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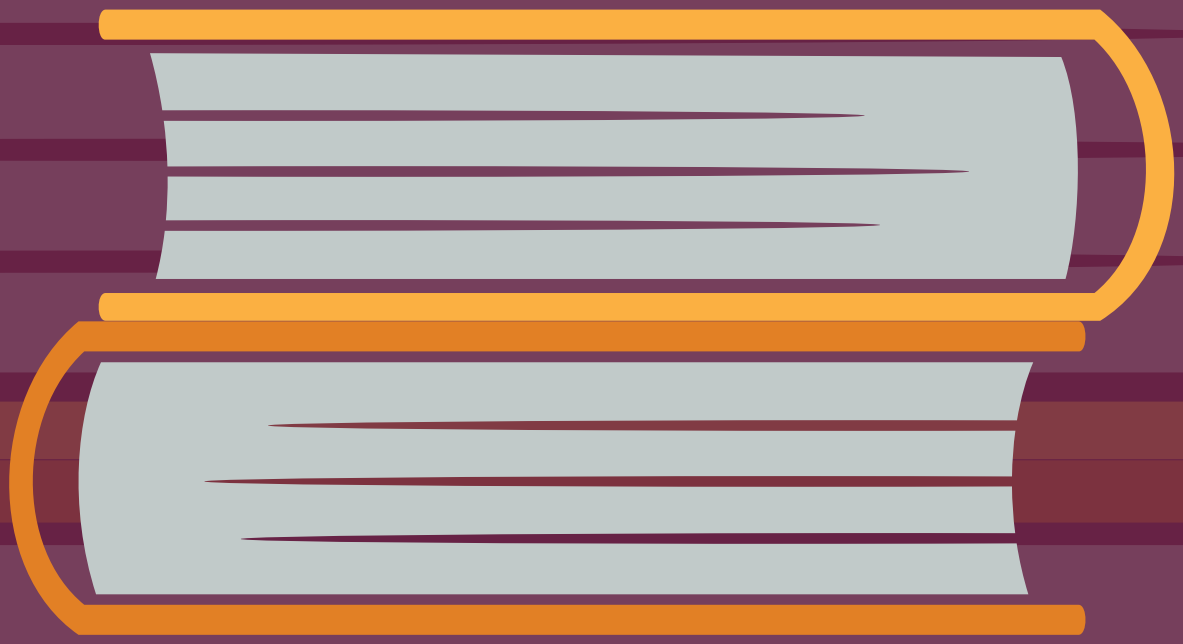
A Road Map to MCAT® Content in Biochemistry Textbooks



Association of
American Medical Colleges

Contents

Introduction

The publishers of the textbooks listed in this publication have provided a "road map" to where the MCAT Foundational Concepts and Content Categories can be found in their publications, by indicating the chapter and/or specific page number(s).

To use this road map, locate the topic you're interested in and read across the columns to see which textbook covers that topic and whether the topic is covered in introductory biology and/or first-year biochemistry courses. Any concepts that don't appear in the road map are covered only in introductory biology.

The Biochemistry Road Map emphasizes biochemistry, a topic introduced to the MCAT exam in 2015. However, we found that the biochemistry textbooks include some of the biology and other content covered on the MCAT exam. In those cases, we included information about biology topics, too. Please note that not all the biology topics are included because the primary focus of this road map is on textbooks covering biochemistry. Where a biology topic is included, it is listed as BIO in the Topic column. For a full list of all content tested on the exam, go to the What's on the MCAT Exam? interactive tool.

The abbreviations in parentheses indicate the courses in which undergraduate students at many college and universities learn about the topics and associated subtopics. The course abbreviations are:

- BC: first-semester biochemistry
- BIO: two-semester sequence of introductory biology
- GC: two-semester sequence of general chemistry
- OC: two-semester sequence of organic chemistry

In preparing for the MCAT exam, you will be responsible for learning the topics and associated subtopics at the levels at which they are taught at many colleges and universities in the courses listed in parentheses. A small number of subtopics have course abbreviations indicated in parentheses. For example, on the first page of the table in the "Topics" column, "Amino Acids" is followed by "(BC, OC)." This means that you're responsible for learning the subtopics about amino acids as they are taught in first-semester biochemistry and the two-semester sequence of organic chemistry.

Visit aamc.org/mcatprep to find more free resources and low-cost products to help you prepare for the MCAT exam.

If you are a publisher of an introductory textbook on biochemistry or related topic and would like to add your publication and information to this reference document, please email mcatprep@aamc.org.

The Medical College Admission Test® (MCAT®) is a program of the Association of American Medical Colleges.

Textbooks Included in This Road Map

Textbook	Link
Biochemistry, 9th ed. Berg JM, Tymoczko J, Gatto Jr. GJ, Stryer L. New York: Macmillan; 2019.	https://macmillanlearning.com/Catalog/product/biochemistry-ninthedition-stryer
Biochemistry: A Short Course, 4th ed. Tymoczko J, Berg JM, Gatto Jr. GJ, Stryer L. New York: Macmillan; 2019.	https://www.macmillanlearning.com/Catalog/product/biochemistryashortcourse-fourthedition-tymoczko
Biology, 2e. Clark MA, Douglas M, Choi J. OpenStax, Rice University; March 28, 2008.	***Free and open source:*** https://openstax.org/details/books/biology-2e
Fundamentals of Biochemistry, 5th ed. Voet D, Voet JG, Pratt CW. Hoboken, NJ: Wiley; 2016.	http://www.wiley.com/WileyCDA/WileyTitle/productCd-EHEP003469.html
Human Physiology, 2nd ed. Derrickson B. Hoboken, NJ: Wiley; 2019.	https://www.wileyplus.com/derrickson-human-physiology-2e/
Karp's Cell and Molecular Biology: Concepts and Experiments, *8th ed.* Iwasa J, Marshall W. Hoboken, NJ: Wiley; 2016.	https://www.wileyplus.com/karps-cell-and-molecular-biology-concepts-and-experiments-binder-ready-version-8th-edition/
Organic Chemistry With a Biological Emphasis, Volumes 1 and 2. Soderberg T. Morris, MN: University of Minnesota; 2016.	***Free and open source:*** Volume I (Chapters 1-8): https://digitalcommons.morris.umn.edu/chem_facpubs/1/ Volume II (Chapters 9-17): https://digitalcommons.morris.umn.edu/chem_facpubs/2/

Foundational Concept 1

Biomolecules have unique properties that determine how they contribute to the structure and function of cells, and how they participate in the processes necessary to maintain life.

Content Category 1A: Structure and function of proteins and their constituent amino acids

Macromolecules formed from amino acids adopt well-defined, three-dimensional structures with chemical properties that are responsible for their participation in virtually every process occurring within and between cells. The three-dimensional structure of proteins is a direct consequence of the nature of the covalently-bonded sequence of amino acids, their chemical and physical properties, and the way in which the whole assembly interacts with water.

Enzymes are proteins that interact in highly regio- and stereo-specific ways with dissolved solutes. They either facilitate the chemical transformation of these solutes or allow for their transport innocuously. Dissolved solutes compete for protein-binding sites, and protein conformational dynamics give rise to mechanisms capable of controlling enzymatic activity.

The infinite variability of potential amino acid sequences allows for adaptable responses to pathogenic organisms and materials. The rigidity of some amino acid sequences makes them suitable for structural roles in complex living systems.

Content in this category covers a range of protein behaviors which originate from the unique chemistry of amino acids themselves. Amino acid classifications and protein structural elements are covered. Special emphasis is placed on enzyme catalysis including mechanistic considerations, kinetics, models of enzyme-substrate interaction, and regulation.

Content Category 1A: Structure and function of proteins and their constituent amino acids

Topic	*Biochemistry*	*Biochemistry: A Short Course*	*Biology, 2e*	*Fundamentals of Biochemistry*	*Human Physiology*	*Karp's Cell and Molecular Biology*	*Organic Chemistry With a Biological Emphasis, Vol. 1*	*Organic Chemistry With a Biological Emphasis, Vol. 2*

Amino Acids (BC, OC)
Description
• Absolute configuration at the α position
• Amino acids as dipolar ions
• Classifications
  ○ Acidic or basic
  ○ Hydrophobic or hydrophilic
Reactions
• Sulfur linkage: cysteine and cysteine
• Peptide linkage: polypeptides and proteins
• Hydrolysis
	Ch. 2
	Proteins: Composition and Structure, pp. 29-42
		Ch. 3
		Amino Acids, pp. 37-45
				Ch.4
				Amino Acids, pp. 80-96
					Ch. 2
					Chemical Composition of the Body, pp. 45-46
					Ch. 7
					The Nervous System and Neuronal Excitability, pp. 232-234
					Ch. 21
					The Digestive System, p. 775
					Ch. 22
					Metabolic Adaptations, Energy Balance, and Temperature Regulation, pp. 793-795
						Ch. 2
						The Chemical Basis of Life, pp. 48-60
							Ch. 1.3D, pp. 41-42
							Ch. 3.3-3.4 pp. 146-158
								Ch. 15.6, pp. 309-316
								Ch. 11.1-11.7, pp. 95-124

Protein Structure (BIO, BC, OC) Structure • 1° structure of proteins • 2° structure of proteins • 3° structure of proteins; role of proline, cystine, hydrophobic bonding • 4° structure of proteins (BIO, BC) Conformational stability • Denaturing and folding • Hydrophobic interactions • Solvation layer (entropy) (BC) Separation techniques • Isoelectric point • Electrophoresis	Ch. 2 Proteins: Composition and Structure, pp. 42-66 Ch. 3 Exploring Proteins and Proteomes, pp. 69-108	Ch. 4 Protein Three-Dimensional Structure, pp. 49-68 Ch. 5 Techniques in Protein Biochemistry, pp. 76-92	Ch. 3.4 Proteins	Ch. 5 Proteins: Primary Structure, pp. 97-130 Ch. 6 Proteins: Three-Dimensional Structure, pp. 131-179	Ch. 2 Chemical Composition of the Body, pp. 32, 45-48	Ch. 2 The Chemical Basis of Life, pp. 48-70 Ch. 18 Techniques in Cell and Molecular Biology, pp. 712, 715-716	Ch. 2.5C pp. 113-15	

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Content Category 1A: Structure and function of proteins and their constituent amino acids *(continued)*

