Contents

V

vi

xix

Preface to the Fourteenth Edition Preface to the First Edition Index of Competencies

Section I General Physiology

۱.	Cell Physiology: Structure and Functionsof Cell Organelle2
	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

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 R	MP 27
Nernst Potential 27	
Goldman-Hodgkin and Katz (GHK) Equation 27	7
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	20
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	
Ion Channel Studies 33 Procedures 33	
Exam-oriented Questions 33	
Exam-oriented Questions 55	
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	
Interstitial Fluid (IF) 35 Intracellular Fluid Compartment (ICF) 35	
Interstitial Fluid (IF) 35 Intracellular Fluid Compartment (ICF) 35 Measurement of Body Fluid Compartments 36	
Interstitial Fluid (IF) 35 Intracellular Fluid Compartment (ICF) 35 Measurement of Body Fluid Compartments 36 Total Body Water 36	
Interstitial Fluid (IF) 35 Intracellular Fluid Compartment (ICF) 35 Measurement of Body Fluid Compartments 36	
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	
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
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	37
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 Regulation of Body Fluid Volume 37 Exogenous and Endogenous Water Input 37	37
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 Regulation of Body Fluid Volume 37 Exogenous and Endogenous Water Input 37 Water Excretion and its Daily Output 37	37
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 Regulation of Body Fluid Volume 37 Exogenous and Endogenous Water Input 37	37
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 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	37
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 Regulation of Body Fluid Volume 37 Exogenous and Endogenous Water Input 37 Water Excretion and its Daily Output 37 Maintenance of Electrolyte Balance 37	37
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 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	37
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 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	37

Sect	tion 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	
0	-	
9. Viscosity and Erythrocyte Sedimentation Rate (ESR)		48
	Introduction 48 Viscosity: Characteristics 48	
	Suspension Stability of Blood (Erythrocyte Sedimenta	ation
	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 Antihaemophilic Factor (AHF) or Antihaemophilic Globulin (AHG) or Platelet Cofactor I 51	
	Factor IX or Christmas Factor or Plasma Thrombo Component (PTC) or Platelet Cofactor II 52	plastin
	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 Fa (LLF) 52	ctor
	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	1

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

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

59

69

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

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 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

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

	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	
		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 Ce	lls 102
	Functions of the Reticuloendothelial System 103	
	Exam-oriented Questions 103	
19.	Immunity	104
	Introduction 104	

17. Blood Groups and Blood Transfusion

73

81

90

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

Contents

ix

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

122

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

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

Human Physiology

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	
	Exam-oriented Questions 142	
25.	Muscle Contraction	143
	Introduction 143	
	Mechanism of Contraction 143	
	Molecular Mechanism of Muscle Contraction (Slidi	ng
	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	
	Exam oriented Questions (11)	
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		
	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



160

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

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

183

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

202

Exam-Oriented Questions 201

34. Electrocardiogram

Introduction 202	
Methods of Recording Electrocardiogram 202	
Electrocardiographic Leads Used both Clinically an	d
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	
Innervations of Heart and Heart Rate	213
Introduction 213	
Nerves of the Heart and their Action 213	

35. 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 xi

Contents

37. Blood Pressure

223

237

Introduction 223 Basal Blood Pressure 223 Physiological Variations 223 Significance of Blood Pressure 224 Systolic Pressure 224 Diastolic Pressure 224 Pulse Pressure 224 Physiological Significance of Blood Pressure 224 Measurement and Recording of Blood Pressure 224 Arterial Blood Pressure 224 Venous Pressure 226 Determinants of Blood Pressure 226 Adjustment of Blood Pressure 226 Efferent Pathways of this Self-adjustment or Homoeostasis of Blood Pressure 227 Vasomotor System 227 Afferent Pathways 228 Role of Sino-aortic Mechanism in the Regulation of Normal Blood Pressure 228 Sino-aortic Mechanism 228 Chemoreceptors Location 229 Aortic Bodies 230 Vascular Receptors other than Sino-Aortic for the Control of Blood Pressure and Flow 230 As Chemoreceptors 231 Mechanism of Regulation of Blood Pressure 231 Short-term Regulating Mechanisms 231 Intermediate Mechanism of Regulation of Blood Pressure 232 Long-term Regulation of Blood Pressure 232 Role of other Hormone in Regulation of Blood Pressure 232 Role of Humoral Vasoconstrictors and Vasodilators 232 Humoral Vasoconstrictors 232 Humoral Vasodilators 233 Chemical Control of Blood Pressure Influenced by Vasomotor Mechanism 233 Exam-oriented Questions 233 38. Velocity of Blood Flow and Radial Pulse 234

