➤ Omega (Ω) Oxidation 228
- De Novo Synthesis of Fatty Acids 228 ➤ Synthesis of Triglycerides 232 ➤ Metabolism of Ketone Bodies 235

12. Cholesterol and Lipoproteins 243

- Cholesterol 244 ➤ Plasma Lipids 247 ➤ Apolipoproteins 249 ➤ Chylomicrons 250
- Very Low-density Lipoproteins 251 ➤ Low-density Lipoproteins 251
- High-density Lipoprotein 252 ➤ Free Fatty Acid 254 ➤ Formation of Bile Acids 255

13. Cardiovascular Diseases, Biomarkers of CVD and Hyperlipidemias 260

- Clinical Significance of Cholesterol 260 ➤ Atherosclerosis 260 ➤ Cardiac Biomarkers 262
- Hypolipoproteinemias 269 ➤ Hyperlipidemias 270
- Rheumatic Fever and Rheumatic Heart Disease (Rheumatic Carditis) 272 ➤ Hypertension 272

| | |
|---|------------|
| 14. Medium Chain Fatty Acid, Polyunsaturated Fatty Acid, Prostaglandins and Compound Lipids | 277 |
| ➤ Digestion of Medium Chain Fatty Acids 277 ➤ Very Long Chain Fatty Acids 277 | |
| ➤ Monounsaturated Fatty Acids 278 ➤ Polyunsaturated Fatty Acids 278 ➤ Synthesis of Compound Lipids 282 | |
| 15. General Amino Acid Metabolism: Urea Cycle and One-carbon Metabolism | 289 |
| ➤ Digestion of Proteins 289 ➤ Absorption of Amino Acids 291 ➤ Intracellular Protein Degradation 291 | |
| ➤ Nitrogen Balance 292 ➤ Interorgan Transport of Amino Acids 293 ➤ General Metabolism of Amino Acids 293 | |
| ➤ Formation of Ammonia 294 ➤ Disposal or Detoxification of Ammonia 296 ➤ Urea Cycle 297 | |
| ➤ Hyperammonemia 300 ➤ One-carbon Metabolism 301 | |
| 16. Metabolism of Aliphatic Amino Acids | 307 |
| ➤ Glycine 307 ➤ Serine 311 ➤ Alanine 312 ➤ Threonine 313 ➤ Methionine 313 | |
| ➤ Cysteine 315 ➤ Metabolism of Sulfur 317 ➤ Glutamic Acid 319 ➤ Glutamine 320 | |
| ➤ Aspartic Acid 321 ➤ Asparagine 321 ➤ Lysine 321 ➤ Arginine 322 ➤ Nitric Oxide 322 | |
| ➤ Polyamines 324 ➤ Branched-chain Amino Acids 325 | |
| 17. Aromatic and Heterocyclic Amino Acids | 332 |
| ➤ Phenylalanine 332 ➤ Tyrosine 332 ➤ Inborn Errors Associated with Phenylalanine 336 | |
| ➤ Tryptophan 339 ➤ Histidine 343 ➤ Proline and Hydroxyproline 344 | |
| ➤ Fate of Carbon Skeletons of Amino Acids 345 ➤ Aminoacidurias 345 | |
| 18. Inherited Metabolic Disorders, Inborn Errors of Metabolism, Prenatal Screening and Newborn Screening | 351 |
| ➤ General Considerations 351 ➤ Tests for Metabolic Disorders in Newborn 352 | |
| ➤ Prenatal Diagnosis 355 ➤ Prenatal Screening 356 ➤ Newborn Screening 357 | |
| 19. Overview of Metabolism and Metabolic Adaptations | 362 |
| ➤ Experimental Study of Metabolism 362 ➤ Metabolism 363 ➤ Homeostasis 364 | |
| ➤ Metabolic Profile Under Well-fed State 364 ➤ Metabolic Adaptations during Fasting 364 | |
| ➤ Metabolic Adaptations during Prolonged Starvation 365 | |
| ➤ Metabolic Profile of Important Organs 367 ➤ Glucose Utilization in Lungs 369 | |
| ➤ Metabolic Changes during Pregnancy 369 ➤ Metabolic Changes during Lactation 371 | |
| ➤ Metabolic Changes in Trauma and Critical Illness 371 | |
| ➤ Importance of Gluconeogenesis in Premature Infants 372 | |
| ➤ Lifestyle Diseases 372 ➤ Related Topics 373 | |
| 20. Heme and Hemoglobin (Pigment Metabolism) | 376 |
| ➤ Heme 376 ➤ Catabolism of Heme 383 ➤ Plasma Bilirubin 385 ➤ Structure of Hemoglobin 388 | |
| ➤ Transport of Oxygen by Hemoglobin 389 ➤ Transport of Carbon Dioxide 392 | |
| ➤ Embryonic Hemoglobins 392 ➤ Fetal Hemoglobin 393 ➤ Hemoglobin A2 393 | |
| ➤ Hemoglobin Derivatives 394 ➤ Hemoglobin (Globin Chain) Variants 395 ➤ Anemias 400 | |