Topic	*Biochemistry*	*Biochemistry: A Short Course*	*Biology, 2e*	*Fundamentals of Biochemistry*	*Human Physiology*	*Karp's Cell and Molecular Biology*	*Organic Chemistry With a Biological Emphasis, Vol. 1*	*Organic Chemistry With a Biological Emphasis, Vol. 2*
Non-Enzymatic Protein Function (BIO, BC) • Binding • Immune system • Motors	Ch. 7 Hemoglobin, pp. 207-225 Ch. 35 Immune System, pp. 1119-1149 (online chapter) Chapter 36 Molecular Motors pp. 1151-1168 (online chapter)	Ch. 9 Hemoglobin, An Allosteric Protein, pp. 161-173	42.1 Innate Immune Response	Ch. 7 Protein Function: Myoglobin and Hemoglobin, Muscle Contraction and Antibodies, pp. 180-220	Ch. 2 Chemical Composition of the Body, pp. 48-52 Ch. 11 Muscle, pp. 382-385 Ch. 17 The Immune System, pp. 625-627	Ch. 2 The Chemical Basis of Life, pp. 73-76 Ch. 7 Interactions Between Cells and Their Environment, pp. 238-241 Ch. 9 The Cytoskeleton and Cell Motility, pp. 315-320		

Enzyme Structure and Function (BIO, BC)
• Function of enzymes in catalyzing biological reactions
• Enzyme classification by reaction type
• Reduction of activation energy
• Substrates and enzyme specificity
• Active Site Model
• Induced-fit Model
• Mechanism of catalysis
  ○ Cofactors
  ○ Coenzymes
  ○ Water-soluble vitamins
• Effects of local conditions on enzyme activity
	Ch. 8
	Enzymes: Basic
	Concept and
	Kinetics,
	pp. 233-264
	Ch. 9
	Catalytic
	Strategies,
	pp. 273-306
		Ch. 6
		Basic Concepts
		of Enzyme
		Action,
		pp. 105-115
			6.5
			Enzymes
				Ch.11
				Enzymatic
				Catalysis,
				pp. 322-360
					Ch. 4
					Energy and
					Metabolism,
					pp. 102-106
					Ch. 21
					The Digestive
					System,
					pp. 762-763
						Ch. 3
						Bioenergetics,
						Enzymes, and
						Metabolism,
						pp. 89-97, 106
							Ch. 6.1-6.4,
							pp. 303-324	

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Content Category 1A: Structure and function of proteins and their constituent amino acids *(continued)*

Topic	*Biochemistry*	*Biochemistry: A Short Course*	*Biology, 2e*	*Fundamentals of Biochemistry*	*Human Physiology*	*Karp's Cell and Molecular Biology*	*Organic Chemistry With a Biological Emphasis, Vol. 1*	*Organic Chemistry With a Biological Emphasis, Vol. 2*
Control of Enzyme Activity (BIO, BC) • Kinetics o General (catalysis) o Michaelis-Menten o Cooperativity • Feedback regulation • Inhibition — types o Competitive o Noncompetitive o Mixed (BC) o Uncompetitive (BC) • Regulatory enzymes o Allosteric enzymes o Covalently modified enzymes o Zymogen	Ch. 8 Enzymes: Basic Concept and Kinetics, pp. 233-264 Ch. 10 Regulatory Strategies, pp. 309-335	Ch. 7 Kinetics and Regulation, pp. 119-134 Ch. 8 Mechanisms and Inhibitor, pp. 143-156	6.5 Enzymes	Ch. 12 Enzyme Kinetics, Inhibition, and Control, pp. 361-401	Ch. 2 Chemical Composition of the Body, pp. 51-52 Ch. 4 Energy and Metabolism, pp. 102-106	Ch. 3 Bioenergetics, Enzymes, and Metabolism, pp. 97-100, 109-110		

Content Category 1B: Transmission of genetic information from the gene to the protein

Biomolecules and biomolecular assemblies interact in specific, highly regulated ways to transfer sequence information between biopolymers in living organisms. By storing and transferring biological information, DNA and RNA enable living organisms to reproduce their complex components from one generation to the next. The nucleotide monomers of these biopolymers, being joined by phosphodiester linkages, form a polynucleotide molecule with a "backbone" composed of repeating sugar-phosphate units and "appendages" of nitrogenous bases. The unique sequence of bases in each gene provides specific information to the cell.

DNA molecules are composed of two polynucleotides that spiral around an imaginary axis, forming a double helix. The two polynucleotides are held together by hydrogen bonds between the paired bases and van der Waals interactions between the stacked bases. The pairing between the bases of two polynucleotides is very specific, and its complementarity allows for a precise replication of the DNA molecule.

The DNA inherited by an organism leads to specific traits by dictating the synthesis of the biomolecules (RNA molecules and proteins) involved in protein synthesis. While every cell in a multicellular organism inherits the same DNA, its expression is precisely regulated such that different genes are expressed by cells at different stages of development, by cells in different tissues, and by cells exposed to different stimuli.

The topics included in this Content Category concern not only the molecular mechanisms of the transmission of genetic information from the gene to the protein (transcription and translation), but also the biosynthesis of the important molecules and molecular assemblies that are involved in these mechanisms. The control of gene expression in prokaryotes and eukaryotes is also included.

Broadly speaking, the field of biotechnology uses biological systems, living organisms, or derivatives thereof, to make or modify products or processes for specific use. The biotechnological techniques emphasized in this Content Category; however, are those that take advantage of the complementary structure of the double-stranded DNA molecule to synthesize, sequence, and amplify them, and to analyze and identify unknown polynucleotide sequences. Included within this treatment of biotechnology are those practical applications which directly impact humans, such as medical applications, human gene therapy, and pharmaceuticals.

Content in this category covers the biopolymers including ribonucleic acid (RNA), deoxyribonucleic acid (DNA), proteins, and the biochemical processes involved in carrying out the transfer of biological information from DNA.

Content Category 1B: Transmission of genetic information from the gene to the protein

Topic	*Biochemistry*	*Biochemistry: A Short Course*	*Biology, 2e*	*Fundamentals of Biochemistry*	*Human Physiology*	*Karp's Cell and Molecular Biology*	*Organic Chemistry With a Biological Emphasis, Vol. 1*	*Organic Chemistry With a Biological Emphasis, Vol. 2*

Nucleic Acid Structure and Function (BIO, OC, BC)
• Description
• Nucleotides and nucleosides
  ○ Sugar phosphate backbone
  ○ Pyrimidine, purine residues
• Deoxyribonucleic acid (DNA): double helix, Watson-Crick model of DNA structure
• Base-pairing specificity: A with T, G with C
• Function in transmission of genetic information (BIO)
• DNA denaturation, reannealing, hybridization
	Ch. 4
	DNA, RNA, and the Flow of Genetic Information,
	pp. 113-140
		Ch. 33
		The Structure of Informational Macromolecules
		pp. 673-690
			Ch. 14.2
			DNA Structure and Function
				Ch. 3
				Nucleotides, Nucleic Acids, and Genetic Information,
				pp. 42-79
				Ch. 23
				Nucleotide Metabolism,
				pp. 803-830
					Ch. 2
					Chemical Composition of the Body,
					pp. 52-55
					Ch. 3
					Cells,
					pp. 75-80
						Ch. 2
						The Chemical Basis of Life,
						pp. 77-79
						Ch. 10
						The Nature of the Gene and the Genome,
						pp. 373-377, 382-387
						Ch. 18
						Techniques in Cell and Molecular Biology,
						pp. 721-722
							Ch. 1.3E,
							pp. 43-45
								Ch. 9.1-9.7,
								pp. 1-38

DNA Replication (BIO) • Mechanism of replication: separation of strands, specific coupling of free nucleic acids • Semi-conservative nature of replication • Specific enzymes involved in replication • Origins of replication, multiple origins in eukaryotes • Replicating the ends of DNA molecules	Ch. 29 DNA Replication, Repair, and Recombination, pp. 949-979	Ch. 34 DNA Replication, pp. 695-709	Ch. 14.3 Basics of DNA Replication Ch. 14.4 DNA Replication in Prokaryotes Ch. 14.5 DNA Replication in Eukaryotes	Ch. 25 DNA Replication, Repair, and Recombination, pp. 879-937	Ch. 3 Cells, pp. 75-80	Ch. 13 DNA Replication and Repair, pp. 512-531		
Repair of DNA (BIO) • Repair during replication • Repair of mutations	Ch. 29 DNA Replication, Repair, and Recombination, pp. 968-970	Ch. 35 DNA Repair and Replication, pp. 715-726	Ch. 14.6 DNA Repair	Ch. 25 DNA Replication, Repair, and Recombination, pp. 909-915	Ch. 3 Cells, pp. 79-81	Ch. 13 DNA Replication and Repair, pp. 531-537		

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Content Category 1B: Transmission of genetic information from the gene to the protein *(continued)*

Topic	*Biochemistry*	*Biochemistry: A Short Course*	*Biology, 2e*	*Fundamentals of Biochemistry*	*Human Physiology*	*Karp's Cell and Molecular Biology*	*Organic Chemistry With a Biological Emphasis, Vol. 1*	*Organic Chemistry With a Biological Emphasis, Vol. 2*
Genetic Code (BIO) • Central Dogma: DNA → RNA → protein • The triplet code • Codon-anticodon relationship • Degenerate code, wobble pairing • Missense, nonsense codons • Initiation, termination codons • Messenger RNA (mRNA)	Ch. 4 DNA, RNA, and the Flow of Genetic Information, pp. 114-133 Ch. 31 Protein Synthesis, pp. 1024-1039	Ch. 1 Biochemistry and the Unity of Life, pp. 8-9 Ch. 39 The Genetic Code, pp. 787-795	Ch. 15.1 The Genetic Code	Ch. 27 Protein Synthesis: Section 1. The Genetic Code, pp. 983-987	Ch. 3 Cells, pp. 75-78	Ch. 11 The Central Dogma: DNA to RNA to Protein, pp. 405-408, 436-450		
Transcription (BIO) • Transfer RNA (tRNA); ribosomal RNA (rRNA) • Mechanism of transcription • mRNA processing in eukaryotes, introns, exons • Ribozymes, spliceosomes, small nuclear ibonucleoproteins (snRNPs), small nuclear RNA (snRNAs) • Functional and evolutionary importance of introns	Ch. 30 RNA Synthesis and Processing, pp. 983-1017	Ch. 36 RNA Synthesis and Regulation in Bacteria, pp. 733-746 Ch. 37 Gene Expression in Eukaryotes, pp. 751-763 Ch. 38 RNA Processing in Eukaryotes, pp. 769-780	Ch. 15.2 Prokaryotic Transcription Ch. 15.3 Eukaryotic Transcription Ch. 15.4 RNA Processing in Eukaryotes	Ch. 26 Transcription and RNA Processing, pp. 938-987	Ch. 3 Cells, pp. 75-76	Ch. 11 The Central Dogma: DNA to RNA to Protein pp. 408-436, 439-442		
Translation (BIO) • Roles of mRNA, tRNA, rRNA • Role and structure of ribosomes • Initiation, termination co-factors • Post-translational modification of proteins	Ch. 31 Protein Synthesis, pp. 1021-1051	Ch. 39 The Genetic Code, pp. 787-799 Ch. 40 The Mechanism of Protein Synthesis, pp. 803-822	Ch. 15.5 Ribosomes and Protein Synthesis	Ch. 27 Protein Synthesis: Section 4. Translation, pp. 1004-1023	Ch. 3 Cells, pp. 76-78	Ch. 11 The Central Dogma: DNA to RNA to Protein, pp. 442-450 Ch. 12 Control of Gene Expression, pp. 509-511		

