

Table of Contents

Preface	xi
--------------------------	-----------

SECTION I. INTRODUCTION

1. Physiologic Principles	1
--	----------

Functional Morphology of the Cell 1	The Capillary Wall 22
Body Fluid Compartments 12	Sodium & Potassium Distribution & Total Body Osmolality 22
Units for Measuring Concentration of Solutes 14	pH & Buffers 24
Composition of Body Fluids 15	Intercellular Communication 24
Forces Producing Movement of Substances Between Compartments 15	Homeostasis 28
Cell Membrane & Resting Membrane Potentials 18	Aging 28

Section I References: 28

SECTION II. PHYSIOLOGY OF NERVE & MUSCLE CELLS

2. Excitable Tissue: Nerve	29
---	-----------

Nerve Cells 29	Nerve Fiber Types & Function 40
Electrical Phenomena in Nerve Cells 32	Nerve Growth Factor 42
Ionic Basis of Excitation & Conduction 37	Glia 42
Properties of Mixed Nerves 39	

3. Excitable Tissue: Muscle	43
--	-----------

Skeletal Muscle 44	Cardiac Muscle (cont'd)
Morphology 44	Mechanical Properties 53
Electrical Phenomena & Ionic Fluxes 45	Metabolism 55
Contractile Responses 46	Pacemaker Tissue 56
Energy Sources & Metabolism 50	Smooth Muscle 56
Properties of Muscles in the Intact Organism 51	Morphology 56
Cardiac Muscle 53	Visceral Smooth Muscle 56
Morphology 53	Multi-Unit Smooth Muscle 59
Electrical Properties 53	

4. Synaptic & Junctional Transmission	60
--	-----------

Synaptic Transmission 60	Neuromuscular Transmission 77
Functional Anatomy 60	The Myoneural Junction 77
Electrical Events at Synapses 62	Nerve Endings in Smooth & Cardiac Muscle 78
Chemical Transmission of Synaptic Activity 65	Denervation Hypersensitivity 79
Inhibition & Facilitation at Synapses 74	

5. Initiation of Impulses in Sense Organs	81
--	-----------

Sense Organs & Receptors 81	Electrical & Ionic Events in Receptors 83
The Senses 81	"Coding" of Sensory Information 85

Section II References: 87

SECTION III. FUNCTIONS OF THE NERVOUS SYSTEM

6. Reflexes	88
The Reflex Arc 88 Monosynaptic Reflexes: The Stretch Reflex 88	Polysynaptic Reflexes: The Withdrawal Reflex 93 General Properties of Reflexes 95
7. Cutaneous, Deep, & Visceral Sensation	97
Pathways 97 Touch 99 Proprioception 100 Temperature 100 Pain 100	Differences Between Somatic & Visceral Sensory Mechanisms 102 Visceral Pain 103 Referral & Inhibition of Pain 104 Other Sensations 106
8. Vision	107
Anatomic Considerations 107 The Image-Forming Mechanism 112 The Photoreceptor Mechanism: Genesis of Action Potentials 114	Responses in the Visual Cortex 118 Other Aspects of Visual Function 120 Color Vision 123 Eye Movements 124
9. Functions of the Ear	126
Anatomic Considerations 126 External & Middle Ear 126 Inner Ear 127 Hearing 130 Auditory Responses 130 Sound Transmission 131 Electrical Phenomena 133 Brain Mechanisms 134	Hearing (cont'd) Deafness 135 Vestibular Function 136 Responses to Rotational & Linear Acceleration 136 Orientation in Space 137 Effects of Labyrinthectomy 137
10. Smell & Taste	138
Smell 138 Receptors & Pathways 138 Physiology of Olfaction 139	Taste 140 Receptor Organs & Pathways 140 Physiology of Taste 141
11. The Reticular Activating System, Sleep, & the Electrical Activity of the Brain	144
The Reticular Formation & the Reticular Activating System 144 The Thalamus & the Cerebral Cortex 144 Evoked Cortical Potentials 145	The Electroencephalogram 146 Physiologic Basis of the EEG & Consciousness 147 Sleep 151 Modulation of Sensory Input 153
12. Control of Posture & Movement	154
Pyramidal System 154 Anatomy 154 Function 156 Extrapyramidal Mechanisms 157 Spinal Integration 158 Medullary Components 160 Midbrain Components 162	Extrapyramidal Mechanisms (cont'd) Cortical Components 162 Basal Ganglia 163 Cerebellum 165 Anatomic & Functional Organization 165 Physiology 168
13. Efferent Pathways to Visceral Effectors	172
Anatomic Organization of Autonomic Outflow 172 Chemical Transmission at Autonomic Junctions 175	Responses of Effector Organs to Autonomic Nerve Impulses 175

