

Contents of Volumes 1 and 2

Volume 1

Section I General Physiology

1. Cell Physiology: Structure and Functions of Cell Organelle
2. Homeostasis
3. Transport Across Cell Membrane
4. Membrane Potential
5. Body Fluids and Blood Volume
- Clinical Case Scenario

Section II Blood

6. Composition and Functions of Blood
7. Specific Gravity of Blood
8. Plasma Proteins
9. Viscosity and Erythrocyte Sedimentation Rate (ESR)
10. Coagulation of Blood
11. Bone Marrow
12. Red Blood Corpuscles (Erythrocytes)
13. Haemoglobin
14. Iron Absorption, Transport, Storage and Excretion
15. Anaemia, Polycythemia, Osmotic Fragility and Blood Indices
16. White Blood Cells and Platelets
17. Blood Groups and Blood Transfusion
18. Formation of Tissue Fluids
19. Immunity
- Clinical Case Scenario

Section III Nerve and Muscle

20. Structure and Functions of Neuron
21. Properties, Classification of Nerve Fibres and Nerve Action Potential
22. Neuromuscular Junction
23. Classification of Muscular Tissue
24. Structure of Skeletal Muscle
25. Muscle Contraction
26. Properties of Skeletal Muscle
27. Cardiac Muscle
28. Smooth Muscles
- Clinical Case Scenario

Section IV Cardiovascular System

29. Introduction to Cardiovascular System
30. Initiation and Spread of Cardiac Impulse
31. Properties of Cardiac Muscle
32. Cardiac Cycle
33. Haemodynamics of Circulatory System and Pressure and Volume Changes during Cardiac Cycle
34. Electrocardiogram
35. Innervations of Heart and Heart Rate
36. Cardiac Output
37. Blood Pressure
38. Velocity of Blood Flow and Radial Pulse
39. Regional Circulation
40. Physiology of Exercise
41. Applied Cardiovascular Physiology: Haemorrhage, Heart Failure, Hypotension, Hypertension and Shock
- Clinical Case Scenario

Section V Respiratory System

42. Functional Organization of Respiratory System
43. Mechanics of Breathing
44. Pulmonary Volumes and Capacities (Spirometry)
45. Alveolar Ventilation and Gases Exchange in Lungs
46. Ventilation and Perfusion in Lungs
47. Transport of Oxygen and Carbon Dioxide in Blood
48. Regulation of Respiration
49. Hypoxia
50. Compressed Air Sickness and Deep Sea Diving
51. Respiration in Abnormal Conditions
52. Artificial Respiration or Resuscitation
53. Acclimatisation
54. Underwater Physiology
55. Vocalisation
- Clinical Case Scenario

Section VI Gastro-intestinal Tract

56. General Outline of Digestive System
57. Digestive Juices
58. Mechanism of Secretion of Various Digestive Juices
59. Movements of Alimentary Canal
60. Digestion and Absorption of Foodstuffs
61. Gastro-intestinal Hormones
- Clinical Case Scenario

Section VII Renal Physiology

62. Functional Anatomy of Excretory System
63. Urine Formation by Kidneys: Renal Blood Flow and their Control
64. Urine Formation by the Kidney: Glomerular Filtration Rate and their Control
65. Tubular Reabsorption and Tubular Secretion (Urine Formation): Water and Electrolytes Balance and Counter-current Mechanism
66. Renal Function Test, Urine, Urinary Characteristic and its Mechanism of Formation
67. Micturition
68. Skin, Body Temperature and its Regulation
69. Regulation of Reaction of Blood and Disturbances in Acid-Base Regulation
- Clinical Case Scenario

Multiple Choice Questions and Vice Voce

Volume 2

Section VIII Endocrines

70. Introduction to Endocrine Gland, Endocrine Hormones and Endocrine Disorders
71. Hypophysis (Pituitary Gland)
72. Thyroid Gland
73. Calcium Homeostasis: Role of Parathyroid Gland
74. Pancreas
75. Adrenal (Suprarenal) Glands
76. Local Hormones
77. Thymus
78. The Pineal Body
- Clinical Case Scenario

Section IX Reproductive System

79. Gonads and Reproduction
80. Male Reproductive Organs
81. Female Reproductive Organs
82. Pregnancy
83. Parturition
84. Foetal Circulation
85. Development of Breast and Lactation
86. Controlled Reproduction and Family Planning
- Clinical Case Scenario

Section X Nervous System

87. Introduction to Nervous System
88. General Principles of the Nervous System
89. Synapse
90. Nerve Endings and Receptors
91. Reflex Action
92. Sensory Systems
93. Arrangement of Grey and White Matters in the Spinal Cord
94. The Ascending and Descending Tracts
95. Brainstem
96. Cerebellum
97. Thalamus
98. Mammillary Bodies and Internal Capsule
99. The Basal Ganglia
100. The Reticular Formation
101. Muscle Tone and Posture
102. Vestibular Apparatus
103. Path of Vestibular Impulse
104. Cerebrum
105. Limbic Lobe and Limbic System
106. Speech
107. Neurophysiology of Learning and Memory
108. Sleep
109. Emotion
110. Cerebrospinal Fluid
111. Autonomic Nervous System
112. Hypothalamus
113. Neurosecretion
114. Cranial Nerves
- Clinical Case Scenario

Section XI Special Senses

115. Sense of Taste
116. Sense of Smell (Olfaction)
117. Physiology of Vision
118. Hearing
- Clinical Case Scenario

Multiple Choice Questions and Vice Voce

Contents

Preface to the Fifteenth Edition

Preface to the First Edition

Index of Competencies

v

vi

xix

Section I General Physiology

1. Cell Physiology: Structure and Functions of Cell Organelle 2

- Introduction 2
- Cell Structure 2
 - Cell Membrane 2
 - Cytoplasm and its Organelles 4
 - Nucleus 6
- Chromatin 7
 - Chromosomes 7
- Applied Physiology 7
- Intercellular Communication and Mode of Communication 7
- Special Structural Features of Cell and Intercellular Communication 7
- Molecular Motors 9
- Apoptosis 9
- Applied Physiology 9
- Methods used to Demonstrate the Functions of the Cells and its Product 10
- Exam-oriented Questions 13

2. Homeostasis 14

- Introduction 14
 - Role of Various Systems of Body in Homeostasis 14
 - Role of Neuroendocrine Reflex in Homeostasis 14
- Feedback Homeostasis Regulations 15
 - Examples of Negative Feedback Mechanism 15
 - Examples of Positive Feedback Mechanism 16
 - Internal Factors Influencing Homeostasis 17
 - External Factors Influencing Homeostasis 17
- Exam-oriented Questions 17

3. Transport Across Cell Membrane 18

- Introduction 18
 - Introducing to Key Terms and Concepts 18
- Important Concepts in Transport Mechanism 18
 - Ion Channels 18
 - Types of Transport Mechanism 19
 - Characteristic Features 21
 - Osmosis 21
- Membrane Transport: Active Transport 22
 - Primary Active Transport 22
 - Secondary Active Transport 23
- Vesicular Transport Mechanisms 25
 - Transport through Cellular Sheets 26
 - Applied Physiology 26
- Exam-oriented Questions 26

4. Membrane Potential 27

- Introduction 27
- Role of Ion in Generating Membrane Potential 27
 - Ionic Mechanisms of Resting Potentials 27
- Physico-chemical Principles Involved in Generating RMP 27
 - Nernst Potential 27
 - Goldman-Hodgkin and Katz (GHK) Equation 27
 - Gibbs-Donnan Membrane Equilibrium 27
- Recording of Membrane Potential 28
- Graded Potential and Action Potential 28
 - Introduction 28
 - Terms Associated with Membrane Potential 29
- Graded Potential 29
 - Local Response of Graded Potential 29
 - Types of Graded Potential 29
 - Summation of Graded Potential 29
- Action Potential 29
 - Characteristics of Action Potential 30
 - Nerve Stimulation and Phases of Action Potential 30
 - Ionic Basis of Action Potential 31
 - Cardiac Action Potentials 31
- Property of Action Potential 32
- Ion Channel Studies 33
 - Procedures 33
- Exam-oriented Questions 33

