

## TEXTBOOK OF



# Medical Physiology

ELEVENTH EDITION



**GUYTON & HALL** 

DIA (442)

### **ELSEVIER** SAUNDERS

Elsevier Inc. 1600 John F. Kennedy Blvd., Suite 1800 Philadelphia, Pennsylvania 19103-2899



### TEXTBOOK OF MEDICAL PHYSIOLOGY

Copyright © 2006, 2000, 1996, 1991, 1986, 1981, 1976, 1971, 1966, 1961, 1956 by Elsevier Inc.

All rights reserved. No part of this publication may be reproduced or transmitted in any form or by any means, electronic or mechanical, including photocopying, recording, or any information storage and retrieval system, without permission in writing from the publisher. Permissions may be sought directly from Elsevier's Health Sciences Rights Department in Philadelphia, PA, USA: phone: (+1) 215 239 3804, fax: (+1) 215 239 3805, e-mail: healthpermissions@elsevier.com. You may also complete your request on-line via the Elsevier homepage (http://www.elsevier.com), by selecting "Customer Support" and then "Obtaining Permissions"

### NOTICE

Knowledge and best practice in this field are constantly changing. As new research and experience broaden our knowledge, changes in practice, treatment and drug therapy may become necessary or appropriate. Readers are advised to check the most current information provided (i) on procedures featured or (ii) by the manufacturer of each product to be administered, to verify the recommended dose or formula, the method and duration of administration, and contraindications. It is the responsibility of the practitioner, relying on their own experience and knowledge of the patient, to make diagnoses, to determine dosages and the best treatment for each individual patient, and to take all appropriate safety precautions. To the fullest extent of the law, neither the Publisher nor the Author assumes any liability for any injury and/or damage to persons or property arising out or related to any use of the material contained in this book.

### Library of Congress Cataloging-in-Publication Data

Guyton, Arthur C.

Textbook of medical physiology / Arthur C. Guyton, John E. Hall-11th ed.

p.; cm

Includes bibliographical references and index.

ISBN-13: 978-0-7216-0240-0

1. Human physiology. 2. Physiology, Pathological. I. Title: Medical physiology. II. Hall, John E. (John Edward) III. Title.

[DNLM: 1. Physiological Processes. QT 104 G992t 2006]

OP34.5.G9 2006

612-dc22

2004051421

644308

ISBN-13: 978-0-7216-0240-0 ISBN-10: 0-7216-0240-1 IE ISBN-13: 978-0-8089-2317-6

IE ISBN-10: 0-8089-2317-X

Publishing Director: Linda Belfus Acquisitions Editor: William Schmitt Managing Editor: Rebecca Gruliow Publishing Services Manager: Tina Rebane Project Manager: Mary Anne Folcher Design Manager: Steven Stave Marketing Manager: John Gore

"ПІВДЕННОУКРАЇНСЬКИЙ національний педагогічний **УНІВЕР**СИТЕТ ІМЕНІ К.Д. УШИНСЬКОГО' БЛІСТЕКА

Cover illustration is a detail from Opus 1972 by Virgil Cantini, Ph.D., with permission of the artist and Mansfield State College, Mansfield, Pennsylvania.

Chapter opener credits: Chapter 43, modified from © Getty Images 21000058038; Chapter 44, modified from © Getty Images 21000044598; Chapter 84, modified from © Corbis.

Printed in China

Last digit is the print number: 9 8 7 6 5

Working together to grow libraries in developing countries

www.elsevier.com | www.bookaid.org | www.sabre.org

ELSEVIER

# TABLE OF CONTENTS

UNITI		The DNA Code in the Cell Nucleus Is	
		Transferred to an RNA Code in the	
Introduction to Physiology: The		Cell Cytoplasm—The Process	20
Cell and General Physiology		of Transcription	30
		Synthesis of RNA	30
		Assembly of the RNA Chain from Activated Nucleotides Using the DNA Strand	
CHAPTER 1		as a Template—The Process of	
<b>Functional Organization of the</b>		"Transcription"	31
Human Body and Control of the		Messenger RNA—The Codons	31
		Transfer RNA—The Anticodons	32
"Internal Environment"	3	Ribosomal RNA	33
Cells as the Living Units of the Body	3	Formation of Proteins on the Ribosomes—	
Extracellular Fluid—The "Internal	2	The Process of "Translation"	33
Environment"	3	Synthesis of Other Substances in the	722
"Homeostatic" Mechanisms of the Major		Cell	35
Functional Systems	4	Control of Gene Function and	25
Homeostasis Extracellular Fluid Transport and Mixing	4	Biochemical Activity in Cells	35
System—The Blood Circulatory System	4	Genetic Regulation	35
Origin of Nutrients in the Extracellular Fluid	5	Control of Intracellular Function by Enzyme Regulation	36
Removal of Metabolic End Products	5	The DNA-Genetic System Also Controls	30
Regulation of Body Functions	5	Cell Reproduction	37
Reproduction	6	Cell Reproduction Begins with Replication	3,
Control Systems of the Body	6	of DNA	37
Examples of Control Mechanisms	6	Chromosomes and Their Replication	38
Characteristics of Control Systems	7	Cell Mitosis	38
Summary—Automaticity of the Body	9	Control of Cell Growth and Cell	
		Reproduction	39
the state of the s		Cell Differentiation	40
CHAPTER 2		Apoptosis—Programmed Cell Death	40
The Cell and Its Functions	11	Cancer	40
Organization of the Cell	11		
Physical Structure of the Cell	12		
Membranous Structures of the Cell	12	IINITTI	
Cytoplasm and Its Organelles	14	UNITII	
Nucleus	17	Membrane Physiology, Nerve,	
Nuclear Membrane	17	and Muscle	
Nucleoli and Formation of Ribosomes	18	and Muscle	
Comparison of the Animal Cell with	18		
Precellular Forms of Life	19	CHADERDA	
Functional Systems of the Cell Ingestion by the Cell—Endocytosis	19	CHAPTER 4	
Digestion of Pinocytotic and Phagocytic	17	Transport of Substances Through	
Foreign Substances Inside the Cell—		the Cell Membrane	45
Function of the Lysosomes	20	The Lipid Barrier of the Cell Membrane,	1113-11
Synthesis and Formation of Cellular		and Cell Membrane Transport	
Structures by Endoplasmic Reticulum		Proteins	45
and Golgi Apparatus	20	Diffusion	46
Extraction of Energy from Nutrients—		Diffusion Through the Cell Membrane	46
Function of the Mitochondria	22	Diffusion Through Protein Channels, and	
Locomotion of Cells	24	"Gating" of These Channels	47
Ameboid Movement	24	Facilitated Diffusion	49
Cilia and Ciliary Movement	24	Factors That Affect Net Rate of Diffusion	50
		Osmosis Across Selectively Permeable	10000
CHAR		Membranes—"Net Diffusion" of Water	51
CHAPTER 3		"Active Transport" of Substances	50
Genetic Control of Protein Synthesis,		Through Membranes	52 53
Cell Function, and Cell Reproduction	27	Primary Active Transport Secondary Active Transport—Co-Transport	23
Genes in the Cell Nucleus	27	and Counter-Transport	54
Genetic Code	29	Active Transport Through Cellular Sheets	55
Short out	29	Active manaport illiough Cellular Sheets	-

CHAPTER 5		CHAPTER 7	
Membrane Potentials and Action		Excitation of Skeletal Muscle:	
Potentials and Action		Neuromuscular Transmission and	
	57	Neuromuscular Transmission and	
Basic Physics of Membrane Potentials		<b>Excitation-Contraction Coupling</b>	85
Membrane Potentials Caused by	57	Transmission of Impulses from Nerve	
Diffusion Diffusion		Endings to Skeletal Muscle Fibers:	
Measuring the Membrane Potential	57	The Neuromuscular Junction	85
Resting Membrane Potential of Nerves	58 59	Secretion of Acetylcholine by the Nerve	
Origin of the Normal Resting Membrane	39	Terminals	85
Potential	60	Molecular Biology of Acetyline Formation and Release	0.0
Nerve Action Potential	61	Drugs That Enhance or Block	88
Voltage-Gated Sodium and Potassium		Transmission at the Neuromuscular	
Channels	62	Junction	88
Summary of the Events That Cause the		Myasthenia Gravis	89
Action Potential	64	Muscle Action Potential	89
Roles of Other Ions During the Action Potential		Spread of the Action Potential to the	
Initiation of the Action Potential	64	Interior of the Muscle Fiber by Way of	
Propagation of the Action Potential	65 65	"Transverse Tubules"	89
Re-establishing Sodium and Potassium	05	Excitation-Contraction Coupling	89
Ionic Gradients After Action Potentials		Transverse Tubule-Sarcoplasmic Reticulum	00
Are Completed—Importance of Energy		System Release of Calcium lons by the	89
Metabolism	66	Sarcoplasmic Reticulum	90
Plateau in Some Action Potentials	66	Carcopiasinic ricultural	90
Rhythmicity of Some Excitable Tissues—		CHAPTER 8	
Repetitive Discharge	67	[1] (1) 1 [1] [1] [1] [1] [1] [1] [1] [1] [1] [	
Special Characteristics of Signal		Contraction and Excitation of	
Transmission in Nerve Trunks Excitation—The Process of Eliciting	68	Smooth Muscle	92
the Action Potential	69	Contraction of Smooth Muscle	92
"Refractory Period" After an Action	09	Types of Smooth Muscle	92
Potential	70	Contractile Mechanism in Smooth Muscle	93
Recording Membrane Potentials and		Regulation of Contraction by Calcium Ions	95
Action Potentials	70	Nervous and Hormonal Control of	
Inhibition of Excitability—"Stabilizers"		Smooth Muscle Contraction	95
and Local Anesthetics	70	Neuromuscular Junctions of Smooth Muscle	95
		Membrane Potentials and Action Potentials	93
		in Smooth Muscle	96
		Effect of Local Tissue Factors and	, ,
		Hormones to Cause Smooth Muscle	
CHAPTER 6		Contraction Without Action Potentials	98
Contraction of Skeletal Muscle	72	Source of Calcium Ions That Cause	
Physiologic Anatomy of Skeletal		Contraction (1) Through the Cell	
Muscle	72	Membrane and (2) from the Sarcoplasmic	5018
Skeletal Muscle Fiber	72	Reticulum	99
General Mechanism of Muscle			
Contraction	74		
Molecular Mechanism of Muscle		UNIT III	
Contraction	74	The Heart	
Molecular Characteristics of the	75	THE HEART	
Contractile Filaments	13	CHARTS	
Effect of Amount of Actin and Myosin Filament Overlap on Tension Developed		CHAPTER 9	
by the Contracting Muscle	77	Heart Muscle; The Heart as a Pump	
Relation of Velocity of Contraction to		and Function of the Heart Valves	103
Load	78	Physiology of Cardiac Muscle	103
<b>Energetics of Muscle Contraction</b>	78	Physiologic Anatomy of Cardiac Muscle	103
Work Output During Muscle Contraction	78	Action Potentials in Cardiac Muscle	104
Sources of Energy for Muscle Contraction	79	ine Cardiac Cycle	106
Characteristics of Whole Muscle	In Carried In	Diastole and Systole	106
Contraction	80	Helationship of the Electrocardiogram to	N. N. P.
Mechanics of Skeletal Muscle Contraction	81	cardiac Cycle	107
Remodeling of Muscle to Match Function	82	Function of the Atria as Primer Pumps	107
Rigor Mortis	83	Function of the Ventricles as Pumps	108