Introduction 234 Velocity of Blood 234 Methods of Measurement of Velocity of Blood 234 Radial Pulse 234 Pressure Pulse 235 Recording of Radial Pulse 235 Clinical Features of Radial Pulse 235 Special Varieties of Pulse 235 Applied Physiology 236 Exam-oriented Questions 236

39. Regional Circulation

Introduction 237 Coronary Circulation 237

Anatomical Considerations 237 Venous Drainage 238 Methods of Study 238 Normal Values 238 Variations of Coronary Inflow during Different Phases of Cardiac Cycle 239 Coronary Inflow 239 Factors Influencing Coronary Circulation 240 Circulatory Status of the Cardiac Muscle under Certain Diseased Conditions 241 Aortic Stenosis 241 Pulmonary Hypertension 241 Aortic Insufficiency 241 Mitral Stenosis 241 Aortic Coarctation 241 Hypertensive Cardiovascular Disease 241 Ischaemic Heart Disease 241 Coronary Spasms and Intercoronary Reflexes 241 Pathological Physiology of Angina Pectoris and Acute Myocardial Infarction 241 Cerebral Circulation 241 Anatomical Considerations 241 Method of Study: Nitrous Oxide Method: Fick Principle 242 Vasomotor Supply 242 Normal Values of Cerebral Circulation 242 Regulation of Cerebral Circulation 243 Existence of Auto-regulation of Cerebral Blood Flow 243 Key Points 243 Factors Controlling Cerebral Circulation 243 Cerebrovascular Resistance 243 Pulmonary Circulation 244 Anatomy of Circulation 244 Method of Recording Pulmonary Arterial Pressure 244 Vasomotor Supply 244 Normal Values of Pulmonary Circulation 244 Functions of Pulmonary Circulation 245 Control of Pulmonary Circulation 245 Peculiarities of Pulmonary Circulation 246 Pulmonary Vascular Reflex 246 Circulatory Status in Different Cardiopulmonary Diseases 246 Mitral Stenosis 246 Emphysema 246 Pulmonary Embolism 246 Atelectasis 246 Removal of Lung 247 Diffuse Sclerosis of Lung Vessels 247 Pulmonary Fibrosis 247 Hepatic Circulation 247 Vascular Arrangement 247 Vasomotor Supply 247 Normal Values of Hepatic Circulation 247 Factors Modifying Hepatic Circulation 248 Peculiarities of Hepatic Circulation 248 Splenic Circulation 249 Control of Blood Flow 249 Renal Circulation 249 Capillary Circulation 249 Histology 249 Methods of Study of Capillary Circulation 249 Vasomotor Supply 249 Control of Capillary Circulation 250 Interchange in the Capillary Area 251 Cutaneous Circulation 251 Anatomy of Cutaneous Circulation 251

Rate of Blood Flow 251

xii

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						

255

40. Physiology of Exercise

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 System276
	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

43. Mechanics of Breathing

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 (FEV₁) Second 291 FEV₁/FVC Ratio (FEV₁%) 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

xiii

	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	4	49
	Alveolar Air 294		
	Composition of Alveolar Air 294		
	Partial Pressure of Gases in Inspired Air, Expired and Alveolar Air 295	Air	
	Effect of Voluntary Hyperpnoea on Alveolar Air	295	
	Breath-holding Time 295		
	Effects of High Altitude on Alveolar Oxygen 29 Factors Controlling Alveolar pCO ₂ 296	6	
	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		50
	Pulmonary Diffusing Capacity for O ₂ (DO ₂) 299		
	Diffusion of CO_2 300		
	Perfusion 300		
	Applied Physiology 300		51
	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		52
	Carbon Dioxide Transport 305 CO ₂ Content and Tension of Blood 305		32
	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	
+0.		309	
	Introduction 309		
	Respiratory Centre 309 Dersal Respiratory Croup (DRC) of Neurons and		
	Dorsal Respiratory Group (DRG) of Neurons and Inspiratory Ramp Signals 310		
	Ventral Respiratory Group of Neurons 310		53
	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		

45. Alveolar Ventilation and Gases Exchange

Nervous Factors Influencing Respiration in Exercise	e 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	
Нурохіа	318
Definition 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
Compressed Air Sickness and Deep Sea Diving 323
Dysbarism (Caisson Disease) 323
Exam-oriented Question 323
Respiration in Abnormal Conditions 324

Respiration in Abnormal Conditions
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

2. 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 B. 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

Human Physiology

xiv

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 and Basic Life Support (BLS) 342