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Content Category 1B: Transmission of genetic information from the gene to the protein *(continued)*

Topic	*Biochemistry*	*Biochemistry: A Short Course*	*Biology, 2e*	*Fundamentals of Biochemistry*	*Human Physiology*	*Karp's Cell and Molecular Biology*	*Organic Chemistry With a Biological Emphasis, Vol. 1*	*Organic Chemistry With a Biological Emphasis, Vol. 2*
Eukaryotic Chromosome Organization (BIO) • Chromosomal proteins • Single copy vs. repetitive DNA • Supercoiling • Heterochromatin vs. euchromatin • Telomeres, centromeres		Ch. 33 The Structure of Informational Macromolecules, pp. 685-690	Ch. 14.2 DNA Structure and Sequencing	Ch. 24 Nucleic Acid Structure: Section 5. Eukaryotic Chromosome Structure, pp. 867-877	Ch. 3 Cells, pp. 73-75	Ch. 1 Introduction to the Study of Cell and Molecular Biology, pp. 7-13 Ch. 10 The Nature of the Gene and the Genome, pp. 381-382 Ch. 12 Control of Gene Expression, pp. 465-473		
Control of Gene Expression in Prokaryotes (BIO) • Operon Concept, Jacob-Monod Model • Gene repression in bacteria • Positive control in bacteria	Ch. 32 The Control of Gene Expression in Prokaryotes, pp. 1057-1071	Ch. 36 RNA Synthesis and Regulation in Bacteria, pp. 733-746	Ch. 16.1 Regulation of Gene Expression Ch. 16.2 Prokaryotic Gene Regulation	Ch. 28 Regulation of Gene Expression: Section 2. Regulation of Prokaryotic Gene Expression, pp. 1043-1051	Ch. 3 Cells, pp. 75-78	Ch. 12 Control of Gene Expression, pp. 455-460, 499-511		

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Content Category 1B: Transmission of genetic information from the gene to the protein *(continued)*

Topic	*Biochemistry*	*Biochemistry: A Short Course*	*Biology, 2e*	*Fundamentals of Biochemistry*	*Human Physiology*	*Karp's Cell and Molecular Biology*	*Organic Chemistry With a Biological Emphasis, Vol. 1*	*Organic Chemistry With a Biological Emphasis, Vol. 2*
Control of Gene Expression in Eukaryotes (BIO) • Transcriptional regulation • DNA binding proteins, transcription factors • Gene amplification and duplication • Post-transcriptional control, basic concept of splicing (introns, exons) • Cancer as a failure of normal cellular controls, oncogenes, tumor-suppressor genes • Regulation of chromatin structure • DNA methylation • Role of noncoding RNAs	Ch. 33 The Control of Gene Expression in Eukaryotes, pp. 1075-1094	Ch. 37 Gene Expression in Eukaryotes, pp. 751-763	Ch. 16.3 Eukaryotic Epigenetic Gene Regulation Ch. 16.4 Eukaryotic Transcription Gene Regulation Ch. 16.5 Eukaryotic Post-Transcriptional Gene Regulation Ch. 16.6 Eukaryotic Translational and Post-Translational Gene Regulation Ch. 16.7 Cancer and Gene Regulation	Ch. 28 Regulation of Gene Expression: Section 3. Regulation of Eukaryotic Gene Expression, pp. 1052-1079	Ch. 3 Cells, pp. 75-78	Ch. 12 Control of Gene Expression, pp. 483-511 Ch. 16 Cancer, pp. 638-649		

(continued)

Content Category 1B: Transmission of genetic information from the gene to the protein *(continued)*

Topic	*Biochemistry*	*Biochemistry: A Short Course*	*Biology, 2e*	*Fundamentals of Biochemistry*	*Human Physiology*	*Karp's Cell and Molecular Biology*	*Organic Chemistry With a Biological Emphasis, Vol. 1*	*Organic Chemistry With a Biological Emphasis, Vol. 2*
Recombinant DNA and Biotechnology (BIO) • Gene cloning • Restriction enzymes • DNA libraries • Generation of cDNA • Hybridization • Expressing cloned genes • Polymerase chain reaction • Gel electrophoresis and Southern blotting • DNA sequencing • Analyzing gene expression • Determining gene function • Stem cells • Practical applications of DNA technology: medical applications, human gene therapy, pharmaceuticals, forensic evidence, nvironmental cleanup, agriculture • Safety and ethics of DNA technology	Ch. 5 Exploring Genes and Genomes, pp. 145-180	Ch. 41 Recombinant DNA Techniques, pp. 827-847	Ch. 17.1 Biotechnology Ch. 17.2 Mapping Genomes Ch. 17.3 Whole-Genome Sequencing Ch. 17.4 Applying Genomics Ch. 17.5 Genomics and Proteomics	Ch. 25 DNA Replication, Repair, and Recombination: Section 6. Recombination, pp. 916-937	Ch. 2 Chemical Composition of the Body, p. 52 Ch. 3 Cells, p. 78 Ch. 17 The Immune System, p. 624	Ch. 1 Introduction to the Study of Cell and Molecular Biology, pp. 17-21 Ch. 12 Control of Gene Expression, pp. 483-484 Ch. 18 Techniques in Cell and Molecular Biology, pp. 692-740		

Content Category 1C: Transmission of heritable information from generation to generation and the processes that increase genetic diversity

The information necessary to direct life functions is contained within discrete nucleotide sequences transmitted from generation to generation by mechanisms that, by nature of their various processes, provide the raw materials for evolution by increasing genetic diversity. Specific sequences of deoxyribonucleic acids store and transfer the heritable information necessary for the continuation of life from one generation to the next. These sequences, called genes — being part of longer DNA molecules — are organized, along with various proteins, into biomolecular assemblies called chromosomes.

Chromosomes pass from parents to offspring in sexually-reproducing organisms. The processes of meiosis and fertilization maintain a species' chromosomes count during the sexual life cycle. Because parents pass on discrete heritable units that retain their separate identities in offspring, the laws of probability can be used to predict the outcome of some, but not all, genetic crosses.

The behavior of chromosomes during meiosis and fertilization is responsible for most of the genetic variation that arises each generation. Mechanisms that contribute to this genetic variation include independent assortment of chromosomes, crossing over, and random fertilization. Other mechanisms, such as mutation, random genetic drift, bottlenecks, and immigration, exist with the potential to affect the genetic diversity of individuals and populations. Collectively, the genetic diversity that results from these processes provides the raw material for evolution by natural selection.

The content in this category covers the mechanisms by which heritable information is transmitted from generation to generation, and the evolutionary processes that generate and act upon genetic variation.

Topic	*Biochemistry*	*Biochemistry: A Short Course*	*Biology, 2e*	*Fundamentals of Biochemistry*	*Human Physiology*	*Karp's Cell and Molecular Biology*
Evidence that DNA is Genetic Material (BIO)			Ch. 14.1 Historical Basis of Modern Understanding	Ch. 3 Nucleotides, Nucleic Acids, and Genetic Information: Section 3. Overview of Nucleic Acid Function, pp. 50-53	Ch. 2 Chemical Composition of the Body, pp. 52-54	Ch. 10 The Nature of the Gene and the Genome, pp. 374-377

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Content Category 1C: Transmission of heritable information from generation to generation and the processes that increase genetic diversity *(continued)*

Topic	*Biochemistry*	*Biochemistry: A Short Course*	*Biology, 2e*	*Fundamentals of Biochemistry*	*Human Physiology*	*Karp's Cell and Molecular Biology*
Mendelian Concepts (BIO) • Phenotype and genotype • Gene • Locus • Allele: single and multiple • Homozygosity and heterozygosity • Wild-type • Recessiveness • Complete dominance • Co-dominance • Incomplete dominance, leakage, penetrance, expressivity • Hybridization: viability • Gene pool			Ch. 12.1 Mendel's Experiments and the Laws of Probability Ch. 12.2 Characteristics and Traits Ch. 12.3 Laws of Inheritance			Ch. 10 The Nature of the Gene and the Genome, pp. 366-373

Meiosis and Other Factors Affecting Genetic Variability (BIO)
• Significance of meiosis
• Important differences between meiosis and mitosis
• Segregation of genes
  ○ Independent assortment
  ○ Linkage
  ○ Recombination
  ◆ Single crossovers
  ◆ Double crossovers
  ◆ Synaptonemal complex
  ◆ Tetrad
  ○ Sex-linked characteristics
  ○ Very few genes on Y chromosome
  ○ Sex determination
  ○ Cytoplasmic/extranuclear inheritance
• Mutation
  ○ General concept of mutation — error in DNA sequence
  ○ Types of mutations: random, translation error, transcription error, base substitution, inversion, addition, deletion, translocation, mispairing
  ○ Advantageous vs. deleterious mutation
  ○ Inborn errors of metabolism
  ○ Relationship of mutagens to carcinogens
• Genetic drift
• Synapsis or crossing-over mechanism for increasing genetic diversity
			Ch. 11.1 The Process of Meiosis
			Ch. 11.2 Sexual Reproduction
			Ch. 13.1 Chromosomal Theory and Genetic Linkage
			Ch. 13.2 Chromosomal Basis of Inherited Disorders
				Ch. 25 DNA Replication, Repair, and Recombination, pp. 879-937	Ch. 23 The Reproductive Systems, pp. 811-813	Ch. 14 Cell Division, pp. 539-581

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Content Category 1C: Transmission of heritable information from generation to generation and the processes that increase genetic diversity *(continued)*