Function of the Values	100		
Function of the Valves Aortic Pressure Curve	109	Flow of Electrical Currents in the Chest	120
Relationship of the Heart Sounds to	109	Around the Heart	126
Heart Pumping	100	Electrocardiographic Leads	127
Work Output of the Heart	109	Three Bipolar Limb Leads	127 129
Graphical Analysis of Ventricular Pumping	110 110	Chest Leads (Precordial Leads)	129
Chemical Energy Required for Cardiac	110	Augmented Unipolar Limb Leads	129
Contraction: Oxygen Utilization by			
the Heart	111		
Regulation of Heart Pumping	111	CHAPTER 12	
Intrinsic Regulation of Heart Pumping—	111	Electrocardiographic Interpretation	
The Frank-Starling Mechanism	111		
Effect of Potassium and Calcium Ions on	111	of Cardiac Muscle and Coronary	
Heart Function	113	Blood Flow Abnormalities: Vectorial	
Effect of Temperature on Heart Function	114	Analysis	131
Increasing the Arterial Pressure Load	11.7	Principles of Vectorial Analysis of	
(up to a Limit) Does Not Decrease the		Electrocardiograms	131
Cardiac Output	114	Use of Vectors to Represent Electrical	
the second second second second	777.1	Potentials	131
		Direction of a Vector Is Denoted in Terms	
CHAPTER 10		of Degrees	131
Rhythmical Excitation of the Heart	116	Axis for Each Standard Bipolar Lead and	
Specialized Excitatory and Conductive	110	Each Unipolar Limb Lead	132
System of the Heart	116	Vectorial Analysis of Potentials Recorded	
Sinus (Sinoatrial) Node	116	in Different Leads	133
Internodal Pathways and Transmission of	110	Vectorial Analysis of the Normal	
the Cardiac Impulse Through the Atria	118	Electrocardiogram	134
Atrioventricular Node, and Delay of Impulse	110	Vectors That Occur at Successive Intervals	
Conduction from the Atria to the Ventricles	118	During Depolarization of the Ventricles—	-
Rapid Transmission in the Ventricular	110	The QRS Complex	134
Purkinje System	119	Electrocardiogram During Repolarization—	
Transmission of the Cardiac Impulse in the	***	The T Wave	134
Ventricular Muscle	119	Depolarization of the Atria—The P Wave	136
Summary of the Spread of the Cardiac		Vectorcardiogram	136
Impulse Through the Heart	120	Mean Electrical Axis of the Ventricular	127
Control of Excitation and Conduction		QRS—And Its Significance	137
in the Heart	120	Determining the Electrical Axis from	127
The Sinus Node as the Pacemaker of the		Standard Lead Electrocardiograms	137
Heart	120	Abnormal Ventricular Conditions That Cause Axis Deviation	138
Role of the Purkinje System in Causing		Conditions That Cause Abnormal	150
Synchronous Contraction of the	Marie	Voltages of the QRS Complex	140
Ventricular Muscle	121	Increased Voltage in the Standard Bipolar	140
Control of Heart Rhythmicity and Impulse		Limb Leads	140
Conduction by the Cardiac Nerves: The	10.1	Decreased Voltage of the Electrocardiogram	140
Sympathetic and Parasympathetic Nerves	121	Prolonged and Bizarre Patterns of the	1,0
		QRS Complex	141
CILADTED 11		Prolonged QRS Complex as a Result of	00000
CHAPTER 11		Cardiac Hypertrophy or Dilatation	141
The Normal Electrocardiogram	123	Prolonged QRS Complex Resulting from	
Characteristics of the Normal		Purkinje System Blocks	141
Electrocardiogram	123	Conditions That Cause Bizarre QRS	
Depolarization Waves Versus		Complexes	141
Repolarization Waves	123	Current of Injury	141
Relationship of Atrial and Ventricular		Effect of Current of Injury on the QRS	
Contraction to the Waves of the	105	Complex	141
Electrocardiogram	125	The J Point—The Zero Reference Potential	
Voltage and Time Calibration of the	125	for Analyzing Current of Injury	142
Electrocardiogram	125	Coronary Ischemia as a Cause of Injury	1.10
Methods for Recording	126	Potential Abnormalities in the Tay	143
Electrocardiograms	126	Abnormalities in the T Wave	145
Pen Recorder	120	Effect of Slow Conduction of the	
Flow of Current Around the Heart	126	Depolarization Wave on the	145
During the Cardiac Cycle	120	Characteristics of the T Wave	145
Recording Electrical Potentials from a		Shortened Depolarization in Portions of	
Partially Depolarized Mass of Syncytial	126	the Ventricular Muscle as a Cause of T Wave Abnormalities	145
Cardiac Muscle	120	1 Wate Abilottilalities	143

CHARER 12		Volume-Pressure Curves of the Arterial	
CHAPTER 13		and Venous Circulations	172
Cardiac Arrhythmias and Their		Autorial Prossure Pulsations	173
Electrocardiographic Interpretation	147	Transmission of Pressure Pulses to the	
Abnormal Sinus Rhythms	147	Peripheral Arteries	174
	147	Clinical Methods for Measuring Systolic	
Tachycardia Bradycardia	147	and Diastolic Pressures	175
	148	Voins and Their Functions	176
Sinus Arrhythmia Abnormal Rhythms That Result from	1.0	Venous Pressures—Right Atrial Pressure	
		(Central Venous Pressure) and	
Block of Heart Signals Within the Intracardiac Conduction Pathways	148	Perinheral Venous Pressures	176
Sinoatrial Block	148	Blood Reservoir Function of the Veins	179
Atrioventricular Block	148		
Incomplete Atrioventricular Heart Block	149		
Incomplete Intraventricular Block—		CHAPTER 16	
Electrical Alternans	150	The Microcirculation and the	
Premature Contractions	150	Lymphatic System: Capillary Fluid	
Premature Atrial Contractions	150	Lymphatic System. Capital y Fluid	
A-V Nodal or A-V Bundle Premature		Exchange, Interstitial Fluid, and	
Contractions	150	Lymph Flow	181
Premature Ventricular Contractions	151	Structure of the Microcirculation and	
Paroxysmal Tachycardia	151	Capillary System	181
Atrial Paroxysmal Tachycardia	152	Flow of Blood in the Capillaries—	101
Ventricular Paroxysmal Tachycardia	152	Vasomotion	182
Ventricular Fibrillation	152	Average Function of the Capillary System	183
Phenomenon of Re-entry—"Circus		Exchange of Water, Nutrients, and	105
Movements" as the Basis for Ventricular		Other Substances Between the Blood	
Fibrillation	153	and Interstitial Fluid	183
Chain Reaction Mechanism of Fibrillation	153	Diffusion Through the Capillary Membrane	183
Electrocardiogram in Ventricular Fibrillation	154	The Interstitium and Interstitial Fluid	184
Electroshock Defibrillation of the Ventricle	154	Fluid Filtration Across Capillaries Is	104
Hand Pumping of the Heart		Determined by Hydrostatic and	
(Cardiopulmonary Resuscitation) as		Colloid Osmotic Pressures, and	
an Aid to Defibrillation	155	Capillary Filtration Coefficient	185
Atrial Fibrillation	155	Capillary Hydrostatic Pressure	186
Atrial Flutter	156	Interstitial Fluid Hydrostatic Pressure	187
Cardiac Arrest	156	Plasma Colloid Osmotic Pressure	188
		Interstitial Fluid Colloid Osmotic Pressure	188
		Exchange of Fluid Volume Through the	100
UNITIV		Capillary Membrane	189
ONITI		Starling Equilibrium for Capillary Exchange	189
The Circulation		Lymphatic System	190
		Lymph Channels of the Body	190
District Control of the Control of t		Formation of Lymph	191
CHAPTER 14		Rate of Lymph Flow	192
<b>Overview of the Circulation; Medical</b>		Role of the Lymphatic System in Controlling	1,52
Physics of Pressure, Flow, and		Interstitial Fluid Protein Concentration,	
		Interstitial Fluid Volume, and Interstitial	
Resistance	161	Fluid Pressure	193
Physical Characteristics of the			911
Circulation	161	A lamest out to be the leader	
Basic Theory of Circulatory Function	163	CHAPTER 17	
Interrelationships Among Pressure,		Local and Humoral Control of Blood	
Flow, and Resistance	164	Flow by 4b T	
Blood Flow	164	Flow by the Tissues	195
Blood Pressure	166	Local Control of Blood Flow in Response	
Resistance to Blood Flow	167	to 1133uc Reeds	195
Effects of Pressure on Vascular Resistance		Mechanisms of Blood Flow Control	196
and Tissue Blood Flow	170	Acute Control of Local Blood Flow	196
		Long-term Blood Flow Regulation	200
CHAPTER 15		Development of Collateral Circulation	
		i lielionellon of Long-Term Local Bland	
Vascular Distensibility and Functions			201
of the Arterial and Venous Systems	171	Humoral Control of the Circulation	201
Vascular Distensibility	171	- 400constrictor Adents	201
Vascular Compliance (or Vascular	1/1	vasodilator Agents	202
		VASCIIIOV Combrel by 1	
Capacitance)	171	Vascular Control by lons and Other Chemical Factors	202