SECTION 3: CLINICAL AND APPLIED BIOCHEMISTRY

| | |
|---|------------|
| 21. Liver and Gastric Function Tests | 413 |
| ➤ Functions of Liver 414 ➤ Clinical Manifestations of Liver Dysfunction 415 | |
| ➤ Liver Function Tests 415 ➤ Reye Syndrome (Hepatic Mitochondrial Damage) 422 | |
| ➤ Gastric Function 422 ➤ Pancreatic Function Tests 424 ➤ Studies on Malabsorption 425 | |

| | |
|---|------------|
| 22. Kidney Function Tests | 429 |
| ➤ Renal Function Tests 429 ➤ Abnormal Constituents of Urine 431 ➤ Markers of GFR 433 | |
| ➤ Markers of Glomerular Permeability 437 ➤ Tests for Tubular Function 439 | |
| ➤ Immunological Tests in Renal Diseases 440 | |
| 23. Plasma Proteins | 444 |
| ➤ Electrophoresis 444 ➤ Albumin 446 ➤ Transport Proteins 448 ➤ Acute Phase Proteins 449 | |
| ➤ Clotting Factors 451 | |
| 24. Acid-Base Balance and pH | 458 |
| ➤ Acids and Bases 459 ➤ Buffers 460 ➤ Buffers of the Body Fluids 461 ➤ Respiratory Regulation of pH 462 | |
| ➤ Renal Regulation of pH 463 ➤ Cellular Buffers 465 ➤ Disturbances in Acid-Base Balance 466 | |
| ➤ Assessment of Acid-Base Parameters 472 ➤ Normal Serum Electrolyte Values 473 | |
| ➤ Related Topics 473 | |
| 25. Water Balance, Electrolyte Balance (Sodium, Potassium, Chloride, Magnesium) and Body Fluids | 477 |
| ➤ Water Balance 477 ➤ Sodium 482 ➤ Potassium 484 ➤ Chloride 486 ➤ Magnesium 486 | |
| ➤ Phosphate 487 ➤ Body Fluids 488 | |
| 26. Free Radicals and Antioxidants | 495 |
| ➤ Generation of Free Radicals 496 ➤ Free Radical Scavenger Systems 497 | |
| ➤ Damage Produced by Reactive Oxygen Species 497 ➤ Clinical Significance 498 | |
| ➤ Lipid Peroxidation 499 ➤ Role of Antioxidants 500 ➤ Related Topics 501 | |
| 27. Detoxification and Biotransformation of Xenobiotics | 503 |
| ➤ Phase One Reactions 504 ➤ Phase Two Reactions; Conjugations 505 | |
| ➤ Phase Three Reactions 507 ➤ Related Topics 508 | |