5. Body Fluids and Blood Volume 34

- Introduction 34
- Total Body Water and its Distribution 34
 - Extracellular Fluid Compartment 34
- Blood Volume 35
- Methods of Determination of Blood Volume 35
 - Blood Volume 35
 - Measurement of Plasma Volume 35
 - Measurement of Interstitial Fluid Volume 35
 - Interstitial Fluid (IF) 35
 - Intracellular Fluid Compartment (ICF) 35
- Measurement of Body Fluid Compartments 36
- Total Body Water 36
- Extracellular Fluid Volume 36
 - Intracellular Fluid Measurement 36
 - Hydrogen Ion Concentration of the Body Fluids 37
 - Regulation of Body Fluid Volume 37
 - Exogenous and Endogenous Water Input 37
 - Water Excretion and its Daily Output 37
 - Maintenance of Electrolyte Balance 37
 - Potassium Conc and its Balance 37
 - Disorders of Fluid Volume 38
- Exam-oriented Questions 38
- Clinical Case Scenario 39
 - General Physiology 39

Section II Blood

6. Composition and Functions of Blood 42

- Introduction 42
- Properties of Blood 42
- Composition of Blood 42
- Functions of Blood 42
- Relative Volume of Corpuscles and Plasma 43
- Exam-oriented Questions 44

7. Specific Gravity of Blood 45

- Introduction 45
- Rise in Specific Gravity 45
- Fall in Specific Gravity 45
- Method of Determination 45
- Exam-oriented Questions 45

8. Plasma Proteins 46

- Introduction 46
- Plasma Proteins Varieties 46
- Origin of Plasma Proteins 46
- Rate of Regeneration of Plasma Proteins: Whipple's Experiment 46
- Whipple's Experiment 46
- Relation of Diet to Plasma Proteins 46
- Functions of Plasma Protein 47
- Exam-oriented Questions 47

9. Viscosity and Erythrocyte Sedimentation Rate (ESR) 48

- Introduction 48
- Viscosity: Characteristics 48
- Suspension Stability of Blood (Erythrocyte Sedimentation Rate or ESR) 48
- ESR Increased and Decreased 49
- Significance of ESR 49
- Physiological Variations in ESR 49
- Exam-oriented Questions 49

10. Coagulation of Blood 50

- Introduction 50
- Importance of Coagulation of Blood 50
- General Characteristics of Coagulation 50
- Blood Coagulation Factors 51
- Factor I or Fibrinogen 51
- Factor II or Prothrombins 51
- Factor III or Thromboplastin 51
- Factor IV or Calcium 51
- Factor V or Labile Factor Accelerator Globulin or Proaccelerin 51
- Factor VII or Stable Factor or Proconvertin 51
- Factor VIII or Antihæmophilic Factor (AHF) or Antihæmophilic Globulin (AHG) or Platelet Cofactor I 51
- Factor IX or Christmas Factor or Plasma Thromboplastin Component (PTC) or Platelet Cofactor II 52
- Factor X or Stuart Factor 52
- Factor XI or Plasma Thromboplastin Antecedent (PTA) 52
- Factor XII or Hageman or Surface Factor 52
- Factor XIII or Fibrin-stabilising or Laki-Lorand Factor (LLF) 52
- Fitzgerald Factor also known as High Molecular Weight Kininogen 52
- Fletcher Factor also known as Prekallikrein 52
- Other Important Factors Participating in Coagulation Mechanism 52

Thrombomodulin 52

Protein C 52

Protein S 52

Anti-thrombin III 52

Tissue Factor Pathway Inhibitor 52

Extrinsic and Intrinsic Mechanisms of Coagulation of Blood 52

Clot Retraction 53

Fibrinolysis 54

Plasminogen 54

Natural Inhibitors of Coagulation 55

Antithrombin Activities Remove Thrombin from Blood 55

Intravascular Clotting or Thrombosis 55

Thrombus 55

Heparin as an anticoagulant 55

Characteristics 55

Applied Physiology 55

Coagulation Disorders 55

Bleeding Disorders 56

Exam-oriented Questions 58

11. Bone Marrow 59

- Introduction 59
- Key Points 59
- Red Bone Marrow 59
- Yellow Bone Marrow 59
- Vascular Arrangement in the Bone Marrow 59
- Functions of Bone Marrow 59
- Formed Elements of Blood 59
- Precursors of Blood Cells 60
- Applied Physiology: Bone Marrow Biopsy 62
- Exam-oriented Questions 62

12. Red Blood Corpuscles (Erythrocytes) 63

- Introduction 63
- Size, Volume, Thickness, etc. of Red Blood Corpuscles 63
- Cytoplasm of the Red Cells 63
- Normal Red Cell Count 63
- Variations of Red Cell Count under Various Physiological Conditions 63
- Abnormal Forms of Erythrocytes 63
- Stages of Blood Formation in the Embryo and Foetus 64
- Site of Development 64
- Important Factors Controlling Erythropoiesis 64
- Maturation of Red Blood Cells 64
- Stages of Development 64
- Factors Regulating Erythropoiesis 66
- Energy Metabolism of RBC 66
- Key Points 66
- Functions of Red Blood Corpuscles 68
- Exam-oriented Questions 68

13. Haemoglobin 69

- Introduction 69
- Chemistry 69
- Structure of Haemoglobin 69
- Properties 70
- Haemoglobin Varieties 70
- Haemoglobin and its Variant 70
- Synthesis of Haemoglobin 70
- Amount of Haemoglobin in Normal Blood 70
- Variations of Hb under Different Physiological Conditions 71
- Derivatives of Haemoglobin 71
- Exam-oriented Questions 72

14. Iron Absorption, Transport, Storage and Excretion 73

- Introduction 73
- Daily Requirement 73
- Distribution of Iron 73
- Absorption and Transport 73
- Key Points 73
- Iron in Blood 73
- Storage of Iron 73
- Excretion 74
- Functions of Iron 74
- Applied: Iron Deficiency Anaemia 75
- Exam-oriented Questions 75

15. Anaemia, Polycythemia, Osmotic Fragility and Blood Indices 76

- Introduction 76
- Other Causes 76
- Sickle Cell Anaemia 76
- Thalassemia 76
- Alpha Thalassemia 78
- Beta Thalassemia 78
- Glucose-6-Phosphate Dehydrogenase Deficiency 78
- Congenital Spherocytosis 78
- Blood Indices and Morphological Classification of Anemia 78
- Determination of Osmotic Fragility of Red Blood Cells 79
- Principle 79
- Procedure 79
- Precautions 79
- Applied Physiology: Haemolysis and Osmotic Fragility 79
- Polycythemia 80
- Exam-oriented Questions 80

16. White Blood Cells and Platelets 81

- White Blood Cells 81
- Variations in Normal Count of White Blood Corpuscles 81
- Classification and Differential Count of White Blood Corpuscles or Leucocytes 81
- Granular Leucocytes or Granulocytes 82
- Neutrophil 82
- Arneth Count or Arneth Index (Modified by von Bonsdorff and Later by Cooke) 82
- Eosinophil (1–4%) 83
- Basophil (0–1%) 83
- Lymphocytes (20–40%) 83
- Small Lymphocyte 83
- Large Lymphocyte 83
- Monocytes (Large Mononuclear Cell, Transitional Cell, etc.) (2–8%) 84
- Characteristic Features 84
- Development of Leucocytes 84
- Development of Granular Leucocytes or Granulocytes 84
- Development of Lymphocytes 85
- Role of Lymphocyte in Immunology 86
- Development of Monocytes 86
- Life and Fate of Leucocytes 86
- Functions of WBC 86
- Applied Physiology: WBC Disorders 86
- Platelets 87
- Properties 87
- Total Number and its Variations 87
- Methods of Counting of Platelets 88
- Development of Platelets 88
- Functions of Platelets 88
- Exam-oriented Questions 89

17. Blood Groups and Blood Transfusion 90

- Blood Groups 90
- A, B and O Groups 90
- Rh Antibodies and Rh Incompatibility 91
- Erythroblastosis Foetalis 91
- M and N Factors: Medicolegal Significance 91
- H Blood Group System and Bombay Phenotype 92
- Blood Transfusion: Blood Groups 92
- Indications for Blood Transfusion 92
- Autologous Transfusion 92
- Mismatched Blood Transfusion 93
- Blood Bank 93
- Blood Storage 93
- Exam-oriented Questions 93

