Contents

Ab	out the author	xiii		Water and Biological Roles	48
Pre	eface	XV		The Photocatalytic Dissociation of the	
Inti	roduction	xvii		Water Molecule Into Its Gaseous Atoms	49
				Water Channels: Aquaporins	51
1.	Organ Systems and Tissues	1		The Role of Water in Protein Folding	53
				Protein-Water Interactions in Enzymatic	
	Treatment of the Injured Knee: Use of			Reactions	56
	Stem Cells to Replace Damaged Cartilage	1		Metabolic Water	57
	Development of Organs	3		Proton Transfer in Liquid Water	57
	Stem Cells	4		The Concentration of Hydrogen lons	
	Gross Structures and Functions of Organ	-113		(Protons) in Solution (pH)	58
	Systems	6		Buffers	59
	Skin	6	1	Receptors	63
	The Skeleton	8		Ion Channels	65
	Cellular Composition of Tissues	13		Enzymatic Pumping Mechanism	66
	Summary	18		Summary	66
	Suggested Reading	19		Suggested Reading	68
	Multiple-Choice Questions	20		Multiple-Choice Questions	69
2.	The Cell	23	4.	Proteins	71
	Cellular Trafficking in Alzheimer's Disease	23		Prion Disease, A Disease of Protein	
	The Effects of Amyloid Beta (Aβ) on			Conformational Change	71
	Synapse Function	26		Actions of Cellular Prion (PrPc)	73
	Cell Membrane	27		Binding to Amyloid Proteins	73
	Nucleus and Cell Division	28		Copper Binding to Cellular Prion Protein	73
	Cytoplasm and Cytoskeleton	32		PrP ^c and Differentiation and Function of	
	Endoplasmic Reticulum	35		Adipocytes	75
	Golgi Apparatus	35		Amino Acids	76
	Mitochondria	38		Amino Acid-Related Diseases	76
	Peroxisome	39		Biochemistry of the Amino Acids	79
	Lysosome	40		Amino Acids Have Two or More Potential	
	Summary	41		Charges	83
	Suggested Reading	42		Numbering of Carbons in Amino Acids	83
	Multiple-Choice Questions	42		Charge State	83
				Synthesis of Nonessential Amino Acids and	
3.	Introductory Discussion on Water,			Amino Acid Degradation	85
	pH, Buffers, and General Features of			Proteins	88
	Receptors, Channels, and Pumps	45		Amino Acid Sequence	89
	Receptors, Chamiers, and Fumps	73		Secondary, Tertiary, and Quaternary Structures	89
	Diabetes Insipidus	45		Protein Folding	91
	Thirst and Arginine Vasopressin	47		Protein Degradation	94
	Action of Arginine Vasopressin on the Distal			Protein Classification	94
	Kidney Tubule	48		Proteomics	95

	Protein Microarray	98	7	Glycogen and Glycogenolysis	183
	Summary Cryo-Electron Microscopy at Near-Atomic	100		Glycogen Storage Disease Type I, von Gierke Disease (and Others: At Least 11 Types of	
	Resolution of Proteins and Macromolecular			Glycogen Storage Disease)	183
	Complexes Without the Need for Crystals	102		Glycogen—The Storage Carbohydrate	184
	Suggested Reading	105		Glucose Metabolism in Muscle	184
	Multiple-Choice Questions	106		Glycogenin and Formation of Glycogen Glycogenolysis (Releasing Glucose from	184
5.	Enzymes	109		Glycogen)	187
	Diagnostic Enzymology	109		Hormonal Control of Glycogen Metabolism	
	Diagnostic Enzymology Enzymes With Multiple Subunits:	109		and Blood Glucose Level	192
		100		Glucagon	192
	Tissue-Specific Isozymes Conord Aspects of Catalysis	109		Epinephrine	195
	General Aspects of Catalysis	111		Insulin	198
	Lineweaver—Burk Equation	114		Glycogen Phosphorylase	199
	Michaelis-Menten Equation	115		Different Glucose Transporters in Different	
	Inhibition of Enzymatic Activity	116		Tissues	200
	Allosterism—Non-Michaelis—Menten Kinetics	123		Summary	201
	Classification	125		Suggested Reading	204
