Contents

UNIT I		UNIT II	
Introduction to Physiology: The Cell and General Physiology		Membrane Physiology, Nerve, and Musc	le
		CHAPTER 4	
CHAPTER 1		Transport of Substances Through Cell	
Functional Organization of the Human Body		Membranes	51
and Control of the "Internal Environment"	3	The Cell Membrane Is a Lipid Bilayer With	
Cells Are the Living Units of the Body	3	Cell Membrane Transport Proteins	51
Extracellular Fluid—The "Internal Environment"	3	Diffusion	52
Homeostasis—Maintenance of a Stable Internal		Active Transport of Substances Through	
Environment	4	Membranes	58
Control Systems of the Body	7		
Physiological Variability	10	CHAPTER 5	
Sex Differences in Physiology and Pathophysiology	10	Membrane Potentials and Action	
Summary—Automaticity of the Body	11	Potentials	63
OUADTED 0		Basic Physics of Membrane Potentials	63
CHAPTER 2		Resting Membrane Potential of Neurons	65
The Cell and Its Functions	13	Neuron Action Potential	67
Organization of the Cell	13	Propagation of the Action Potential	71
Cell Structure	14	Importance of Energy Metabolism for	
Functional Systems of the Cell	21	Reestablishing Sodium and Potassium Ionic	
Locomotion of Cells	26	Gradients After Action Potentials Are	
		Completed	72
CHAPTER 3		Plateau in Some Action Potentials	72
Genetic Control of Protein Synthesis, Cell		Rhythmicity of Some Excitable Tissues—	
Function, and Cell Reproduction	31	Repetitive Discharge	73
Cell Nucleus Genes Control Protein Synthesis	31	Special Characteristics of Signal Transmission	
Transcription—Transfer of Cell Nucleus DNA		in Nerve Trunks	74
Code to Cytoplasm RNA Code	33	Excitation—The Process of Eliciting the Action	
Translation—Formation of Proteins on the		Potential	75
Ribosomes	37	CHAPTER 6	
Protein Enzymes Control Synthesis of Other		Contraction of Skeletal Muscle	79
Substances in the Cell	38	Physiological Anatomy of Skeletal Muscle	79
Regulation of Gene Function and Biochemical		General Mechanism of Muscle Contraction	81
Activity in Cells	39	Molecular Mechanisms of Muscle Contraction	82
The DNA-Genetic System Controls Cell		Energetics of Muscle Contraction	86
Reproduction	41	Characteristics of Whole Muscle Contraction	87
Cell Differentiation	45		
Apoptosis—Programmed Cell Death	46		
Cancer	46		

CHAPTER 7		Prolonged and Bizarre Patterns of the	
Excitation of Skeletal Muscle: Neuromuscular		QRS Complex	151
Transmission and Excitation-Contraction		Current of Injury on the Electrocardiogram	152
Coupling	93	Abnormalities in the T Wave	155
Neuromuscular Junction and Transmission of Impulses From Nerve Endings to Skeletal		CHAPTER 13	
Muscle Fibers	93	Cardiac Arrhythmias and Their	
Muscle Action Potential	97	Electrocardiographic Interpretation	159
Excitation-Contraction Coupling	97	Abnormal Sinus Rhythms	159
CHAPTER 8		Heart Block Within the Intracardiac Conduction Pathways	160
Excitation and Contraction of Smooth		Premature Contractions	162
Muscle	101	Paroxysmal Tachycardia	164
Contraction of Smooth Muscle	101	Ventricular Fibrillation	165
Regulation of Contraction By Calcium Ions	103	Atrial Fibrillation	168
Nervous and Hormonal Control of Smooth		Atrial Flutter	169
Muscle Contraction	105	Cardiac Arrest	170
UNIT III		UNIT IV	
The Heart		The Circulation	
CHAPTER 9			
Cardiac Muscle; The Heart as a Pump and		CHAPTER 14	
Function of the Heart Valves	113	Overview of the Circulation: Pressure,	
Cardiac Muscle Physiology	113	Flow, and Resistance	173
The Cardiac Cycle	118	Physical Characteristics of the Circulation	173
Regulation of Heart Pumping	123	Basic Principles of Circulatory Function	175
		Interrelationships of Pressure, Flow, and	475
CHAPTER 10		Resistance	175
Rhythmical Excitation of the Heart	127	CHAPTER 15	
Specialized Excitatory and Conductive System			
of the Heart	127	Vascular Distensibility and Functions of the Arterial and Venous Systems	183
Control of Excitation and Conduction in	404	Vascular Distensibility	183
the Heart	131	Arterial Pressure Pulsations	184
CHAPTER 11		Veins and Their Functions	188
	405	veins and their runctions	100
Fundamentals of Electrocardiography	135	CHAPTER 16	
Waveforms of the Normal Electrocardiogram	135	The Microcirculation and Lymphatic	
Flow of Current Around the Heart During the	137	System: Capillary Fluid Exchange,	
Cardiac Cycle	138	Interstitial Fluid, and Lymph Flow	193
Electrocardiographic Leads	130	Structure of the Microcirculation and	
CHAPTER 12		Capillary System	193
Electrocardiographic Interpretation of		Vasomotion Causes Intermittent Capillary	
Cardiac Muscle and Coronary Blood Flow		Blood Flow	194
Abnormalities: Vectorial Analysis	143	Exchange of Substances Between the	
Vectorial Analysis of Electrocardiograms		Blood and Interstitial Fluid	195
Vectorial Analysis of the Normal	143	Interstitium and Interstitial Fluid	196
Electrocardiogram		Fluid Filtration Across Capillaries	197
Mean Electrical Axis of the Ventricular	145	Lymphatic System	201
QRS and Its Significance	4.40		
Conditions That Cause Abnormal	148		
Voltages of the QRS Complex	150		

150

CHAPTER 17		Heart Failure With Preserved Ejection Fraction	284
Local and Humoral Control of Tissue		High-Output Heart Failure	285
Blood Flow	207		