18. Formation of Tissue Fluids 94

- Introduction 94
- Composition of Tissue Fluid 94
- Functions of Tissue Fluid 94
- Oedema and its Causes 95
- Aggregation of Tissue Fluid 95
- Lymph and Lymphatics 95
- Characteristic Features 95
- Properties of Lymph 95
- Composition of Lymph 95
- Solids 95
- Rate of Flow 95
- Factors Responsible for Formation of Lymph 97
- Functions of Lymph 98
- Lymph Node 98
- Structure of Lymph Node 98
- Functions of Lymph Node 99
- Structure of Spleen 99
- Splenic Pulp 99
- Marginal Zone 100
- Functions of Spleen 101
- Classification, Varieties and Distribution of RE Cells 102
- Functions of the Reticuloendothelial System 103
- Exam-oriented Questions 103

19. Immunity 104

- Introduction 104
- Innate Defenses 104
- Complement 105
- Adaptive Defenses 106
- Development of the Acquired Immune System 106
- Humoral Immunity 107
- Acquired Humoral Response: Formation of Primary and Secondary Antibodies 107
- Types of Acquired Immunity 107
- Antibody Mediated Humoral Response 108
- Cell-mediated Immune Response 108
- T Cell Activation 109
- Function of T Helper Cells, Cytotoxic T Cells and Suppressor T Cells 109
- Organ Transplant 110
- Severe Combined Immunodeficiency (SCID) Syndrome 110
- Acquired Immune Deficiency Syndrome (AIDS) 110
- Hypersensitivity 110
- Exam-oriented Questions 111
- Clinical Case Scenario 112
- Blood 112
- Recent Advances: Innate Immunity 113

2008 Nobel Prize for Physiology and Medicine: HIV Virus	114
Notable Contributions: Diseases, Drugs, Immunity and Recovery	114

Section III Nerve and Muscle

20. Structure and Functions of Neuron 118

Introduction	118
Histological Structure	118
Neuron	118
Structure of Nerve Fibres	118
Neuroglia	120
Functions of Neuroglia	120
Axonal Transport and Nourishment of Neurons	121
Role of Neurotrophins in Neuronal Development	121
Exam-oriented Questions	121

21. Properties, Classification of Nerve Fibres and Nerve Action Potential 122

Introduction: Properties of Nerve Fibres	122
Excitability	122
Generation of Action Potential and Excitability of the Nerve	122
Ionic Basis of Excitability of Nerve	122
Excitability Depends upon Following Factors	124
Compound Action Potential	124
Conductivity	124
Factors Affecting Conductivity and Excitability	125
All-or-none Law	126
Refractory Period	126
Summation	126
Adaptation	126
Accommodation	126
Unfatigability	126
Heat Production in Nerve Fibre	126
Classification of Nerve Fibres	127
Mechanism of Conduction of the Nerve Impulse	127
Saltatory Conduction in the Myelinated Nerve Fibre	128
Physiological Properties of the Nerve Fibres	129
Degeneration and Regeneration of Nerve	129
Sunderland Classification of Nerve Injury	129
Regeneration	130
Degeneration and Regeneration of Nerve	130
Transneuronal Degeneration	130
Applied Physiology	130
Cathode Ray Oscilloscope (CRO)	130
Exam-oriented Questions	131

22. Neuromuscular Junction 132

Introduction	132
Anatomical Considerations	132
Neuromuscular Junction	132
Presynaptic Terminal	132
Synaptic Cleft	133
Post-synaptic Membrane	133
Synthesis of Acetylcholine in Motor Neuron	133
Sequence of Events in Neuromuscular Transmission	133
Neuromuscular Blockers	134
Applied Physiology	134
Exam-oriented Questions	135

23. Classification of Muscular Tissue 136

Introduction	136
Muscle Classification	136
Exam-oriented Question	137

24. Structure of Skeletal Muscle 138

Introduction	138
Distribution	138
Origin and Development	138
General Features	138
Histological Structure of Muscle Fibres	138
Myofibrils: Characteristic Features	138
Myosin Filaments	139
Actin Filament	140
Sarcotubular System	141
Blood Vessels, Lymphatics and Nerves of Skeletal Muscle	141
Ending of Muscle in Tendon	141
Exam-oriented Questions	142

25. Muscle Contraction 143

Introduction	143
Mechanism of Contraction	143
Molecular Mechanism of Muscle Contraction (Sliding Filament Theory of AF Huxley and HE Huxley)	143
Changes during Muscular Contraction	146
Role of Creatine Phosphate or Phosphagen and Adenosine Triphosphate (ATP)	146
Muscular Contraction and its Relationship with the Breakdown of ATP	147
Oxygen Utilization and CO ₂ Production	147
Cori Cycle	147
Thermal Changes	148
Electrical Changes	148
Strength–Duration Relationship—Chronaxie and Rheobase	148
Muscular Disorders	149
Exam-oriented Questions	149

26. Properties of Skeletal Muscle 150

Introduction	150
Excitability and Contractility	150
Refractory Period	154
Tonicity	154
Conductivity	154
Extensibility and Elasticity	154
Contraction of Skeletal Muscle	154
Exam-oriented Questions	155

27. Cardiac Muscle 156

Introduction	156
Blood Vessels, Lymphatics and Nerves of Cardiac Muscle	158
Exam-oriented Questions	159

28. Smooth Muscles 160

Introduction	160
Histology	160
Contractile Mechanism	161
Properties of Plain (Smooth) Muscles	161
Excitability and Contractility	161
Functions of the Muscular Tissue	163
Rigor Mortis	163
Exam-oriented Questions	163
Clinical Case Scenario	165
Nerve Muscle	165
Recent Update: A Newly Discovered Muscle: The Tensor of the Vastus Intermedius	166

Section IV Cardiovascular System

29. Introduction to Cardiovascular System 170

- Introduction 170
- Anatomical Considerations of the Heart 171
 - Key Points 171
 - Valves of the Heart 172
 - Action of the Valves 173
 - Histology of the Cardiac Muscle 174
 - Valves of the Veins 176
 - Blood Vessels (Vasa Vasorum) 176
 - Factors that Maintain Circulation 176
 - Special Junctional Tissues 176
 - Sino-atrial Node (Keith and Flack, 1907) 177
 - Atrioventricular Node (Tawara, 1906) 177
 - Bundle of His 178
 - Bundle Branch 178
 - Purkinje Fibres 179
- Exam-oriented Questions 179

30. Initiation and Spread of Cardiac Impulse 180

- Origin of the Heartbeat 180
 - Initiation of Impulse and Localisation of Pacemaker 180
 - Conduction Over Atrial Muscle 180
 - Conduction Over AV Node 180
 - Conduction Over Bundle of His and the Right and Left Bundle Branches 181
 - Conduction through Purkinje Systems 181
 - Conduction through Ventricular Muscle 181
- Heart Block 181
- Exam-oriented Questions 182

31. Properties of Cardiac Muscle 183

- Introduction 183
- Rhythmicity 183
- Excitability 183
- Conduction 184
- Contraction 185
- All-or-none Response 185
- Staircase Phenomenon 185
- Refractory Period 185
- Tone 185
- Functional Syncytium 186
- Exam-oriented Questions 186

32. Cardiac Cycle 187

- Introduction 187
- Cardiac Cycle Time 187
- Summary of the Sequence of Events in Cardiac Cycle 190
- Time Relations of the Various Events 191
- Summary of the Time Relations 191
- Exam-oriented Questions 192

33. Haemodynamics of Circulatory System and Pressure and Volume Changes during Cardiac Cycle 193

- Haemodynamics of Circulatory System 193
 - Blood Flow through Vessel 193
 - Structural Overview 193
 - Overall Blood Flow in Circulation 193
 - Pattern of Blood Flow 193
 - Blood Flow Resistance (Peripheral Resistance) 194
 - Velocity of Blood Flow 194
 - Lumen of the Blood Vessel 194
 - Effect of Gravity on Mean Blood Pressure 194
 - Regulation of Blood Flow 195

- Acute Control of Local Blood Flow 195
- Long-term Control of Local Blood Flow 195
- Role of Humoral Vasoconstrictors and Vasodilators 195
- Pressure Volume Changes 196
- Methods of Study 196
 - Pressure Changes 196
 - Intraventricular Pressure Changes and Assessment 196
 - Ventricular Systole 196
 - Ventricular Diastole 196
 - Intra-atrial Pressure Changes 197
 - Jugular Pressure Tracing (Venous Pulse) 197
 - Ventricular Volume Changes 198
- Composite Representation of the Sequential Changes in the Pressure and Volume events in the Heart and Blood Vessels during the Cardiac Cycle Correlating with Phonocardiogram and Electrocardiogram 198
- Heart Sounds 199
- Exam-oriented Questions 201