	Coenzymes	127		Multiple-Choice Questions	204
	Prosthetic Groups	134		Multiple Choice Questions	201
	Enzyme Filamentation in Cellular Regulation	136	8.	Glycolysis and Gluconeogenesis	207
	Drugs That Operate as Enzyme Inhibitors	137			
	Drug Resistance	138		Hemolytic Anemia: Glyceraldehyde-3-	
	Rational Drug Design	141		Phosphate Dehydrogenase Deficiency	207
	Enzyme Replacement Therapy—Gaucher			(A Rare Disease)	207
	Disease	141		Hemolytic Anemia	207
	Summary	143		Methemoglobin Reductase Pathway	207
	Suggested Reading	144		Rapoport-Luebering Shunt	207
	Multiple-Choice Questions	145		The Pentose Phosphate Pathway Glycolysis, the Emden–Meyerhof Pathway	208
6.	Insulin and Sugars	147		Phosphofructokinase Enzymes Involved in the Conversion of Fructose-6-Phosphate to	
	Diabetes	147		Fructose-1,6-Bisphosphate	214
	Insulin	152		Cell Proliferation and Tumor Growth—The	
	The Pancreatic β-Cell and Insulin Secretion	154		Warburg Effect	216
	Detrimental Effects of Diabetes	156		Gluconeogenesis	216
	Synthetic Sweeteners	156		Alanine Cycle	217
	Chemistry of Simple Sugars	158		Glucose Can Be Formed From Glycerol	217
	Glucose Transport	162		Small-Molecule Regulation of	
	Pentose Phosphate Pathway	164		Gluconeogenesis	218
	Conversion of Ribose to Deoxyribose	167		Glucose Transporters	222
	Carbohydrate Constituents of	107		Glucose Transporter Structure/Function	222
	Proteins—Glycoproteins	167		Summary	222
	Transfer of Nucleotide Sugars Into the Golgi	107		Suggested Reading	223
		172		Multiple-Choice Questions	224
	Cisternae Curars in Blood Croup Protoins	172		Tricing Control Quiestina	
	Sugars in Blood Group Proteins Engage of A and B Blood	1/2	9.	Lipids	227
	Enzymatic Conversion of A and B Blood Types to Type O (Universal Depart)	172			227
	Types to Type O (Universal Donor)	173		Hypercholesterolemia Autosomal Posossivo Hypercholesterolemia	227
	Lactose Intolerance	174		Autosomal Recessive Hypercholesterolemia	220
	Glycobiology	174		Protein And D. 100 Protein Mutations	230
	Summary	176		ApoB-100 Protein Mutations Normal LDL Eupstion at Tissue Colls	230
	Suggested Reading	180		Normal LDL Function at Tissue Cells	231
	Multiple-Choice Ouestions	181		Biosynthesis of Cholesterol	231

	Inhibition of Liver HMG-CoA Reductase		Probing Libraries for Specific Genes	320
	by Drugs (Statins)	233	Hybridization Techniques	321
	The ARH Protein	235	Amplification of DNA Sequences:	
	Bile Acids	236	Polymerase Chain Reaction	322
	Fatty Acids and Fat	236	Identification of a Specific Gene on a	
	Glycerol and Its Substituents; Triglycerides	240	Chromosome	323
	Fat (Triglyceride) Digestion and Uptake	242	Determining DNA Sequence	323
	Chylomicrons	244	Inhibitors of DNA Synthesis	326
	β-Oxidation	245	DNA Editing	328
	Activation and Transport of Fatty Acids Into		RNA Interference	332
	Mitochondria	246	Coding DNA	333
	Unsaturated Fatty Acids	252	Noncoding DNA	333
	Ketone Bodies	252	Introns	334
	Lipid Metabolism, Lipid Droplets,		Transposons	335
	and Hormonal Control	255	Alu Elements	335
	Fatty Acid Synthesis	259	5'-Capping of RNA Containing Exons and	
	Phospholipids and Membranes	265	Introns	335
	Lipins	266	Polyadenylation of Pre-mRNA	337
	Synthesis and Degradation of Ceramide	268	Overall Transcription—Translation Process	337
	Glycosphingolipids	271	Intron Exclusion From Pre-mRNA	339
	Properties of Lipoproteins	273	Coding RNA	339
	Lipid Anchoring of Proteins to Membranes	276	Noncoding RNAs	340