Local Blood Flow Is Controlled in Response		CHAPTER 23	
to Tissue Needs	207	Heart Valves and Heart Sounds; Valvular	
Mechanisms of Local Blood Flow Control	207	and Congenital Heart Defects	287
Humoral Control of the Circulation	216	Heart Sounds	287
		Abnormal Circulatory Dynamics in	
CHAPTER 18		Valvular Heart Disease	291
Nervous Regulation of the Circulation		Abnormal Circulatory Dynamics in	
and Rapid Control of Arterial Pressure	219	Congenital Heart Defects	293
Nervous Regulation of the Circulation	219	Use of Extracorporeal Circulation	
Special Features of Nervous Control of		During Cardiac Surgery	295
Arterial Pressure	228	Hypertrophy of the Heart in Valvular and	
CHAPTER 19		Congenital Heart Disease	295
		CHAPTER 24	
Role of the Kidneys in Long-Term Control		Circulatory Shock and Its Treatment	297
of Arterial Pressure and in Hypertension: The Integrated System for Arterial		Physiological Causes of Shock	297
Pressure Regulation	231	Hypovolemic Shock Due to Hemorrhage	298
Renal-Body Fluid System for Arterial	201	Distributive Shock Is Characterized By Severe	
Pressure Control	231	Peripheral Vasodilation	303
Role of the Renin-Angiotensin System in		Obstructive Shock Is Usually Due to Noncardiac	
Arterial Pressure Control	238	Causes of Reduced Cardiac Output	305
Summary of Integrated Multifaceted		Physiology of Treatment in Shock	305
Systems for Arterial Pressure Regulation	245	Circulatory Arrest	306
CHAPTER 20		UNIT V	
Cardiac Output, Venous Return, and	240	UNIT V The Body Fluids and Kidneys	
Cardiac Output, Venous Return, and Their Regulation	249		
Cardiac Output, Venous Return, and Their Regulation Normal Values for Cardiac Output at Rest			
Cardiac Output, Venous Return, and Their Regulation Normal Values for Cardiac Output at Rest and During Activity	249 249	The Body Fluids and Kidneys CHAPTER 25	
Cardiac Output, Venous Return, and Their Regulation Normal Values for Cardiac Output at Rest		The Body Fluids and Kidneys	
Cardiac Output, Venous Return, and Their Regulation Normal Values for Cardiac Output at Rest and During Activity Control of Cardiac Output By Venous Return-	249	The Body Fluids and Kidneys CHAPTER 25 Regulation of Body Fluid Compartments:	309
Cardiac Output, Venous Return, and Their Regulation Normal Values for Cardiac Output at Rest and During Activity Control of Cardiac Output By Venous Return- Frank-Starling Mechanism of the Heart	249249	The Body Fluids and Kidneys CHAPTER 25 Regulation of Body Fluid Compartments: Extracellular and Intracellular Fluids;	309
Cardiac Output, Venous Return, and Their Regulation Normal Values for Cardiac Output at Rest and During Activity Control of Cardiac Output By Venous Return- Frank-Starling Mechanism of the Heart	249249	The Body Fluids and Kidneys CHAPTER 25 Regulation of Body Fluid Compartments: Extracellular and Intracellular Fluids; Edema	309
Cardiac Output, Venous Return, and Their Regulation Normal Values for Cardiac Output at Rest and During Activity Control of Cardiac Output By Venous Return- Frank-Starling Mechanism of the Heart Methods for Measuring Cardiac Output	249249	The Body Fluids and Kidneys CHAPTER 25 Regulation of Body Fluid Compartments: Extracellular and Intracellular Fluids; Edema Intake and Output of Fluids and Solutes Are	309
Cardiac Output, Venous Return, and Their Regulation Normal Values for Cardiac Output at Rest and During Activity Control of Cardiac Output By Venous Return- Frank-Starling Mechanism of the Heart Methods for Measuring Cardiac Output CHAPTER 21	249249	The Body Fluids and Kidneys CHAPTER 25 Regulation of Body Fluid Compartments: Extracellular and Intracellular Fluids; Edema Intake and Output of Fluids and Solutes Are Balanced During Long-Term Steady-State	
Cardiac Output, Venous Return, and Their Regulation Normal Values for Cardiac Output at Rest and During Activity Control of Cardiac Output By Venous Return- Frank-Starling Mechanism of the Heart Methods for Measuring Cardiac Output CHAPTER 21 Muscle Blood Flow and Cardiac Output	249249	The Body Fluids and Kidneys CHAPTER 25 Regulation of Body Fluid Compartments: Extracellular and Intracellular Fluids; Edema Intake and Output of Fluids and Solutes Are Balanced During Long-Term Steady-State Conditions	309
Cardiac Output, Venous Return, and Their Regulation Normal Values for Cardiac Output at Rest and During Activity Control of Cardiac Output By Venous Return- Frank-Starling Mechanism of the Heart Methods for Measuring Cardiac Output CHAPTER 21 Muscle Blood Flow and Cardiac Output During Exercise; The Coronary Circulation	249 249 260	The Body Fluids and Kidneys CHAPTER 25 Regulation of Body Fluid Compartments: Extracellular and Intracellular Fluids; Edema Intake and Output of Fluids and Solutes Are Balanced During Long-Term Steady-State Conditions Body Fluid Compartments	309
Cardiac Output, Venous Return, and Their Regulation Normal Values for Cardiac Output at Rest and During Activity Control of Cardiac Output By Venous Return- Frank-Starling Mechanism of the Heart Methods for Measuring Cardiac Output CHAPTER 21 Muscle Blood Flow and Cardiac Output During Exercise; The Coronary Circulation and Ischemic Heart Disease	249 249 260 263	The Body Fluids and Kidneys CHAPTER 25 Regulation of Body Fluid Compartments: Extracellular and Intracellular Fluids; Edema Intake and Output of Fluids and Solutes Are Balanced During Long-Term Steady-State Conditions Body Fluid Compartments Constituents of Extracellular and	309 310