34. Electrocardiogram 202

- Introduction 202
- Methods of Recording Electrocardiogram 202
- Electrocardiographic Leads Used both Clinically and Experimentally 203
- Unipolar Limb Leads 205
- Augmented Unipolar Limb Leads 206
- Normal ECG Recorded in Chest Leads 207
- Significance of Various Leads and their Limitations 207
- Electrocardiographic Appearances under Certain Cardiac Disorders 208
- ECG Changes in Atrial Tachycardia, Atrial Flutter and Atrial Fibrillation 208
- Ventricular Premature Beat or Extra Systole 209
- Ventricular Paroxysmal Tachycardia 209
- Ventricular Fibrillation 209
- Wolff-Parkinson-White Syndrome 209
- Myocardial Infarction 210
- Myocardial Infarction: Coronary Ischaemia and Current Injury 210
- Mean Electrical Axis of the Heart 210
- Determination of Electrical Axis 210
- Ventricular Conditions that may Cause Axis Deviation 211
- Exam-oriented Questions 212

35. Innervations of Heart and Heart Rate 213

- Introduction 213
- Nerves of the Heart and their Action 213
- Vagus Nerves 213
- Tonic Action of the Vagus Nerves 214
- Sympathetic Nerves 214
- Cardiac Centres 214
- Heart Rate 214
- Factors Affecting Heart Rate 214
- Regulation of Heart Rate 215
- Applied Physiology 217
- Exam-oriented Questions 217

36. Cardiac Output 218

- Introduction 218
- Normal Values: 5–6 Litres/Minute 218
- Important Terminology and Definitions 218
- Distribution of Cardiac Output 218
- Cardiac Reserve 218
- Factors Affecting Cardiac Output 219
- Control of Cardiac Output 219
 - Preload Depends on Ventricular Filling and Venous Return 219

Cardiac Contractility	219	Anatomical Considerations	237
Afterload	220	Venous Drainage	238
Methods of Measuring Cardiac Output	221	Methods of Study	238
Dye Method: Stewart and Hamilton's Dye Dilution Method	221	Normal Values	238
Employing for Measuring Cardiac Output		Variations of Coronary Inflow during Different Phases of Cardiac Cycle	239
Fick Principle Using O ₂ and CO ₂	221	Coronary Inflow	239
Physical Method: Ballistocardiography	222	Factors Influencing Coronary Circulation	240
Thermo-dilution Method (Cold Saline Method)	222	Circulatory Status of the Cardiac Muscle under Certain Diseased Conditions	241
Applied Physiology	222	Aortic Stenosis	241
Doppler Echocardiography	222	Pulmonary Hypertension	241
Calculation	222	Aortic Insufficiency	241
Exam-oriented Questions	222	Mitral Stenosis	241
37. Blood Pressure	223	Aortic Coarctation	241
Introduction	223	Hypertensive Cardiovascular Disease	241
Basal Blood Pressure	223	Ischaemic Heart Disease	241
Physiological Variations	223	Coronary Spasms and Intercoronary Reflexes	241
Significance of Blood Pressure	224	Pathological Physiology of Angina Pectoris and Acute Myocardial Infarction	241
Systolic Pressure	224	Cerebral Circulation	241
Diastolic Pressure	224	Anatomical Considerations	241
Pulse Pressure	224	Method of Study: Nitrous Oxide Method:	
Physiological Significance of Blood Pressure	224	Fick Principle	242
Measurement and Recording of Blood Pressure	224	Vasomotor Supply	242
Arterial Blood Pressure	224	Normal Values of Cerebral Circulation	242
Venous Pressure	226	Regulation of Cerebral Circulation	243
Determinants of Blood Pressure	226	Existence of Auto-regulation of Cerebral Blood Flow	243
Adjustment of Blood Pressure	226	Key Points	243
Efferent Pathways of this Self-adjustment or Homoeostasis of Blood Pressure	227	Factors Controlling Cerebral Circulation	243
Vasomotor System	227	Cerebrovascular Resistance	243
Afferent Pathways	228	Pulmonary Circulation	244
Role of Sino-aortic Mechanism in the Regulation of Normal Blood Pressure	228	Anatomy of Circulation	244
Sino-aortic Mechanism	228	Method of Recording Pulmonary Arterial Pressure	244
Chemoreceptors Location	229	Vasomotor Supply	244
Aortic Bodies	230	Normal Values of Pulmonary Circulation	244
Vascular Receptors other than Sino-Aortic for the Control of Blood Pressure and Flow	230	Functions of Pulmonary Circulation	245
As Chemoreceptors	231	Control of Pulmonary Circulation	245
Mechanism of Regulation of Blood Pressure	231	Peculiarities of Pulmonary Circulation	246
Short-term Regulating Mechanisms	231	Pulmonary Vascular Reflex	246
Intermediate Mechanism of Regulation of Blood Pressure	232	Circulatory Status in Different Cardiopulmonary Diseases	246
Long-term Regulation of Blood Pressure	232	Mitral Stenosis	246
Role of other Hormone in Regulation of Blood Pressure	232	Emphysema	246
Role of Humoral Vasoconstrictors and Vasodilators	232	Pulmonary Embolism	246
Humoral Vasoconstrictors	232	Atelectasis	246
Humoral Vasodilators	233	Removal of Lung	247
Chemical Control of Blood Pressure Influenced by Vasomotor Mechanism	233	Diffuse Sclerosis of Lung Vessels	247
Exam-oriented Questions	233	Pulmonary Fibrosis	247
38. Velocity of Blood Flow and Radial Pulse	234	Hepatic Circulation	247
Introduction	234	Vascular Arrangement	247
Velocity of Blood	234	Vasomotor Supply	247
Methods of Measurement of Velocity of Blood	234	Normal Values of Hepatic Circulation	247
Radial Pulse	234	Factors Modifying Hepatic Circulation	248
Pressure Pulse	235	Peculiarities of Hepatic Circulation	248
Recording of Radial Pulse	235	Splenic Circulation	249
Clinical Features of Radial Pulse	235	Control of Blood Flow	249
Special Varieties of Pulse	235	Renal Circulation	249
Applied Physiology	236	Capillary Circulation	249
Exam-oriented Questions	236	Histology	249
39. Regional Circulation	237	Methods of Study of Capillary Circulation	249
Introduction	237	Vasomotor Supply	249
Coronary Circulation	237	Control of Capillary Circulation	250
		Interchange in the Capillary Area	251
		Cutaneous Circulation	251
		Anatomy of Cutaneous Circulation	251
		Rate of Blood Flow	251

Regulation of Blood Flow: Nervous Control	251
Vascular Response of Skin	252
Auto-regulation of Skin Blood Flow	252
Normal Colour of the Skin	252
Skeletal Muscle Circulation	253
Vascular Arrangement in Skeletal Muscle	253
Rate of Blood Flow Through Muscle	253
Basal Tone of Arterioles	253
Control of Skeletal Muscle Blood Flow	253
Exam-oriented Questions	254
40. Physiology of Exercise	255
Introduction	255
Muscular Exercise	255
Changes in Cardiovascular System	256
Heart Rate Changes during Exercise	256
Circulatory Status during Exercise	257
Changes in Respiration	258
Blood Cell Changes during Exercise	258
Body Temperature	258
Body Fluid Changes during Exercise	259
Kidney Function in Exercise	259
Digestive System	259
Endocrine Status	260
Aerobic Training	260
Isometric and Isotonic Exercises	260
Cardiovascular and Cardiorespiratory Response to Isometric Exercise	260
Sedentary Lifestyle and Health Implication	261
Introduction	261
Health Implication in Sedentary Lifestyle	261
Role of Nutrition in Exercise	262
Over-exercising and Ill Effects on Health	262
Cardiorespiratory Changes under Different Environmental Conditions (Heat and Cold)	262
Exam-oriented Questions	262
41. Applied Cardiovascular Physiology: Haemorrhage, Heart Failure, Hypotension, Hypertension and Shock	263
Haemorrhage	263
Compensatory Changes after Haemorrhage	263
Heart Failure	264
Types of Heart Failure	264
Role of Compensatory Mechanisms in Heart Failure	265
Management and Prevention	265
Hypotension	265
Orthostatic Hypotension	265
Hypertension	265
Signs and Symptoms	265
Pathophysiology of Hypertension	266
Shock	267
Types of Shock	267
Clinical Features of Shock	267
Stages of Shock	267
Physiology of Treatment in Shock	270
Applied Physiology: Cardiovascular System	270
Cardiac Disorders	270
Exam-oriented Questions	271
Clinical Case Scenario	272
Cardiovascular System	272
Important Cardiovascular Research Study: Framingham Heart Study	273
First Cardiac Catheterization and Future Development of Technique	273
Open-heart Surgery	273
Recent Advances in Cardiovascular Research	273