14. Neural Centers Regulating Visceral Function	178
Medulla Oblongata 178	
Hypothalamus 179	
Anatomic Considerations 179	
Hypothalamic Function 181	
Relation of Hypothalamus to Autonomic Function 181	
Relation to Sleep 183	
Hypothalamus (cont'd)	
Relation to Cyclic Phenomena 183	
Hunger 183	
Thirst 185	
Control of Posterior Pituitary Secretion 186	
Control of Anterior Pituitary Secretion 190	
Temperature Regulation 193	
15. Neurophysiologic Basis of Instinctual Behavior & Emotions	198
Anatomic Considerations 198	
Limbic Functions 199	
Sexual Behavior 200	
Fear & Rage 202	
Motivation 203	
Brain Chemistry, Behavior, & Synaptic Transmission in the Central Nervous System 204	
16. "Higher Functions of the Nervous System": Conditioned Reflexes, Learning, & Related Phenomena	208
Learning 209	
Memory 211	
Functions of the Neocortex 212	

Section III References: 216

SECTION IV. ENDOCRINOLOGY & METABOLISM

17. Energy Balance, Metabolism, & Nutrition	218
Energy Metabolism 218	
Metabolic Rate 218	
Energy Balance 222	
Intermediary Metabolism 222	
General Considerations 222	
Carbohydrate Metabolism 224	
Intermediary Metabolism (cont'd)	
Protein Metabolism 231	
Fat Metabolism 237	
Nutrition 245	
Essential Dietary Components 245	
18. The Thyroid Gland	250
Anatomic Considerations 250	
Formation & Secretion of Thyroid Hormones 251	
Transport & Metabolism of Thyroid Hormones 253	
Effects of Thyroid Hormones 255	
Mechanism of Action of Thyroid Hormones 258	
Regulation of Thyroid Secretion 258	
Clinical Correlates 259	
19. Endocrine Functions of the Pancreas & the Regulation of Carbohydrate Metabolism	264
Islet Cell Structure 264	
Structure, Biosynthesis, & Secretion of Insulin 265	
Fate of Secreted Insulin 267	
Consequences of Insulin Deficiency & Actions of Insulin 267	
Insulin Excess 274	
Mechanism of Action of Insulin 274	
Regulation of Insulin Secretion 275	
Glucagon 278	
Other Islet Cell Hormones 280	
Endocrine Regulation of Carbohydrate Metabolism 281	
Hypoglycemia & Diabetes Mellitus in Humans 282	
20. The Adrenal Medulla & Adrenal Cortex	284
Adrenal Morphology 284	
Adrenal Medulla 285	
Structure & Function of Medullary Hormones 285	
Regulation of Adrenal Medullary Secretion 287	
Adrenal Cortex 288	
Structure & Biosynthesis of Adrenocortical Hormones 288	
Transport, Metabolism, & Excretion of Adrenocortical Hormones 292	
Effects of Adrenal Androgens & Estrogens 294	
Adrenal Cortex (cont'd)	
Physiologic Effects of Glucocorticoids 294	
Pharmacologic & Pathologic Effects of Glucocorticoids 297	
Regulation of Glucocorticoid Secretion 298	
Effects of Mineralocorticoids 302	
Regulation of Aldosterone Secretion 304	
Role of Mineralocorticoids in the Regulation of Salt Balance 306	
Summary of the Effects of Adrenocortical Hyper- & Hypofunction in Humans 306	

21. Hormonal Control of Calcium Metabolism & the Physiology of Bone	308
Calcium & Phosphorus Metabolism 308	
Bone Physiology 309	
Vitamin D and the Hydroxychole- calciferols 311	
The Parathyroid Glands 312	
Calcitonin 315	
Effects of Other Hormones on Calcium Metabolism 317	
22. The Pituitary Gland	318
Morphology 318	
Intermediate Lobe Hormones 320	
Growth Hormone 321	
Physiology of Growth 325	
Pituitary Insufficiency 328	
Pituitary Hyperfunction in Humans 329	
23. The Gonads: Development & Function of the Reproductive System	331
Sex Differentiation & Development 331	
Chromosomal Sex 331	
Embryology of the Human Reproductive System 334	
Aberrant Sexual Differentiation 337	
Puberty 338	
Precocious & Delayed Puberty 339	
Menopause 340	
Pituitary Gonadotropins & Prolactin 340	
The Male Reproductive System 342	
Structure 342	
Gametogenesis & Ejaculation 343	
The Male Reproductive System (cont'd)	
Endocrine Function of the Testes 345	
Control of Testicular Function 348	
Abnormalities of Testicular Function 348	
The Female Reproductive System 349	
The Menstrual Cycle 349	
Ovarian Hormones 354	
Control of Ovarian Function 357	
Abnormalities of Ovarian Function 359	
Pregnancy 359	
Lactation 361	
24. Other Organs With Established or Suggested Endocrine Functions	364
The Endocrine Functions of the Kidneys: Renin & Erythropoietin 364	
Pineal 368	