Vocalisation 342 Articulation and Resonance 343 Basic Life Support (BLS) 343 Basic Life Support Sequence 343 Collapsed Victim 343 CAB 344 Compressions 344 Automated External Defibrillators (AEDs) 344 Airway and Ventilations 345 Opening the Airway 345 Ventilations 345 Choking 346 Adult Choking Sequence 347 Unresponsive Victim 347 Chain of Survival 347 Exam-oriented Questions 347 Clinical Case Scenario 348 Respiratory System 348 Recent Advances 348

Sec	tion VI Gastro-intestinal Tract	
56.	General Outline of Digestive System	350
	Introduction 350	
	Anatomical Consideration 350	
	Histological Structure 351	
	Innervation of the Digestive Tract 351	
	Functions of the Digestive System 352	
	Histology of Tongue 352	
	Glands 355	
	Nerve Supply 355	
	Functions 355	
	Salivary Glands 355	
	Histology of Salivary Glands 355	
	Pharynx or Throat Cavity 357	
	Oesophagus 357	
	Histology 357	
	Stomach 358	
	Histology of Stomach 359	
	Functions of Stomach 360	
	Small Intestine 360	
	Vermiform Appendix 362	

Large Intestine 362 Rectum 362 Anal Canal 362 Brief Summary of the Chief Identifying Features of Different Parts of the Digestive Tract 362 Exam-oriented Questions 362 57. Digestive Juices 363 Introduction 363 Saliva 363 Characteristics 363 Composition 363 Functions 363 Gastric Juice 364 Composition 364 Characteristics 364 Functions 364 Pancreatic Juice 364 Characteristics 364 Succus Entericus 365 Characteristics 365 Composition 365 Intestinal Juice Enzymes 365 Carbohydrate Splitting 365 Functions 365 Biles 365 Introduction 365 Composition of Bile 366 Functions of Bile 366 Bile Salts 367 Variety and Chemistry 367 Synthesis of Bile Salts 367 Enterohepatic Circulation and Fate of Bile Salts 367 Functions of Bile Salts 367 Bile Pigments 368 Chemistry and Varieties 368 Origin and Formation 368 Site of Formation, Circulation and Fate 368 Exam-oriented Questions 370 58. Mechanism of Secretion of Various

371 **Digestive Juices** Introduction 371 Saliva 371 Nerve Supply of Salivary Glands 371 Significance of Double Nerve Supply 372 Salivary Secretion and Reflexes 372 Reflex Control of Rate of Flow and Composition of Saliva 373 Disturbances of Salivary Secretion 373 Gastric Secretions 373 Cephalic Phase 374 Gastric Phase 375 Gastric Phase Characteristic Features 375 Intestinal Phase 375 Action of Other Hormones on Gastric Secretion 376 Interrelation between the Different Phases 377 Gastric Function Test 377 Investigation of Gastric Secretion in Man 377 Other Functional Tests 378 Origin and Character of the Important Constituents of Gastric Juice 379 Hydrochloric Acid 379 Applied Physiology: Peptic Ulcer 379 Pepsin 380 Mucin 380

Intrinsic Factor 380

Contents

Neuropoietic Factor 380 Pancreas 380 Development 381 Mechanism of Pancreatic Secretions 381 Nervous Phase 381 Chemical Phase 382 Influence of Various Foodstuffs on Pancreatic Secretion 383 Applied Physiology 383 Liver 383 Anatomy 383 Gall Bladder: Structure and Functions 383 Mechanism of Bile Secretion 384 Mechanism of Secretion 384 Mechanism of Expulsion of Bile 385 Factors Controlling Movements of Gall Bladder 385 Functions of Gall Bladder 386 Applied Physiology 386 Mechanism of Secretion of Succus Entericus (Intestinal Juice) 386 Mechanism 387 Applied Physiology 387 Summary of Secretions of the Various Digestive Juices 387 Exam-oriented Questions 388

59. Movements of Alimentary Canal

389

401

Introduction 389 Facts about Movement 389 Cause of Movements 389 Relation with Degree of Activity 389 Deglutition (Swallowing) 389 Common Disturbances in the Swallowing 391 Movements of Stomach 391 Applied Physiology 393 Vomiting (Emesis) 393 Movements of Small Intestine 395 Frequency 395 Movements of Villi 397 Applied Physiology 397 Movements of Large Intestine 397 Functions of Large Intestine 398 Rate of Progress of Barium Meal 398 Applied Physiology—Large Intestine 400 Defaecation 400 Mechanism 400 Exam-oriented Questions 400