Section V Respiratory System

42. Functional Organization of Respiratory System	276
Structure of the Respiratory Tract	276
Trachea	276
Functions of Respiratory Tract	276
Reflexes Help in Clearing Irritating agents from Respiratory Passage	277
Respiratory Units	277
Broncho-pulmonary Anastomosis	277
Pulmonary Alveoli	277
Respiratory Functions of Lung	278
Pleural Cavity and Intra-pleural Pressure	279
Intra-pleural Pressure	279
Surface Tension at the Fluid–Air Interface within the Alveoli and the Role of Surfactant	279
Pressure Changes in the Pleural Cavity and its Relation to Volume Changes in the Lungs	280
Exam-oriented Questions	280
43. Mechanics of Breathing	281
Introduction	281
Diaphragm	281
Intercostal Muscles	282
Motion of the Ribs during Inspiration and Expiration	282
Accessory Muscles of Respiration	283
Resistance to Breathing	283
Elastic Resistance	283
Lung Compliance	283
Measurement of Lung Compliance and Pressure–Volume Curve	283
Viscous or Non-elastic Resistance	284
Elastic Forces and Characteristics of Compliance Pressure–Volume Curve	284
Elastic Forces of Lung Tissue	284
Alveolar Radius and its Relation to Surface tension	284
Energy Utilization for Respiration	285
Applied Physiology	285
Exam-oriented Questions	286
44. Pulmonary Volumes and Capacities (Spirometry)	287
Introduction	287
Lung Volumes	288
Tidal Volume (TV = 500 ml)	288
Respiratory Minute Volume (RMV)	288
Inspiratory Reserve Volume (IRV)	288
Expiratory Reserve Volume (ERV)	288
Residual Volume (RV)	288
Lung Capacities	288
Inspiratory Capacity (IC)	288
Functional Residual Capacity (FRC)	288
Total Lung Capacity (TLC)	288
Vital Capacity (VC)	288
Forced Expiratory Volume (FEV)	289
Functional Residual Capacity (FRC)	290
Forced Vital Capacity (FVC)	291
Forced Expiratory Volume in 1 (FEV ₁) Second	291
FEV ₁ /FVC Ratio (FEV ₁ %)	291
Forced Expiratory Flow (FEF)	291
Peak Expiratory Flow (PEF)	291
Breathing Reserve (BR)	292
Applied Physiology: Obstructive and Restrictive Lung Disease	292
Exam-oriented Questions	292

45. Alveolar Ventilation and Gases Exchange in Lungs	293	
Alveolar Ventilation	293	
Respiratory 'Dead Space'	293	
Definition	293	
Measurement of Dead Space Volume	293	
Nitrogen Meter Method	293	
Intrapulmonary Gas-mixing or Even Distribution of Inspired Air	294	
Methods of Detection of Uneven Ventilation	294	
Alveolar Air	294	
Composition of Alveolar Air	294	
Partial Pressure of Gases in Inspired Air, Expired Air and Alveolar Air	295	
Effect of Voluntary Hyperpnoea on Alveolar Air	295	
Breath-holding Time	295	
Effects of High Altitude on Alveolar Oxygen	296	
Factors Controlling Alveolar $p\text{CO}_2$	296	
Anatomical Shunt	296	
Physiological Shunt	297	
Applied Physiology	297	
Hyperventilation and Hypoventilation	297	
Exam-oriented Questions	297	
46. Ventilation and Perfusion in Lungs	298	
Diffusion	298	
Factors Controlling Diffusion	299	
Summary of Factors Affecting Diffusion through Fluids and Respiratory Membrane	299	
Diffusion through Respiratory Membrane	299	
Pulmonary Diffusing Capacity for O_2 (DO_2)	299	
Diffusion of CO_2	300	
Perfusion	300	
Applied Physiology	300	
Exam-oriented Questions	300	
47. Transport of Oxygen and Carbon Dioxide in Blood	301	
Introduction	301	
Oxygen Transport	301	
Percentage Saturation of Haemoglobin	302	
Dissociation Curve for Haemoglobin	302	
Nature of the Curve	303	
Explanation of the Sigmoid Shape of the Curve	303	
Oxygen Exchange in the Lungs	304	
Oxygen Transport in the Tissues	304	
Applied Physiology	305	
Carbon Dioxide Transport	305	
CO_2 Content and Tension of Blood	305	
Transport	305	
Carbon Dioxide Dissociation Curves	306	
Summary: Transport of Oxygen and Carbon Dioxide in Blood	308	
Exam-oriented Questions	308	
48. Regulation of Respiration	309	
Introduction	309	
Respiratory Centre	309	
Dorsal Respiratory Group (DRG) of Neurons and Inspiratory Ramp Signals	310	
Ventral Respiratory Group of Neurons	310	
Mechanism of Rhythmic Respiration	310	
Role of Abdominal Muscles in Respiration	310	
Role of Reflex in Respiration	310	
Voluntary Control of Respiration	313	
Chemical Control of Respiration	313	
CO_2 and Respiration	313	
Nervous Factors Influencing Respiration in Exercise	315	
Periodic Breathing	315	
Cheyne-Stokes Breathing	315	
Factors Involved in Development of Cheyne-Stokes Breathing Pattern	315	
Mechanism of Cheyne-Stokes Breathing	317	
Kussmaul's Breathing	317	
Exam-oriented Questions	317	
49. Hypoxia	318	
Definition	318	
Classification of Hypoxia	318	
Anoxic Hypoxia or Arterial Hypoxia	318	
Causes of Arterial Hypoxia	318	
Anaemic Hypoxia	319	
Stagnant Hypoxia or Hypokinetic Hypoxia	319	
Histotoxic Hypoxia	319	
Altitude Hypoxia	319	
Oxygen Therapy in Hypoxia	320	
Dyspnoea	321	
Dyspnoea due to Alteration in Chemical Composition of Blood	321	
Factors Affecting Diffusion of Gases Across the Alveolo-capillary Membrane (Alveolo-capillary Block Syndrome)	321	
Excessive Work of the Respiratory Muscles	322	
Applied Physiology	322	
Psychogenic or Emotional Dyspnoea	322	
Exam-oriented Questions	322	
50. Compressed Air Sickness and Deep Sea Diving	323	
Dysbarism (Caisson Disease)	323	
Exam-oriented Question	323	
51. Respiration in Abnormal Conditions	324	
Asphyxia	324	
Definition	324	
Classification	324	
Essential Conditions of Asphyxia	324	
Hyperpnoea	324	
Causes	324	
Effects of Voluntary Hyperpnoea	324	
Orthopnoea	326	
Cyanosis	326	
Factors Causing Cyanosis	326	
Applied Physiology	326	
Exam-oriented Questions	327	
52. Artificial Respiration or Resuscitation	328	
Methods of Artificial Respiration	328	
Manual Methods	328	
Sylvester's Method	329	
Holger-Nielsen Method	329	
Mouth-to-mouth Method	329	
Eve's Rocking Method	329	
Instrumental Method	329	
Drinker's Method	329	
Resuscitator	329	
In the Newborn Baby	329	
Exam-oriented Questions	331	
53. Acclimatisation	332	
Compensatory Changes at Moderately High Altitude	332	
Changes in Acclimatisation	332	
Natural Acclimatisation of Natives Residing at High Altitude	332	
Acute Mountain Sickness	333	

Mountaineering 333
 Atmosphere High Altitude Physiology 334
 Hypoxia 334
 Problem Faced by Aviators 334
 Radiation Hazards 335
 Dysbarism at High Altitude (Decompression Sickness) 335
 Explosive Decompression 335
 Effect of Centrifugal Acceleratory Forces 336
 Protection of Body against Centrifugal Acceleratory Forces 336
 Parachute Jump 337
 Weightlessness in Space (Zero-G State) 338
 Exam-oriented Questions 338