Cardiac Output, Venous Return, and Their Regulation Normal Values for Cardiac Output at Rest and During Activity Control of Cardiac Output By Venous Return- Frank-Starling Mechanism of the Heart Methods for Measuring Cardiac Output CHAPTER 21 Muscle Blood Flow and Cardiac Output During Exercise; The Coronary Circulation and Ischemic Heart Disease Blood Flow Regulation in Skeletal Muscle	249 249 260	The Body Fluids and Kidneys CHAPTER 25 Regulation of Body Fluid Compartments: Extracellular and Intracellular Fluids; Edema Intake and Output of Fluids and Solutes Are Balanced During Long-Term Steady-State Conditions Body Fluid Compartments Constituents of Extracellular and Intracellular Fluids	309 310
Cardiac Output, Venous Return, and Their Regulation Normal Values for Cardiac Output at Rest and During Activity Control of Cardiac Output By Venous Return- Frank-Starling Mechanism of the Heart Methods for Measuring Cardiac Output CHAPTER 21 Muscle Blood Flow and Cardiac Output During Exercise; The Coronary Circulation and Ischemic Heart Disease Blood Flow Regulation in Skeletal Muscle at Rest and During Exercise Coronary Circulation	249 249 260 263	CHAPTER 25 Regulation of Body Fluid Compartments: Extracellular and Intracellular Fluids; Edema Intake and Output of Fluids and Solutes Are Balanced During Long-Term Steady-State Conditions Body Fluid Compartments Constituents of Extracellular and Intracellular Fluids Measurement of Body Fluid Compartment	309 310 311
Cardiac Output, Venous Return, and Their Regulation Normal Values for Cardiac Output at Rest and During Activity Control of Cardiac Output By Venous Return- Frank-Starling Mechanism of the Heart Methods for Measuring Cardiac Output CHAPTER 21 Muscle Blood Flow and Cardiac Output During Exercise; The Coronary Circulation and Ischemic Heart Disease Blood Flow Regulation in Skeletal Muscle at Rest and During Exercise Coronary Circulation CHAPTER 22	249 249 260 263 263 266	CHAPTER 25 Regulation of Body Fluid Compartments: Extracellular and Intracellular Fluids; Edema Intake and Output of Fluids and Solutes Are Balanced During Long-Term Steady-State Conditions Body Fluid Compartments Constituents of Extracellular and Intracellular Fluids Measurement of Body Fluid Compartment Volumes—Indicator-Dilution Principle	309 310 311
Cardiac Output, Venous Return, and Their Regulation Normal Values for Cardiac Output at Rest and During Activity Control of Cardiac Output By Venous Return- Frank-Starling Mechanism of the Heart Methods for Measuring Cardiac Output CHAPTER 21 Muscle Blood Flow and Cardiac Output During Exercise; The Coronary Circulation and Ischemic Heart Disease Blood Flow Regulation in Skeletal Muscle at Rest and During Exercise Coronary Circulation CHAPTER 22 Heart Failure	249 249 260 263	The Body Fluids and Kidneys CHAPTER 25 Regulation of Body Fluid Compartments: Extracellular and Intracellular Fluids; Edema Intake and Output of Fluids and Solutes Are Balanced During Long-Term Steady-State Conditions Body Fluid Compartments Constituents of Extracellular and Intracellular Fluids Measurement of Body Fluid Compartment Volumes—Indicator-Dilution Principle Fluid Exchange and Osmotic Equilibrium Between Intracellular and Extracellular Fluid Volume and Osmolality of Extracellular and	309 310 311 312
Cardiac Output, Venous Return, and Their Regulation Normal Values for Cardiac Output at Rest and During Activity Control of Cardiac Output By Venous Return- Frank-Starling Mechanism of the Heart Methods for Measuring Cardiac Output CHAPTER 21 Muscle Blood Flow and Cardiac Output During Exercise; The Coronary Circulation and Ischemic Heart Disease Blood Flow Regulation in Skeletal Muscle at Rest and During Exercise Coronary Circulation CHAPTER 22 Heart Failure Circulatory Dynamics in Heart Failure	249 249 260 263 263 266 275 275	The Body Fluids and Kidneys CHAPTER 25 Regulation of Body Fluid Compartments: Extracellular and Intracellular Fluids; Edema Intake and Output of Fluids and Solutes Are Balanced During Long-Term Steady-State Conditions Body Fluid Compartments Constituents of Extracellular and Intracellular Fluids Measurement of Body Fluid Compartment Volumes—Indicator-Dilution Principle Fluid Exchange and Osmotic Equilibrium Between Intracellular and Extracellular Fluid Volume and Osmolality of Extracellular and Intracellular Fluids in Abnormal States	309 310 311 312