CHAPTER 18		Cardiac Output Regulation Is the Sum of	
Nervous Regulation of the Circulation,		Blood Flow Regulation in All the Local	
and Rapid Control of Arterial Pressure	204	Tissues of the Body—Tissue Metabolism Regulates Most Local Blood Flow	233
Nervous Regulation of the Circulation	204	The Heart Has Limits for the Cardiac Output	233
Autonomic Nervous System	204	That It Can Achieve	234
Role of the Nervous System in Rapid	4.8	What Is the Role of the Nervous System in	
Control of Arterial Pressure	208	Controlling Cardiac Output?	235
Increase in Arterial Pressure During Muscle		Pathologically High and Pathologically	226
Exercise and Other Types of Stress	208	Low Cardiac Outputs High Cardiac Output Caused by Reduced	236
Reflex Mechanisms for Maintaining Normal Arterial Pressure	209	Total Peripheral Resistance	236
Central Nervous System Ischemic	209	Low Cardiac Output	237
Response—Control of Arterial Pressure		A More Quantitative Analysis of Cardiac	
by the Brain's Vasomotor Center in		Output Regulation	237
Response to Diminished Brain Blood	0.10	Cardiac Output Curves Used in the	237
Flow Special Features of Nervous Control	212	Quantitative Analysis Venous Return Curves	238
of Arterial Pressure	213	Analysis of Cardiac Output and Right Atrial	230
Role of the Skeletal Nerves and Skeletal	213	Pressure, Using Simultaneous Cardiac	
Muscles in Increasing Cardiac Output		Output and Venous Return Curves	241
and Arterial Pressure	213	Methods for Measuring Cardiac	242
Respiratory Waves in the Arterial Pressure	214	Output	243
Arterial Pressure "Vasomotor" Waves— Oscillation of Pressure Reflex Control		Pulsatile Output of the Heart as Measured by an Electromagnetic or Ultrasonic	
Systems	214	Flowmeter	243
		Measurement of Cardiac Output Using the	
CHARER 10		Oxygen Fick Principle	244
CHAPTER 19		Indicator Dilution Method for Measuring	244
Dominant Role of the Kidney in Long-		Cardiac Output	244
Term Regulation of Arterial Pressure			
and in Hypertension: The Integrated		CHAPTER 21	
System for Pressure Control	216	Muscle Blood Flow and Cardiac	
Renal-Body Fluid System for Arterial	Sal :	Output During Exercise; the	
Pressure Control	216	Coronary Circulation and Ischemic	
Quantitation of Pressure Diuresis as a Basis		Heart Disease	246
for Arterial Pressure Control	217	Blood Flow in Skeletal Muscle	
Chronic Hypertension (High Blood Pressure)		and Blood Flow Regulation	
Is Caused by Impaired Renal Fluid Excretion	220	During Exercise	246
The Renin-Angiotensin System:	ologi	Rate of Blood Flow Through the Muscles	246
Its Role in Pressure Control and in		Control of Blood Flow Through the Skeletal Muscles	247
Hypertension	223	Total Body Circulatory Readjustments	241
Components of the Renin-Angiotensin	223	During Exercise	247
System Types of Hypertension in Which Angiotensin	LLJ	Coronary Circulation	249
Is Involved: Hypertension Caused by a		Physiologic Anatomy of the Coronary Blood	- 10
Renin-Secreting Tumor or by Infusion		Supply Normal Coronary Blood Flow	249
of Angiotensin II	226	Control of Coronary Blood Flow	249 250
Other Types of Hypertension Caused by		Special Features of Cardiac Muscle	250
Combinations of Volume Loading and Vasoconstriction	227	Metabolism	251
"Primary (Essential) Hypertension"	228	Ischemic Heart Disease	252
Summary of the Integrated,		Causes of Death After Acute Coronary	252
Multifaceted System for Arterial	220	Occlusion Stages of Recovery from Acute	253
Pressure Regulation	230	Myocardial Infarction	254
		Function of the Heart After Recovery	
CHAPTER 20		from Myocardial Infarction	255
Cardiac Output, Venous Return,		Pain in Coronary Heart Disease	255
	232	Surgical Treatment of Coronary Disease	256
and Their Regulation	LJL		
Normal Values for Cardiac Output at Rest and During Activity	232	CHAPTER 22	
Control of Cardiac Output by Venous		Cardiac Failure	258
Return—Role of the Frank-Starling		Dynamics of the Circulation in	
Mechanism of the Heart	232	Cardiac Failure	258

	increased vascular
Chronic Stage of Failure—Fluid Retention Capacity	and Histamine 28
Helps to Compensate Cardiac Output 259 Anaphylactic Shock	and mistaning
Summary of the Changes That Occur After Shock	28,
Acute Cardina Fallows (Commenced Sentic Snock	ent in Shock 28
Heart Failure" 260 Physiology of Treatn	lent in Shock
Dynamics of Severe Cardiac Failure— Replacement Therapy	ith Sympothomics 28
Decompensated Heart Failure 260 Treatment of Snock V	vith Sympathomimetic
	Useful, Sometimes
Low-Output Cardiac Failure— Not	28;
Cardiogenic Shock 262 Other Therapy	287
Edema in Patients with Cardiac Failure 263 Circulatory Arrest	28;
Cardiac Reserve 264 Effect of Circulatory	Arrest on the Brain 28
Quantitative Graphical Method for Analysis	
of Cardiac Failure 265	T TT 17
UN	ITV
CHAPTER 23 The Body Fluids:	nd Kidnove
Inc Doug Lacence	ina Kluneys
Heart Valves and Heart Sounds;	D 2.5
Dynamics of Valvular and Congenital C H A P T E	
Heart Defects 269 The Body Fluid Co	mpartments:
Heart Sounds 269 Extracellular and In	
	1 7 1
Valvular Lecione	-71
Abnormal Circulatory Dynamics in Fluid Intake and Out	
Valvular Heart Disease 272 During Steady-State	
Dynamics of the Circulation in Aortic Daily Intake of Water	291
Stenosis and Aortic Requiritation 272 Daily Loss of Body W	
Dynamics of Mitral Stanosis and Mitral Body Fluid Comparts	
Regurgitation 273 Illuracellular Fluid Cor	
Circulatory Dynamics During Evercise in Extracellular Fluid Co	
Patients with Valvular Lesions 273 Blood Volume	293
Abnormal Circulatory Dynamics in Constituents of Extra	
Congenital Heart Defects 274 Intracellular Fluids	293
Patent Ductus Arteriosus—A Left-to-Right Ionic Composition of	
Shunt 274 Interstitial Fluid is S	
Tetralogy of Fallot—A Right-to-Left Shunt 274 Important Constituent	s of the Intracellular
Causes of Congenital Anomalies 276 Fluid	295
Use of Extracorporeal Circulation Measurement of Flui	Volumes in the
During Cardiac Surgery 276 Different Body Fluid	Compartments—
Hypertrophy of the Heart in Valvular  The Indicator-Dilution of Management of Manageme	on Principle 295
and Congenital Heart Disease 276 Determination of Vol	umes of Specific
Body Fluid Compar	tments 295
C H A P T E R 2 4 Regulation of Fluid E	xchange and
	n Between
Circulatory Shock and Physiology of Basic Principles of C	tracellular Fluid 296
Its Treatment  278  Basic Principles of O Osmotic Pressure	smosis and
Physiologic Causes of Shock 278 Osmotic Equilibrium	296
Circulatory Shock Caused by Decreased  Between Intracellu	is maintained
Cardiac Output 278 Extracellular Fluids	ear and
Circulatory Shock That Occurs Without  Diminished Cardiac Output  Volume and Osmolali	290
Diminished Cardiac Output 278 and Intracellular FI	Ly of Extracellular
What Happens to the Arterial Pressure in States	aids in Abnormal
Circulatory Shock? 279 Effect of Adding Salin	Columbia
Tissue Deterioration Is the End Result of Extracellular Fluid	Solution to the
Circulatory Shock, Whatever the Cause 2/9 Glucose and Other S.	dutions
Stages of Shock 2/9 Administered for N	stritism D. 301
Oliock Calling Aprilormalitie	of Fluid V
nequiation: Hypons	tromin and
neiationship of blooding fortaine to	3/11
Cardiac Output and Arterial Pressure 2/9 Causes of Hyponatren	ia: Even- w.
Hemorrhagic Shock 280 Causes of Hypernatre	nia: Water I
Irreversible Shock 284 Excess Sodium	
Hypovolemic Shock Caused by Plasma Edema: Excess Fluid	in the Tie 302
	in the Tissues 302 302

	Table of	Contents	xix
Summary of Causes of Extracellular Edema Safety Factors That Normally Prevent	303	Importance of GFR Autoregulation in Preventing Extreme Changes in Renal	
Edema Fluids in the "Potential Spaces" of	304	Excretion  Rela of Tubulaglamarular Foodback in	323
the Body	305	Role of Tubuloglomerular Feedback in Autoregulation of GFR	323
	303	Myogenic Autoregulation of Renal Blood Flow and GFR	325
CHAPTER 26		Other Factors That Increase Renal Blood	323
Urine Formation by the Kidneys:		Flow and GFR: High Protein Intake and Increased Blood Glucose	325
I. Glomerular Filtration, Renal Blood		Increased blood Gladose	323
Flow, and Their Control	307		
Multiple Functions of the Kidneys in			
Homeostasis	307	CHAPTER 27	
Physiologic Anatomy of the Kidneys General Organization of the Kidneys and	308	Urine Formation by the Kidneys:	
Urinary Tract	308	II. Tubular Processing of the	
Renal Blood Supply	309	Glomerular Filtrate	327
The Nephron Is the Functional Unit of the		Reabsorption and Secretion by the	
Kidney	310	Renal Tubules	327
Micturition	311	Tubular Reabsorption Is Selective and	
Physiologic Anatomy and Nervous	0.1.1	Quantitatively Large	327
Connections of the Bladder	311	Tubular Reabsorption Includes	220
Transport of Urine from the Kidney		Passive and Active Mechanisms Active Transport	328 328
Through the Ureters and into the Bladder	312	Passive Water Reabsorption by Osmosis	320
Innervation of the Bladder	312	Is Coupled Mainly to Sodium	
Filling of the Bladder and Bladder Wall		Reabsorption	332
Tone; the Cystometrogram	312	Reabsorption of Chloride, Urea, and Other	
Micturition Reflex	313	Solutes by Passive Diffusion	332
Facilitation or Inhibition of Micturition		Reabsorption and Secretion Along	
by the Brain	313	Different Parts of the Nephron	333
Abnormalities of Micturition	313	Proximal Tubular Reabsorption	333
Urine Formation Results from		Solute and Water Transport in the Loop	224
Glomerular Filtration, Tubular	314	of Henle Distal Tubule	334 336
Reabsorption, and Tubular Secretion Filtration, Reabsorption, and Secretion of	314	Late Distal Tubule and Cortical Collecting	330
Different Substances	315	Tubule	336
Glomerular Filtration—The First Step in	1919	Medullary Collecting Duct	337
Urine Formation	316	Summary of Concentrations of Different	TOMES D
Composition of the Glomerular Filtrate	316	Solutes in the Different Tubular	
GFR Is About 20 Per Cent of the Renal		Segments	338
Plasma Flow	316	Regulation of Tubular Reabsorption	339
Glomerular Capillary Membrane	316	Glomerulotubular Balance—The Ability	
Determinants of the GFR	317	of the Tubules to Increase Reabsorption	
Increased Glomerular Capillary Filtration Coefficient Increases GFR	318	Rate in Response to Increased Tubular Load	339
Increased Bowman's Capsule Hydrostatic	V200	Peritubular Capillary and Renal Interstitial	337
Pressure Decreases GFR	318	Fluid Physical Forces	339
Increased Glomerular Capillary Colloid		Effect of Arterial Pressure on Urine	
Osmotic Pressure Decreases GFR	318	Output—The Pressure-Natriuresis and	
Increased Glomerular Capillary Hydrostatic	16987	Pressure-Diuresis Mechanisms	341
Pressure Increases GFR	319	Hormonal Control of Tubular Reabsorption	342
Renal Blood Flow	320	Sympathetic Nervous System Activation	0.40
Renal Blood Flow and Oxygen	220	Increases Sodium Reabsorption	343
Consumption	320 320	Use of Clearance Methods to Quantify	343
Determinants of Renal Blood Flow Blood Flow in the Vasa Recta of the Renal	320	Kidney Function Inulin Clearance Can Be Used to Estimate	343
Medulia is Very Low Compared with Flow		GFR GFR	344
in the Renal Cortex	321	Creatine Clearance and Plasma Creatinine	344
Physiologic Control of Glomerular		Clearance Can Be Used to Estimate	
Filtration and Renal Blood Flow	321	GFR COST TO SOUTH TO SOUTH THE SOUTH	344
Sympathetic Nervous System Activation		PAH Clearance Can Be Used to Estimate	
Decreases GFR	321	Renal Plasma Flow	345
Hormonal and Autacoid Control of Renal		Filtration Fraction Is Calculated from GFR	
Circulation	322	Divided by Renal Plasma Flow	346
Autoregulation of GFR and Renal	222	Calculation of Tubular Reabsorption or	346
Blood Flow	323	Secretion from Renal Clearance	340