Topic	*Biochemistry*	*Biochemistry: A Short Course*	*Biology, 2e*	*Fundamentals of Biochemistry*	*Human Physiology*	*Karp's Cell and Molecular Biology*
Analytic Methods (BIO) • Hardy-Weinberg Principle • Test cross • Gene mapping: crossover frequencies • Biometry: statistical methods			Ch. 19.1 Population Evolution Ch. 19.2 Population Genetics Ch. 19.3 Adaptive Evolution			Ch. 10 The Nature of the Gene and the Genome, pp. 370-373
Evolution (BIO) • Natural selection o Fitness concept o Selection by differential reproduction o Concepts of natural and group selection o Evolutionary success as increase in percentage representation in the gene pool of the next generation • Speciation o Polymorphism o Adaptation and specialization o Inbreeding o Outbreeding o Bottlenecks • Evolutionary time as measured by gradual random changes in genome			Ch. 18.1 Understanding Evolution Ch. 18.2 Formation of New Species Ch. 18.3 Reconnection and Speciation Rates	Ch. 1 Introduction to the Chemistry of Life, pp. 1-22		Ch. 2 The Chemical Basis of Life, pp. 76-77 Ch. 10 The Nature of the Gene and the Genome, pp. 394-395
Principles of Bioenergetics (BC, GC) • Bioenergetics/thermodynamics o Free energy/K_{eq} ◆ Equilibrium constant ◆ Relationship of the equilibrium constant and $\Delta G°$ o Concentration ◆ Le Châtelier's Principle o Endothermic/exothermic reactions o Free energy: G o Spontaneous reactions and $\Delta G°$ • Phosphoryl group transfers and ATP o ATP hydrolysis $\Delta G << 0$ o ATP group transfers • Biological oxidation-reduction o Half-reactions o Soluble electron carriers • Flavoproteins	Ch. 8 Enzymes: Basic Concept and Kinetics, pp. 236-241 Ch. 15 Metabolism: Basic Concepts and Design, pp. 463-486 Ch. 18 Oxidative Phosphorylation, pp. 576-582	Ch. 6 Basic Concepts of Enzyme Action, pp. 108-114 Ch. 15 Metabolism: Basic Concepts and Designs, pp. 287-292 Ch. 20 The Electron Transport Chain, pp. 402-413	6.1 Energy and Metabolism 6.2 Potential, Kinetic, Free, and Activation Energy 6.3 The Laws of Thermodynamics 6.4 ATP: Adenosine Triphosphate	Ch. 12 Enzyme Kinetics, Inhibition, and Control, pp. 361-401	Ch. 4 Metabolism, pp. 100-113	Ch. 3 Bioenergetics, Enzymes, and Metabolism

(continued)

Content Category 1C: Transmission of heritable information from generation to generation and the processes that increase genetic diversity *(continued)*

Topic	*Biochemistry*	*Biochemistry: A Short Course*	*Biology, 2e*	*Fundamentals of Biochemistry*	*Human Physiology*	*Karp's Cell and Molecular Biology*

Carbohydrates (BC, OC)
• Description
  ○ Nomenclature and classification, common names
  ○ Absolute configuration
  ○ Cyclic structure and conformations of hexoses
  ○ Epimers and anomers
• Hydrolysis of the glycoside linkage
• Monosaccharides
• Disaccharides
  ○ Polysaccharides
	Ch. 11 Carbohydrates, pp. 341-365	Ch. 10 Carbohydrates, pp. 181-201	3.2 Carbohydrates	Ch. 8 Carbohydrates, pp. 221-244	Ch. 2 Chemical Composition of the Body, pp. 37-40
					Ch. 4 Metabolism, pp. 113-121
						Ch. 2 The Chemical Basis of Life, pp. 41-46

Content Category 1D: Principles of bioenergetics and fuel molecule metabolism

Living things harness energy from fuel molecules in a controlled manner in order to sustain all the processes responsible for maintaining life. Cell maintenance and growth is energetically costly. Cells harness the energy stored in fuel molecules, such as carbohydrates and fatty acids, and convert it into smaller units of chemical potential known as adenosine triphosphate (ATP).

The hydrolysis of ATP provides a ready source of energy for cells that can be coupled to other chemical processes in order to make them thermodynamically favorable. Fuel molecule mobilization, transport, and storage are regulated according to the needs of the organism.

The content in this category covers the principles of bioenergetics and fuel molecule catabolism. Details of oxidative phosphorylation including the role of chemiosmotic coupling and biological electron transfer reactions are covered, as are the general features of fatty acid and glucose metabolism. Additionally, regulation of these metabolic pathways, fuel molecule mobilization, transport, and storage are covered.

Topic	*Biochemistry*	*Biochemistry: A Short Course*	*Biology, 2e*	*Fundamentals of Biochemistry*	*Human Physiology*	*Karp's Cell and Molecular Biology*	*Organic Chemistry With a Biological Emphasis, Vol. 2*
Glycolysis, Gluconeogenesis, and the Pentose Phosphate Pathway (BIO, BC) • Glycolysis (aerobic), substrates and products o Feeder pathways: glycogen, starch metabolism • Fermentation (anaerobic glycolysis) • Gluconeogenesis (BC) • Pentose phosphate pathway (BC) • Net molecular and energetic results of respiration processes	Ch. 16 Glycolysis and Gluconeogenesis, pp. 491-531 Ch. 20 The Calvin Cycle and the Pentose Phosphate Pathway, pp. 659-672	Ch. 16 Glycolysis, pp. 311-336 Ch. 17 Gluconeogenesis, pp. 343-355 Ch. 26 The Pentose Phosphate Pathway, pp. 519-530	7.2 Glycolysis (Note: does not cover pentose-phosphate pathway)	Ch. 14 Introduction to Metabolism, pp. 442-477 Ch. 15 Glucose Catabolism, pp. 448-522	Ch. 4 Metabolism, pp. 106-121 Ch. 11 Muscle, pp. 394-396	Ch. 3 Bioenergetics, Enzymes, and Metabolism, pp. 105-111	

Principles of Metabolic Regulation (BC)
• Regulation of metabolic pathways (BIO, BC)
  o Maintenance of a dynamic steady state
• Regulation of glycolysis and gluconeogenesis
• Metabolism of glycogen
• Regulation of glycogen synthesis and breakdown
  o Allosteric and hormonal control
• Analysis of metabolic control
	Ch. 15 Metabolism: Basic Concepts and Design, pp. 483-487
	Ch. 16 Glycolysis and Gluconeogenesis, pp. 511-516, 525-533
	Ch. 21 Glycogen Metabolism, pp. 679-702
		Ch. 15 Metabolism: Basic Concepts and Design, pp. 283-304
		Ch. 24 Glycogen Degradation, pp. 485-497
		Ch. 25 Glycogen Synthesis, pp. 503-513
			7.7 Regulation of Cellular Respiration	Ch. 14 Introduction to Metabolism, pp. 442-477
				Ch. 15 Glucose Catabolism, pp. 448-522
				Ch.16 Glycogen Metabolism and Gluconeogenesis
					Ch. 4 Metabolism, pp. 106-121	Ch. 3 Bioenergetics, Enzymes, and Metabolism, pp. 105-111	

(continued)

Content Category 1D: Principles of bioenergetics and fuel molecule metabolism *(continued)*

Topic	*Biochemistry*	*Biochemistry: A Short Course*	*Biology, 2e*	*Fundamentals of Biochemistry*	*Human Physiology*	*Karp's Cell and Molecular Biology*	*Organic Chemistry With a Biological Emphasis, Vol. 2*
Citric Acid Cycle (BIO, BC) • Acetyl-CoA production (BC) • Reactions of the cycle, substrates and products • Regulation of the cycle • Net molecular and energetic results of respiration processes	Ch. 17 The Citric Acid Cycle, pp. 541- 564	Ch. 18 Preparation for the Cycle, pp. 363-372 Ch. 19 Harvesting Electrons from the Cycle, pp. 377-388	7.3 Oxidation of Pyruvate and the Citric Acid Cycle	Ch. 17 Citric Acid Cycle, pp. 558-587	Ch. 4 Metabolism, pp. 106-113	Ch. 5 Aerobic Respiration and the Mitochondrion, pp. 175-177	Ch. 17.3, pp. 397-401

Metabolism of Fatty Acids and Proteins (BIO, BC)
• Description of fatty acids (BC)
• Digestion, mobilization, and transport of fats
• Oxidation of fatty acids
  ○ Saturated fats
  ○ Unsaturated fats
• Ketone bodies (BC)
• Anabolism of fats (BIO)
• Nontemplate synthesis: biosynthesis of lipids and polysaccharides (BIO)
• Metabolism of proteins (BIO)
	Ch. 12 Lipids and Cell Membranes, pp. 373-379
	Ch. 22 Fatty Acid Metabolism, pp. 709-742
	Ch. 23 Protein Turnover and Amino Acid Catabolism, pp. 751-758
		Ch. 11 Lipids, pp. 207-218
		Ch. 14 Digestion, pp. 276-278
		Ch. 27 Fatty Acid Degradation, pp. 537-551
		Ch. 28 Fatty Acid Synthesis, pp. 557-569
				Ch. 14 Introduction to Metabolism, pp. 442-477	Ch. 4 Metabolism, pp. 121-125	Ch. 3 Bioenergetics, Enzymes, and Metabolism, pp. 103-111	Ch. 13.1-13.4, pp. 192-211

Oxidative Phosphorylation (BIO, BC)
• Electron transport chain and oxidative phosphorylation, substrates and products, general features of the pathway
• Electron transfer in mitochondria
  ○ NADH, NADPH
  ○ Flavoproteins
  ○ Cytochromes
• ATP synthase, chemiosmotic coupling
  ○ Proton motive force
• Net molecular and energetic results of respiration processes
• Regulation of oxidative phosphorylation
• Mitochondria, apoptosis, oxidative stress (BC)
	Ch. 18 Oxidative Phosphorylation, pp. 573-611	Ch. 20 The Electron Transport Chain, pp. 399-415
		Ch. 21 The Proton-Motive Force, pp. 419-437
			7.4 Oxidative Phosphorylation	Ch. 14 Introduction to Metabolism, pp. 442-477	Ch. 4 Metabolism, pp. 106-113	Ch. 5 Aerobic Respiration and the Mitochondrion, pp. 168-186	

(continued)

Content Category 1D: Principles of bioenergetics and fuel molecule metabolism *(continued)*

Topic	*Biochemistry*	*Biochemistry: A Short Course*	*Biology, 2e*	*Fundamentals of Biochemistry*	*Human Physiology*	*Karp's Cell and Molecular Biology*	*Organic Chemistry With a Biological Emphasis, Vol. 2*
Hormonal Regulation and Integration of Metabolism (BC) • Higher-level integration of hormone structure and function • Tissue-specific metabolism • Hormonal regulation of fuel metabolism • Obesity and regulation of body mass	Ch. 27 The Integration of Metabolism, pp. 889-913			Ch. 14 Introduction to Metabolism, pp. 442-477 Ch. 15 Glucose Catabolism, pp. 448-522 Ch.16 Glycogen Metabolism and Gluconeogenesis, pp. 523-557	Ch. 13 The Endocrine System, pp. 447-456	Ch. 3 Bioenergetics, Enzymes, and Metabolism, pp. 109-110	

Foundational Concept 2

Highly organized assemblies of molecules, cells, and organs interact to carry out the functions of living organisms.