Cardiac Output, Venous Return, and Their Regulation Normal Values for Cardiac Output at Rest and During Activity Control of Cardiac Output By Venous Return- Frank-Starling Mechanism of the Heart Methods for Measuring Cardiac Output CHAPTER 21 Muscle Blood Flow and Cardiac Output During Exercise; The Coronary Circulation and Ischemic Heart Disease Blood Flow Regulation in Skeletal Muscle at Rest and During Exercise Coronary Circulation CHAPTER 22 Heart Failure Circulatory Dynamics in Heart Failure Unilateral Left Heart Failure	249 249 260 263 263 266	The Body Fluids and Kidneys CHAPTER 25 Regulation of Body Fluid Compartments: Extracellular and Intracellular Fluids; Edema Intake and Output of Fluids and Solutes Are Balanced During Long-Term Steady-State Conditions Body Fluid Compartments Constituents of Extracellular and Intracellular Fluids Measurement of Body Fluid Compartment Volumes—Indicator-Dilution Principle Fluid Exchange and Osmotic Equilibrium Between Intracellular and Extracellular Fluid Volume and Osmolality of Extracellular and Intracellular Fluids in Abnormal States Glucose and Other Solutions Administered	309 310 311 312 314
Cardiac Output, Venous Return, and Their Regulation Normal Values for Cardiac Output at Rest and During Activity Control of Cardiac Output By Venous Return- Frank-Starling Mechanism of the Heart Methods for Measuring Cardiac Output CHAPTER 21 Muscle Blood Flow and Cardiac Output During Exercise; The Coronary Circulation and Ischemic Heart Disease Blood Flow Regulation in Skeletal Muscle at Rest and During Exercise Coronary Circulation CHAPTER 22 Heart Failure Circulatory Dynamics in Heart Failure Unilateral Left Heart Failure—Cardiogenic	249 249 260 263 263 266 275 275 279	The Body Fluids and Kidneys CHAPTER 25 Regulation of Body Fluid Compartments: Extracellular and Intracellular Fluids; Edema Intake and Output of Fluids and Solutes Are Balanced During Long-Term Steady-State Conditions Body Fluid Compartments Constituents of Extracellular and Intracellular Fluids Measurement of Body Fluid Compartment Volumes—Indicator-Dilution Principle Fluid Exchange and Osmotic Equilibrium Between Intracellular and Extracellular Fluid Volume and Osmolality of Extracellular and Intracellular Fluids in Abnormal States Glucose and Other Solutions Administered for Nutritive Purposes	309 310 311 312 314
Cardiac Output, Venous Return, and Their Regulation Normal Values for Cardiac Output at Rest and During Activity Control of Cardiac Output By Venous Return- Frank-Starling Mechanism of the Heart Methods for Measuring Cardiac Output CHAPTER 21 Muscle Blood Flow and Cardiac Output During Exercise; The Coronary Circulation and Ischemic Heart Disease Blood Flow Regulation in Skeletal Muscle at Rest and During Exercise Coronary Circulation CHAPTER 22 Heart Failure Circulatory Dynamics in Heart Failure Unilateral Left Heart Failure Low-Output Cardiac Failure—Cardiogenic Shock	249 249 260 263 263 266 275 275 279 279	CHAPTER 25 Regulation of Body Fluid Compartments: Extracellular and Intracellular Fluids; Edema Intake and Output of Fluids and Solutes Are Balanced During Long-Term Steady-State Conditions Body Fluid Compartments Constituents of Extracellular and Intracellular Fluids Measurement of Body Fluid Compartment Volumes—Indicator-Dilution Principle Fluid Exchange and Osmotic Equilibrium Between Intracellular and Extracellular Fluid Volume and Osmolality of Extracellular and Intracellular Fluids in Abnormal States Glucose and Other Solutions Administered for Nutritive Purposes Clinical Abnormalities of Fluid Volume	309 310 311 312 314 316
Cardiac Output, Venous Return, and Their Regulation Normal Values for Cardiac Output at Rest and During Activity Control of Cardiac Output By Venous Return- Frank-Starling Mechanism of the Heart Methods for Measuring Cardiac Output CHAPTER 21 Muscle Blood Flow and Cardiac Output During Exercise; The Coronary Circulation and Ischemic Heart Disease Blood Flow Regulation in Skeletal Muscle at Rest and During Exercise Coronary Circulation CHAPTER 22 Heart Failure Circulatory Dynamics in Heart Failure Unilateral Left Heart Failure Low-Output Cardiac Failure—Cardiogenic Shock Edema in Patients With Heart Failure	249 249 260 263 263 266 275 275 279 279 280	CHAPTER 25 Regulation of Body Fluid Compartments: Extracellular and Intracellular Fluids; Edema Intake and Output of Fluids and Solutes Are Balanced During Long-Term Steady-State Conditions Body Fluid Compartments Constituents of Extracellular and Intracellular Fluids Measurement of Body Fluid Compartment Volumes—Indicator-Dilution Principle Fluid Exchange and Osmotic Equilibrium Between Intracellular and Extracellular Fluid Volume and Osmolality of Extracellular and Intracellular Fluids in Abnormal States Glucose and Other Solutions Administered for Nutritive Purposes Clinical Abnormalities of Fluid Volume Regulation: Hyponatremia and	309 310 311 312 314 316 317
Cardiac Output, Venous Return, and Their Regulation Normal Values for Cardiac Output at Rest and During Activity Control of Cardiac Output By Venous Return- Frank-Starling Mechanism of the Heart Methods for Measuring Cardiac Output CHAPTER 21 Muscle Blood Flow and Cardiac Output During Exercise; The Coronary Circulation and Ischemic Heart Disease Blood Flow Regulation in Skeletal Muscle at Rest and During Exercise Coronary Circulation CHAPTER 22 Heart Failure Circulatory Dynamics in Heart Failure Unilateral Left Heart Failure Low-Output Cardiac Failure—Cardiogenic Shock Edema in Patients With Heart Failure Cardiac Reserve	249 249 260 263 263 266 275 275 279 279	CHAPTER 25 Regulation of Body Fluid Compartments: Extracellular and Intracellular Fluids; Edema Intake and Output of Fluids and Solutes Are Balanced During Long-Term Steady-State Conditions Body Fluid Compartments Constituents of Extracellular and Intracellular Fluids Measurement of Body Fluid Compartment Volumes—Indicator-Dilution Principle Fluid Exchange and Osmotic Equilibrium Between Intracellular and Extracellular Fluid Volume and Osmolality of Extracellular and Intracellular Fluids in Abnormal States Glucose and Other Solutions Administered for Nutritive Purposes Clinical Abnormalities of Fluid Volume Regulation: Hyponatremia and Hypernatremia	309 310 311 312 314 316 317