	Summary	276	RNA Components of the Spliceosome	345
	Suggested Reading	281	RNA Secondary Structures	345
	Multiple-Choice Questions	283	Genomics	345
	Case Study	285	Next-Generation Sequencing	348
	Familial Hypercholesterolemia	285	Proteomics	349
	Learning Questions	285	Gene Therapy	350
	Suggested Reading	285	Summary	352
			Suggested Reading	354
10.	Nucleic Acids and Molecular		Multiple-Choice Questions	355
	Genetics	287		
			11. Protein Biosynthesis	357
	Huntington's Disease, A Single-Gene Mutation	287		
	Purines and Pyrimidines	289	Defects in Mitochondrial Oxidative	
	Base Pairing	292	Phosphorylation and Disease: Deficiency	
	The Structure of DNA	295	in Mitochondrial Translation	357
	Biosynthesis of Purines and Pyrimidines	295	Protein Synthesis in the Mitochondrion	357
	Purine Interconversions	299	Mitochondrial Encephalomyopathy With	2
	Catabolism of Purine and Pyrimidine	200	Lactic Acidosis and Stroke-Like Episodes	357
	Nucleotides	299	Protein Synthesis Directed by the Nucleus	359
	Salvage Pathway	302	The Ribosome	360
	Pyrimidine Catabolism	303	Structure of Transfer RNA	366
	Deoxyribose-Containing Nucleotides	304	Initiation: Amino Acid Transfer RNA Synthase	366
	Formation of Deoxyribose From Ribose	201	Elongation and Peptidyltransferase Ribozyme	368
	Only in Its Nucleotide Form	304	Termination Inhibitors of Protoin Combosis	371
	Disorders of Purine and Pyrimidine	205	Inhibitors of Protein Synthesis Proteins Synthesized in the Cytoplasm but	371
	Metabolism Piographesis of December beautiful and the second sec	305	Proteins Synthesized in the Cytoplasm but	271
	Biosynthesis of Deoxyribonucleic	206	Destined for the Mitochondria Proteins Destined for the Nucleus	371 372
	Acid in the Nucleus Mitochandrial DNA Synthosis	306 311	Proteins Destined for the Nucleus Proteins Destined for Other Sites, Including	3/2
	Mitochondrial DNA Synthesis DNA Mutations and Damage	312	the Plasma Membrane and Secretion	
	Epigenetics and Damage	314	from the Cell	373
	Restriction Enzymes	317	Summary	373
	restriction Litzyines	317		3/3

	Models of Hormone Action of Anterior Pituitary Hormones	484	Suggested Reading Multiple-Choice Questions	557 558
	Adrenocorticotropic Hormone	484		
	α-Melanocyte-Stimulating Hormone;		17. Growth Factors and Cytokines	559
	Melanotropin, Intermedin	484		555
	Growth Hormone	488	Prospects for Cytokine Tumor Necrosis	
	Prolactin	488	Factor-Related Apoptosis-Inducing	
	Thyroid-Stimulating Hormone, Thyrotropin	488	Ligand and Ovarian Cancer	559
	The Gonadotropins: Luteinizing Hormone	100	Tumor Necrosis Factor-Related Apoptosis-	
	and Follicle-Stimulating Hormone	490	Inducing Ligand and Its Mechanism	560
	Overview of the Release and Functioning	430	The Tumor Necrosis Factor Superfamily	562
	of the Arginine Vasopressin and Oxytocin		Growth Factors	563
	Hormones From the Posterior Pituitary	493	Platelet-Derived Growth Factor	568
		493	Epidermal Growth Factor	572
	Orexins (Hypocretins): Hypothalamic	101	Transforming Growth Factor	574
	Hormones Controlling Sleep and Feeding	494	Fibroblast Growth Factor	577
	Adiponectin From Adipose (Fat) Tissue	495	Neurotrophins and Nerve Growth Factor	579
	Hormones of the Gastrointestinal Tract	497	Colony-Stimulating Factor	583
	Gastrin	498	Erythropoietin	587
	Food Intake and Hormones	499	Interferon	591
	Hormones Affecting Food Intake	509	Insulin-Like Growth Factors (IGF-I, IGF-II)	594
	Summary	509		
	Suggested Reading	514	Interleukins	596