Content Category 2A: Assemblies of molecules, cells, and groups of cells within multicellular organisms

The processes necessary to maintain life are executed by assemblies of molecules, cells, and groups of cells, all of which are organized into highly specific structures as determined by the unique properties of their component molecules. The processes necessary to maintain life require that cells create and maintain internal environments within the cytoplasm and within certain organelles that are different from their external environments.

Cell membranes separate the internal environment of the cell from the external environment. The specialized structure of the membrane, as described in the fluid mosaic model, allows the cell to be selectively permeable and dynamic, with homeostasis maintained by the constant movement of molecules across the membranes through a combination of active and passive processes driven by several forces, including electrochemical gradients.

Eukaryotic cells also maintain internal membranes that partition the cell into specialized regions. These internal membranes facilitate cellular processes by minimizing conflicting interactions and increasing surface area where chemical reactions can occur. Membrane-bound organelles localize different processes or enzymatic reactions in time and space.

Through interactions between proteins bound to the membranes of adjacent cells, or between membrane-bound proteins and elements of the extracellular matrix, cells of multicellular organisms organize into tissues, organs, and organ systems. Certain membrane-associated proteins also play key roles in providing identification of tissues or recent events in the cell's history for purposes of recognition of "self" versus foreign molecules.

The content in this category covers the composition, structure, and function of cell membranes; the structure and function of the membrane-bound organelles of eukaryotic cells; and the structure and function of the major cytoskeletal elements. It covers the energetics of and mechanisms by which molecules, or groups of molecules, move across cell membranes. It also covers how cell-cell junctions and the extracellular matrix interact to form tissues with specialized functions. Epithelial tissue and connective tissue are covered in this category.

Content Category 2A: Assemblies of molecules, cells, and groups of cells within multicellular organisms

Topic	*Biochemistry*	*Biochemistry: A Short Course*	*Biology, 2e*	*Fundamentals of Biochemistry*	*Human Physiology*	*Karp's Cell and Molecular Biology*	*Organic Chemistry With a Biological Emphasis, Vol. 1*
Plasma Membrane (BIO, BC) • General function in cell containment • Composition of membranes o Lipid components (BIO, BC, OC) ◆ Phospholipids (and phosphatids) ◆ Steroids ◆ Waxes o Protein components o Fluid mosaic model • Membrane dynamics • Solute transport across membranes o Thermodynamic considerations o Osmosis ◆ Colligative properties; osmotic pressure (GC) o Passive transport o Active transport ◆ Sodium/potassium pump • Membrane channels • Membrane potential • Membrane receptors • Exocytosis and endocytosis • Intercellular junctions (BIO) o Gap junctions o Tight junctions o Desmosomes	Ch. 12 Lipids and Cell Membranes, pp. 373-398 Ch. 13 Membrane Channels and Pumps, pp. 403-431	Ch.12 Membrane Structure and Function, pp. 223-239	4.6 Connections Between Cells and Cellular Activities 5.1 Components and Structure 5.2 Passive Transport 5.3 Active Transport 5.4 Bulk Transport	Ch. 9 Lipids and Biological Membranes, pp. 245-292 Ch.10 Membrane Transport, pp. 293-321	Ch. 3 Cells, pp. 61-64, 91-92 Ch. 5 Transport Across the Plasma Membrane Ch. 6 Cell Signaling, pp. 160-161	Ch. 4 The Structure and Function of the Plasma Membrane Ch. 7 Interactions Between Cells and Their Environment, pp. 222-253 Ch. 8 Cytoplasmic Membrane Systems: Structure, Function, and Membrane Trafficking, pp. 290, 293-300	Ch. 1.3A, pp. 35-39 Ch. 2.5C, pp. 112-113

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Content Category 2A: Assemblies of molecules, cells, and groups of cells within multicellular organisms *(continued)*

Topic	*Biochemistry*	*Biochemistry: A Short Course*	*Biology, 2e*	*Fundamentals of Biochemistry*	*Human Physiology*	*Karp's Cell and Molecular Biology*	*Organic Chemistry With a Biological Emphasis, Vol. 1*
Membrane-Bound Organelles and Defining Characteristics of Eukaryotic Cells (BIO) • Defining characteristics of eukaryotic cells: membrane-bound nucleus, presence of organelles, mitotic division • Nucleus o Compart-mentalization, storage of genetic information o Nucleolus: location and function o Nuclear envelope, nuclear pores • Mitochondria o Site of ATP production o Inner and outer membrane structure (BIO, BC) o Self-replication • Lysosomes: membrane-bound vesicles containing hydrolytic enzymes • Endoplasmic reticulum o Rough and smooth components o Rough endoplasmic reticulum site of ribosomes o Double membrane structure o Role in membrane biosynthesis o Role in biosynthesis of secreted proteins • Golgi apparatus: general structure and role in packaging and secretion • Peroxisomes: organelles that collect peroxides		Ch. 1 Biochemistry and the Unity of Life, pp. 9-15 Ch. 20 The Electron Transport Chain, pp. 400-402	4.3 Eukaryotic Cells	Ch. 9 Lipids and Biological Membranes, pp. 245-292 Ch.10 Membrane Transport, pp. 293-321 Ch. 11 Enzymatic Catalysis, pp. 322-360	Ch. 3 Cells, pp. 64-75	Ch. 5 Aerobic Respiration and the Mitochondrion, pp. 168-187 Ch. 8 Cytoplasmic Membrane Systems: Structure, Function, and Membrane Trafficking, pp. 257-288 Ch. 12 Control of Gene Expression, pp. 460-465, 480-483	
Cytoskeleton (BIO) • General function in cell support and movement • Microfilaments: composition and role in cleavage and contractility • Microtubules: composition and role in support and transport • Intermediate filaments, role in support • Composition and function of cilia and flagella • Centrioles, microtubule organizing centers			4.5 The Cytoskeleton	Ch. 1 Introduction to the Chemistry of Life, pp. 1-22	Ch. 3 Cells, pp. 69-71	Ch. 9 The Cytoskeleton and Cell Motility	

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Content Category 2A: Assemblies of molecules, cells, and groups of cells within multicellular organisms *(continued)*

Topic	*Biochemistry*	*Biochemistry: A Short Course*	*Biology, 2e*	*Fundamentals of Biochemistry*	*Human Physiology*	*Karp's Cell and Molecular Biology*	*Organic Chemistry With a Biological Emphasis, Vol. 1*
Tissues Formed From Eukaryotic Cells (BIO) • Epithelial cells • Connective tissue cells			33.2 Animal Primary Tissues	Ch. 7 Protein Function: Myoglobin and Hemoglobin, Muscle Contraction, and Antibodies: Section 2. Muscle Contraction, pp. 200-201	Ch. 3 Cells, pp. 84-92		

Content Category 2B: The structure, growth, physiology, and genetics of prokaryotes and viruses

The highly organized assembly of molecules that is the cell represents the fundamental unit of structure, function, and organization in all living organisms. In the hierarchy of biological organization, the cell is the simplest collection of matter capable of carrying out the processes that distinguish living organisms. As such, cells have the ability to undergo metabolism; maintain homeostasis, including ionic gradients; the capacity to grow; move in response to their local environments; respond to stimuli; reproduce; and adapt to their environment in successive generations.

Life at cellular levels arises from structural order, and its dynamic modulation. It does so in response to signals, thereby reflecting properties that result from individual and interactive features of molecular assemblies, their compartmentalization, and their interaction with environmental signals at many spatial and temporal scales.

The content in this category covers the classification, structure, growth, physiology, and genetics of prokaryotes, and the characteristics that distinguish them from eukaryotes. Viruses are also covered here.

Topic	*Biology, 2e*	*Fundamentals of Biochemistry*	*Karp's Cell and Molecular Biology*
Cell Theory (BIO) • History and development • Impact on biology		Ch. 1 Introduction to the Chemistry of Life, pp. 1-22	Ch. 1 Introduction to the Study of Cell and Molecular Biology, pp. 1-3

Classification and Structure of Prokaryotic Cells (BIO)
• Prokaryotic domains
  ○ Archaea
  ○ Bacteria
• Major classifications of bacteria by shape
  ○ Bacilli (rod-shaped)
  ○ Spirilli (spiral shaped)
  ○ Cocci (spherical)
• Lack of nuclear membrane and mitotic apparatus
• Lack of typical eukaryotic organelles
• Presence of cell wall in bacteria
• Flagellar propulsion, mechanism
	Ch. 22.1
	Prokaryotic Diversity
	Ch. 22.2
	Structure of Prokaryotes: Bacteria and Archaea
		Ch. 1
		Introduction to the Chemistry of Life,
		pp. 1-22
			Ch. 1
			Introduction to the Study of Cell and Molecular Biology,
			pp. 7-15

Growth and Physiology of Prokaryotic Cells (BIO) • Reproduction by fission • High degree of genetic adaptability, acquisition of antibiotic resistance • Exponential growth • Existence of anaerobic and aerobic variants • Parasitic and symbiotic • Chemotaxis	Ch. 22.3 Prokaryotic Metabolism Ch. 22.4 Bacterial Diseases in Humans Ch. 22.5 Beneficial Prokaryotes	Ch. 22 Mammalian Fuel Metabolism: Integration and Regulation, pp. 773	Ch. 1 Introduction to the Study of Cell and Molecular Biology, pp. 7-15

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Content Category 2B: The structure, growth, physiology, and genetics of prokaryotes and viruses *(continued)*

Topic	*Biology, 2e*	*Fundamentals of Biochemistry*	*Karp's Cell and Molecular Biology*
Genetics of Prokaryotic Cells (BIO) • Existence of plasmids, extragenomic DNA • Transformation: incorporation into bacterial genome of DNA fragments from external medium • Conjugation • Transposons (also present in eukaryotic cells)		Ch. 1 Introduction to the Chemistry of Life, pp. 1-22	Ch. 12 Control of Gene Expression, pp. 455-460
Virus Structure (BIO) • General structural characteristics (nucleic acid and protein, enveloped and nonenveloped) • Lack organelles and nucleus • Structural aspects of typical bacteriophage • Genomic content: RNA or DNA • Size relative to bacteria and eukaryotic cells	Ch. 21.1 Viral Evolution, Morphology, and Classification		Ch. 1 Introduction to the Study of Cell and Molecular Biology, pp. 23-25

Viral Life Cycle (BIO)
• Self-replicating biological units that must reproduce within specific host cell
• Generalized phage and animal virus life cycles
  ○ Attachment to host, penetration of cell membrane or cell wall, and entry of viral genetic material
  ○ Use of host synthetic mechanism to replicate viral components
  ○ Self-assembly and release of new viral particles
• Transduction: transfer of genetic material by viruses
• Retrovirus life cycle: integration into host DNA, reverse transcriptase, HIV
• Prions and viroids: subviral particles
	Ch. 21.2
	Virus Infections and Hosts
	Ch. 21.3
	Prevention and Treatment of Viral Infections
	Ch. 21.4
	Other Acellular Entities: Prions and Viroids
			Ch. 13
			DNA Replication and Repair, p. 526

Content Category 2C: Processes of cell division, differentiation, and specialization

The ability of organisms to reproduce their own kind is the characteristic that best distinguishes living things. In sexually reproducing organisms, the continuity of life is based on the processes of cell division and meiosis.