CHARTER 20		CHAPTER 29	
CHAPTER 28		Denal Pegulation of Potassium,	
Regulation of Extracellular Fluid		Coloium Phosphate, and Magnesium;	
Osmolarity and Sodium		Integration of Renal Mechanisms for	
Concentration	348	Integration of Kenai Mechanisms for	
The Kidneys Excrete Excess Water		Control of Blood Volume and	
by Forming a Dilute Urine	348	Extracellular Fluid Volume	365
Antidiuretic Hormone Controls Urine		Population of Potassium Excretion	
Concentration	348	and Potassium Concentration in	
Renal Mechanisms for Excreting a		Extracellular Fluid	365
Dilute Urine	349	Regulation of Internal Potassium	
The Kidneys Conserve Water by	250	Distribution	366
Excreting a Concentrated Urine	350	Overview of Renal Potassium Excretion	367
Obligatory Urine Volume	350	Potassium Secretion by Principal Cells of	
Requirements for Excreting a Concentrated		Late Distal and Cortical Collecting	
Urine—High ADH Levels and Hyperosmotic	350	Tubules	367
Renal Medulla Countercurrent Mechanism Produces a	330	Summary of Factors That Regulate	
Hyperosmotic Renal Medullary Interstitium	351	Potassium Secretion: Plasma Potassium	
Role of Distal Tubule and Collecting Ducts in	331	Concentration, Aldosterone, Tubular Flow	200
Excreting a Concentrated Urine	352	Rate, and Hydrogen Ion Concentration	368
Urea Contributes to Hyperosmotic Renal		Control of Renal Calcium Excretion	
Medullary Interstitium and to a		and Extracellular Calcium Ion	371
Concentrated Urine	353	Concentration Control of Calcium Excretion by the	3/1
Countercurrent Exchange in the Vasa Recta		Kidneys	372
Preserves Hyperosmolarity of the		Regulation of Renal Phosphate Excretion	372
Renal Medulla	354	Control of Renal Magnesium Excretion	3/2
Summary of Urine Concentrating Mechanism		and Extracellular Magnesium Ion	
and Changes in Osmolarity in Different	255	Concentration	373
Segments of the Tubules  Quantifying Renal Urine Concentration	355	Integration of Renal Mechanisms for	
and Dilution: "Free Water" and Osmolar		Control of Extracellular Fluid	373
Clearances	357	Sodium Excretion Is Precisely Matched to	
Disorders of Urinary Concentrating	337	Intake Under Steady-State Conditions	373
Ability	357	Sodium Excretion Is Controlled by Altering	
Control of Extracellular Fluid Osmolarity		Glomerular Filtration or Tubular Sodium	
and Sodium Concentration	358	Reabsorption Rates	374
Estimating Plasma Osmolarity from Plasma		Importance of Pressure Natriuresis and	
Sodium Concentration	358	Pressure Diuresis in Maintaining Body Sodium and Fluid Balance	374
Osmoreceptor-ADH Feedback System	358	Pressure Natriuresis and Diuresis Are Key	3/4
ADH Synthesis in Supraoptic and Paraventricular Nuclei of the		Components of a Renal-Body Fluid	
Hypothalamus and ADH Release from		Feedback for Regulating Body Fluid	
the Posterior Pituitary	359	Volumes and Arterial Pressure	375
Cardiovascular Reflex Stimulation of ADH	337	Precision of Blood Volume and Extracellular	
Release by Decreased Arterial Pressure		Fluid Volume Regulation	376
and/or Decreased Blood Volume	360	Distribution of Extracellular Fluid	
Quantitative Importance of Cardiovascular		between the Interstitial Spaces and	
Reflexes and Osmolarity in Stimulating		vascular System	376
ADH Secretion	360	Nervous and Hormonal Factors Increase	
Other Stimuli for ADH Secretion	360	the Effectiveness of Renal-Body Fluid Feedback Control	
Role of Thirst in Controlling Extracellular		recuback Control	377
Fluid Osmolarity and Sodium Concentration	361	Sympathetic Nervous System Control of	
Central Nervous System Centers for Thirst	361	Renal Excretion: Arterial Baroreceptor and	277
Stimuli for Thirst	361	Low-Pressure Stretch Receptor Reflexes Role of Angiotensin II In Controlling Renal	377
Threshold for Osmolar Stimulus of Drinking	362		377
Integrated Responses of Osmoreceptor-ADH		Role of Aldosterone in Controlling Renal	3//
and Thirst Mechanisms in Controlling			378
Extracellular Fluid Osmolarity and Sodium		Role of ADH in Controlling Renal Water	3,0
Concentration	362		379
Role of Angiotensin II and Aldosterone		Role of Atrial Natriuretic Peptide in	200
in Controlling Extracellular Fluid	2		378
Osmolarity and Sodium Concentration	362	""Legrated Hesponses to Chamber	
Salt-Appetite Mechanism for Controlling Extracellular Fluid		Sodium Intake	380
Sodium Concentration and Volume	363	Conditions That Cause Large Increases	
Mes and the second seco	303	in Blood Volume and Extracellular Fluid Volume	280
			420

Increased Blood Volume and Extracellular Fluid Volume Caused by Heart Diseases	380	Renal Correction of Acidosis—Increased Excretion of Hydrogen Ions and	
Increased Blood Volume Caused by	200	Addition of Bicarbonate lons to the	200
Increased Capacity of Circulation Conditions That Cause Large Increases in Extracellular Fluid Volume but with	380	Extracellular Fluid  Acidosis Decreases the Ratio of HCO <sub>3</sub> <sup>-</sup> /H <sup>+</sup> in  Renal Tubular Fluid	396 396
Normal Blood Volume	201	Renal Correction of Alkalosis—Decreased	390
Nephrotic Syndrome—Loss of Plasma Proteins in Urine and Sodium Retention	381	Tubular Secretion of Hydrogen Ions and Increased Excretion of	
by the Kidneys	381	Bicarbonate lons	396
Liver Cirrhosis—Decreased Synthesis of	301	Alkalosis Increases the Ratio of HCO <sub>3</sub> <sup>-</sup> /H <sup>+</sup>	370
Plasma Proteins by the Liver and		in Renal Tubular Fluid	396
Sodium Retention by the Kidneys	381	Clinical Causes of Acid-Base Disorders	397
		Respiratory Acidosis Is Caused by	
		Decreased Ventilation and Increased Pco <sub>2</sub>	397
CHAPTER 30		Respiratory Alkalosis Results from Increased	
- 1. 2015 - 1. 2015 - 1. 2015 - 1. 2016 - 1. 2016 - 1. 2016 - 1. 2016 - 1. 2016 - 1. 2016 - 1. 2016 - 1. 2016		Ventilation and Decreased Pco₂	397
Regulation of Acid-Base Balance	383	Metabolic Acidosis Results from Decreased	
Hydrogen Ion Concentration Is		Extracellular Fluid Bicarbonate	207
Precisely Regulated	383	Concentration	397
Acids and Bases—Their Definitions		Treatment of Acidosis or Alkalosis	398
and Meanings	383	Clinical Measurements and Analysis of	398
Defenses Against Changes in Hydrogen		Acid-Base Disorders Complex Acid-Base Disorders and Use of	390
Ion Concentration: Buffers, Lungs,	204	the Acid-Base Nomogram for Diagnosis	399
and Kidneys Buffering of Hydrogen Ions in the Body	384	Use of Anion Gap to Diagnose Acid-Base	3,,
Fluids	385	Disorders	400
Bicarbonate Buffer System	385	On the Asset of the State of the Internation	2101
Quantitative Dynamics of the Bicarbonate	303	CHARTER 21	
Buffer System	385	CHAPTER 31	
Phosphate Buffer System	387	Kidney Diseases and Diuretics	402
Proteins: Important Intracellular		Diuretics and Their Mechanisms of	
Buffers	387	Action	402
Respiratory Regulation of Acid-Base		Osmotic Diuretics Decrease Water	
Balance Comment of the Comment of th	388	Reabsorption by Increasing Osmotic	727272
Pulmonary Expiration of CO <sub>2</sub> Balances	200	Pressure of Tubular Fluid	402
Metabolic Formation of CO <sub>2</sub>	388	"Loop" Diuretics Decrease Active	
Increasing Alveolar Ventilation Decreases		Sodium-Chloride-Potassium Reabsorption	402
Extracellular Fluid Hydrogen Ion Concentration and Raises pH	388	in the Thick Ascending Loop of Henle Thiazide Diuretics Inhibit Sodium-Chloride	403
Increased Hydrogen Ion Concentration	300	Reabsorption in the Early Distal Tubule	404
Stimulates Alveolar Ventilation	389	Carbonic Anhydrase Inhibitors Block	101
Renal Control of Acid-Base Balance	390	Sodium-Bicarbonate Reabsorption in the	
Secretion of Hydrogen Ions and		Proximal Tubules	404
Reabsorption of Bicarbonate lons		Competitive Inhibitors of Aldosterone	
by the Renal Tubules	390	Decrease Sodium Reabsorption from and	
Hydrogen Ions Are Secreted by Secondary		Potassium Secretion into the Cortical	
Active Transport in the Early Tubular	201	Collecting Tubule	404
Segments	391	Diuretics That Block Sodium Channels	
Filtered Bicarbonate Ions Are Reabsorbed		in the Collecting Tubules Decrease	101
by Interaction with Hydrogen lons in the Tubules	391	Sodium Reabsorption Kidney Diseases	404 404
Primary Active Secretion of Hydrogen Ions in	371	Acute Renal Failure	404
the Intercalated Cells of Late Distal and		Prerenal Acute Renal Failure Caused by	707
Collecting Tubules	392	Decreased Blood Flow to the Kidney	405
Combination of Excess Hydrogen Ions		Intrarenal Acute Renal Failure Caused by	9,000
with Phosphate and Ammonia Buffers		Abnormalities within the Kidney	405
in the Tubule—A Mechanism for	200	Postrenal Acute Renal Failure Caused by	
Generating "New" Bicarbonate lons	392	Abnormalities of the Lower Urinary	74 E
Phosphate Buffer System Carries Excess		Tract	406
Hydrogen lons into the Urine and	202	Physiologic Effects of Acute Renal Failure	406
Generates New Bicarbonate	393	Chronic Renal Failure: An Irreversible	
Excretion of Excess Hydrogen Ions and		Decrease in the Number of Functional	406
Generation of New Bicarbonate by the Ammonia Buffer System	393	Nephrons Vicious Circle of Chronic Renal Failure	400
Quantifying Renal Acid-Base Excretion	394	Leading to End-Stage Renal Disease	407
Regulation of Renal Tubular Hydrogen Ion		Injury to the Renal Vasculature as a Cause	707
Secretion	395	of Chronic Renal Failure	408