SECTION 4: NUTRITION

| | |
|---|------------|
| 28. Fat Soluble Vitamins (A, D, E and K) | 513 |
| ➤ Vitamin A 513 ➤ Vitamin D (Cholecalciferol) 519 ➤ Vitamin E 523 ➤ Vitamin K 524 | |
| 29. Water-soluble Vitamins | 530 |
| ➤ B Complex Group of Vitamins 530 ➤ Thiamine (Vitamin B ₁) 531 ➤ Riboflavin (Vitamin B ₂) 532 | |
| ➤ Niacin 534 ➤ Vitamin B ₆ 536 ➤ Pantothenic Acid 537 ➤ Biotin 539 ➤ Folic Acid 540 | |
| ➤ Vitamin B ₁₂ 543 ➤ Choline 547 ➤ Inositol 547 ➤ Ascorbic Acid (Vitamin C) 548 | |
| 30. Mineral Metabolism and Abnormalities | 558 |
| ➤ Calcium (Ca ⁺⁺) 559 ➤ Phosphorus 566 ➤ Sulfur 566 ➤ Iron (Fe) 567 ➤ Copper (Cu) 574 | |
| ➤ Iodine 575 ➤ Zinc (Zn) 575 ➤ Fluoride 576 ➤ Selenium (Se) 576 ➤ Manganese (Mn) 577 | |
| ➤ Molybdenum (Mo) 577 ➤ Cobalt (Co) 577 ➤ Nickel (Ni) 577 ➤ Chromium (Cr) 578 | |
| ➤ Lithium (Li) 578 ➤ Related Topics 578 | |
| 31. Energy Metabolism and Nutrition | 583 |
| ➤ Calorific Value 583 ➤ Respiratory Quotient 583 ➤ Energy Requirements of a Normal Person 584 | |
| ➤ Requirements of Dietary Nutrients 586 ➤ Proximate Principles 586 ➤ Protein Energy Malnutrition 590 | |
| ➤ Obesity 592 ➤ Regulators of Appetite 592 ➤ Adipose Tissue Talks to Brain through Factors 592 | |
| ➤ Prescription of Diet 593 ➤ Human Microbiota and Microbiome 600 | |

32. Heavy Metal Poisons and Environmental Pollution 606

- Heavy Metal Poisons 606 ➤ Corrosives 608 ➤ Cyanide Poisoning 608
- Carbon Monoxide Poisoning 608 ➤ Irritants 608 ➤ Pesticides and Insecticides 608
- Occupational and Industrial Hazards 609 ➤ Air Pollutants 609 ➤ Toxic Substances in Foodstuffs 610
- Pollutants in Household 611 ➤ Cosmetics and Toxicity 611 ➤ Related Topics 612

SECTION 5: MOLECULAR BIOLOGY**33. Nucleotides: Chemistry and Metabolism 617**

- Composition of Nucleotides 617 ➤ Functions of Nucleotides 617 ➤ Nucleosides 618
- Nucleotides 618 ➤ Nucleoside Triphosphates 619 ➤ Cyclic Nucleotides 620
- Digestion of Nucleic Acids 620 ➤ Biosynthesis of Purine Nucleotides 620
- Degradation of Purine Nucleotides 624 ➤ Disorders of Purine Metabolism 625
- De Novo Synthesis of Pyrimidine 627 ➤ Disorders of Pyrimidine Metabolism 629
- Deoxyribonucleotide Formation 629 ➤ Combined Regulation of Purine and Pyrimidine Synthesis 629
- Synthesis of Deoxythymidine Nucleotides 630
- Anticancer Agents Acting on Pyrimidine Synthesis or Pyrimidine Analogues 630
- Degradation of Pyrimidine Nucleotides 630

34. Deoxyribonucleic Acid: Structure, Organization and Replication 635

- Structure of DNA 635 ➤ Replication of DNA 639 ➤ Elongation of DNA Strand 641
- Discontinuous Synthesis and Okazaki Pieces 642 ➤ Condensation into Chromatin Structure 643
- Modification after Replication 643 ➤ Cell Cycle 644 ➤ DNA Repair Mechanisms 644
- Telomere and Telomerase 646 ➤ Hydrolysis of DNA 647 ➤ Inhibitors of DNA Replication 647

35. Transcription and Translation 651

- Ribonucleic Acid 651 ➤ Central Dogma of Molecular Biology 652 ➤ Transcription Process 652
- Protein Biosynthesis 657 ➤ Genetic Code 659 ➤ Translation Process 660 ➤ Mitochondrial DNA 665
- Micro-RNA 666 ➤ Interfering RNA or RNAi or siRNA 666 ➤ Antisense Therapy 667
- Aptamers 667 ➤ Genomics and Proteomics 667

36. Inheritance, Mutations, Cell Cycle and Control of Gene Expression 673

- Basic Principles of Heredity 673 ➤ Genetic Disorders 676 ➤ Mutations 676
- Cell Cycle 680 ➤ Apoptosis (Programmed Cell Death) 681
- Regulation of Gene Expression 683

37. Recombinant DNA Technology and Gene Therapy 690

- Recombinant DNA Technology 690 ➤ Restriction Endonucleases 691 ➤ Vectors 692
- Procedure of DNA Recombination 692 ➤ Gene Library 694 ➤ Linkage Analysis 695 ➤ CRISPR-CAS9 696
- Gene Therapy 697 ➤ Animal Cloning 699 ➤ Stem Cells 700 ➤ Related Topics 701