The process of cell division is an integral part of the cell cycle. The progress of eukaryotic cells through the cell cycle is regulated by a complex molecular control system. Malfunctions in this system can result in unabated cellular division, and ultimately the development of cancer.

In the embryonic development of multicellular organisms, a fertilized egg gives rise to cells that differentiate into many different types of cells, each with a different structure, corresponding function, and location within the organism. During development, spatial-temporal gradients in the interactions between gene expression and various stimuli result in the structural and functional divergence of cells into specialized structure, organs, and tissues. The interaction of stimuli and genes is also explained by the progression of stem cells to terminal cells.

The content in this category covers the cell cycle; the causes, genetics, and basic properties of cancer; the processes of meiosis and gametogenesis; and the mechanisms governing cell specialization and differentiation.

Topic	*Biochemistry*	*Biochemistry: A Short Course*	*Biology, 2e*	*Fundamentals of Biochemistry*	*Human Physiology*	*Karp's Cell and Molecular Biology*

Mitosis (BIO)
• Mitotic process: prophase, metaphase, anaphase, telophase, interphase
• Mitotic structures
  ○ Centrioles, asters, spindles
  ○ Chromatids, centromeres, kinetochores
  ○ Nuclear membrane breakdown and reorganization
  ○ Mechanisms of chromosome movement
• Phases of cell cycle: G0, G1, S, G2, M
• Growth arrest
• Control of cell cycle
• Loss of cell-cycle controls in cancer cells
			10.2 The Cell Cycle
			10.3 Control of the Cell Cycle
			10.4 Cancer and the Cell Cycle
					Ch. 3 Cells, pp. 79-83	Ch. 14 Cell Division

Biosignalling (BC) • Oncogenes, apoptosis	Ch. 14 Signal-Transduction Pathways, pp. 455-457	Ch. 13 Signal-Transduction Pathways, pp. 245-261	9.3 Response to the Signal 10.4 Cancer and the Cell Cycle	Ch. 13 Biochemical Signaling, pp. 402-441	Ch. 3 Cells, p. 82	Ch. 16 Cancer

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Content Category 2C: Processes of cell division, differentiation, and specialization *(continued)*

Topic	*Biochemistry*	*Biochemistry: A Short Course*	*Biology, 2e*	*Fundamentals of Biochemistry*	*Human Physiology*	*Karp's Cell and Molecular Biology*

Reproductive System (BIO)
• Gametogenesis by meiosis
• Ovum and sperm
  ○ Differences in formation
  ○ Differences in morphology
  ○ Relative contribution to next generation
• Reproductive sequence: fertilization, implantation, development, birth
			11.1 The Process of Meiosis
			11.2 Sexual Reproduction
					Ch. 23 The Reproductive Systems, pp. 811-816, 823-827	Ch. 14 Cell Division, pp. 539-581

Embryogenesis (BIO)
• Stages of early development (order and general features of each)
  ○ Fertilization
  ○ Cleavage
  ○ Blastula formation
  ○ Gastrulation
  ◆ First cell movements
  ◆ Formation of primary germ layers (endoderm, mesoderm, ectoderm)
  ○ Neurulation
• Major structures arising out of primary germ layers
• Neural crest
• Environment-gene interaction in development
			43.6 Fertilization and Early Embryonic Development		Ch. 23 The Reproductive Systems, pp. 840-851	

Mechanisms of Development (BIO)
• Cell specialization
  ○ Determination
  ○ Differentiation
  ○ Tissue types
• Cell-cell communication in development
• Cell migration
• Pluripotency: stem cells
• Gene regulation in development
• Programmed cell death
• Existence of regenerative capacity in various species
• Senescence and aging
					Ch. 1 An Introduction to Physiology, pp. 5-6
					Ch. 23 The Reproductive Systems, p. 839
						Ch. 7 Interactions Between Cells and Their Environment, pp. 226-234
						Ch. 15 Cell Signaling and Signal Transduction: Communication Between Cells, pp. 621-625

Foundational Concept 3

Complex systems of tissues and organs sense the internal and external environments of multicellular organisms, and through integrated functioning, maintain a stable internal environment within an ever-changing external environment.

Content Category 3A: Structure and functions of the nervous and endocrine systems and ways in which these systems coordinate the organ systems

The nervous and endocrine systems work together to detect external and internal signals, transmit and integrate information, and maintain homeostasis. They do all of this by producing appropriate responses to internal and external cues and stressors. The integration of these systems both with one another, and with the other organ systems, ultimately results in the successful and adaptive behaviors that allow for the propagation of the species.

Animals have evolved a nervous system that senses and processes internal and external information that is used to facilitate and enhance survival, growth, and reproduction. The nervous system interfaces with sensory and internal body systems to coordinate physiological and behavioral responses ranging from simple movements and small metabolic changes to long-distance migrations and social interactions. The physiological processes for nerve signal generation and propagation involve specialized membranes with associated proteins that respond to ligands and/or electrical field changes, signaling molecules and, by extension, the establishment and replenishment of ionic electrochemical gradients requiring ATP.

The endocrine system of animals has evolved to produce chemical signals that function internally to regulate stress responses, reproduction, development, energy metabolism, growth, and various individual and interactive behaviors. The integrated contributions of the nervous and endocrine systems to bodily functions are exemplified by the process whereby the signaling of neurons regulates hormone release, and by the targeting of membrane or nuclear receptors on neurons by circulating hormones.

The content in this category covers the structure, function, and basic aspects of nervous and endocrine systems, and their integration. The structure and function of nerve cells is also included in this category.

Content Category 3A: Structure and functions of the nervous and endocrine systems and ways in which these systems coordinate the organ systems

Topic	*Biochemistry*	*Biochemistry: A Short Course*	*Biology, 2e*	*Fundamentals of Biochemistry*	*Human Physiology*	*Karp's Cell and Molecular Biology*

Nervous System: Structure and Function (BIO)
• Major Functions
  ○ High level control and integration of body systems
  ○ Adaptive capability to external influences
• Organization of vertebrate nervous system
• Sensor and effector neurons
• Sympathetic and parasympathetic nervous systems: antagonistic control
• Reflexes
  ○ Feedback loop, reflex arc
  ○ Role of spinal cord and supraspinal circuits
• Integration with endocrine system: feedback control
					Ch. 7
					The Nervous System and Neuronal Excitability, pp. 191-193
					Ch. 10
					Autonomic and Somatic Nervous Systems
						Ch. 4
						The Structure and Function of the Plasma Membrane, pp. 158-167

Nerve Cell (BIO)
• Cell body: site of nucleus, organelles
• Dendrites: branched extensions of cell body
• Axon: structure and function
• Myelin sheath, Schwann cells, insulation of axon
• Nodes of Ranvier: propagation of nerve impulse along axon
• Synapse: site of impulse propagation between cells
• Synaptic activity: transmitter molecules
• Resting potential: electrochemical gradient
• Action potential
  ○ Threshold, all-or-none
  ○ Sodium/potassium pump
• Excitatory and inhibitory nerve fibers: summation, frequency of firing
• Glial cells, neuroglia
			35.1 Neurons and Glial Cell		Ch. 7
					The Nervous System and Neuronal Excitability, pp. 193-223
						Ch. 4
						The Structure and Function of the Plasma Membrane, pp. 118-119, 158-167

Biosignalling (BC)
• Gated ion channels
  ○ Voltage gated
  ○ Ligand gated
• Receptor enzymes
• G protein-coupled receptors
	Ch. 13
	Membrane Channels and Pumps, pp. 403-431
	Ch. 14
	Signal-Transduction Pathways, pp. 437-459
		Ch. 12
		Membrane Structure and Function, pp. 231-239
		Ch. 13
		Signal-Transduction Pathways, pp. 245-261
			9.1 Signaling Molecules and Cellular Receptors
			9.2 Propagation of the Signal
				Ch. 13
				Biochemical Signaling, pp. 402-441
					Ch. 6
					Cell Signaling, pp. 169-185
					Ch. 7
					The Nervous System and Neuronal Excitability, pp. 201-202
						Ch. 4
						The Structure and Function of the Plasma Membrane, pp. 143-151
						Ch. 15
						Cell Signaling and Cell Transduction: Communication Between Cells pp. 582-598

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Content Category 3A: Structure and functions of the nervous and endocrine systems and ways in which these systems coordinate the organ systems *(continued)*

Topic	*Biochemistry*	*Biochemistry: A Short Course*	*Biology, 2e*	*Fundamentals of Biochemistry*	*Human Physiology*	*Karp's Cell and Molecular Biology*

Lipids (BC, OC)
• Description; structure
  ○ Steroids
  ○ Terpenes and terpenoids
	Ch. 26
	The Biosynthesis of Membrane Lipids and Steroids, pp. 858-882
		Ch. 29
		Lipid Synthesis: Storage Lipids, Phospholipids and Cholesterol, pp. 577-601
			3.3
			Lipids
				Ch. 9
				Lipids and Biological Membranes, pp. 245-292
					Ch. 2
					Chemical Composition of the Body, pp. 40-45
						Ch. 2
						The Chemical Basis of Life, pp. 46-49

Endocrine System: Hormones and Their Sources (BIO) • Function of endocrine system: specific chemical control at cell, tissue, and organ level • Definitions of endocrine gland, hormone • Major endocrine glands: names, locations, products • Major types of hormones • Neuroendrocrinology — relation between neurons and hormonal systems			37.1 Types of Hormones 37.2 How Hormones Work 37.5 Endocrine Glands		Ch. 13 The Endocrine System, pp. 448-456	
Endocrine System: Mechanisms of Hormone Action (BIO) • Cellular mechanisms of hormone action • Transport of hormones: blood supply • Specificity of hormones: target tissue • Integration with nervous system: feedback control regulation by second messengers			37.3 Regulation of Body Processes	Ch. 22 Mammalian Fuel Metabolism: Integration and Regulation: Section 2. Hormonal Control of Fuel Metabolism, pp. 781-785	Ch. 13 The Endocrine System, pp. 448-456	Ch. 15 Cell Signaling and Cell Transduction: Communication Between Cells, pp. 583-586, 599-602

Content Category 3B: Structure and integrative functions of the main organ systems

Animals use a number of highly organized and integrated organ systems to carry out the necessary functions associated with maintaining life processes. Within the body, no organ system is an island. Interactions and coordination between organ systems allow organisms to engage in the processes necessary to sustain life. For example, the organs and structures of the circulatory system carry out a number of functions, such as transporting:

- nutrients absorbed in the digestive system;
- gases absorbed from the respiratory system and muscle tissue;
- hormones secreted from the endocrine system; and
- blood cells produced in bone marrow to and from cells in the body to help fight disease.