		CHAPTER 34	
Injury to the Glomeruli as a Cause of		Resistance of the Body to Infection: II.	
Chronic Renal Failure— Glomerulonephritis	408	Resistance of the Body	
Injury to the Renal Interstitium as a	700	Immunity and Allergy	439
Cause of Chronic Renal Failure—		Innate Immunity Acquired (Adaptive) Immunity	439
Pyelonephritis	409		439
Nephrotic Syndrome—Excretion of Protein		Both Types of Acquired Immunity Are	440
in the Urine Because of Increased	409	Initiated by Antideris	440
Glomerular Permeability Nephron Function in Chronic Renal Failure	409	I ymphocytes Are Responsible for	
Effects of Renal Failure on the Body	102	Acquired Immunity	440
Fluids—Uremia	411	proprocessing of the I and B Lymphocytes	440
Hypertension and Kidney Disease	412	T Lymphocytes and B-Lymphocyte Antibodies React Highly Specifically	
Specific Tubular Disorders	413	Against Specific Antigens—Role of	
Treatment of Renal Failure by Dialysis with an Artificial Kidney	414	Lymphocyte Clones	442
with an Artificial Kidney	414	Origin of the Many Clones of Lymphocytes	442
		Specific Attributes of the B-Lymphocyte	
UNITVI		System—Humoral Immunity and the	
UNIT VI		Antibodies	443
Blood Cells, Immunity, and Blood		Special Attributes of the T-Lymphocyte	
Clotting		System-Activated T Cells and Cell-	446
010000		Mediated Immunity Several Types of T Cells and Their Different	446
CHAPTER 32		Functions	446
		Tolerance of the Acquired Immunity	770
Red Blood Cells, Anemia, and		System to One's Own Tissues—Role	
Polycythemia	419	of Preprocessing in the Thymus and	
Red Blood Cells (Erythrocytes)	419	Bone Marrow	448
Production of Red Blood Cells	420	Immunization by Injection of Antigens	448
Formation of Hemoglobin Iron Metabolism	424 425	Passive Immunity	449
Life Span and Destruction of Red Blood	423	Allergy and Hypersensitivity Allergy Caused by Activated T Cells:	449
Cells	426	Delayed-Reaction Allergy	449
Anemias	426	Allergies in the "Allergic" Person, Who Has	עדד
Effects of Anemia on Function of the		Excess IgE Antibodies	449
Circulatory System	427		
Polycythemia Effect of Polycythemia on Function of the	427	CHAPTER 35	
Circulatory System	428	Blood Types; Transfusion; Tissue and	
	720	Organ Transplantation	151
CHAPTER 33		Antigenicity Causes Immune Reactions	451
		of Blood	451
Resistance of the Body to Infection: I.		O-A-B Blood Types	451
Leukocytes, Granulocytes, the		A and B Antigens—Agglutinogens	451
Monocyte-Macrophage System, and		Aggiutinins	452
Inflammation	429	Agglutination Process In Transfusion Reactions	
Leukocytes (White Blood Cells)	429	Blood Typing	452
General Characteristics of Leukocytes	429	Rh Blood Types	453
Genesis of the White Blood Cells	430	Rh Immune Response	453 453
Life Span of the White Blood Cells  Neutrophils and Macrophages Defend	431	Iranstusion Reactions Population	433
Against Infections	431		454
Phagocytosis	431	rightsplantation of Ticours	455
Monocyte-Macrophage Cell System	731		
(Reticuloendothelial System)	432	in Transplanted Tissue	455
Inflammation: Role of Neutrophils and		CII A D T -	
Macrophages Inflammation	434	CHAPTER 36	
Macrophage and Neutrophil Responses	434	Hemostasis and Blood Coomileties	457
During Inflammation	434	THE HELIOSTAGE	457
Eosinophils	436	Vascular Constriction	457
Basophils	436	Formation of the Platelet D	457
Leukopenia	436	Blood Coagulation in the Ruptured  Vessel	31/3
The Leukemias	437	Fibrous Organization	458
Effects of Leukemia on the Body	437	Fibrous Organization or Dissolution of the	400
			458

Mechanism of Blood Coagulation	459	CHAPTER 38	
Conversion of Prothrombin to Thrombin	459	Pulmonary Circulation, Pulmonary	
Conversion of Fibrinogen to Fibrin—			400
Formation of the Clot	460	Edema, Pleural Fluid	483
Vicious Circle of Clot Formation	460	Physiologic Anatomy of the Pulmonary	
Initiation of Coagulation: Formation of		Circulatory System	483
Prothrombin Activator	461	Pressures in the Pulmonary System	483
Prevention of Blood Clotting in the		Blood Volume of the Lungs	484
Normal Vascular System—Intravascular		Blood Flow Through the Lungs and	
Anticoagulants	463	Its Distribution	485
Lysis of Blood Clots—Plasmin	464	Effect of Hydrostatic Pressure	
Conditions That Cause Excessive		Gradients in the Lungs on Regional	
Bleeding in Human Beings	464	Pulmonary Blood Flow	485
Decreased Prothrombin, Factor VII,		Zones 1, 2, and 3 of Pulmonary Blood Flow	485
Factor IX,and Factor X Caused by		Effect of Increased Cardiac Output on	
Vitamin K Deficiency	464	Pulmonary Blood Flow and Pulmonary	
Hemophilia	465	Arterial Pressure During Heavy Exercise	486
Thrombocytopenia	465	Function of the Pulmonary Circulation	
Thromboembolic Conditions in the		When the Left Atrial Pressure Rises as a	
Human Being	465	Result of Left-Sided Heart Failure	487
Femoral Venous Thrombosis and Massive		Pulmonary Capillary Dynamics	487
Pulmonary Embolism	466	Capillary Exchange of Fluid in the Lungs,	9230
Disseminated Intravascular Coagulation	466	and Pulmonary Interstitial Fluid Dynamics	487
Anticoagulants for Clinical Use	466	Pulmonary Edema	488
Heparin as an Intravenous Anticoagulant	466	Fluid in the Pleural Cavity	489
Coumarins as Anticoagulants	466		
Prevention of Blood Coagulation Outside		CHAPTER 39	
the Body	466		
Blood Coagulation Tests	467	Physical Principles of Gas Exchange;	
Bleeding Time	467	Diffusion of Oxygen and Carbon	
Clotting Time	467	Dioxide Through the Respiratory	
Prothrombin Time	467	Membrane	407
			491
UNIT VII		Physics of Gas Diffusion and Gas	107
UNIIVII		Partial Pressures	491
Respiration		Molecular Basis of Gas Diffusion	491
		Gas Pressures in a Mixture of Gases—	401
CHAPTER 37		"Partial Pressures" of Individual Gases	491
<b>Pulmonary Ventilation</b>	471	Pressures of Gases Dissolved in Water	100
		and Tissues	492
Mechanics of Pulmonary Ventilation	471	Vapor Pressure of Water	492
Muscles That Cause Lung Expansion and	171	Diffusion of Gases Through Fluids— Pressure Difference Causes Net	
Contraction	471		102
Movement of Air In and Out of the Lungs		Diffusion	493 493
and the Pressures That Cause the	472	Diffusion of Gases Through Tissues	493
Movement	4/2	Composition of Alveolar Air—Its Relation	493
Effect of the Thoracic Cage on Lung	474	to Atmospheric Air Rate at Which Alveolar Air Is Renewed by	493
Expansibility  Dulman and Consoities	475		494
Pulmonary Volumes and Capacities	7/3	Atmospheric Air Oxygen Concentration and Partial Pressure	494
Recording Changes in Pulmonary Volume—	475	in the Alveoli	101
Spirometry	4/3	CO <sub>2</sub> Concentration and Partial Pressure in	494
Abbreviations and Symbols Used in	476	the Alveoli	495
Pulmonary Function Tests	7/0	Expired Air	495
Determination of Functional Residual		Diffusion of Gases Through the	473
Capacity, Residual Volume, and Total	476	Respiratory Membrane	496
Lung Capacity—Helium Dilution Method	470	Factors That Affect the Rate of Gas	490
Minute Respiratory Volume Equals	477		
Respiratory Rate Times Tidal Volume	477	Diffusion Through the Respiratory Membrane	498
Alveolar Ventilation "Dood Space" and its Effect on Alveolar	7//		470
"Dead Space" and Its Effect on Alveolar Ventilation	477	Diffusing Capacity of the Respiratory Membrane	498
	478	Effect of the Ventilation-Perfusion	490
Rate of Alveolar Ventilation	4/0		499
Functions of the Respiratory	478	Ratio on Alyeolar Gas Concentration Po <sub>2</sub> -Pco <sub>2</sub> , Va/Q Diagram	500
Passageways Trackage Bronchi and Propobles	478	Concept of the "Physiological Shunt"	500
Trachea, Bronchi, and Bronchioles	4/0	(When Va/Q is Greater Than Normal)	500
Normal Respiratory Functions of the	190	Abnormalities of Ventilation-Perfusion Ratio	501
Nose	480	ADIOTHER DE VEHILIALION-PERIUSION HALIO	201

		Chronic Breathing of Low Oxygen Stimulates	
CHAPTER 40		Respiration Even More—The Phenomenon	
Transport of Oxygen and Carbon		- # "A colimatization"	519
Dioxide in Blood and Tissue Fluids	502	Composite Effects of PCO2, pri, and PO2 on	319
Transport of Oxygen from the Lungs to		Alvociar Ventilation	519
the Body Tissues	502	Regulation of Respiration During	
Diffusion of Oxygen from the Alveoli to the		Evereico	520
Pulmonary Capillary Blood	502	Other Factors That Affect Respiration	521
Transport of Oxygen in the Arterial Blood	503	Sleep Apnea	522
Diffusion of Oxygen from the Peripheral	502		
Capillaries into the Tissue Fluid Diffusion of Oxygen from the Peripheral	503	CHAPTER 42	
Capillaries to the Tissue Cells	504	Respiratory Insufficiency—	
Diffusion of Carbon Dioxide from the		Pathophysiology, Diagnosis, Oxygen	
Peripheral Tissue Cells into the			
Capillaries and from the Pulmonary		Therapy	524
Capillaries into the Alveoli Role of Hemoglobin in Oxygen Transport	504	Useful Methods for Studying Respiratory	-
Reversible Combination of Oxygen with	505	Abnormalities Study of Blood Gases and Blood pH	524
Hemoglobin	505	Measurement of Maximum Expiratory Flow	524 525
Effect of Hemoglobin to "Buffer" the		Forced Expiratory Vital Capacity and Forced	323
Tissue Po <sub>2</sub>	507	Expiratory Volume	526
Factors That Shift the Oxygen-Hemoglobin		Physiologic Peculiarities of Specific	
Dissociation Curve—Their Importance for Oxygen Transport	507	Pulmonary Abnormalities	526
Metabolic Use of Oxygen by the Cells	508	Chronic Pulmonary Emphysema Pneumonia	526
Transport of Oxygen in the Dissolved State	509	Atelectasis	527 528
Combination of Hemoglobin with Carbon		Asthma	529
Monoxide—Displacement of Oxygen	509	Tuberculosis	530
Transport of Carbon Dioxide in the Blood Chemical Forms in Which Carbon Dioxide	510	Hypoxia and Oxygen Therapy	530
Is Transported	510	Oxygen Therapy in Different Types of	
Carbon Dioxide Dissociation Curve	511	Hypoxia Cyanosis	530
When Oxygen Binds with Hemoglobin,	SECOND .	Hypercapnia	531 531
Carbon Dioxide Is Released (the Haldane		Dyspnea	532
Effect) to Increase CO <sub>2</sub> Transport Change in Blood Acidity During Carbon	511	Artificial Respiration	532
Dioxide Transport	512		
Respiratory Exchange Ratio	512		
		UNIT VIII	
CHAPTER 41			
Regulation of Respiration	514	Aviation, Space, and Deep-Sea	
Respiratory Center	514	Diving Physiology	
Dorsal Respiratory Group of Neurons—Its	317		
Control of Inspiration and of Respiratory		CHAPTER 43	
Rhythm A Pneumotaxic Center Limits the Duration	514	Aviation High Alex	
of Inspiration and Increases the		Aviation, High-Altitude, and Space Physiology	
Respiratory Rate	514	Effects of Laws	537
Ventral Respiratory Group of Neurons—		Effects of Low Oxygen Pressure on the	
Functions in Both Inspiration and		Alveolar Pos at Different Co.	537
Expiration Lung Inflation Signals Limit Inspiration—	515	- O Dicauling Pilip Ovve	537
The Hering-Breuer Inflation Reflex	515	Po <sub>2</sub> at Different Altitudes	538
Control of Overall Respiratory Center	313	Acute Effects of Hypoxia	538
Activity	516	ACCIIMATIZATION to I am D	539
Chemical Control of Respiration	516	Natural Acclimatization of Native Human  Beings Living at High Alive	
Direct Chemical Control of Respiratory		Reduced Work Canasity Attitudes	540
Center Activity by Carbon Dioxide and Hydrogen Ions	516	and Positive Effect of Acclimatization	540
Peripheral Chemoreceptor System for	516		540
Control of Respiratory Activity—Role		Pulmonary Edema	540
of Oxygen in Respiratory Control	518	Chronic Mountain Sickness Effects of Accelerate	541
Effect of Low Arterial Po <sub>2</sub> to Stimulate Alveolar Ventilation When Arterial Carbon		Effects of Acceleratory Forces on the	
Dioxide and Hydrogen Ion Concentrations		Centrifugal Accelerate Space Physiology	541
Remain Normal	519	Effects of Linear Acceleratory Forces on the	541
		body Forces on the	542
			The second secon