60. Digestion and Absorption of Foodstuffs

Introduction 401 Digestion of Carbohydrates 401 Introduction 401 Different forms of Carbohydrates 401 Digestion of Proteins 402 Introduction 402 Different Forms of Protein 403 Digestion of Nucleoprotein 403 Digestion of Casein 403 Digestion of Milk 404 Digestion of Collagen and Gelatin 404 Digestion of Mucin 404 Digestion of Lipids 404 Digestion in the Pancreatic Juice 404 Absorption 405 Definition 405 Absorption of Carbohydrates 405 Absorption of Proteins 405

Fats Absorption 406 Process of Absorption 406 Water Absorption 406 Absorption of Electrolytes 406 Faeces 407 Contents and Characteristics 407 Exam-oriented Questions 407

61. Gastro-intestinal Hormones

Introduction 408 Gastrin 408 Cholecystokinin (CCK) or Pancreozymin 409 Regulation of Secretion of Cholecystokinin 409 Glucagon-like Peptide-1 409 Gastric Inhibitory Polypeptide (GIP) 409 Vasoactive Intestinal Peptide (VIP) 409 Urogastrone 409 Villikinin 409 Enterocrinin 410 Motilin 410 Neurotensin 410 Somatostatin 410 Gastrin Releasing Peptide 410 Ghrelin 410 Peptide YY 410 Substance P 410 Bombesin 410 Exam-oriented Questions 410 Clinical Case Scenario 411 Gastrointestinal Tract 411 Recent Advances: Treatment of Peptic Ulcer 411 Recent Advances: Capsule Endoscopy 412

408

Section VII Renal Physiology

62.	Functional Anatomy of Excretory System	414
	Introduction 414	
	Kidneys 414	
	Characteristic Features 414	
	Nephron 415	
	Uriniferous Tubules 416	
	Types of Nephrons 416	
	Renal Tubules 419	
	Proximal Convoluted Tubule (PCT) 419	
	Henle's Loop 419	
	Distal Convoluted Tubule (DCT) 420	
	Collecting Tubule 421	
	Juxtaglomerular Apparatus 421	
	Regulation of Renin Secretion 422	
	Renal Circulation 423	
	Peculiarities 423	
	Peculiarities of Renal Circulation 425	
	Exam-oriented Questions 426	
63.	Urine Formation by Kidneys: Renal Blood Flow and their Control	427
	Introduction 427	
	Autoregulation of Renal Blood Flow 427	
	Nervous Control 428	
	Other Factors 429	
	Blood Glucose Level 429	
	Hormones Influencing Renal Functions 429	
	Measurement of Renal Blood Flow 429	
	Functions of Kidney and Glomerulus 430	
	Functions of Kidney 430	
	Exam-oriented Questions 430	

Human Physiology

xvi

	Jrine Formation by the Kidney: Glomerular Filtration Rate and their Control 431
Ι	ntroduction 431
	Key Points 431
	Glomeruli as Ultrafilter 433
	Functions of Glomerulus 433
1	Applied physiology: Chronic Kidney Disease and Glomerular Filtration Rate 435
ł	Fubular Reabsorption and Tubular Secretion (Urine Formation): Water and Electrolytes Balance and Counter-current Mechanism 436
I	ntroduction 436
	Methods of Study of Tubular Functions 436 Gelective Reabsorption 436 Glucose 436
	Water 437
	Sodium and Chloride 439
	Potassium 439
	Bicarbonate 441
	Phosphate 442
I	Reabsorption of other Substances 442
	Tubular Secretion 442
	Formation of Some New Substances 442
E	Exam-oriented Questions 444
	Renal Function Test, Urine, Urinary Characteristic and its Mechanism of Formation 445
ſ	ntroduction 445
	Assuming 445
ĺ.,	Test for measurement of GFR 446
	Inulin Clearance (A Measure of Glomerular Filtration Rate) 446
	Creatinine Clearance Test 446
[I. Test to Measure Excretory Function 446
	Urea Clearance Test (Van Slyke) 446
	II. Test to Estimate Tubular Secretion Capacity 447
	V. Test to Measure Renal Blood Flow 447
	Jrine, Urinary Characteristic and its Mechanism of Formation 447
	ntroduction 447
(Other Characteristics 448
	Colour 448
	Reaction 448
	Specific Gravity 448
	Turbidity 448 Odour 448
	Odour 448 Osmotic Pressure 448
<i>,</i>	Composition of Urine 448
•	Normal Constituents of Urine 448
,	Abnormal Constituents of Urine 449
1	Protein 449
	Glucose 450
	Ketone Bodies 450
	Presence of Blood in Urine 450
	Pigments 450
	Calculi and Casts 450
	Pus 450
	Hormones 450
J	Factors Affecting Formation of Urine 451
	Reaction of Urine 451
	Mechanism of Regulation of Blood Reaction by the Kidneys 451
F	Bicarbonate Mechanism 451
I	Phosphate Mechanism 452
1	Ammonia Mechanism 453
ľ H I	Mechanism of Regulation of Blood Reaction by the Kidneys 451 Bicarbonate Mechanism 451 Phosphate Mechanism 452