38. Molecular Diagnostics 703

- DNA Preparation 703 ➤ Magnetic Beads based Extraction 703 ➤ RNA Extraction 703
- Hybridization Techniques 704 ➤ Applications of DNA Hybridization in Medicine 705
- Polymerase Chain Reaction 707 ➤ Mutation Detection Techniques 710 ➤ DNA Sequencing 712
- Next Generation Sequencing 712 ➤ Third Generation Sequencing 712
- Fourth Generation Sequencing 713

SECTION 6: ADVANCED BIOCHEMISTRY

| | |
|--|------------|
| 39. Clinical Laboratory Practice: Laboratory Instrumentation, Techniques and Quality Control | 719 |
| <ul style="list-style-type: none"> ➤ Electrophoresis 719 ➤ Ultracentrifugation 721 ➤ Chromatography 722 ➤ Immunoassays 724 ➤ Colorimeter 727 ➤ Spectrophotometer 728 ➤ Chemiluminescence 728 ➤ Flame Photometer 730 ➤ Ion Selective Electrodes 730 ➤ The pH Meter 730 ➤ Biosensors 731 ➤ Mass Spectrometry 732 ➤ Interpretation of Laboratory Data 733 ➤ Specimen Collection 735 ➤ Quality Control 736 ➤ Laboratory Safety 738 ➤ Related Topics 738 | |
| 40. Immunochemistry | 742 |
| <ul style="list-style-type: none"> ➤ Innate and Adaptive Immunity 743 ➤ Antigens 743 ➤ Immune Response 743 ➤ Structure of Immunoglobulins 744 ➤ Different Classes of Immunoglobulins 745 ➤ Paraproteinemias 747 ➤ Complement System 748 ➤ Immunodeficiency States 749 ➤ Primary and Secondary Immune Responses 749 ➤ Transposition of Genes 750 ➤ Gene, Cistron, Split Gene and Polypeptide 750 ➤ Molecular Structure of Antigens 750 ➤ Soluble Factors 751 ➤ Hybridoma Technology and Monoclonal Antibodies 753 ➤ Concepts Involved in Development of Vaccines 755 | |
| 41. Biochemistry of COVID-19 and AIDS | 758 |
| <ul style="list-style-type: none"> ➤ Viruses in General 758 ➤ Coronavirus Disease 759 ➤ RT-PCR 762 ➤ Epidemic of Acquired Immunodeficiency Syndrome 764 ➤ Human Immunodeficiency Virus 765 ➤ Immunology of AIDS 766 ➤ Laboratory Diagnosis 766 ➤ Anti-retroviral Therapy Against HIV 767 ➤ Prevention 767 | |
| 42. Biochemistry of Cancer | 770 |
| <ul style="list-style-type: none"> ➤ Etiology of Cancer 770 ➤ Oncogenic Viruses 772 ➤ Oncogenes 774 ➤ Oncosuppressor Genes 775 ➤ Growth Factors 776 ➤ Differences between Normal and Tumor Cells 776 ➤ Tumor Immunology 778 ➤ Tumor Markers 779 ➤ Anticancer Drugs 781 ➤ Related Topics 783 | |
| 43. Extracellular Matrix and Tissue Proteins in Health and Diseases | 785 |
| <ul style="list-style-type: none"> ➤ Extracellular Matrix 785 ➤ Collagen 786 ➤ Elastin 788 ➤ Keratins 789 ➤ Contractile Proteins 789 ➤ Muscle Proteins 789 ➤ Cellular and Subcellular Movements 792 ➤ Lens Proteins 793 ➤ Nerve Cells 793 ➤ Prions 795 ➤ Biochemistry of Aging 797 ➤ Snake Venom 799 | |
| 44. Hormones | 802 |
| <ul style="list-style-type: none"> ➤ Hormones Acting through Cyclic AMP 803 ➤ Calcium-based Signal Transduction 805 ➤ Hormones Acting through PIP2 Cascade 805 ➤ Hormones with Intracellular Receptors 806 ➤ Hypothalamic Hormones 807 ➤ Hormones of Anterior Pituitary 808 ➤ Adrenal Cortical Hormones 811 ➤ Sex Hormones 815 ➤ Thyroid Hormones 817 ➤ Gut Hormones 820 ➤ Growth Factors and Growth Factor Receptors 821 ➤ Related Topics 823 | |
| 45. Isotopes and Nanomedicine | 827 |
| <ul style="list-style-type: none"> ➤ Isotopes 827 ➤ Atomic Number and Atomic Weight 828 ➤ Radioactivity 828 ➤ Biological Effects of Radiation 832 ➤ Radiation Protection 833 ➤ Bioinformatics 833 ➤ Computational Drug Designing 834 ➤ Nanomedicine 834 ➤ Bioprinting 835 | |
| Appendices | 837 |
| <i>Index</i> | 865 |