"Artificial Climate" in the Sealed	5.42	CHAPTER 46	
Spacecraft Weightlessness in Space	543 543	Sensory Receptors, Neuronal Circuits	
Weightiessness in Space	343	for Processing Information	572
CHARTER		Types of Sensory Receptors and the	
CHAPTER 44		Sensory Stimuli They Detect	572
Physiology of Deep-Sea Diving and		Differential Sensitivity of Receptors	572
Other Hyperbaric Conditions	545	Transduction of Sensory Stimuli into	572
Effect of High Partial Pressures of		Nerve Impulses Local Electrical Currents at Nerve Endings—	573
Individual Gases on the Body	545	Receptor Potentials	573
Nitrogen Narcosis at High Nitrogen		Adaptation of Receptors	575
Pressures	545	Nerve Fibers That Transmit Different	
Oxygen Toxicity at High Pressures	546	Types of Signals, and Their	
Carbon Dioxide Toxicity at Great Depths in the Sea	547	Physiologic Classification	576
Decompression of the Diver After Excess	347	Transmission of Signals of Different	
Exposure to High Pressure	547	Intensity in Nerve Tracts—Spatial and	577
Scuba (Self-Contained Underwater	3.7	Temporal Summation	577
Breathing Apparatus) Diving	549	Transmission and Processing of Signals in Neuronal Pools	578
Special Physiologic Problems in		Relaying of Signals Through Neuronal	370
Submarines	550	Pools	579
Hyperbaric Oxygen Therapy	550	Prolongation of a Signal by a Neuronal	
		Pool—"Afterdischarge"	581
		Instability and Stability of Neuronal	
UNITIX		Circuits	583
The Newsons Systems A. Conoral		Inhibitory Circuits as a Mechanism for	502
The Nervous System: A. General		Stabilizing Nervous System Function Synaptic Fatigue as a Means for Stabilizing	583
<b>Principles and Sensory Physiology</b>		the Nervous System	583
		the Nervous System	505
CHAPTER 45			
Organization of the Nervous System,			
		CHAPTER 47	
Basic Functions of Synapses,	555	Somatic Sensations: I. General	
"Transmitter Substances"	555	Organization, the Tactile and	
General Design of the Nervous System	555	Position Senses	585
Central Nervous System Neuron: The Basic	555	CLASSIFICATION OF SOMATIC SENSES	585
Functional Unit Sensory Part of the Nervous System—	333	Detection and Transmission of Tactile	303
Sensory Receptors	555	Sensations	585
Motor Part of the Nervous System—		Detection of Vibration	587
Effectors	556	TICKLE AND ITCH	587
Processing of Information—"Integrative"	The same	Sensory Pathways for Transmitting	
Function of the Nervous System	556	Somatic Signals into the Central	507
Storage of Information—Memory	557	Nervous System	587
Major Levels of Central Nervous System	557	Dorsal Column–Medial Lemniscal System	588 588
Function	557	Anterolateral System  Transmission in the Dorsal Column—	200
Spinal Cord Level Lower Brain or Subcortical Level	558	Medial Lemniscal System	588
Higher Brain or Cortical Level	558	Anatomy of the Dorsal Column—Medial	
Comparison of the Nervous System		Lemniscal System	588
with a Computer	558	Somatosensory Cortex	589
Central Nervous System Synapses	559	Somatosensory Association Areas	592
Types of Synapses—Chemical and	550	Overall Characteristics of Signal	
Electrical	559	Transmission and Analysis in the Dorsal	592
Physiologic Anatomy of the Synapse	559	Column-Medial Lemniscal System	594
Chemical Substances That Function as	562	Position Senses Interpretation of Sensory Stimulus Intensity	593
Synaptic Transmitters Electrical Events During Neuronal Excitation	564	Judgment of Stimulus Intensity	594
Electrical Events During Neuronal		Position Senses	594
Inhibition	566	Transmission of Less Critical Sensory	
Special Functions of Dendrites for Exciting		Signals in the Anterolateral Pathway	595
Neurons	568	Anatomy of the Anterolateral Pathway	595
Relation of State of Excitation of the Neuron		Some Special Aspects of	500
to Rate of Firing	569	Somatosensory Function	596
Some Special Characteristics of	570	Function of the Thalamus in Somatic	596
Synaptic Transmission	570	Sensation	350

basai Ganglia—Their Motor Functions	/0/	Headquarters for the Limbic System	725
Function of the Basal Ganglia in Executing		Vegetative and Endocrine Control	732
Patterns of Motor Activity—The Putamen	700	Vegetative and Endocrine Control	72-
Circuit	708	Functions of the Hypothalamus Behavioral Functions of the Hypothalamus	733
Role of the Basal Ganglia for Cognitive		and Associated Limbic Structures	72.
Control of Sequences of Motor Patterns—	700	"Reward" and "Punishment" Function of	734
The Caudate Circuit	709		726
Function of the Basal Ganglia to Change		the Limbic System	735
the Timing and to Scale the Intensity of	700	Importance of Reward or Punishment in	724
Movements	709	Behavior	736
Functions of Specific Neurotransmitter		Specific Functions of Other Parts of	724
Substances in the Basal Ganglial		the Limbic System	736
System	710	Functions of the Hippocampus	736
Integration of the Many Parts of the	710	Functions of the Amygdala	737
Total Motor Control System	712	Function of the Limbic Cortex	738
Spinal Level	712		
Hindbrain Level	712	CHAPTER 59	
Motor Cortex Level	712		
What Drives Us to Action?	713	States of Brain Activity—Sleep, Brain	
		Waves, Epilepsy, Psychoses	739
CHAPTER 57		Sleep	739
		Slow-Wave Sleep	739
<b>Cerebral Cortex, Intellectual Functions</b>		REM Sleep (Paradoxical Sleep,	
of the Brain, Learning and Memory	714	Desynchronized Sleep)	740
Physiologic Anatomy of the Cerebral		Basic Theories of Sleep	740
Cortex	714	Physiologic Effects of Sleep	741
Functions of Specific Cortical Areas	715	Brain Waves	741
Association Areas	716	Origin of Brain Waves	742
Comprehensive Interpretative Function of		Effect of Varying Levels of Cerebral	
the Posterior Superior Temporal Lobe—		Activity on the Frequency of the EEG	743
"Wernicke's Area" (a General		Changes in the EEG at Different Stages of	
Interpretative Area)	718	Wakefulness and Sleep	743
Functions of the Parieto-occipitotemporal		Epilepsy	743
Cortex in the Nondominant Hemisphere	719	Grand Mal Epilepsy	743
Higher Intellectual Functions of the		Petit Mal Epilepsy	744
Prefrontal Association Areas	719	Focal Epilepsy	744
Function of the Brain in		Psychotic Behavior and Dementia—	
Communication—Language Input		Roles of Specific Neurotransmitter	
and Language Output	720	Systems	745
Function of the Corpus Callosum and		Depression and Manic-Depressive	
Anterior Commissure to Transfer		Psychoses—Decreased Activity of the	
Thoughts, Memories, Training, and		Norepinephrine and Serotonin	
Other Information Between the Two	700	Neurotransmitter Systems	745
Cerebral Hemispheres	722	Schizophrenia—Possible Exaggerated	
Thoughts, Consciousness, and Memory	723	Function of Part of the Dopamine System	
Memory—Roles of Synaptic Facilitation and	722		745
Synaptic Inhibition	723	Alzheimer's Disease—Amyloid Plaques and Depressed Memory	710
Short-Term Memory	724 724	and bepressed Memory	746
Intermediate Long-Term Memory	725		
Long-Term Memory	725	CHAPTER 60	
Consolidation of Memory	123	The Autonomic Nervous System and	
		the Advand M. J. B.	
CHAPTER 58		the Adrenal Medulla	748
		General Organization of the Autonomic	
Behavioral and Motivational		Nervous System	748
Mechanisms of the Brain—The		Physiologic Anatomy of the Sympathetic	
Limbic System and the		Nervous System	748
Hypothalamus	728	Preganglionic and Postganglionic	
		Sympathetic Neurons	748
Activating-Driving Systems of the Brain	728	Physiologic Anatomy of the	
Control of Cerebral Activity by Continuous	720	Parasympathetic Nervous System	750
Excitatory Signals from the Brain Stem	728	Basic Characteristics of Sympathetic	
Neurohormonal Control of Brain Activity	730 731	and Parasympathetic Function	750
Limbic System Functional Anatomy of the Limbic	/31	Cholinergic and Adrenergic Fibers—	
System; Key Position of the		Secretion of Acetylcholine or	
Hypothalamus	731	Norepinephrine	750
and the second s	751	Receptors on the Effector Organs	752