The content in this category covers the structure and function of the major organ systems of the body including the respiratory, circulatory, lymphatic, immune, digestive, excretory, reproductive, muscle, skeletal, and skin systems. Also covered in this category is the integration of these systems and their control and coordination by the endocrine and nervous systems.

Topic	*Biochemistry*	*Biology, 2e*	*Human Physiology*	*Karp's Cell and Molecular Biology*

Respiratory System (BIO)
• General function
  ○ Gas exchange, thermoregulation
  ○ Protection against disease: particulate matter
• Structure of lungs and alveoli
• Breathing mechanisms
  ○ Diaphragm, rib cage, differential pressure
  ○ Resiliency and surface tension effects
• Thermoregulation: nasal and tracheal capillary beds; evaporation, panting
• Particulate filtration: nasal hairs, mucus/cilia system in lungs
• Alveolar gas exchange
  ○ Diffusion, differential partial pressure
  ○ Henry's Law (GC)
• pH control
• Regulation by nervous control
  ○ CO_2 sensitivity
		39.1 Systems of Gas Exchange
		39.2 Gas Exchange across Respiratory Surfaces
		39.3 Breathing
		39.4 Transport of Gases in Human Bodily Fluids
			Ch. 18 The Respiratory System	Ch. 5 Aerobic Respiration and the Mitochondrion, p. 168
				Ch. 9 The Cytoskeleton and Cell Motility, pp. 327-334

(continued)

Content Category 3B: Structure and integrative functions of the main organ systems *(continued)*

Topic	*Biochemistry*	*Biology, 2e*	*Human Physiology*	*Karp's Cell and Molecular Biology*
Circulatory System (BIO) • Functions: circulation of oxygen, nutrients, hormones, ions and fluids, removal of metabolic waste • Role in thermoregulation • Four-chambered heart: structure and function • Endothelial cells • Systolic and diastolic pressure • Pulmonary and systemic circulation • Arterial and venous systems (arteries, arterioles, venules, veins) o Structural and functional differences o Pressure and flow characteristics • Capillary beds o Mechanisms of gas and solute exchange o Mechanism of heat exchange o Source of peripheral resistance • Composition of blood o Plasma, chemicals, blood cells o Erythrocyte production and destruction; spleen, bone marrow o Regulation of plasma volume • Coagulation, clotting mechanisms • Oxygen transport by blood o Hemoglobin, hematocrit o Oxygen content o Oxygen affinity o Oxygen transport by blood; modification of oxygen affinity • Carbon dioxide transport and level in blood • Nervous and endocrine control		40.1 Overview of the Circulatory System 40.2 Components of the Blood 40.3 Mammalian Heart and Blood Vessels 40.4 Blood Flow and Blood Pressure Regulation	Ch. 14 The Cardiovascular System: The Heart Ch. 15 The Cardiovascular System: Blood Vessels and Hemodynamics Ch. 16 The Cardiovascular System: The Blood	
Lymphatic System (BIO) • Structure of lymphatic system • Major functions o Equalization of fluid distribution o Transport of proteins and large glycerides o Production of lymphocytes involved in immune reactions o Return of materials to the blood			Ch. 17 The Immune System, pp. 613-615	Ch. 17 The Immune Response, pp. 688-691

(continued)

Content Category 3B: Structure and integrative functions of the main organ systems *(continued)*

Topic	*Biochemistry*	*Biology, 2e*	*Human Physiology*	*Karp's Cell and Molecular Biology*
Immune System (BIO) • Innate (nonspecific) vs. adaptive (specific) immunity • Adaptive immune system cells o T-lymphocytes o B-lymphocytes • Innate immune system cells o Macrophages o Phagocytes • Concept of antigen and antibody • Antigen presentation • Clonal selection • Antigen-antibody recognition • Structure of antibody molecule • Recognition of self vs. nonself, autoimmune diseases • Major histocompatibility complex	42.1 Innate Immune Response 42.2 Adaptive Immune Response 42.3 Antibodies 42.4 Disruptions in the Immune System		Ch. 17 The Immune System, pp. 615-645	Ch. 17 The Immune Response
Digestive System (BIO) • Ingestion o Saliva as lubrication and source of enzymes o Ingestion; esophagus, transport function • Liver o Structural relationship of liver within gastrointestinal system o Production of bile o Role in blood glucose regulation, detoxification • Bile o Storage in gall bladder o Function • Pancreas o Production of enzymes o Transport of enzymes to small intestine • Small Intestine o Absorption of food molecules and water o Function and structure of villi o Production of enzymes, site of digestion o Neutralization of stomach acid o Structure (anatomic subdivisions) • Large Intestine o Absorption of water o Bacterial flora o Structure (gross) *(continued)*		34.1 Digestive Systems 34.2 Nutrition and Energy Production 34.3 Digestive System Processes 34.4 Digestive System Regulation	Ch. 21 The Digestive System	Ch. 1 Introduction to the Study of Cell and Molecular Biology, pp. 3-5 Ch. 15 Cell Signaling and Cell Transduction: Communication Between Cells, pp. 599-602

(continued)

Content Category 3B: Structure and integrative functions of the main organ systems *(continued)*

Topic	*Biochemistry*	*Biology, 2e*	*Human Physiology*	*Karp's Cell and Molecular Biology*

Digestive System (BIO)
continued
• Rectum: storage and elimination of waste, feces
• Muscular control
  ○ Peristalsis
• Endocrine control
  ○ Hormones
  ○ Target tissues
• Nervous control: the enteric nervous system				

Excretory System (BIO)
• Roles in homeostasis
  ○ Blood pressure
  ○ Osmoregulation
  ○ Acid-base balance
  ○ Removal of soluble nitrogenous waste
• Kidney structure
  ○ Cortex
  ○ Medulla
• Nephron structure
  ○ Glomerulus
  ○ Bowman's capsule
  ○ Proximal tubule
  ○ Loop of Henle
  ○ Distal tubule
  ○ Collecting duct
• Formation of urine
  ○ Glomerular filtration
  ○ Secretion and reabsorption of solutes
  ○ Concentration of urine
  ○ Counter-current multiplier mechanism
• Storage and elimination: ureter, bladder, urethra
• Osmoregulation: capillary reabsorption of H2O, amino acids, glucose, ions
• Muscular control: sphincter muscle
		41.1 Osmoregulation and Osmotic Balance
		41.2 The Kidneys and Osmoregulatory Organs
		41.3 Excretion Systems
		41.4 Nitrogenous Wastes
		41.5 Hormonal Control of Osmoregulatory Functions
			Ch. 19 The Urinary System
			Ch. 20 Fluid, Electrolyte, and Acid-Base Homeostasis	

(continued)

Content Category 3B: Structure and integrative functions of the main organ systems *(continued)*

Topic	*Biochemistry*	*Biology, 2e*	*Human Physiology*	*Karp's Cell and Molecular Biology*
Reproductive System (BIO) • Male and female reproductive structures and their functions • Gonads • Genitalia • Differences between male and female structures • Hormonal control of reproduction • Male and female sexual development • Female reproductive cycle • Pregnancy, parturition, lactation • Integration with nervous control		43.3 Human Reproductive Anatomy and Gametogenesis 43.4 Hormonal Control of Human Reproduction 43.5 Human Pregnancy and Birth	Ch. 23 The Reproductive Systems	
Muscle System (BIO) • Important functions o Support: mobility o Peripheral circulatory assistance o Thermoregulation (shivering reflex) • Structure of three basic muscle types: striated, smooth, cardiac • Muscle structure and control of contraction o T-tubule system o Contractile apparatus o Sarcoplasmic reticulum o Fiber type o Contractile velocity of different muscle types • Regulation of cardiac muscle contraction • Oxygen debt: fatigue • Nervous control o Motor neurons o Neuromuscular junction, motor end plates o Sympathetic and parasympathetic innervation o Voluntary and involuntary muscles		38.4 Muscle Contraction and Locomotion	Ch. 11 Muscle Ch. 12 Control of Body Movement	Ch. 4 The Structure and Function of the Plasma Membrane, pp. 162-167 Ch. 9 The Cytoskeleton and Cell Motility, pp. 345-352
Specialized Cell-Muscle Cell (BIO) • Structural characteristics of striated, smooth, and cardiac muscle • Abundant mitochondria in red muscle cells: ATP source • Organization of contractile elements: actin and myosin filaments, crossbridges, sliding filament model • Sarcomeres: "I" and "A" bands, "M" and "Z" lines, "H" zone • Presence of troponin and tropomyosin • Calcium regulation of contraction		38.4 Muscle Contraction and Locomotion	Ch. 11 Muscle	Ch. 9 The Cytoskeleton and Cell Motility, pp. 345-352

(continued)

Content Category 3B: Structure and integrative functions of the main organ systems *(continued)*

Topic	*Biochemistry*	*Biology, 2e*	*Human Physiology*	*Karp's Cell and Molecular Biology*

Skeletal System (BIO)
• Functions
  ○ Structural rigidity and support
  ○ Calcium storage
  ○ Physical protection
• Skeletal structure
  ○ Specialization of bone types, structures
  ○ Joint structures
  ○ Endoskeleton vs. exoskeleton
• Bone structure
  ○ Calcium/protein matrix
  ○ Cellular composition of bone
• Cartilage: structure and function
• Ligaments, tendons
• Endocrine control
		38.1 Types of Skeletal Systems
		38.2 Bone
		38.3 Joints and Skeletal Movement
			Ch. 13 The Endocrine System, pp. 459-462, 489-492	

Skin System (BIO)
• Structure
  ○ Layer differentiation, cell types
  ○ Relative impermeability to water
• Functions in homeostasis and osmoregulation
• Functions in thermoregulation
  ○ Hair, erectile musculature
  ○ Fat layer for insulation
  ○ Sweat glands, location in dermis
  ○ Vasoconstriction and vasodilation in surface capillaries
• Physical protection
  ○ Nails, calluses, hair
  ○ Protection against abrasion, disease organisms
• Hormonal control: sweating, vasodilation, and vasoconstriction
			Ch. 17 The Immune System, pp. 615-616	

Foundational Concept 4

Complex living organisms transport materials, sense their environment, process signals, and respond to changes using processes that can be understood in terms of physical principles.