Cardiac Output, Venous Return, and Their Regulation Normal Values for Cardiac Output at Rest and During Activity Control of Cardiac Output By Venous Return- Frank-Starling Mechanism of the Heart Methods for Measuring Cardiac Output CHAPTER 21 Muscle Blood Flow and Cardiac Output During Exercise; The Coronary Circulation and Ischemic Heart Disease Blood Flow Regulation in Skeletal Muscle at Rest and During Exercise Coronary Circulation CHAPTER 22 Heart Failure Circulatory Dynamics in Heart Failure Unilateral Left Heart Failure Low-Output Cardiac Failure—Cardiogenic Shock Edema in Patients With Heart Failure	249 249 260 263 263 266 275 275 279 279 280	CHAPTER 25 Regulation of Body Fluid Compartments: Extracellular and Intracellular Fluids; Edema Intake and Output of Fluids and Solutes Are Balanced During Long-Term Steady-State Conditions Body Fluid Compartments Constituents of Extracellular and Intracellular Fluids Measurement of Body Fluid Compartment Volumes—Indicator-Dilution Principle Fluid Exchange and Osmotic Equilibrium Between Intracellular and Extracellular Fluid Volume and Osmolality of Extracellular and Intracellular Fluids in Abnormal States Glucose and Other Solutions Administered for Nutritive Purposes Clinical Abnormalities of Fluid Volume Regulation: Hyponatremia and	309 310 311 312 314 316 317

CHAPTER 26		Regulation of Renal Phosphate Excretion	400
The Urinary System: Functional Anatomy		Regulation of Renal Magnesium Excretion	
and Urine Formation By the Kidneys	325	and Extracellular Magnesium Ion	
Multiple Functions of the Kidneys	325	Concentration	401
Physiological Anatomy of the Kidneys	326	Integration of Renal Mechanisms for Control	
Urine Formation Results From Glomerular		of Extracellular Fluid	401
Filtration, Tubular Reabsorption, and		Distribution of Extracellular Fluid Between	
Tubular Secretion	328	Interstitial Spaces and Vascular System	404
Micturition	331	Nervous and Hormonal Factors Increase	
CHAPTER 27		Effectiveness of Renal-Body Fluid	
		Feedback Control	405
Glomerular Filtration, Renal Blood Flow, and Their Control	335	Integrated Responses to Changes in Sodium	40=
Glomerular Filtration—The First Step in Urine	333	Intake	407
Formation	335	Conditions That Cause Large Increases in	
Determinants of GFR	337	Blood Volume and Extracellular Fluid	406
Renal Blood Flow	340	Volume	408
Physiological Control of GFR and Renal	340	Conditions That Cause Large Increases in Extracellular Fluid Volume With Normal or	
Blood Flow	341	Reduced Blood Volume	409
Autoregulation of GFR and Renal Blood Flow	343	CHAPTER 31	408
	0.0	Acid-Base Regulation	411
CHAPTER 28		Hydrogen Ion Concentration Is Precisely	7
Renal Tubular Reabsorption and Secretion	349	Regulated	411
Tubular Reabsorption Is Quantitatively		Acids and Bases—Definitions and Meanings	411
Large and Highly Selective	349	Defending Against Changes in H ⁻	711
Tubular Reabsorption Includes Passive and		Concentration: Buffers, Lungs, and Kidneys	412
Active Mechanisms	349	Buffering of H ⁺ in the Body Fluids	412
Reabsorption and Secretion Along Different		Bicarbonate Buffer System	413
Parts of the Nephron	355	Phosphate Buffer System	415
Regulation of Tubular Reabsorption	361	Proteins Are Important Intracellular Buffers	415
Use of Clearance Methods to Quantify Kidney		Respiratory Regulation of Acid-Base Balance	416
Function	367	Renal Control of Acid-Base Balance	417
CHAPTER 29		Secretion of H+ and Reabsorption of HC0,~	
Urine Concentration and Dilution;		By the Renal Tubules	418
Regulation of Extracellular Fluid		Combination of Excess H ⁻ With Phosphate	
Osmolarity and Sodium Concentration	373	and Ammonia Buffers in the Tubule	
Kidneys Excrete Excess Water By Forming		Generates "New" HCO ₃ "	420
Dilute Urine	373	Quantifying Renal Acid-Base Excretion	422
Kidneys Conserve Water By Excreting		Regulation of Renal Tubular H ⁺ Secretion	422
Concentrated Urine	374	Renal Correction of Acidosis—Increased	
Countercurrent Multiplier Mechanism	376	Excretion of H ⁻ and Addition of HC0 ₃ ~ to the Extracellular Fluid	423
Control of Extracellular Fluid Osmolarity	202	Renal Correction of Alkalosis—Decreased	420
and Sodium Concentration	383	Tubular Secretion of H ⁺ and Increased	
CHAPTER 30		Excretion of HCO ₃ -	424
Renal Regulation of Potassium, Calcium,		CHAPTER 32	
Phosphate, and Magnesium; Integration of			404
Renal Mechanisms for Control of Blood		Diuretics and Kidney Diseases	429
Volume and Extracellular Fluid Volume	391	Diuretics and Their Mechanisms of Action	429 43
Regulation of Internal Potassium Distribution	391	Kidney Diseases Acute Kidney Injury	432