	Multiple-Choice Questions	515	Overview	597
			Summary	597
16.	Steroid Hormones	517	Suggested Reading	604
		/	Multiple-Choice Questions	605
	Stress	517		
	Nociceptin	517	18. Membrane Transport	607
	Responses to Stress	518		
	Production of High Levels of Cortisol		Cystic Fibrosis (Mucoviscidosis) and	
	(Cushing's Disease) and Subnormal		Aberrant Ion Transport	607
	Levels of Cortisol (Addison's Disease)	522	Types of Membrane Transport	611
	Adrenal Cortex	523	Absorption of Large Molecules Binding to	
		0_0	Absorption of Large Morecares binding to	
	Structures of Steroid Hormone Receptors	526	Receptors on the Cell Surface	611
				611 611
	Structures of Steroid Hormone Receptors	526	Receptors on the Cell Surface	
	Structures of Steroid Hormone Receptors Coactivators and Corepressors	526	Receptors on the Cell Surface Exocytosis	611
	Structures of Steroid Hormone Receptors Coactivators and Corepressors Physiological Functions of Steroid Hormones	526 534	Receptors on the Cell Surface Exocytosis Passive Diffusion (Osmosis)	611
	Structures of Steroid Hormone Receptors Coactivators and Corepressors Physiological Functions of Steroid Hormones From Specific Receptor Knockouts	526 534 535	Receptors on the Cell Surface Exocytosis Passive Diffusion (Osmosis) Facilitated Diffusion	611 613 614
	Structures of Steroid Hormone Receptors Coactivators and Corepressors Physiological Functions of Steroid Hormones From Specific Receptor Knockouts Steroid Transporting Proteins in Plasma	526 534 535 538	Receptors on the Cell Surface Exocytosis Passive Diffusion (Osmosis) Facilitated Diffusion Active Transport Requiring Energy	611 613 614 616
	Structures of Steroid Hormone Receptors Coactivators and Corepressors Physiological Functions of Steroid Hormones From Specific Receptor Knockouts Steroid Transporting Proteins in Plasma Enzymatic Inactivation of Cortisol Cortisol and Aldosterone	526 534 535 538 538	Receptors on the Cell Surface Exocytosis Passive Diffusion (Osmosis) Facilitated Diffusion Active Transport Requiring Energy Simple and Coupled Transporters Ions and Gradients	611 613 614 616 617
	Structures of Steroid Hormone Receptors Coactivators and Corepressors Physiological Functions of Steroid Hormones From Specific Receptor Knockouts Steroid Transporting Proteins in Plasma Enzymatic Inactivation of Cortisol Cortisol and Aldosterone Dehydroepiandrosterone	526 534 535 538 538 538	Receptors on the Cell Surface Exocytosis Passive Diffusion (Osmosis) Facilitated Diffusion Active Transport Requiring Energy Simple and Coupled Transporters	611 613 614 616 617
	Structures of Steroid Hormone Receptors Coactivators and Corepressors Physiological Functions of Steroid Hormones From Specific Receptor Knockouts Steroid Transporting Proteins in Plasma Enzymatic Inactivation of Cortisol Cortisol and Aldosterone Dehydroepiandrosterone Structural Considerations of Steroid Hormones	526 534 535 538 538 541 544	Receptors on the Cell Surface Exocytosis Passive Diffusion (Osmosis) Facilitated Diffusion Active Transport Requiring Energy Simple and Coupled Transporters lons and Gradients Entry of Magnesium and Divalent lons Into Cells	611 613 614 616 617 619