Section IV References: 369

SECTION V. GASTROINTESTINAL FUNCTION

25. Digestion & Absorption	371
Carbohydrates 372	
Proteins & Nucleic Acids 374	
Lipids 375	
Absorption of Water & Electrolytes 377	
Absorption of Vitamins & Minerals 378	
26. Gastrointestinal Secretion & Motility	380
Gastrointestinal Hormones 381	
Mouth & Esophagus 384	
Stomach 386	
Regulation of Gastric Secretion & Motility 388	
Other Functions of the Stomach 390	
Exocrine Portion of the Pancreas 391	
Liver & Biliary System 393	
Small Intestine 397	
Colon 400	

Section V References: 404

SECTION VI. CIRCULATION

27. Circulating Body Fluids	405
The Circulatory System 405	
Blood 405	
Bone Marrow 405	
White Blood Cells 407	
Immune Mechanisms 408	
Platelets 411	
Blood (cont'd)	
Red Blood Cells 412	
Blood Types 416	
Plasma 419	
Hemostasis 420	
Lymph 423	

28. The Heart: Origin of the Heartbeat & the Electrical Activity of the Heart	424
Origin & Spread of Cardiac Excitation 424	
The Electrocardiogram 426	
Cardiac Arrhythmias 431	
Electrocardiographic Findings in Other Cardiac & Systemic Diseases 437	
29. The Heart as a Pump	441
Mechanical Events of the Cardiac Cycle 441	
Cardiac Output 445	
30. Dynamics of Blood & Lymph Flow	452
Anatomic Considerations 452	
Biophysical Considerations 454	
Arterial & Arteriolar Circulation 458	
Capillary Circulation 462	
Lymphatic Circulation & Interstitial Fluid Volume 463	
Venous Circulation 464	
31. Cardiovascular Regulatory Mechanisms	466
Local Regulatory Mechanisms 466	
Systemic Regulatory Mechanisms 467	
32. Circulation Through Special Regions	476
Cerebral Circulation 476	
Anatomic Considerations 476	
Cerebrospinal Fluid 477	
The Blood-Brain Barrier 479	
Cerebral Blood Flow 480	
Regulation of Cerebral Circulation 483	
Cerebral Circulation (cont'd)	
Brain Metabolism & Oxygen Requirements 484	
Coronary Circulation 485	
Splanchnic Circulation 488	
Circulation of the Skin 489	
Placental & Fetal Circulation 490	
33. Cardiovascular Homeostasis in Health & Disease	494
Compensations for Gravitational Effects 494	
Exercise 496	
Hemorrhage & Hemorrhagic Shock 498	
Other Forms of Shock 500	
Fainting 502	
Heart Failure 502	
Hypertension 504	

Section VI References: 506

SECTION VII. RESPIRATION

34. Pulmonary Function	507
Properties of Gases 507	
Mechanics of Respiration 508	
Gas Exchange in the Lung 516	
Pulmonary Circulation 516	
Other Functions of the Respiratory System 518	
35. Gas Transport Between the Lungs & the Tissues	520
Oxygen Transport 520	
Buffers in Blood 523	
Carbon Dioxide Transport 525	
36. Regulation of Respiration	527
Neural Control of Breathing 527	
Regulation of Respiratory Center Activity 529	
Chemical Control of Breathing 529	
Nonchemical Influences on Respiration 533	
37. Respiratory Adjustments in Health & Disease	535
Effects of Exercise 535	
Hypoxia 537	
Hypoxic Hypoxia 538	
Other Forms of Hypoxia 542	
Oxygen Treatment 543	
Hypercapnia & Hypocapnia 544	
Effects of Increased Barometric Pressure 545	
Artificial Respiration 546	

Section VII References: 548

SECTION VIII. FORMATION & EXCRETION OF URINE

38. Renal Function 549

Functional Anatomy 549	Acidification of the Urine & Bicarbonate Excretion 566
Renal Circulation 552	Regulation of Na^+ & Cl^- Excretion 568
Glomerular Filtration 554	Regulation of K^+ Excretion 571
Tubular Function 556	Diuretics 571
Water Excretion 560	Effects of Disordered Renal Function 572

39. Micturition 574

Filling of the Bladder 574	Abnormalities of Micturition 575
Emptying of the Bladder 574	

40. Regulation of Extracellular Fluid Composition & Volume 577

Defense of Tonicity 577	Defense of Specific Ionic Composition 578
Defense of Volume 577	Defense of H^+ Concentration 578

Section VIII References: 584

Appendix 585

General References 585	Standard Respiratory Symbols 591
Normal Values & the Statistical Evaluation of Data 585	Equivalents of Metric, United States, & English Measures 591
Appendix References 587	Greek Alphabet 592
Abbreviations & Symbols Commonly Used in Physiology 588	

Index 593

Tables

Atomic Weights	Inside Front Cover
Ranges of Normal Values in Human Whole Blood, Plasma, or Serum	Inside Back Cover