Regulation of Renal Potassium Excretion	392	CKD Is Often Associated With Irreversible	432
Regulation of Renal Calcium Excretion and		Loss of Functional Nephrons	434
Extracellular Calcium Ion Concentration	397	_ooo or ranononar reopinions	-0-

UNIT VI		UNIT VII	
Blood Cells, Immunity, and Blood		Respiration	
Coagulation		Roophution	
		CHAPTER 38	
CHAPTER 33			501
Red Blood Cells, Anemia, and		Pulmonary Ventilation Mechanics of Pulmonary Ventilation	501
Polycythemia	447	Pulmonary Volumes and Capacities	504
Red Blood Cells (Erythrocytes)	447	Alveolar Ventilation	507
Iron Metabolism	452	Aiveolai ventilation	301
Anemias	454	CHAPTER 39	
Polycythemia	455	Pulmonary Circulation, Pulmonary	
		Edema, and Pleural Fluid	513
CHAPTER 34		Physiological Anatomy of the Pulmonary	
Resistance of the Body to Infection:		Circulatory System	513
I. Leukocytes, Granulocytes, the		Pressures in the Pulmonary Circulatory System	513
Monocyte-Macrophage System, and	457	Blood Volume of the Lungs	514
Inflammation	457	Blood Flow Through the Lungs and Its	
Leukocytes (White Blood Cells)	457	Distribution	514
Neutrophils and Macrophages Defend	450	Effect of Hydrostatic Pressure Gradients in the	
Against Infections	459	Lungs on Regional Pulmonary Blood Flow	515
Monocyte-Macrophage Cell System	460	Pulmonary Capillary Dynamics	517
(Reticuloendothelial System) Inflammation: Role of Neutrophils and	460	Fluid in the Pleural Cavity	519
	462	CHAPTER 40	
Macrophages Eosinophils	464		
Basophils	465	Principles of Gas Exchange; Diffusion of	
Leukopenia	465	Oxygen and Carbon Dioxide Through Respiratory Membranes	521
Leukemias	465	Compositions of Alveolar Air and	JZ 1
CHAPTER 35	400	Atmospheric Air Are Different	523
		Diffusion of Gases Through the Respiratory	
Resistance of the Body to Infection:	407	Membrane	525
II. Immunity and Allergy	467		
Acquired (Adaptive) Immunity	467	CHAPTER 41	
Allergy and Hypersensitivity	477	Transport of Oxygen and Carbon	
Sex Differences in Innate and Adaptive Immunity	479	Dioxide in Blood and Tissue Fluids	531
CHAPTER 36		Transport of Oxygen From the Lungs to	
Blood Types, Transfusion, and Tissue and		the Body Tissues	531
Organ Transplantation	481	Transport of CO ₂ in Blood	538
Antigenicity Causes Immune Reactions of Blood	481	Respiratory Exchange Ratio	540
O-A-B Blood Types	481		
Rh Blood Types	483	CHAPTER 42	
Transfusion Reactions Resulting From		Regulation of Respiration	E 4 4
Mismatched Blood Types	484	Respiratory Center	541
Transplantation of Tissues and Organs	485	Chemical Control of Respiration	541
CHAPTER 37		Peripheral Chemoreceptor System—Role	543
Hemostasis and Blood Coagulation	487	of Oxygen in Respiratory Control	544
Hemostasis Events	487	Regulation of Respiration During Exercise	547
Mechanism of Blood Coagulation	489		
Conditions That Cause Excessive Bleeding	703	CHAPTER 43	
in Humans	494	Respiratory Insufficiency—Pathophysiology,	
Thromboembolic Conditions	496	Diagnosis, Oxygen Therapy	551
Anticoagulants for Clinical Use	497	Methods for Studying Respiratory	
Blood Coagulation Tests	497	Abnormalities	551
<u> </u>			

Pathophysiology of Specific Pulmonary		CHAPTER 48	
Abnormalities	553	Somatic Sensations: I. General	
Hypoxia and Oxygen Therapy	556	Organization, Tactile and Position Senses	609
Hypercapnia—Excess Carbon Dioxide		Classification of Somatic Senses	609
in the Body Fluids	558	Detection and Transmission of Tactile	
Respiratory Resuscitation and Mechanical		Sensations	609
Ventilators	558	Sensory Pathways for Transmitting Somatic	000
		Signals Into the Central Nervous System	611
UNIT VII		Transmission in the Dorsal Column-Medial	011
Aviation, Space, and Deep-Sea Diving			611
Physiology		Lemniscal System Transmission of Sansary Signals in the	011
rilysiology		Transmission of Sensory Signals in the Anterolateral Pathway	619
CHAPTER 44		·	0.0
		CHAPTER 49	
Aviation, High Altitude, and Space Physiology	563	Somatic Sensations: II. Pain, Headache,	
	563	and Thermal Sensations	623
Effects of Low Oxygen Pressure on the Body	303	Fast Pain and Slow Pain and Their Qualities	623
AUADTED 45		Pain Receptors (Nociceptors) and Their	
CHAPTER 45		Stimulation	623
Physiology of Deep-Sea Diving and		Dual Pathways for Transmission of Pain	
Other Hyperbaric Conditions	571	Signals Into the Central Nervous System	624
Effect of High Partial Pressures of Individual		Pain Suppression (Analgesia) System in the	
Gases on the Body	571	Brain and Spinal Cord	626
Self-Contained Underwater Breathing		Referred Pain	628
Apparatus (SCUBA) Diving	575	Visceral Pain	628
		Thermal Sensations	632
UNIT IX			
The Nervous System: A. General Princip	les	IIIIT V	
and Sensory Physiology		UNIT X	
		The Nervous System: B. The Special Sens	ses
CHAPTER 46		011107770 70	
Organization of the Nervous System,		CHAPTER 50	
Basic Functions of Synapses and		The Eye: I. Optics of Vision	637
Neurotransmitters	579	Physical Principles of Optics	637
General Design of the Nervous System	579	Optics of the Eye	640
Major Levels of Central Nervous System		Fluid System of the Eye—Intraocular Fluid	646
Function	581		
Comparison of the Nervous System to		CHAPTER 51	
a Computer	582	The Eye: II. Receptor and Neural Function	