	Structures of Steroid Hormone Receptors Coactivators and Corepressors Physiological Functions of Steroid Hormones From Specific Receptor Knockouts Steroid Transporting Proteins in Plasma Enzymatic Inactivation of Cortisol Cortisol and Aldosterone Dehydroepiandrosterone Structural Considerations of Steroid Hormones Receptor Activation	526 534 535 538 538 541 544 545	Receptors on the Cell Surface Exocytosis Passive Diffusion (Osmosis) Facilitated Diffusion Active Transport Requiring Energy Simple and Coupled Transporters Ions and Gradients Entry of Magnesium and Divalent Ions Into Cells Proton (H ⁺) Transport	611 613 614 616 617 619
	Structures of Steroid Hormone Receptors Coactivators and Corepressors Physiological Functions of Steroid Hormones From Specific Receptor Knockouts Steroid Transporting Proteins in Plasma Enzymatic Inactivation of Cortisol Cortisol and Aldosterone Dehydroepiandrosterone Structural Considerations of Steroid Hormones Receptor Activation Vitamin D Hormone	526 534 535 538 538 541 544 545 545	Receptors on the Cell Surface Exocytosis Passive Diffusion (Osmosis) Facilitated Diffusion Active Transport Requiring Energy Simple and Coupled Transporters lons and Gradients Entry of Magnesium and Divalent Ions Into Cells Proton (H ⁺) Transport Monocarboxylate Transporter:	611 613 614 616 617 619 624 625
	Structures of Steroid Hormone Receptors Coactivators and Corepressors Physiological Functions of Steroid Hormones From Specific Receptor Knockouts Steroid Transporting Proteins in Plasma Enzymatic Inactivation of Cortisol Cortisol and Aldosterone Dehydroepiandrosterone Structural Considerations of Steroid Hormones Receptor Activation Vitamin D Hormone Thyroid Hormone	526 534 535 538 538 541 544 545	Receptors on the Cell Surface Exocytosis Passive Diffusion (Osmosis) Facilitated Diffusion Active Transport Requiring Energy Simple and Coupled Transporters lons and Gradients Entry of Magnesium and Divalent Ions Into Cells Proton (H ⁺) Transport Monocarboxylate Transporter: A Cotransporter (Symporter)	611 613 614 616 617 619
	Structures of Steroid Hormone Receptors Coactivators and Corepressors Physiological Functions of Steroid Hormones From Specific Receptor Knockouts Steroid Transporting Proteins in Plasma Enzymatic Inactivation of Cortisol Cortisol and Aldosterone Dehydroepiandrosterone Structural Considerations of Steroid Hormones Receptor Activation Vitamin D Hormone Thyroid Hormone Environmental Xenobiotics That Agonize or	526 534 535 538 538 538 541 544 545 545 547 548	Receptors on the Cell Surface Exocytosis Passive Diffusion (Osmosis) Facilitated Diffusion Active Transport Requiring Energy Simple and Coupled Transporters lons and Gradients Entry of Magnesium and Divalent Ions Into Cells Proton (H ⁺) Transport Monocarboxylate Transporter: A Cotransporter (Symporter) Citrate Transporters in Mitochondria and	611 613 614 616 617 624 625 628
	Structures of Steroid Hormone Receptors Coactivators and Corepressors Physiological Functions of Steroid Hormones From Specific Receptor Knockouts Steroid Transporting Proteins in Plasma Enzymatic Inactivation of Cortisol Cortisol and Aldosterone Dehydroepiandrosterone Structural Considerations of Steroid Hormones Receptor Activation Vitamin D Hormone Thyroid Hormone Environmental Xenobiotics That Agonize or Antagonize the Estrogen Receptor	526 534 535 538 538 541 544 545 545	Receptors on the Cell Surface Exocytosis Passive Diffusion (Osmosis) Facilitated Diffusion Active Transport Requiring Energy Simple and Coupled Transporters lons and Gradients Entry of Magnesium and Divalent lons Into Cells Proton (H ⁺) Transport Monocarboxylate Transporter: A Cotransporter (Symporter) Citrate Transporters in Mitochondria and Plasma Membrane	611 613 614 616 617 619 624 625 629