Excitatory and Inhibitory Actions of		Physiological Anatomy of the	771
Sympathetic and Parasympathetic		Gastrointestinal Wall	771
Stimulation	753	Neural Control of Gastrointestinal	773
Effects of Sympathetic and Parasympathetic		Function—Enteric Nervous System	113
Stimulation on Specific Organs	753	Differences Between the Myenteric and	774
Function of the Adrenal Medullae	755	Submucosal Plexuses	114
Relation of Stimulus Rate to Degree of		Types of Neurotransmitters Secreted by	775
Sympathetic and Parasympathetic Effect	756	Enteric Neurons	113
Sympathetic and Parasympathetic "Tone"	756	Hormonal Control of Gastrointestinal	776
Denervation Supersensitivity of Sympathetic		Motility	770
and Parasympathetic Organs after	100000	Functional Types of Movements in the	776
Denervation	756	Gastrointestinal Tract	776
Autonomic Reflexes	757	Propulsive Movements—Peristalsis	777
Stimulation of Discrete Organs in Some		Mixing Movements	///
Instances and Mass Stimulation in		Gastrointestinal Blood Flow—	777
Other Instances by the Sympathetic	757	"Splanchnic Circulation"	,,,
and Parasympathetic Systems	757	Anatomy of the Gastrointestinal Blood	778
"Alarm" or "Stress" Response of the	750	Supply  Start of Cut Activity and Metabolic	770
Sympathetic Nervous System	758	Effect of Gut Activity and Metabolic	
Medullary, Pontine, and Mesencephalic		Factors on Gastrointestinal Blood	778
Control of the Autonomic Nervous	750	Flow	770
System	758	Nervous Control of Gastrointestinal Blood	779
Pharmacology of the Autonomic	750	Flow	119
Nervous System	759		
Drugs That Act on Adrenergic Effector	750		
Organs—Sympathomimetic Drugs	759	CHAPTER 63	
Drugs That Act on Cholinergic Effector	759	Propulsion and Mixing of Food in the	
Organs Drugs That Stimulate or Block Sympathetic	139		781
and Parasympathetic Postganglionic		Alimentary Tract	
Neurons	759	Ingestion of Food	781
Neurons	137	Mastication (Chewing)	781
		Swallowing (Deglutition)	782
CHAPTER 61		Motor Functions of the Stomach	784 784
Cerebral Blood Flow, Cerebrospinal		Storage Function of the Stomach	704
Fluid, and Brain Metabolism	761	Mixing and Propulsion Of Food in the	
	761	Stomach—The Basic Electrical Rhythm	784
Cerebral Blood Flow	761	of the Stomach Wall	785
Normal Rate of Cerebral Blood Flow	761	Stomach Emptying Regulation of Stomach Emptying	785
Regulation of Cerebral Blood Flow	763	Movements of the Small Intestine	786
Cerebral Microcirculation	703	Missing Contractions (Cognontation	700
Cerebral Stroke Occurs When Cerebral	763	Mixing Contractions (Segmentation	786
Blood Vessels are Blocked	763	Contractions) Propulsive Movements	787
Cerebrospinal Fluid System	703	Function of the Ileocecal Valve	788
Cushioning Function of the Cerebrospinal	763	Movements of the Colon	788
Fluid	703	Defecation	789
Formation, Flow, and Absorption of	764	Other Autonomic Reflexes That Affect	,0,
Cerebrospinal Fluid	765	Bowel Activity	790
Cerebrospinal Fluid Pressure	,00	Dowel Activity	
Obstruction to Flow of Cerebrospinal Fluid	766		
Can Cause Hydrocephalus	,00		
Blood-Cerebrospinal Fluid and Blood-Brain	766	CHAPTER 64	
Barriers Brain Edema	766	Secretory Functions of the Alimentary	
Brain Metabolism	767		701
Brain Metabolisin		Tract	791
		General Principles of Alimentary Tract	70:
UNIT XII		Secretion	791
UNII AII		Anatomical Types of Glands	791
<b>Gastrointestinal Physiology</b>		Basic Mechanisms of Stimulation of the	70
Gasti Omicostina a mjorovogj		Alimentary Tract Glands	791
		Basic Mechanism of Secretion by Glandular	79
CHAPTER 62		Cells	191
General Principles of Gastrointestinal		Lubricating and Protective Properties of	
Function—Motility, Nervous Control,		Mucus, and Importance of Mucus in the Gastrointestinal Tract	793
and Blood Circulation	771	Secretion of Saliva	793
	,,,	Nervous Regulation of Salivary Secretion	794
General Principles of Gastrointestinal	771	Esophageal Secretion	795
Motility	//1		

Gastric Secretion	794	Diarrhea	822
Characteristics of the Gastric Secretions	794	Paralysis of Defecation in Spinal Cord	9 1 1
Pyloric Glands—Secretion of Mucus and		Injuries	823
Gastrin	797	General Disorders of the	******
Surface Mucous Cells	797	Gastrointestinal Tract	823
Stimulation of Gastric Acid Secretion	797	Vomiting	823
Regulation of Pepsinogen Secretion	798	Nausea	824
Inhibition of Gastric Secretion by Other		Gastrointestinal Obstruction	824
Post-Stomach Intestinal Factors	798		02.
Chemical Composition of Gastrin And Other	,,,,		
Gastrointestinal Hormones	799		
Pancreatic Secretion	799	HNIT VIII	
Pancreatic Digestive Enzymes	799	UNIT XIII	
Secretion of Bicarbonate Ions	800	Metabolism and Temperature	
Regulation of Pancreatic Secretion	800		
Secretion of Bile by the Liver; Functions	000	Regulation	
of the Biliary Tree	802	The second section of the sect	
Physiologic Anatomy of Biliary Secretion	802		
Function of Bile Salts in Fat Digestion and	002	CHAPTER 67	
Absorption	804		
Liver Secretion of Cholesterol and	004	Metabolism of Carbohydrates,	
Gallstone Formation	804	and Formation of Adenosine	
Secretions of the Small Intestine	805	Triphosphate	829
Secretion of Mucus by Brunner's Glands in	005		02)
the Duodenum	805	Release of Energy from Foods, and the Concept of "Free Energy"	920
Secretion of Intestinal Digestive Juices by	005	Role of Adenosine Triphosphate in	829
the Crypts of Lieberkühn	805	Metabolism	920
Regulation of Small Intestine Secretion—	005	Central Role of Glucose in	829
Local Stimuli	806	Carbohydrate Metabolism	830
Secretions of the Large Intestine	806	Transport of Glucose Through the	030
	000	Cell Membrane	831
		Insulin Increases Facilitated Diffusion of	031
CHAPTER 65		Glucose	021
Digestion and Absorption in the		Phosphorylation of Glucose	831 831
<b>Gastrointestinal Tract</b>	808	Glycogen Is Stored in Liver and	031
	000	Muscle	831
Digestion of the Various Foods by	000	Glycogenesis—The Process of Glycogen	031
Hydrolysis	808	Formation	832
Digestion of Carbohydrates	809	Removal of Stored Glycogen—	032
Digestion of Proteins	810	Glycogenolysis	022
Digestion of Fats	811	Release of Energy from the Glucose	832
Basic Principles of Gastrointestinal	010	Molecule by the Glycolytic Pathway	832
Absorption	812	Summary of ATP Formation During the	032
Anatomical Basis of Absorption	812	Breakdown of Glucose	026
Absorption in the Small Intestine	813	Control of Energy Release from Stored	836
Absorption of Water	814	Glycogen When the Body Needs Additional	
Absorption of lons	814	Energy Energy	026
Absorption of Nutrients	815	Anaerobic Release of Energy—"Anaerobic	836
Absorption in the Large Intestine:	017	Glycolysis"	026
Formation of Feces	817	Release of Energy from Glucose by the	836
		Pentose Phosphate Pathway	027
CHAPTER 66		Glucose Conversion to Glycogen or Fat	837
		Formation of Carbohydrates from	838
Physiology of Gastrointestinal		Proteins and Fats—"Gluconeogenesis"	020
Disorders	819	Blood Glucose	838
Disorders of Swallowing and of the			839
Esophagus	819		
Disorders of the Stomach	819	0 11 1 5 = -	
Peptic Ulcer	820	CHAPTER 68	
Specific Causes of Peptic Ulcer in the	30348	Lipid Metabolism	940
Human Being	821		840
Disorders of the Small Intestine	821	Transport of Lipids in the Body Fluids	840
Abnormal Digestion of Food in the Small		Transport of Triglycerides and Other Lipids	
Intestine—Pancreatic Failure	821	from the Gastrointestinal Tract by Lymph—The Chylomicrons	100
Malabsorption by the Small Intestine		Removal of the Chylomicrons	840
Mucosa—Sprue	822	Removal of the Chylomicrons from the Blood	
Disorders of the Large Intestine	822	"Free Fatty Acide" Are Tree	841
Constipation	822	"Free Fatty Acids" Are Transported in the	-
		Blood in Combination with Albumin	841

Lipoproteins—Their Special Function in		CHAPTER 71	
Transporting Cholesterol and		Dietary Balances; Regulation of	
Phospholipids	841		
Fat Deposits	842	Feeding; Obesity and Starvation;	
Adipose Tissue	842	Vitamins and Minerals	865
Liver Lipids Use of Triglycerides for Energy:	842	Energy Intake and Output Are Balanced	1000
Formation of Adenosine Triphosphate	842	Under Steady-State Conditions	865
Formation of Acetoacetic Acid in the	042	Dietary Balances	865 865
Liver and Its Transport in the Blood	844	Energy Available in Foods	003
Synthesis of Triglycerides from	Safe S	Methods for Determining Metabolic Utilization of Proteins, Carbohydrates,	
Carbohydrates	844	and Fats	866
Synthesis of Triglycerides from Proteins	845	Regulation of Food Intake and Energy	the Li
Regulation of Energy Release from		Storage	865
Triglycerides	846	Neural Centers Regulate Food Intake	867
Obesity	846	Factors That Regulate Quantity of Food	
Phospholipids and Cholesterol	846 846	Intake	870
Phospholipids Cholesterol	847	Obesity	872
Cellular Structural Functions of	047	Decreased Physical Activity and	
Phospholipids and Cholesterol—		Abnormal Feeding Regulation as Causes of Obesity	872
Especially for Membranes	848	Treatment of Obesity	873
Atherosclerosis	848	Inanition, Anorexia, and Cachexia	874
Basic Causes of Atherosclerosis—The		Starvation	874
Roles of Cholesterol and Lipoproteins	850	Vitamins Vitamins	875
Other Major Risk Factors for	050	Vitamin A	875
Atherosclerosis Prevention of Atherosclerosis	850 850	Thiamine (Vitamin B <sub>1</sub> )	875
Prevention of Atheroscierosis	030	Niacin	876
		Riboflavin (Vitamin B <sub>2</sub> )	876 876
CHAPTER 69		Vitamin B <sub>12</sub> Folic Acid (Pteroylglutamic Acid)	877
Protein Metabolism	852	Pyridoxine (Vitamin B <sub>6</sub> )	877
	852	Pantothenic Acid	877
Basic Properties Amino Acids	852	Ascorbic Acid (Vitamin C)	877
Transport and Storage of Amino Acids	854	Vitamin D	878
Blood Amino Acids	854	Vitamin E	878
Storage of Amino Acids as Proteins in the		Vitamin K	878
Cells	854	Mineral Metabolism	878
Functional Roles of the Plasma	0.55	NAME OF TAXABLE PARTY OF TAXABLE PARTY.	THE ENGLISH
Proteins	855	CHAPTER 72	
Essential and Nonessential Amino Acids	855 857	Energetics and Metabolic Rate	881
Obligatory Degradation of Proteins Hormonal Regulation of Protein	037	Adenosine Triphosphate (ATP)	e mu
Metabolism	857	Functions as an "Energy Currency"	aft.
Bonnetos cara properturas conditiones de persona		in Metabolism	881
		Phosphocreatine Functions as an	
CHAPTER 70		Accessory Storage Depot for Energy	882
The Liver as an Organ	859	and as an "ATP Buffer" Anaerobic Versus Aerobic Energy	882
Physiologic Anatomy of the Liver	859	Summary of Energy Utilization by the	002
Hepatic Vascular and Lymph	90155 A	Cells	883
Systems	859	Control of Energy Release in the Cell	884
Blood Flows Through the Liver from the	HAME !	Metabolic Rate	884
Portal Vein and Hepatic Artery	860	Measurement of the Whole-Body Metabolic	B) (23)
The Liver Functions as a Blood Reservoir	860	Rate	885
The Liver Has Very High Lymph Flow	860	Energy Metabolism—Factors That	005
Regulation of Liver Mass—Regeneration	860	Influence Energy Output	885
Hepatic Macrophage System Serves a	861	Overall Energy Requirements for Daily Activities	885
Blood-Cleansing Function  Metabolic Functions of the Liver	861	Basal Metabolic Rate (BMR)—The	A E OCT
Carbohydrate Metabolism	861	Minimum Energy Expenditure for the	Touble:
Fat Metabolism	861	Body to Exist	886
Protein Metabolism	862	Energy Used for Physical Activities	887
Other Metabolic Functions of the Liver	862	Energy Used for Processing Food—	語の語
Measurement of Bilirubin in the Bile	OLIVE OF STREET	Thermogenic Effect of Food	887
as a Clinical Diagnostic Tool	862	Energy Used for Nonshivering	5
Jaundice Excess Bilirubin in the	0.00	Thermogenesis—Role of Sympathetic	887
Extracellular Fluid	863	Stimulation	00/