54. Underwater Physiology 339

Introduction 339
 Nitrogen 339
 Oxygen 339
 Mechanism of Oxygen Poisoning 340
 Carbon Dioxide 340
 Helium 340
 Underwater Respiration 340
 SCUBA Diving 341
 Exam-oriented Question 341

55. Vocalisation 342

Vocalisation 342
 Articulation and Resonance 343
 Exam-oriented Questions 343
 Clinical Case Scenario 344
 Respiratory System 344
 Recent Advances 344

Section VI Gastro-intestinal Tract

56. General Outline of Digestive System 346

Introduction 346
 Anatomical Consideration 346
 Histological Structure 347
 Innervation of the Digestive Tract 347
 Functions of the Digestive System 348
 Histology of Tongue 348
 Glands 351
 Nerve Supply 351
 Functions 351
 Salivary Glands 351
 Histology of Salivary Glands 351
 Pharynx or Throat Cavity 353
 Oesophagus 353
 Histology 353
 Stomach 354
 Histology of Stomach 355
 Functions of Stomach 356
 Small Intestine 356
 Vermiform Appendix 358
 Large Intestine 358
 Rectum 358
 Anal Canal 358
 Brief Summary of the Chief Identifying Features of Different Parts of the Digestive Tract 358
 Exam-oriented Questions 358

57. Digestive Juices 359

Introduction 359
 Saliva 359
 Characteristics 359
 Composition 359

 Functions 359
 Gastric Juice 360
 Composition 360
 Characteristics 360
 Functions 360
 Pancreatic Juice 360
 Characteristics 360
 Succus Entericus 361
 Characteristics 361
 Composition 361
 Intestinal Juice Enzymes 361
 Carbohydrate Splitting 361
 Functions 361
 Biles 361
 Introduction 361
 Composition of Bile 362
 Functions of Bile 362
 Bile Salts 363
 Variety and Chemistry 363
 Synthesis of Bile Salts 363
 Enterohepatic Circulation and Fate of Bile Salts 363
 Functions of Bile Salts 363
 Bile Pigments 364
 Chemistry and Varieties 364
 Origin and Formation 364
 Site of Formation, Circulation and Fate 364
 Exam-oriented Questions 366

58. Mechanism of Secretion of Various Digestive Juices 367

Introduction 367
 Saliva 367
 Nerve Supply of Salivary Glands 367
 Significance of Double Nerve Supply 368
 Salivary Secretion and Reflexes 368
 Reflex Control of Rate of Flow and Composition of Saliva 369
 Disturbances of Salivary Secretion 369
 Gastric Secretions 369
 Cephalic Phase 370
 Gastric Phase 371
 Gastric Phase Characteristic Features 371
 Intestinal Phase 371
 Action of Other Hormones on Gastric Secretion 372
 Interrelation between the Different Phases 373
 Gastric Function Test 373
 Investigation of Gastric Secretion in Man 373
 Other Functional Tests 374
 Origin and Character of the Important Constituents of Gastric Juice 375
 Hydrochloric Acid 375
 Applied Physiology: Peptic Ulcer 375
 Pepsin 376
 Mucin 376
 Intrinsic Factor 376
 Neurotrophic Factor 376
 Pancreas 376
 Development 377
 Mechanism of Pancreatic Secretions 377
 Nervous Phase 377
 Chemical Phase 378
 Influence of Various Foodstuffs on Pancreatic Secretion 379
 Applied Physiology 379
 Liver 379
 Anatomy 379
 Gall Bladder: Structure and Functions 379

Mechanism of Bile Secretion	380	
Mechanism of Secretion	380	
Mechanism of Expulsion of Bile	381	
Factors Controlling Movements of Gall Bladder	381	
Functions of Gall Bladder	382	
Applied Physiology	382	
Mechanism of Secretion of Succus Entericus (Intestinal Juice)	382	
Mechanism	383	
Applied Physiology	383	
Summary of Secretions of the Various Digestive Juices	383	
Exam-oriented Questions	384	
59. Movements of Alimentary Canal		385
Introduction	385	
Facts about Movement	385	
Cause of Movements	385	
Relation with Degree of Activity	385	
Deglutition (Swallowing)	385	
Common Disturbances in the Swallowing	387	
Movements of Stomach	387	
Applied Physiology	389	
Vomiting (Emesis)	389	
Movements of Small Intestine	391	
Frequency	391	
Movements of Villi	393	
Applied Physiology	393	
Movements of Large Intestine	393	
Functions of Large Intestine	394	
Rate of Progress of Barium Meal	394	
Applied Physiology—Large Intestine	396	
Defaecation	396	
Mechanism	396	
Exam-oriented Questions	396	
60. Digestion and Absorption of Foodstuffs		397
Introduction	397	
Digestion of Carbohydrates	397	
Introduction	397	
Different forms of Carbohydrates	397	
Digestion of Proteins	398	
Introduction	398	
Different Forms of Protein	399	
Digestion of Nucleoprotein	399	
Digestion of Casein	399	
Digestion of Milk	400	
Digestion of Collagen and Gelatin	400	
Digestion of Mucin	400	
Digestion of Lipids	400	
Digestion in the Pancreatic Juice	400	
Absorption	401	
Definition	401	
Absorption of Carbohydrates	401	
Absorption of Proteins	401	
Fats Absorption	402	
Process of Absorption	402	
Water Absorption	402	
Absorption of Electrolytes	402	
Faeces	403	
Contents and Characteristics	403	
Exam-oriented Questions	403	
61. Gastro-intestinal Hormones		404
Introduction	404	
Gastrin	404	
Cholecystokinin (CCK) or Pancreozymin	405	
Regulation of Secretion of Cholecystokinin	405	
Glucagon-like Peptide-1	405	
Gastric Inhibitory Polypeptide (GIP)	405	
Vasoactive Intestinal Peptide (VIP)	405	
Urogastrone	405	
Villikin	405	
Enterocrinin	406	
Motilin	406	
Neurotensin	406	
Somatostatin	406	
Gastrin Releasing Peptide	406	
Ghrelin	406	
Peptide YY	406	
Substance P	406	
Bombesin	406	
Exam-oriented Questions	406	
Clinical Case Scenario	407	
Gastrointestinal Tract	407	
Recent Advances: Treatment of Peptic Ulcer	407	
Recent Advances: Capsule Endoscopy	408	
Section VII Renal Physiology		
62. Functional Anatomy of Excretory System		410
Introduction	410	
Kidneys	410	
Characteristic Features	410	
Nephron	411	
Uriferous Tubules	412	
Types of Nephrons	412	
Renal Tubules	415	
Proximal Convoluted Tubule (PCT)	415	
Henle's Loop	415	
Distal Convoluted Tubule (DCT)	416	
Collecting Tubule	417	
Juxtaglomerular Apparatus	417	
Regulation of Renin Secretion	418	
Renal Circulation	419	
Peculiarities	419	
Peculiarities of Renal Circulation	421	
Exam-oriented Questions	422	
63. Urine Formation by Kidneys: Renal Blood Flow and their Control		423
Introduction	423	
Autoregulation of Renal Blood Flow	423	
Nervous Control	424	
Other Factors	425	
Blood Glucose Level	425	
Hormones Influencing Renal Functions	425	
Measurement of Renal Blood Flow	425	
Functions of Kidney and Glomerulus	426	
Functions of Kidney	426	
Exam-oriented Questions	426	
64. Urine Formation by the Kidney: Glomerular Filtration Rate and their Control		427
Introduction	427	
Key Points	427	
Glomeruli as Ultrafilter	429	
Functions of Glomerulus	429	
Applied physiology: Chronic Kidney Disease and Glomerular Filtration Rate	431	

65. Tubular Reabsorption and Tubular Secretion (Urine Formation): Water and Electrolytes Balance and Counter-current Mechanism 432

- Introduction 432
- Methods of Study of Tubular Functions 432
- Selective Reabsorption 432
 - Glucose 432
 - Water 433
 - Sodium and Chloride 435
 - Potassium 435
 - Bicarbonate 437
 - Phosphate 438
- Reabsorption of other Substances 438
 - Tubular Secretion 438
 - Formation of Some New Substances 438
- Exam-oriented Questions 440