	Structures of Steroid Hormone Receptors Coactivators and Corepressors Physiological Functions of Steroid Hormones From Specific Receptor Knockouts Steroid Transporting Proteins in Plasma Enzymatic Inactivation of Cortisol Cortisol and Aldosterone Dehydroepiandrosterone Structural Considerations of Steroid Hormones Receptor Activation Vitamin D Hormone Thyroid Hormone Environmental Xenobiotics That Agonize or Antagonize the Estrogen Receptor Cross talk Between Steroid Receptors and	526 534 535 538 538 541 544 545 547 548	Receptors on the Cell Surface Exocytosis Passive Diffusion (Osmosis) Facilitated Diffusion Active Transport Requiring Energy Simple and Coupled Transporters Ions and Gradients Entry of Magnesium and Divalent Ions Into Cells Proton (H ⁺) Transport Monocarboxylate Transporter: A Cotransporter (Symporter) Citrate Transporters in Mitochondria and Plasma Membrane Intestinal Transport of Di- and Tripeptides	611 613 614 616 619 624 625 629 629
	Structures of Steroid Hormone Receptors Coactivators and Corepressors Physiological Functions of Steroid Hormones From Specific Receptor Knockouts Steroid Transporting Proteins in Plasma Enzymatic Inactivation of Cortisol Cortisol and Aldosterone Dehydroepiandrosterone Structural Considerations of Steroid Hormones Receptor Activation Vitamin D Hormone Thyroid Hormone Environmental Xenobiotics That Agonize or Antagonize the Estrogen Receptor Cross talk Between Steroid Receptors and Peptide Hormones	526 534 535 538 538 538 541 544 545 547 548 549	Receptors on the Cell Surface Exocytosis Passive Diffusion (Osmosis) Facilitated Diffusion Active Transport Requiring Energy Simple and Coupled Transporters Ions and Gradients Entry of Magnesium and Divalent Ions Into Cells Proton (H ⁺) Transport Monocarboxylate Transporter: A Cotransporter (Symporter) Citrate Transporters in Mitochondria and Plasma Membrane Intestinal Transport of Di- and Tripeptides Amino Acid Transporters	611 613 614 616 617 619 624 625 629
	Structures of Steroid Hormone Receptors Coactivators and Corepressors Physiological Functions of Steroid Hormones From Specific Receptor Knockouts Steroid Transporting Proteins in Plasma Enzymatic Inactivation of Cortisol Cortisol and Aldosterone Dehydroepiandrosterone Structural Considerations of Steroid Hormones Receptor Activation Vitamin D Hormone Thyroid Hormone Environmental Xenobiotics That Agonize or Antagonize the Estrogen Receptor Cross talk Between Steroid Receptors and Peptide Hormones Sex Hormones	526 534 535 538 538 538 541 544 545 547 548 549 550	Receptors on the Cell Surface Exocytosis Passive Diffusion (Osmosis) Facilitated Diffusion Active Transport Requiring Energy Simple and Coupled Transporters lons and Gradients Entry of Magnesium and Divalent lons Into Cells Proton (H ⁺) Transport Monocarboxylate Transporter: A Cotransporter (Symporter) Citrate Transporters in Mitochondria and Plasma Membrane Intestinal Transport of Di- and Tripeptides Amino Acid Transporters The Glutamate Synapse and Excitatory	611 613 614 616 617 619 624 625 629 630