CHAPTER 73		Growth Hormone Promotes Growth of	
<b>Body Temperature, Temperature</b>		Many Body Tissues	922
	000	Growth Hormone Has Several Metabolic	
Regulation, and Fever	889	Effects	922
Normal Body Temperatures	889	Growth Hormone Stimulates Cartilage and	000
Body Temperature Is Controlled by		Bone Growth	923
Balancing Heat Production Against		Growth Hormone Exerts Much of Its Effect	
Heat Loss	889	Through Intermediate Substances Called	
Heat Production	889	"Somatomedins" (Also Called "Insulin-Like	022
Heat Loss	890	Growth Factors")	923 924
Regulation of Body Temperature—Role	00.4	Regulation of Growth Hormone Secretion	924
of the Hypothalamus	894	Abnormalities of Growth Hormone Secretion	920
Neuronal Effector Mechanisms That	005	Posterior Pituitary Gland and Its	927
Decrease or Increase Body Temperature	895	Relation to the Hypothalamus	928
Concept of a "Set-Point" for Temperature	000	Chemical Structures of ADH and Oxytocin	928
Control	896	Physiological Functions of ADH	929
Behavioral Control of Body Temperature	897	Oxytocic Hormone	121
Abnormalities of Body Temperature	898		
Regulation Fever	898	CHAPTER 76	
Exposure of the Body to Extreme Cold	900	Thyroid Metabolic Hormones	931
Exposure of the Body to Extreme Cold	900	Synthesis and Secretion of the Thyroid	
		Metabolic Hormones	931
		lodine Is Required for Formation of	,01
UNIT XIV		Thyroxine	931
O IV I I A I V		lodide Pump (lodide Trapping)	932
Endocrinology and Reproduction		Thyroglobulin, and Chemistry of Thyroxine	
80		and Triiodothyronine Formation	932
		Release of Thyroxine and Trilodothyronine	
CHAPTER 74		from the Thyroid Gland	933
Introduction to Endocrinology	905	Transport of Thyroxine and Triiodothyronine	
Coordination of Body Functions by	, , ,	to Tissues	934
	905	Physiologic Functions of the Thyroid	
Chemical Messengers Chemical Structure and Synthesis of	303	Hormones	934
Hormones	906	Thyroid Hormones Increase the	
Hormone Secretion, Transport, and	200	Transcription of Large Numbers of Genes	934
Clearance from the Blood	908	Thyroid Hormones Increase Cellular	
Feedback Control of Hormone Secretion	909	Metabolic Activity	934
Transport of Hormones in the Blood	909	Effect of Thyroid Hormone on Growth	936
"Clearance" of Hormones from the Blood	909	Effects of Thyroid Hormone on Specific	000
Mechanisms of Action of Hormones	910	Bodily Mechanisms	936
Hormone Receptors and Their Activation	910	Regulation of Thyroid Hormone	020
Intracellular Signaling After Hormone		Secretion	938
Receptor Activation	910	Anterior Pituitary Secretion of TSH Is	
Second Messenger Mechanisms for		Regulated by Thyrotropin-Releasing	938
Mediating Intracellular Hormonal		Hormone from the Hypothalamus	930
Functions	912	Feedback Effect of Thyroid Hormone to Decrease Anterior Pituitary Secretion	
Hormones That Act Mainly on the Genetic		of TSH	939
Machinery of the Cell	915	Diseases of the Thyroid	940
Measurement of Hormone	015	Hyperthyroidism	940
Concentrations in the Blood	915	Symptoms of Hyperthyroidism	940
Radioimmunoassay	915	Hypothyroidism	941
Enzyme-Linked Immunosorbent Assay	916	Cretinism	942
(ELISA)	910		
		CHADTED	
CHAPTER 75		CHAPTER 77	
		Adrenocortical Hormones	944
Pituitary Hormones and Their Control		Synthesis and Secretion of	
by the Hypothalamus	918	Adrenocortical Hormones	944
Pituitary Gland and Its Relation to the		Functions of the Mineralocorticoids-	
Hypothalamus	918	Aldosterone	947
Hypothalamus Controls Pituitary		Renal and Circulatory Effects of	
Secretion	919	Aldosterone	948
Hypothalamic-Hypophysial Portal Blood	Marines and	Aldosterone Stimulates Sodium and	
Vessels of the Anterior Pituitary Gland	920	Potassium Transport in Sweat Glands,	
Physiological Functions of Growth		Salivary Glands, and Intestinal Epithelial	074000
Hormone	921	Cells	949

Control of Male Sexual Functions by		Response of the Mother's Body to	1034
Hormones from the Hypothalamus and		Pregnancy	1054
Anterior Pituitary Gland	1006	Changes in the Maternal Circulatory System	1000
Abnormalities of Male Sexual Function	1008	During Pregnancy	1035
Prostate Gland and Its Abnormalities	1008	Parturition	1036
Hypogonadism in the Male	1008	Increased Uterine Excitability Near Term	1036
Testicular Tumors and Hypergonadism in		Onset of Labor—A Positive Feedback	
the Male	1009	Mechanism for Its Initiation	1037
Pineal Gland—Its Function in Controlling		Abdominal Muscle Contractions During	
Seasonal Fertility in Some Animals	1009	Labor	1037
Seasonal Pertility in Some Ammais	1007	Mechanics of Parturition	1037
		Separation and Delivery of the Placenta	1038
CHAPTER 81		Labor Pains	1038
Female Physiology Before Pregnancy		Involution of the Uterus After Parturition	1038
	1011	Lactation	1038
and Female Hormones	1011	Development of the Breasts	1038
Physiologic Anatomy of the Female		Initiation of Lactation—Function of	1000
Sexual Organs	1011		1039
Female Hormonal System	1011	Prolactin Ejection (or "Let-Down") Process in Milk	1037
Monthly Ovarian Cycle; Function of the		Ejection (or Let-Down ) Process in with	1040
Gonadotropic Hormones	1012	Secretion—Function of Oxytocin	1040
Gonadotropic Hormones and Their Effects		Milk Composition and the Metabolic Drain	1041
on the Ovaries	1012	on the Mother Caused by Lactation	1041
Ovarian Follicle Growth—The "Follicular"			
Phase of the Ovarian Cycle	1013	CHAPTER 83	
Corpus Luteum—"Luteal" Phase of the		Fetal and Neonatal Physiology	1042
Ovarian Cycle	1014		1012
Summary	1015	Growth and Functional Development	1042
Functions of the Ovarian Hormones—		of the Fetus	1042
Estradiol and Progesterone	1016	Development of the Organ Systems	1042
Chemistry of the Sex Hormones	1016	Adjustments of the Infant to	1011
Functions of the Estrogens—Their Effects	1010	Extrauterine Life	1044
Functions of the Estrogens—Their Enects		Onset of Breathing	1044
on the Primary and Secondary Female Sex	1017	Circulatory Readjustments at Birth	1045
Characteristics	1018	Nutrition of the Neonate	1047
Functions of Progesterone	1018	Special Functional Problems in the	The Sale Reserve
Monthly Endometrial Cycle and Menstruation	1010	Neonate	1047
Regulation of the Female Monthly		Respiratory System	1047
Rhythm—Interplay Between the		Circulation	1047
Ovarian and Hypothalamic-Pituitary	1010	Fluid Balance, Acid-Base Balance, and	
Hormones	1019	Renal Function	1048
Feedback Oscillation of the Hypothalamic-	7007	Liver Function	1048
Pituitary-Ovarian System	1021	Digestion, Absorption, and Metabolism	
Puberty and Menarche	1021	of Energy Foods; and Nutrition	1048
Menopause	1022	Immunity	1049
Abnormalities of Secretion by the	1000	Endocrine Problems	1049
Ovaries	1023	Special Problems of Prematurity	1050
Female Sexual Act	1023	Immature Development of the Premature	
Female Fertility	1024	Infant	1050
		Instability of the Homeostatic Control	
CHAPTER 82		Systems in the Premature Infant	1050
0 11 11 1 2 11	1007	Danger of Blindness Caused by Excess	1050
Pregnancy and Lactation	1027	Oxygen Therapy in the Premature Infant	1051
Maturation and Fertilization of the Ovum	1027	Growth and Development of the Child	1051
Transport of the Fertilized Ovum in the			1052
Fallopian Tube	1028	Behavioral Growth	1032
Implantation of the Blastocyst in the Uterus	1029		
Early Nutrition of the Embryo	1029	THE REAL PROPERTY AND ASSOCIATION OF THE PROPERTY ASSOCIATION OF THE P	
Function of the Placenta	1029	UNITXV	
Developmental and Physiologic Anatomy			
of the Placenta	1029	Sports Physiology	
Hormonal Factors in Pregnancy	1031		
Human Chorionic Gonadotropin and Its		CHADTEDOA	
Effect to Cause Persistence of the		CHAPTER 84	
Corpus Luteum and to Prevent	1032	Sports Physiology	1055
Menstruation	1032	Muscles in Exercise	1055
Secretion of Estrogens by the Placenta	1032	Strength, Power, and Endurance of Muscles	1053
Secretion of Progesterone by the Placenta	1033	Muscle Metabolic Systems in Exercise	1050
Human Chorionic Somatomammotropin			105
Other Hormonal Factors in Pregnancy	1034	Phosphocreatine-Creatine System	103

	Table of	Contents	xxxv
Nutrients Used During Muscle Activity Effect of Athletic Training on Muscles and Muscle Performance Respiration in Exercise Cardiovascular System in Exercise Body Heat in Exercise	1059 1060 1061 1062 1065	Body Fluids and Salt in Exercise Drugs and Athletes Body Fitness Prolongs Life Index	1065 1065 1066 1067