Elimination of Acids 453 Elimination of Alkalis 454 Glycosuria 454 Glycosuria due to Hyperglycaemia 454 Glycosuria due to Less Tubular Reabsorption 455 Factors Controlling Volume of Urine 455 Abnormal Volume of Urine 456 Applied Physiology 456 Exam-oriented Questions 457

67. Micturition

Introduction 458 Structure of Urinary Bladder 458 Mechanism of Filling of Bladder 459 Mechanism of Micturition 459 Key Features 459 Micturition Reflex 460 Centres of Micturition 461 Effect of Lesion of Autonomic Nerves 461 Applied: Pathological Conditions involving Bladder Control Physiology 462 Artificial Kidney 463 Exam-oriented Questions 463

458

68. Skin, Body Temperature and its Regulation 464

Introduction 464 Structure 464 Epidermis 464 Dermis (Cutis Vera or True Skin) 465 Functions of Skin 465 Glands in the Skin 466 Mechanism of Secretion of Sweat 466 Composition of Sweat 467 Sebaceous Glands 467 Composition of Sebum 467 Control 467 Special Structures of Skin 469 Nails (Ungues) 469 Hair (Pili) 469 Body Temperature and its Regulation 470 Introduction 470 Factors Affecting Body Temperature 470 Regulation of Body Temperature 471 Mechanisms of Heat Production (Thermogenesis) 471 Mechanisms of Heat Loss (Thermolysis) 472 Nervous System and Thermotaxis 472 Interaction of Central and Peripheral Factors 473 Role of Endocrines 474 Temperature Regulation in the Newborn Infant 474 Mechanism of Regulation of Body Temperature 474 Decreased Body Temperature and Responses 474 Other Factors 474 Effects of Exposure to High and Low Atmospheric Temperature 474 Physiological Alterations of Body Mechanisms on Exposure to Hot Atmosphere 474 Life in Deserts 475 Physiological Alterations of Body Mechanisms on Exposure to Cold Atmosphere 476 Effect of Sudden Change of Atmospheric Temperature 476 Pyrexia 476 Physiological Responses due to Pyrexia (Fever) 476 Hypothermia 476 Physiological Responses to (Deliberate) Hypothermia 476

Contents

xvii

Applied Physiology 477 Exam-oriented Questions 478

69.	Regulation of Reaction of Blood andDisturbances in Acid–Base Regulation479
	Introduction 479
	Respiratory H ⁺ 479
	Metabolic H ⁺ 479
	Acid-base, Hydrogen Ion Concentration and pH 479
	Acid and Base 479
	Hydrogen Ion Concentration 480
	pH 480
	Calculation of pH 480
	Calculation of [H ⁺] Ion Concentration 480
	The pH Scale 480
	Physiological Importance of Maintenance of pH 481
	Buffers, Lungs and Kidney 482
	Buffer Action 482
	Bicarbonate Buffer System 482
	Bicarbonate Buffer System and its importance as
	Extracellular Buffer 482
	Role of Kidney and Lung 482
	Role of Respiration in Acid–Base Balance 484
	Role of Kidneys in Acid–Base Balance 484
	Disturbances in Acid–Base Regulation 485
	Respiratory Acidosis 485
	Definition 485
	Pathophysiology 485
	Compensatory Mechanism 485
	Metabolic Alkalosis 485
	Definition 485

```
Respiratory Compensation 486
Renal Compensation 486
Metabolic Acidosis 486
Definition 486
Compensation 486
Respiratory Alkalosis 486
Definition 486
Renal Compensation 487
Assessment of the Acid–Base Status 487
Exam-oriented Questions 487
Clinical Case Scenario 488
Kidney 488
Applied Physiology 489
Peritoneal Dialysis 489
Renal Transplantation 489
```

Multiple Choice Questions

General Physiology 492 Blood 496 Nerve and Muscle 500 Cardiovascular System 504 Respiratory System 508 Gastro-intestinal Tract 511 Renal System 515 References 519

Appendi	
	١

A1-A5

Index

11–16

xviii