	Structures of Steroid Hormone Receptors Coactivators and Corepressors Physiological Functions of Steroid Hormones From Specific Receptor Knockouts Steroid Transporting Proteins in Plasma Enzymatic Inactivation of Cortisol Cortisol and Aldosterone Dehydroepiandrosterone Structural Considerations of Steroid Hormones Receptor Activation Vitamin D Hormone Thyroid Hormone Environmental Xenobiotics That Agonize or Antagonize the Estrogen Receptor Cross talk Between Steroid Receptors and Peptide Hormones Sex Hormones Peroxisome Proliferators and Their Receptors	526 534 535 538 538 538 541 544 545 547 548 549	Receptors on the Cell Surface Exocytosis Passive Diffusion (Osmosis) Facilitated Diffusion Active Transport Requiring Energy Simple and Coupled Transporters lons and Gradients Entry of Magnesium and Divalent Ions Into Cells Proton (H ⁺) Transport Monocarboxylate Transporter: A Cotransporter (Symporter) Citrate Transporters in Mitochondria and Plasma Membrane Intestinal Transport of Di- and Tripeptides Amino Acid Transporters The Glutamate Synapse and Excitatory Amino Acid Transporters	611 613 614 616 617 619 624 625 629 630 632
	Structures of Steroid Hormone Receptors Coactivators and Corepressors Physiological Functions of Steroid Hormones From Specific Receptor Knockouts Steroid Transporting Proteins in Plasma Enzymatic Inactivation of Cortisol Cortisol and Aldosterone Dehydroepiandrosterone Structural Considerations of Steroid Hormones Receptor Activation Vitamin D Hormone Thyroid Hormone Environmental Xenobiotics That Agonize or Antagonize the Estrogen Receptor Cross talk Between Steroid Receptors and Peptide Hormones Sex Hormones Peroxisome Proliferators and Their Receptors Glucocorticoid Induction of Programmed	526 534 535 538 538 538 541 544 545 547 548 549 550 551	Receptors on the Cell Surface Exocytosis Passive Diffusion (Osmosis) Facilitated Diffusion Active Transport Requiring Energy Simple and Coupled Transporters Ions and Gradients Entry of Magnesium and Divalent Ions Into Cells Proton (H ⁺) Transport Monocarboxylate Transporter: A Cotransporter (Symporter) Citrate Transporters in Mitochondria and Plasma Membrane Intestinal Transport of Di- and Tripeptides Amino Acid Transporters The Glutamate Synapse and Excitatory Amino Acid Transport Proteins	611 613 614 616 617 619 624 625 629 630 632 633
	Structures of Steroid Hormone Receptors Coactivators and Corepressors Physiological Functions of Steroid Hormones From Specific Receptor Knockouts Steroid Transporting Proteins in Plasma Enzymatic Inactivation of Cortisol Cortisol and Aldosterone Dehydroepiandrosterone Structural Considerations of Steroid Hormones Receptor Activation Vitamin D Hormone Thyroid Hormone Environmental Xenobiotics That Agonize or Antagonize the Estrogen Receptor Cross talk Between Steroid Receptors and Peptide Hormones Sex Hormones Peroxisome Proliferators and Their Receptors	526 534 535 538 538 538 541 544 545 547 548 549 550	Receptors on the Cell Surface Exocytosis Passive Diffusion (Osmosis) Facilitated Diffusion Active Transport Requiring Energy Simple and Coupled Transporters lons and Gradients Entry of Magnesium and Divalent Ions Into Cells Proton (H ⁺) Transport Monocarboxylate Transporter: A Cotransporter (Symporter) Citrate Transporters in Mitochondria and Plasma Membrane Intestinal Transport of Di- and Tripeptides Amino Acid Transporters The Glutamate Synapse and Excitatory Amino Acid Transporters	611 613 614 616 617 619 624 625 629 630 632

	Multidrug Resistance Channel (MDR): A Membe	er	Alcoholism	72!