66. Renal Function Test, Urine, Urinary Characteristic and its Mechanism of Formation 441

- Introduction 441
 - Assuming 441
- I. Test for measurement of GFR 442
 - Inulin Clearance (A Measure of Glomerular Filtration Rate) 442
 - Creatinine Clearance Test 442
- II. Test to Measure Excretory Function 442
 - Urea Clearance Test (Van Slyke) 442
- III. Test to Estimate Tubular Secretion Capacity 443
- IV. Test to Measure Renal Blood Flow 443
- Urine, Urinary Characteristic and its Mechanism of Formation 443
- Introduction 443
- Other Characteristics 444
 - Colour 444
 - Reaction 444
 - Specific Gravity 444
 - Turbidity 444
 - Odour 444
 - Osmotic Pressure 444
- Composition of Urine 444
 - Normal Constituents of Urine 444
- Abnormal Constituent of Urine 445
 - Protein 445
 - Glucose 446
 - Ketone Bodies 446
 - Presence of Blood in Urine 446
 - Pigments 446
 - Calculi and Casts 446
 - Pus 446
 - Hormones 446
- Factors Affecting Formation of Urine 447
- Reaction of Urine 447
- Mechanism of Regulation of Blood Reaction by the Kidneys 447
- Bicarbonate Mechanism 447
- Phosphate Mechanism 448
- Ammonia Mechanism 449
- Elimination of Acids 449
- Elimination of Alkalis 450
- Glycosuria 450
 - Glycosuria due to Hyperglycaemia 450
 - Glycosuria due to Less Tubular Reabsorption 451
- Factors Controlling Volume of Urine 451
 - Abnormal Volume of Urine 452
 - Applied Physiology 452
- Exam-oriented Questions 453

67. Micturition 454

- Introduction 454
- Structure of Urinary Bladder 454
- Mechanism of Filling of Bladder 455
- Mechanism of Micturition 455
 - Key Features 455
 - Micturition Reflex 456
 - Centres of Micturition 457
- Effect of Lesion of Autonomic Nerves 457
 - Applied: Pathological Conditions involving Bladder Control Physiology 458
- Artificial Kidney 459
- Exam-oriented Questions 459

68. Skin, Body Temperature and its Regulation 460

- Introduction 460
- Structure 460
 - Epidermis 460
 - Dermis (Cutis Vera or True Skin) 461
- Functions of Skin 461
 - Glands in the Skin 462
 - Mechanism of Secretion of Sweat 462
- Composition of Sweat 463
 - Sebaceous Glands 463
 - Composition of Sebum 463
 - Control 463
- Special Structures of Skin 465
 - Nails (Ungues) 465
 - Hair (Pili) 465
- Body Temperature and its Regulation 466
- Introduction 466
- Factors Affecting Body Temperature 466
- Regulation of Body Temperature 467
 - Mechanisms of Heat Production (Thermogenesis) 467
 - Mechanisms of Heat Loss (Thermolysis) 468
 - Nervous System and Thermotaxis 468
 - Interaction of Central and Peripheral Factors 469
 - Role of Endocrines 470
- Temperature Regulation in the Newborn Infant 470
 - Mechanism of Regulation of Body Temperature 470
 - Decreased Body Temperature and Responses 470
 - Other Factors 470
- Effects of Exposure to High and Low Atmospheric Temperature 470
 - Physiological Alterations of Body Mechanisms on Exposure to Hot Atmosphere 470
 - Life in Deserts 471
 - Physiological Alterations of Body Mechanisms on Exposure to Cold Atmosphere 472
 - Effect of Sudden Change of Atmospheric Temperature 472
- Pyrexia 472
 - Physiological Responses due to Pyrexia (Fever) 472
- Hypothermia 472
 - Physiological Responses to (Deliberate) Hypothermia 472
 - Applied Physiology 473
- Exam-oriented Questions 474

69. Regulation of Reaction of Blood and Disturbances in Acid-Base Regulation 475

- Introduction 475
 - Respiratory H⁺ 475
 - Metabolic H⁺ 475
- Acid-base, Hydrogen Ion Concentration and pH 475

Acid and Base	475
Hydrogen Ion Concentration	476
pH	476
Calculation of pH	476
Calculation of $[H^+]$ Ion Concentration	476
The pH Scale	476
Physiological Importance of Maintenance of pH	477
Buffers, Lungs and Kidney	478
Buffer Action	478
Bicarbonate Buffer System	478
Bicarbonate Buffer System and its importance as Extracellular Buffer	478
Role of Kidney and Lung	478
Role of Respiration in Acid–Base Balance	480
Role of Kidneys in Acid–Base Balance	480
Disturbances in Acid–Base Regulation	481
Respiratory Acidosis	481
Definition	481
Pathophysiology	481
Compensatory Mechanism	481
Metabolic Alkalosis	481
Definition	481
Respiratory Compensation	482
Renal Compensation	482
Metabolic Acidosis	482
Definition	482
Compensation	482
Respiratory Alkalosis	482
Definition	482

Renal Compensation	483
Assessment of the Acid–Base Status	483
Exam-oriented Questions	483
Clinical Case Scenario	484
Kidney	484
Applied Physiology	485
Peritoneal Dialysis	485
Renal Transplantation	485

Multiple Choice Questions and Viva Voce

General Physiology	488
Blood	492
Nerve and Muscle	496
Cardiovascular System	500
Respiratory System	504
Gastro-intestinal Tract	507
Renal System	511
References	515
Viva Voce and Frequently Asked Critical Exam Questions Recap: Questions and Answers	516
General Physiology	516
Homeostasis	518
Transport Across Cell Membrane	519
Topic Action Potential	519
Blood	522

Index

I–II

Index of Competencies

Competency Based Curriculum for the Indian Medical Graduate

Code	Competency	Chapter	Page number
General Physiology			
PY1.1	Describe the structure and functions of a mammalian cell	1	2–6
PY1.2	Describe and discuss the principles of homeostasis	2	14–17
PY1.3	Describe intercellular communication	1	7, 8
PY1.4	Describe apoptosis–programmed cell death	1	9, 10
PY1.5	Describe and discuss transport mechanisms across cell membranes	3	18–26
PY1.6	Describe the fluid compartments of the body, its ionic composition and measurements	5	34–38
PY1.7	Describe the concept of pH and Buffer systems in the body	App 1	485–487
PY1.8	Describe and discuss the molecular basis of resting membrane potential and action potential in excitable tissue	4	27–33
PY1.9	Demonstrate the ability to describe and discuss the methods used to demonstrate the functions of the cells and its products, its communications and their applications in clinical care and research	1	10–13
Haematology (Blood)			
PY2.1	Describe the composition and functions of blood components	6	42–44
PY2.2	Discuss the origin, forms, variations and functions of plasma proteins	8	46–47
PY2.3	Describe and discuss the synthesis and functions of Haemoglobin and explain its breakdown. Describe variants of haemoglobin	13	69–72
PY2.4	Describe RBC formation (erythropoiesis and its regulation) and its functions	12	63–68
PY2.5	Describe different types of anaemias	15	76–80
PY2.6	Describe WBC formation (granulopoiesis) and its regulation	16	81–86
PY2.7	Describe the formation of platelets, functions and variations	16	87–88
PY2.8	Describe the physiological basis of hemostasis and, anticoagulants. Describe bleeding and clotting disorders (Hemophilia, purpura)	10	50–58
PY2.9	Describe different blood groups and discuss the clinical importance of blood grouping, blood banking and transfusion	17	90–93
PY2.10	Define and classify different types of immunity. Describe the development of immunity and its regulation	19	104–111
PY2.11	Estimate Hb, RBC, TLC, RBC indices, DLC, Blood groups, BT/CT	Refer to <i>Manual of Practical Physiology</i>	
PY2.12	Describe test for ESR, Osmotic fragility, Hematocrit. Note the findings and interpret the test results, etc. (Note ESR: Chapter 9, pages 62–64)	Refer to <i>Manual of Practical Physiology</i>	
PY2.13	Describe steps for reticulocyte and platelet count (Refer to Chapter 12, page 83)	Refer to <i>Manual of Practical Physiology</i>	
Nerve and Muscle Physiology			
PY3.1	Describe the structure and functions of a neuron and neuroglia; Discuss nerve growth factor and other growth factors/cytokines	20	118–121
PY3.2	Describe the types, functions and properties of nerve fibers	20	122–131
PY3.3	Describe the degeneration and regeneration in peripheral nerves	21	129–130
PY3.4	Describe the structure of neuromuscular junction and transmission of impulses	22	132–134
PY3.5	Discuss the action of neuromuscular blocking agents	22	134–135
PY3.6	Describe the pathophysiology of Myasthenia gravis	22	134
PY3.7	Describe the different types of muscle fibres and their structure	24	138–142
PY3.8	Describe action potential and its properties in different muscle types (skeletal and smooth)	26, 28	143–145, 161–163
PY3.9	Describe the molecular basis of muscle contraction in skeletal and in smooth muscles	25, 28	143–149, 161–165
PY3.10	Describe the mode of muscle contraction (isometric and isotonic)	26	154
PY3.11	Explain energy source and muscle metabolism	25	145–148
PY3.12	Explain the gradation of muscular activity	26	151
PY3.13	Describe muscular dystrophy: myopathies	25	149
PY3.14	Perform Ergography	Refer to <i>Manual of Practical Physiology</i>	
PY3.15	Demonstrate effect of mild, moderate and severe exercise and record changes in cardiorespiratory parameters	Refer to <i>Manual of Practical Physiology</i>	
PY3.16	Demonstrate Harvard Step test and describe the impact on induced physiologic parameters in a simulated environment	Refer to <i>Practical Manual</i>	
PY3.17	Describe Strength-duration curve	21	124
PY3.18	Observe with Computer assisted learning (i) amphibian nerve-muscle experiments (ii) amphibian cardiac experiments	Refer to <i>Manual of Practical Physiology</i>	
Gastro-intestinal Physiology			
PY4.1	Describe the structure and functions of digestive system	56	346–358
PY4.2	Describe the composition, mechanism of secretion, functions, and regulation of saliva, gastric, pancreatic, intestinal juices and bile secretion	57	359–366
		58	367–384
PY4.3	Describe GIT movements, regulation and functions. Describe defecation reflex. Explain role of dietary fibre.	59	385–396
PY4.4	Describe the physiology of digestion and absorption of nutrients	60	397–403
PY4.5	Describe the source of GIT hormones, their regulation and functions	61	404–406