Competencies as per MCI-CBME Curriculum

| Competency code | Competency | Chapter number in this textbook |
|---|---|---------------------------------|
| Topic: Biochemical Basis of Life | | |
| BI-1.1 | Describe the molecular and functional organization of a cell and its sub-cellular components | 2 |
| Topic: Enzymology | | |
| BI-2.1 | Explain fundamental concepts of enzyme, isoenzyme, alloenzyme, coenzyme and cofactors. Enumerate the main classes of enzymes according to IUBMB nomenclature | 4 |
| BI-2.2 | Observe the estimation of SGOT & SGPT | 4 |
| BI-2.3 | Describe and explain the basic principles of enzyme activity | 4 |
| BI-2.4 | Describe and discuss enzyme inhibitors as poisons and drugs as therapeutic enzymes | 4 |
| BI-2.5 | Describe and discuss the clinical utility of various serum enzymes as markers of pathological conditions | 4, 13, 21 |
| BI-2.6 | Discuss use of enzymes in laboratory investigations (Enzyme-based analysis) | 4 |
| BI-2.7 | Interpret laboratory results of enzyme activities and describe the clinical utility of various enzymes as markers of pathological conditions | 4, 13, 21 |
| Topic: Carbohydrates, chemistry and metabolism | | |
| BI-3.1 | Discuss and differentiate monosaccharides, di-saccharides and polysaccharides giving examples of main carbohydrates as energy fuel, structural element, and storage in the human body | 5 |
| BI-3.2 | Describe the processes involved in digestion and assimilation of carbohydrates from food | 8 |
| BI-3.3 | Describe and discuss the digestion and estimation of carbohydrates from food | 8 |
| BI-3.4 | Define and differentiate the pathways of carbohydrate metabolism (Glycolysis, gluconeogenesis, glycogen metabolism, HMP shunt) | 8 |
| BI-3.5 | Describe and discuss the regulation, functions and integration of carbohydrate along with associated diseases/disorders | 9, 10 |
| BI-3.6 | Describe and discuss the concepts of TCA cycle as a amphibolic pathway and its regulation | 7 |
| BI-3.7 | Describe the common poisons that inhibit crucial enzymes of carbohydrate (Flouride/arsenite) | 7 |
| BI-3.8 | Discuss and interpret laboratory results of analytes associated with metabolism of carbohydrates | 5 |
| BI-3.9 | Discuss the metabolism and significance of blood glucose regulation in health and disease | 9 |
| BI-3.10 | Explain the basis and rationale of biochemical tests done in the following conditions: diabetes mellitus | 9 |
| Topic: Lipids, chemistry and metabolism | | |
| BI-4.1 | Describe and discuss main classes of lipids (Essential/non-essential fatty acids, cholesterol and hormonal steroids, triglycerides, major phospholipids and sphingolipids) relevant to human system and their major functions | 6, 12 |

(Contd...)

(Contd...)