Central Nervous System Synapses	582	of the Retina	649
Special Characteristics of Synaptic Transmission	595	Anatomy and Function of Structural Elements	
CHAPTER 47		of the Retina	649
Sensory Receptors and Neuronal Circuits		Photochemistry of Vision	651
for Processing Information	597	Color Vision	655
Types of Sensory Receptors and the Stimuli	331	Neural Function of the Retina	656
They Detect	597		
Transduction of Sensory Stimuli Into Nerve		CHAPTER 52	
Impulses	598	The Eye: III. Central Neurophysiology	
Signal Intensity Transmission in Nerve		of Vision	663
Tracts—Spatial and Temporal Summation			
riadis opaliai and remperai cammation	602	Visual Pathways	663
Transmission and Processing of Signals in	602	Visual Pathways Organization and Function of the Visual Cortex	663 664
	602 603 607	•	

Eye Movements and Their Control	667	Functions of Specific Cortical Areas	740
Autonomic Control of Accommodation		The Corpus Callosum and Anterior	
and Pupillary Aperture	671	Commissure Transfer Thoughts, Memories,	
ALLARTER FO		Training, and Other Information Between	7.40
CHAPTER 53		the Two Cerebral Hemispheres	746
The Sense of Hearing	675	Thoughts, Consciousness, and Memory	747
Tympanic Membrane and the Ossicular System	675	CHAPTER 59	
Cochlea	676	The Limbic System and the Hypothalamus-	
Central Auditory Mechanisms	681	Behavioral and Motivational Mechanisms	
CHAPTER 54		of the Brain	753
		Activating—Driving Systems of the Brain	753
The Chemical Senses—Taste and Smell	687	Limbic System	756
Sense of Taste	687	The Hypothalamus, a Major Control	
Sense of Smell	691	Headquarters for the Limbic System	757
		Specific Functions of Other Parts of the	
UNIT XI		Limbic System	761
The Nervous System: C. Motor and		CHAPTER 60	
Integrative Neurophysiology			
		States of Brain Activity—Sleep, Brain Waves,	765
CHAPTER 55		Epilepsy, Psychoses, and Dementia	765
Spinal Cord Motor Functions; The Cord		Sleep	765
Reflexes	697	CHAPTER 61	
Organization of the Spinal Cord for Motor		The Autonomic Nervous System and	
Functions	697	the Adrenal Medulla	777
Muscle Sensory Receptors—Muscle Spindles and		General Organization of the Autonomic	
Golgi Tendon Organs—and Their Roles in		Nervous System	777
Muscle Control	699	Basic Characteristics of Sympathetic and	
Flexor Reflex and the Withdrawal Reflexes	703	Parasympathetic Function	779
Crossed Extensor Reflex	705	Selective Stimulation of Target Organs By	
Reciprocal Inhibition and Reciprocal	705	Sympathetic and Parasympathetic Systems or	70-
Innervation	705	"Mass Discharge"	787
Reflexes of Posture and Locomotion	705	CHAPTER 62	
CHAPTER 56		Cerebral Blood Flow, Cerebrospinal Fluid, and	
Cortical and Brain Stem Control of Motor		Brain Metabolism	791
Function	709	Cerebral Blood Flow	791
Motor Cortex and Corticospinal Tract	709	Cerebral Microcirculation	794
Control of Motor Functions By the Brain Stem	715	Cerebrospinal Fluid System	794
Vestibular Sensations and Maintenance of		Brain Metabolism	798
Equilibrium	716		
CHAPTER 57		UNIT XII	
Cerebellum and Basal Ganglia Contributions			
to Overall Motor Control	723	Gastrointestinal Physiology	
The Cerebellum and Its Motor Functions	723	CHAPTER 63	
The Basal Ganglia and Their Motor Functions	732		
Integration of the Many Parts of the Entire	. 02	General Principles of Gastrointestinal	
Motor Control System	736	Function—Motility, Nervous and Hormonal	001
•	-	Control, Blood Circulation, and Microbiota	803
CHAPTER 58		General Principles of Gastrointestinal Motility Neural Control of Gastrointestinal	803
Cerebral Cortex, Intellectual Functions		Function—Enteric Nervous System	805
of the Brain, Learning, and Memory	739	Hormonal Control of Gastrointestinal Motility	807
Physiological Anatomy of the Cerebral Cortex	739	Hormonal Control of Castrollitestinal Motility	501

Functional Movements in the Gastrointestinal		CHAPTER 71	
Tract	809	The Liver	889
Gastrointestinal Blood Flow—Splanchnic		Physiological Anatomy of the Liver	889
Circulation	810	Hepatic Vascular and Lymph Systems	889
Gastrointestinal Microbiota	812	Metabolic Functions of the Liver	891
CHAPTER 64		CHAPTER 72	
Propulsion and Mixing of Food in the		Dietary Balances; Regulation of Feeding;	
Alimentary Tract	815	Obesity and Starvation; Vitamins and Minerals	897
Ingestion of Food	815	Energy Intake and Output Are Balanced	
Motor Functions of the Stomach	817	Under Steady-State Conditions	897
Movements of the Small Intestine	820	Regulation of Food Intake and Energy	
Movements of the Colon	822	Storage	899
Other Autonomic Reflexes That Affect Bowel			
Activity	824	CHAPTER 73	
CHAPTER 65		Energetics and Metabolic Rate	915
Secretory Functions of the Alimentary Tract	825	v	
General Principles of Alimentary Tract		CHAPTER 74	
Secretion	825	Body Temperature Regulation and Fever	923
Secretion of Saliva	827	Normal Body Temperatures	923
Gastric Secretion	829	Body Temperature Is Controlled By	320
Pancreatic Secretion	832	Balancing Heat Production and Heat Loss	923
Bile Secretion By the Liver	835	Regulation of Body Temperature—Role of the	020
Secretions of the Small Intestine	838	Hypothalamus	927
Secretion of Mucus By the Large Intestine	839	Abnormalities of Body Temperature	02.