	of the Adenosine Triphosphate-Binding		Drugs	725
	Cassette Transporter Superfamily	638	Fat-Soluble Vitamins	720
	Blood-Brain Barrier	639	Vitamin A (β-Carotene)	726
	Summary	639	Vitamin D (1,25-Dihydroxyvitamin D3,	
	Multiple-Choice Questions	642	Active Form)	729
	Case Study	643	Vitamin E (α-Tocopherol)	732
	Cystic Fibrosis	643	Vitamin K	733
	Learning Questions	644	Balanced Nutrition	736
	Suggested Reading	644	Nutrient Intake	737
	Suggested Reading	644	Eye Health	737
			The Vegan Diet	737
19.	Micronutrients (Metals and Iodine)	647	The Ketogenic (Keto) Diet and Weight Loss	738
		6.47	The Mediterranean Diet: Probably the	
	Iron-deficiency Anemia	647	Healthiest Diet	739
	Uptake of Iron During Digestion	650	Dietary Considerations in Chronic Kidney	
	Hepcidin, A Peptide Hormone, Is the Principal		Disease	741
	Regulator of Iron Homeostasis	654	Summary	744
	Hemojuvelin, An Anchored Membrane		Suggested Reading	744
	Protein Stimulates Hepcidin Transcription		Multiple-Choice Questions	745
	Through Bone Morphogenic		Case Study	746
	(Morphogenetic) Proteins and Smad	655	Diet and Fatty Liver Disease	746
	Heme Synthesis	658	Learning Questions	747
	Hemoglobin Formation	659	Suggested Reading	747
	Trace Elements	667		
	Trace Metals	667	21. Blood and Lymphatic System	749
	Copper	667		
	Magnesium (Mg ²⁺)	674	Deep Vein Thrombosis	749
	Zinc (Zn ²⁺)	678	Factor V Leiden	749
	Molybdenum (Mo ²⁺)	680	Blood-Clotting Mechanism	750
	Selenium (Se ²⁻)	682	Blood	752
1.0	Selenodeiodinases	682	Transport of Oxygen	754
	Selenophosphate Synthase	683	Glycation of Proteins	761
100	Calcium (Ca ²⁺)	684	Carbon Dioxide	764
	lodine (I)	694	Degradation of the Red Blood Cell	766
	Summary	697	Bilirubin	767
	Suggested Reading	698	Blood Cells	767
	Multiple-Choice Questions	700	Blood Proteins	768
			Blood Type and Rh Factor	768
20.	Vitamins and Nutrition	703	Origin of Nonself Blood Type Antibodies	771
		700	Rh Antigen	772
	Vitamin D Deficiency	703	Lymphatic System	772
	Vitamins	703	Thymosin	776
	Water-Soluble Vitamins	703	Summary	777
	Thiamine (Vitamin B1, Aneurine)	705	Suggested Reading	779
	Riboflavin (Vitamin B2)	707	Multiple-Choice Questions	780
	Niacin (Vitamin B3)	708		
	Pantothenic Acid (Vitamin B5, Pantothenate)	709	List of Abbreviations	783
	Pyridoxine, Pyridoxal, and Pyridoxamine		Appendix 1: Abbreviations of the Common	
	(Vitamin B6)	711	Amino Acids	793
	Biotin (Vitamin H)	715	Appendix 2: The Genetic Code	795
	Cobalamin (Vitamin B12)	716	Appendix 3: Weights and Measures	797
	Folic Acid (Vitamin B9, Pteroylglutamic Acid)	720	Appendix 4: Answer Key for Chapter Questions	799
	Ascorbic Acid (Vitamin C)	723	Index	831
	Addiction	725		