| Competency code | Competency | Chapter number in this textbook |
|--|--|---------------------------------|
| Topic: Lipids, chemistry and metabolism | | |
| BI-4.2 | Describe the processes involve in digestion and absorption of dietary lipids and key features of their metabolism | 11 |
| BI-4.3 | Explain the regulation of lipoprotein metabolism and associated disorders | 12 |
| BI-4.4 | Describe the structure and function of lipoproteins, their functions, interrelations and relations with atherosclerosis | 12, 13 |
| BI-4.5 | Interpret laboratory results of analytes associated with metabolism of lipids | 13 |
| BI-4.6 | Describe the therapeutic uses of prostaglandins and inhibitors of eicosanoid synthesis | 14 |
| BI-4.7 | Interpret laboratory results of analytes associated with metabolism of lipids | 13, 44 |
| Topic: Proteins, chemistry and metabolism | | |
| BI-5.1 | Describe and discuss structural organization of proteins | 3 |
| BI-5.2 | Describe and discuss functions of proteins and structure-function relationship in relevant areas, e.g., hemoglobin and selected hemoglobinopathies | 3, 20 |
| BI-5.3 | Describe the digestion and absorption of dietary proteins | 15 |
| BI-5.4 | Describe common disorders associated with protein metabolism | 15, 16, 17, 18 |
| BI-5.5 | Interpret laboratory results of analytes associated with metabolism of proteins | 15,17,18, 22 |
| BI-6.1 | Discuss the metabolic processes that take place in specific organs in the body in the fed and fasting states | 19, 8, 9 |
| BI-6.2 | Describe and discuss the metabolic processes in which nucleotides are involved | 33 |
| BI-6.3 | Describe the common disorders associated with nucleotide metabolism | 33 |
| BI-6.4 | Discuss the laboratory results of analytes associated with gout and Lesch Nyhan syndrome | 33 |
| BI-6.5 | Describe the biochemical role of vitamins in the body and explain the manifestations of their deficiency | 28, 29 |
| BI-6.6 | Describe the biochemical processes involved in generation of energy in cells | 7 |
| BI-6.7 | Describe the processes involved in maintenance of normal pH, water and electrolyte balance of body fluids and the derangements associated with these | 24, 25 |
| BI-6.8 | Discuss and interpret results of arterial blood gas (ABG) analysis in various disorders | 24 |
| BI-6.9 | Describe the functions of various minerals in the body, their metabolism and homeostasis | 30, 32 |
| BI-6.10 | Enumerate and describe the disorders associated with mineral metabolism | 30, 32 |
| BI-6.11 | Describe the functions of heme in the body and describe the processes involved in its metabolism and describe porphyrin metabolism | 20 |
| BI-6.12 | Describe the major types of hemoglobin and its derivatives found in the body and their physiological/pathological relevance | 20 |
| BI-6.13 | Describe the functions of the kidney, liver, thyroid and adrenal glands | 21, 22, 44 |
| BI-6.14 | Describe the tests that are commonly done in clinical practice to assess the functions of these organs (kidney, liver, thyroid and adrenal glands) | 21, 22, 44 |
| BI-6.15 | Describe the abnormalities of kidney, liver, thyroid and adrenal glands | 21, 22, 44 |
| Topic: Molecular Biology | | |
| BI-7.1 | Describe the structure and functions of DNA and RNA and outline the cell cycle. | 34, 35, 36 |
| BI-7.2 | Describe the processes involved in replication and repair of DNA and the transcription and translation mechanisms | 34, 35 |

(Contd...)

(Contd...)