CHAPTER 66		Regulation	931
Digestion and Absorption in the			
Gastrointestinal Tract	841	UNIT XIV	
Digestion of Various Foods By Hydrolysis	841	Endocrinology and Reproduction	
Basic Principles of Gastrointestinal	-		
Absorption	845	CHAPTER 75	
Absorption in the Small Intestine	846	Introduction to Endocrinology	937
Absorption in the Large Intestine and		Coordination of Body Functions By Chemical	
Formation of Feces	850	Messengers	937
CHAPTER 67	000	Chemical Structure and Synthesis of Hormones	937
		Hormone Secretion, Transport, and Clearance	
Physiology of Gastrointestinal Disorders	851	From the Blood	941
LIAUS VIII		Mechanisms of Action of Hormones	942
UNIT XIII		CHAPTER 76	
Metabolism and Temperature Regulati	o n	Pituitary Hormones and Their Control	
		By the Hypothalamus	951
CHAPTER 68		Pituitary Gland and Its Relation to the	951
Metabolism of Carbohydrates and			054
Formation of Adenosine Triphosphate	861	Hypothalamus The Hypothalamus Controls Bituitory Secretion	951
CHAPTER 69		The Hypothalamus Controls Pituitary Secretion	952
	074	Physiological Functions of Growth Hormone	954
Lipid Metabolism	871	Posterior Pituitary Gland and Its Relation to the Hypothalamus	961
Basic Chemical Structure of Triglycerides (Neutral Fat)	871	to the risponialamus	30
Transport of Lipids in the Body Fluids	871	CHAPTER 77	
	07.1	Thyroid Metabolic Hormones	965
CHAPTER 70		Synthesis and Secretion of Thyroid Metabolic	
		-	

			Contents
Physiological Functions of the Thyroid Hormones	968	Male Sexual Act	1042
Regulation of Thyroid Hormone Secretion	972	Testosterone and Other Male Sex Hormones	1043
CHAPTER 78		CHAPTER 82	
Adrenocortical Hormones Corticosteroids: Mineralocorticoids,	979	Female Physiology Before Pregnancy and Female Hormones	1053
Glucocorticoids, and Androgens	979	Physiological Anatomy of the Female	1053
Synthesis and Secretion of Adrenocortical		Sexual Organs	1053
Hormones	979	Female Hormonal System	
Functions of Mineralocorticoids—Aldosterone	982	Monthly Ovarian Cycle and Function of	1054
Functions of Glucocorticoids	986	Gonadotropic Hormones	
CHAPTER 79		Functions of Ovarian Hormones—Estradiol and Progesterone	1058
Insulin, Glucagon, and Diabetes Mellitus	999	Regulation of Female Monthly Rhythm—	
Insulin and Its Metabolic Effects	999	Interplay Between Ovarian and	1063
Glucagon and Its Functions	1008	Hypothalamic-Pituitary Hormones	1068
Summary of Blood Glucose Regulation	1010	Female Sexual Act CHAPTER 83	
CHAPTER 80		Pregnancy and Lactation	1073
Parathyroid Hormone, Calcitonin, Calcium		Maturation and Fertilization of the Ovum	1073
and Phosphate Metabolism, Vitamin D, Bone	.	Early Nutrition of the Embryo	1075
and Teeth	1017	Anatomy and Function of the Placenta	1075
Overview of Calcium and Phosphate		Hormonal Factors in Pregnancy	1077
Regulation in Extracellular Fluid and Plasma	1017	Parturition—Birth of the Baby	1082
Bone and Its Relationship to Extracellular		Lactation	1085
Calcium and Phosphate	1019	CHAPTER 84	
Vitamin D	1023	Fetal and Neonatal Physiology	1089
Parathyroid Hormone	1025	retar and Neomatar r myslology	1009
Calcitonin	1028	UNIT XV	
Summary of Control of Calcium Ion			
Concentration	1029	Sports Physiology	
Physiology of the Teeth	1032		
		CHAPTER 85	
CHAPTER 81		Sports Physiology	1101
Reproductive and Hormonal Functions			
of the Male (and Function of the Pineal			
Gland)	1037		

1037

Spermatogenesis