Code	Competency	Chapter	Page number
PY4.6	Describe the gut-brain axis	56	358
PY4.7	Describe and discuss the structure and functions of liver and gall bladder	58	379–381
PY4.8	Describe and discuss gastric function tests, pancreatic exocrine function tests and liver function tests	58	375–378
PY4.9	Discuss the physiology aspects of: Peptic ulcer, gastroesophageal reflux disease, vomiting, diarrhoea, constipation, Adynamic ileus, Hirschsprung's disease	58 59	381–382 389–396
PY4.10	Demonstrate the correct clinical examination of the abdomen in a normal volunteer or simulated environment	Refer to <i>Manual of Practical Physiology</i>	
Cardiovascular Physiology (CVS)			
PY5.1	Describe the functional anatomy of heart including chambers, sounds; and Pacemaker tissue and conducting system.	29	170–179
PY5.2	Describe the properties of cardiac muscle including its morphology, electrical, mechanical and metabolic functions	31	183–186
PY5.3	Discuss the events occurring during the cardiac cycle	32	187–192
PY5.4	Describe generation, conduction of cardiac impulse	30	180–182
PY5.5	Describe the physiology of electrocardiogram (ECG), its applications and the cardiac axis	34	202–208
PY5.6	Describe abnormal ECG, arrhythmias, heart block and myocardial Infarction	34	209–212
PY5.7	Describe and discuss haemodynamics of circulatory system	33	193–201
PY5.8	Describe and discuss local and systemic cardiovascular regulatory mechanisms	37	227–233
PY5.9	Describe the factors affecting heart rate, regulation of cardiac output and blood pressure	35, 36, 37	213–217, 218–222
PY5.10	Describe and discuss regional circulation including microcirculation, lymphatic circulation, coronary, cerebral, capillary, skin, foetal, pulmonary and splanchnic circulation	39	237–254
PY5.11	Describe the patho-physiology of shock, syncope and heart failure	41	263–271
PY5.12	Record blood pressure and pulse at rest and in different grades of exercise and postures in a volunteer or simulated environment	Refer to <i>Manual of Practical Physiology</i>	
PY5.13	Record and interpret normal ECG in a volunteer or simulated environment	Refer to <i>Manual of Practical Physiology</i>	
PY5.14	Observe cardiovascular autonomic function tests in a volunteer or simulated environment	Refer to <i>Manual of Practical Physiology</i>	
PY5.15	Demonstrate the correct clinical examination of the cardiovascular system in a normal volunteer or simulated environment	Refer to <i>Manual of Practical Physiology</i>	
PY5.16	Record arterial pulse tracing using finger plethysmography in a volunteer or simulated environment	Refer to <i>Manual of Practical Physiology</i>	
Respiratory Physiology			
PY6.1	Describe the functional anatomy of respiratory tract	42	276–280
PY6.2	Describe the mechanics of normal respiration, pressure changes during ventilation, lung volume and capacities, alveolar surface tension, compliance, airway resistance, ventilation, V/P ratio, diffusion capacity of lungs	42 43, 44	281–286 287–297
PY6.3	Describe and discuss the transport of respiratory gases: Oxygen and carbon dioxide	47	301–308
PY6.4	Describe and discuss the physiology of high altitude and deep sea diving	53 54	332–338 339–341
PY6.5	Describe and discuss the principles of artificial respiration, oxygen therapy, acclimatization and decompression sickness.	52 53, 54	328–331 332–338, 339–341
PY6.6	Describe and discuss the pathophysiology of dyspnoea, hypoxia, cyanosis asphyxia; drowning, periodic breathing	49 51	318–322 324–327
PY6.7	Describe and discuss lung function tests and their clinical significance	44	287–292
PY6.8	Demonstrate the correct technique to perform and interpret Spirometry	Refer to <i>Manual of Practical Physiology</i>	
PY6.9	Demonstrate the correct clinical examination of the respiratory system in a normal volunteer or simulated environment	Refer to <i>Manual of Practical Physiology</i>	
PY6.10	Demonstrate the correct technique to perform measurement of peak expiratory flow rate in a normal volunteer or simulated environment	Refer to <i>Manual of Practical Physiology</i>	
Renal Physiology			
PY7.1	Describe structure and function of kidney	62	410–417
PY7.2	Describe the structure and functions of juxtaglomerular apparatus and role of reninangiotensin system	62	417–419
PY7.3	Describe the mechanism of urine formation involving processes of filtration, tubular reabsorption and secretion; concentration and diluting mechanism	63, 64 and 65	424–445
PY7.4	Describe and discuss the significance and implication of renal clearance	66	441–443
PY7.5	Describe the renal regulation of fluid and electrolytes and acid-base balance	65, 69	432–438, 447–453
PY7.6	Describe the innervations of urinary bladder, physiology of micturition and its abnormalities	67	504–509
PY7.7	Describe artificial kidney, dialysis and renal transplantation	67, 69	459, 485
PY7.8	Describe and discuss renal function tests	66	441–453
PY7.9	Describe cystometry and discuss the normal cystometrogram	67	455–456
Integrated Physiology			
PY11.1	Describe and discuss mechanism of temperature regulation	68	460–474
PY11.2	Describe and discuss adaptation to altered temperature (heat and cold)	68	470–473
PY11.3	Describe and discuss mechanism of fever, cold injuries and heat stroke	68	470–474
PY11.4	Describe and discuss cardio-respiratory and metabolic adjustments during exercise; physical training effects	40	256–258
PY11.5	Describe and discuss physiological consequences of sedentary lifestyle	Refer to Vol 2	Ch 112 (913)
PY11.6	Describe physiology of infancy	Refer to Vol 2	Ch 84 (696–701)
PY11.7	Describe and discuss physiology of aging; free radicals and antioxidants	Refer to Vol 1	A1
PY11.8	Discuss and compare cardio-respiratory changes in exercise (isometric and isotonic) with that in the resting state and under different environmental conditions (heat and cold)	40	260–261
PY11.9	Interpret growth charts	Refer to <i>Manual of Practical Physiology</i>	
PY11.10	Interpret anthropometric assessment of infants	Refer to <i>Manual of Practical Physiology</i>	
PY11.11	Discuss the concept, criteria for diagnosis of Brain death and its implications	Refer to <i>Manual of Practical Physiology</i>	
PY11.12	Discuss the physiological effects of meditation	Refer Vol 2, Integration Lectures Section	
PY11.13	Obtain history and perform general examination in the volunteer/simulated environment	Refer to <i>Manual of Practical Physiology</i>	
PY11.14	Demonstrate Basic Life Support in a simulated environment (Appendix 7, Vol 2)	Refer to <i>Manual of Practical Physiology</i>	