| Competency code | Competency | Chapter number in this textbook |
|--|--|---------------------------------|
| Topic: Molecular Biology | | |
| BI-7.3 | Describe gene mutations and basic mechanism of regulation of gene expression | 36 |
| BI-7.4 | Describe applications of molecular technologies like recombinant DNA technology, PCR in the diagnosis and treatment of diseases with genetic basis | 37, 38 |
| BI-7.5 | Describe the role of xenobiotics in disease | 27 |
| BI-7.6 | Describe the anti-oxidant defence systems in the body | 26 |
| BI-7.7 | Describe the role of oxidative stress in the pathogenesis of conditions such as cancer, complications of diabetes mellitus and atherosclerosis | 9, 26, 42, 13 |
| Topic: Nutrition | | |
| BI-8.1 | Discuss the importance of various dietary components and explain importance of dietary fiber | 31 |
| BI-8.2 | Describe the types and causes of protein energy malnutrition and its effects | 31 |
| BI-8.3 | Provide dietary advice for optimal health in childhood and adult, in disease conditions like diabetes mellitus, coronary artery disease and in pregnancy | 31 |
| BI-8.4 | Describe the causes (including dietary habits), effects and health risks associated with being overweight/obesity | 9, 31 |
| BI-8.5 | Summarize the nutritional importance of commonly used items of food including fruits and vegetables (macro-molecules and its importance) | 31 |
| Topic: Extracellular matrix | | |
| BI-9.1 | List the functions and components of the extracellular matrix (ECM) | 43 |
| BI-9.2 | Discuss the involvement of ECM components in health and disease | 43 |
| BI-9.3 | Describe protein targeting and sorting along with its associated disorders | 35 |
| Topic: Oncogenesis and immunity | | |
| BI-10.1 | Describe the cancer initiation, promotion oncogenes and oncogene activation. Also focus on p53 and apoptosis | 42 |
| BI-10.2 | Describe various biochemical tumor markers and the biochemical basis of cancer therapy | 42 |
| BI-10.3 | Describe the cellular and humoral components of the immune system and describe the types and structure of antibody | 40 |
| BI-10.4 | Describe and discuss innate and adaptive immune responses, self/non-self recognition and the central role of T-helper cells in immune responses | 40 |
| BI-10.5 | Describe antigens and concepts involved in vaccine development | 40 |
| Topic: Biochemical laboratory tests | | |
| BI-11.1 | Describe commonly used laboratory apparatus and equipments, good safe laboratory practice and waste disposal | 39 |
| BI-11.2 | Describe the preparation of buffers and estimation of pH | 24 |
| BI-11.3 | Describe the chemical components of normal urine | 22 |
| BI-11.4 | Perform urine analysis to estimate and determine normal and abnormal constituents | 22 |
| BI-11.5 | Describe screening of urine for inborn errors and describe the use of paper chromatography | 18, 39 |
| BI-11.6 | Describe the principles of colorimetry | 39 |
| BI-11.7 | Demonstrate the estimation of serum creatinine and creatinine clearance | 22 |
| BI-11.8 | Demonstrate estimation of serum proteins, albumin and A:G ratio | 23 |
| BI-11.9 | Demonstrate the estimation of serum total cholesterol and HDL Cholesterol | 13 |
| BI-11.10 | Demonstrate the estimation of triglycerides | 13 |

(Contd...)

(Contd...)

| Competency code | Competency | Chapter number in this textbook |
|--|--|---------------------------------|
| Topic: Biochemical laboratory tests | | |
| BI-11.11 | Demonstrate estimation of calcium and phosphorous | 30 |
| BI-11.12 | Demonstrate the estimation of serum bilirubin | 20 |
| BI-11.13 | Demonstrate the estimation of SGOT/ SGPT | 21, 4 |
| BI-11.14 | Demonstrate the estimation of alkaline phosphatase | 21 |
| BI-11.15 | Describe and discuss the composition of CSF | 25 |
| BI-11.16 | Observe use of commonly used equipments/techniques in biochemistry laboratory including: | |
| | pH meter | 39 |
| | Paper chromatography of amino acid | 39 |
| | Protein electrophoresis | 39 |
| | TLC, PAGE | 39 |
| | Electrolyte analysis by ISE | 39 |
| | ABG analyzer | 39 |
| | ELISA | 39 |
| | Immunodiffusion | 39 |
| | Autoanalyser | 39 |
| | Quality control | 39 |
| | DNA isolation from blood/ tissue | 38 |
| BI-11.17 | Explain the basis and rationale of biochemical tests done in the following conditions: | |
| | Diabetes mellitus | 9 |
| | Dyslipidemia | 13 |
| | Myocardial infarction | 13 |
| | Renal failure | 22 |
| | Gout | 33 |
| | Proteinuria | 22 |
| | Nephrotic syndrome | 22 |
| | Edema | 23 |
| | Jaundice | 20 |
| | Liver diseases | 21 |
| | Pancreatitis | 22 |
| | Disorders of acid- base balance | 24 |
| | Thyroid disorders | 44 |
| BI-11.18 | Discuss the principles of spectrophotometry | 3, 39 |
| BI-11.19 | Outline the basic principles involved in the functioning of instruments commonly used in a biochemistry laboratory and their applications | 39 |
| BI-11.20 | Identify abnormal constituents in urine, interpret the findings and correlate these with pathological states | 22 |
| BI-11.21 | Demonstrate estimation of glucose, creatinine, urea and total protein in serum | 9, 22, 23 |
| BI-11.22 | Calculate albumin: globulin (AG) ratio and creatinine clearance | 22, 23 |
| BI-11.23 | Calculate energy content of different food items, identify food items with high and low glycemic index and explain the importance of these in the diet | 31 and Appendix V |
| BI-11.24 | Enumerate advantages and/or disadvantages of use of unsaturated, saturated and trans fats in food | 14, 31 |