Content Category 4B: Importance of fluids for the circulation of blood, gas movement, and gas exchange

Fluids are featured in several physiologically important processes, including the circulation of blood, gas movement into and out of the lungs, and gas exchange into the blood. The energetic requirements of fluid dynamics can be modeled using physical equations. A thorough understanding of fluids is necessary to understand the origins of numerous forms of disease.

The content in this category covers hydrostatic pressure, fluid flow rates, viscosity, the Kinetic Molecular Theory of Gases, and the Ideal Gas Law.

Topic	*Biology, 2e*	*Human Physiology*
Circulatory System (BIO) • Arterial and venous systems; pressure and flow characteristics	40.3 Mammalian Heart and Blood Vessels 40.4 Blood Flow and Blood Pressure Regulation	Ch. 15 The Cardiovascular System: Blood Vessels and Hemodynamics

Content Category 4C: Electrochemistry and electrical circuits and their elements

Charged particles can be set in motion by the action of an applied electrical field and can be used to transmit energy or information over long distances. The energy released during certain chemical reactions can be converted to electrical energy, which can be harnessed to perform other reactions or work.

Physiologically, a concentration gradient of charged particles is set up across the cell membrane of neurons at considerable energetic expense. This allows for the rapid transmission of signals using electrical impulses — changes in the electrical voltage across the membrane — under the action of some external stimulus.

The content in this category covers electrical circuit elements, electrical circuits, and electrochemistry.

Topic	*Biology, 2e*	*Human Physiology*	*Karp's Cell and Molecular Biology*
Specialized Cell — Nerve Cell (BIO) • Myelin sheath, Schwann cells, insulation of axon • Nodes of Ranvier: propagation of nerve impulse along axon	35.1 Neurons and Glial Cells	Ch. 7 The Nervous System and Neuronal Excitability, pp. 193-199	Ch. 4 The Structure and Function of the Plasma Membrane, pp. 118-119, 158-167

Foundational Concept 5

The principles that govern chemical interactions and reactions form the basis for a broader understanding of the molecular dynamics of living systems.

Content Category 5A: Unique nature of water and its solutions

In order to fully understand the complex and dynamic nature of living systems, it is first necessary to understand the unique nature of water and its solutions. The unique properties of water allow it to strongly interact with and mobilize many types of solutes, including ions. Water is also unique in its ability to absorb energy and buffer living systems from the chemical changes necessary to sustain life.

The content in this category covers the nature of solutions, solubility, acids, bases, and buffers.

Topic	*Biochemistry*	*Biochemistry: A Short Course*	*Biology, 2e*	*Fundamentals of Biochemistry*	*Human Physiology*	*Karp's Cell and Molecular Biology*	*Organic Chemistry With a Biological Emphasis, Vol. 1*
Acid/Base Equilibria (GC, BC) • Bronsted-Lowry definition of acid, base • Ionization of water o K_w, its approximate value ($K_w = [H^+][OH^-] = 10^{-14}$ at 25°C, 1 atm) o Definition of pH: pH of pure water • Conjugate acids and bases (e.g., NH_4^+ and NH3) • Strong acids and bases (e.g., nitric, sulfuric) • Weak acids and bases (e.g., acetic, benzoic) o Dissociation of weak acids and bases with or without added salt o Hydrolysis of salts of weak acids or bases o Calculation of pH of solutions of salts of weak acids or bases • Equilibrium constants K_a and K_b: pK_a, pK_b • Buffers o Definition and concepts (common buffer systems) o Influence on titration curves	Ch. 1 Biochemistry: An Evolving Science, pp. 14-16	Ch. 2 Water, Weak Bonds and the Generation of Order Out of Chaos, pp. 26-31	2.2 Water	Ch. 2 Water: Section 2. Chemical Properties of Water, pp. 31-40	Ch. 20 Fluid, Electrolyte, and Acid-Base Homeostasis, pp. 737-744	Ch. 2 The Chemical Basis of Life, pp. 32-39	Ch. 7.1-7.8, pp. 331-373
Ions in Solutions (GC, BC) • Anion, cation: common names, formulas and charges for familiar ions (e.g., NH_4^+ ammonium, PO_4^{3-} phosphate, SO_4^{2-} sulfate) • Hydration, the hydronium ion		Ch. 2 Water, Weak Bonds and the Generation of Order Out of Chaos, pp. 18-23		Ch. 2 Water: Section 2. Chemical Properties of Water, pp. 31-40	Ch. 2 Chemical Composition of the Body pp. 25-29	Ch. 2 The Chemical Basis of Life, pp. 32-39	

Content Category 5B: Nature of molecules and intermolecular interactions

Covalent bonding involves the sharing of electrons between atoms. If the result of such interactions is not a network solid, then the covalently bonded substance will be discrete and molecular.

The shape of molecules can be predicted based on electrostatic principles and quantum mechanics since only two electrons can occupy the same orbital. Bond polarity (both direction and magnitude) can be predicted based on knowledge of the valence electron structure of the constituent atoms. The strength of intermolecular interactions depends on molecular shape and the polarity of the covalent bonds present. The solubility and other physical properties of molecular substances depend on the strength of intermolecular interactions.

The content in this category covers the nature of molecules and includes covalent bonding, molecular structure, nomenclature, and intermolecular interactions.

Topic	*Organic Chemistry With a Biological Emphasis, Vol. 1*

Covalent Bond (GC)
• Lewis Electron Dot formulas
  ○ Resonance structures
  ○ Formal charge
  ○ Lewis acids and bases
• Partial ionic character
  ○ Role of electronegativity in determining charge distribution
  ○ Dipole Moment
• Ω and π bonds
  ○ Hybrid orbitals: sp^3, sp^2, sp and respective geometries
  ○ Valence shell electron pair repulsion and the prediction of shapes of molecules (e.g., NH_3, H_2O, CO_2)
  ○ Structural formulas for molecules involving H, C, N, O, F, S, P, Si, Cl
  ○ Delocalized electrons and resonance in ions and molecules
• Multiple bonding
  ○ Effect on bond length and bond energies
  ○ Rigidity in molecular structure
• Stereochemistry of covalently bonded molecules (OC)
  ○ Isomers
  ◆ Structural isomers
  ◆ Stereoisomers (e.g., diastereomers, enantiomers, cis/trans isomers)
  ◆ Conformational isomers
  ○ Polarization of light, specific rotation
  ○ Absolute and relative configuration
  ◆ Conventions for writing *R* and *S* forms
  ◆ Conventions for writing *E* and *Z* forms
	Ch. 1.1-3.9,
	pp. 5-173

Liquid Phase — Intermolecular Forces (GC) • Hydrogen bonding • Dipole Interactions • Van der Waals' Forces (London dispersion forces)	Ch. 1.4B-D

Content Category 5C: Separation and purification methods

Analysis of complex mixtures of substances — especially biologically relevant materials — typically requires separation of the components. Many methods have been developed to accomplish this task, and the method used is dependent on the types of substances which comprise the mixture. All these methods rely on the magnification of potential differences in the strength of intermolecular interactions.

The content in this category covers separation and purification methods including extraction, liquid and gas chromatography, and electrophoresis.

Topic	*Biochemistry*	*Biochemistry: A Short Course*	*Fundamentals of Biochemistry*	*Karp's Cell and Molecular Biology*

Separations and Purifications (OC, BC)
• Extraction: distribution of solute between two immiscible solvents
• Distillation
• Chromatography
  ○ Basic principles involved in separation process
  ◆ Column chroma-tography, gas-liquid chroma-tography
  ◆ High pressure liquid chroma-tography
  ○ Paper chromatography
  ○ Thin-layer chromatography
• Separation and purification of peptides and proteins (BC)
  ○ Electrophoresis
  ○ Quantitative analysis
  ○ Chromatography
  ◆ Size-exclusion
  ◆ Ion-exchange
  ◆ Affinity
• Racemic mixtures, separation of enantiomers (OC)
	Ch. 3 Exploring Proteins and Proteomes, pp. 69-105	Ch. 5 Techniques in Protein Biochemistry, pp. 75-98	Ch. 5 Proteins: Primary Structure: Section 2. Protein Purification and Analysis, pp. 99-108	Ch. 18 Techniques in Cell and Molecular Biology, pp. 692-716

Content Category 5D: Structure, function, and reactivity of biologically-relevant molecules

The structure of biological molecules forms the basis of their chemical reactions including oligomerization and polymerization. Unique aspects of each type of biological molecule dictate their role in living systems, whether providing structure or information storage, or serving as fuel and catalysts.

The content in this category covers the structure, function, and reactivity of biologically-relevant molecules including the mechanistic considerations that dictate their modes of reactivity.

Topic	*Biochemistry*	*Biochemistry: A Short Course*	*Biology, 2e*	*Fundamentals of Biochemistry*	*Human Physiology*	*Karp's Cell and Molecular Biology*	*Organic Chemistry With a Biological Emphasis, Vol. 1*	*Organic Chemistry With a Biological Emphasis, Vol. 2*

Nucleotides and Nucleic Acids (OC, BC, BIO)
• Nucleotides and nucleosides: composition
  ○ Sugar phosphate backbone
  ○ Pyrimidine, purine residues
• Deoxyribonucleic acid: DNA; double helix
• Chemistry (OC, BC)
• Other functions (OC, BC)
	Ch. 4
	DNA, RNA and the Flow of Genetic Information, pp. 114-124
		Ch. 33
		The Structure of Informational Macromolecule: DNA and RNA, pp. 673-690
			3.5
			Nucleic Acids
				Ch. 3
				Nucleotides, Nucleic Acids, and Genetic Information, pp. 42-79
					Ch. 2
					Chemical Composition of the Body, pp. 52-54
						Ch. 2
						The Chemical Basis of Life, pp. 77-79
						Ch. 10
						The Nature of the Gene and the Genome, pp. 373-377, 382-387
						Ch. 18
						Techniques in Cell and Molecular Biology, pp. 721-722
							Ch. 1.3E, pp. 43-45	Ch. 9.1-9.8, pp. 1-38

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Content Category 5D: Structure, function, and reactivity of biologically-relevant molecules *(continued)*

Topic	*Biochemistry*	*Biochemistry: A Short Course*	*Biology, 2e*	*Fundamentals of Biochemistry*	*Human Physiology*	*Karp's Cell and Molecular Biology*	*Organic Chemistry With a Biological Emphasis, Vol. 1*	*Organic Chemistry With a Biological Emphasis, Vol. 2*
Amino Acids, Peptides, Proteins (OC, BC) • Amino acids: description o Absolute configuration at the α position o Dipolar ions o Classification ◆ Acidic or basic ◆ Hydrophilic or hydrophobic o Synthesis of α-amino acids (OC) ◆ Strecker Synthesis ◆ Gabriel Synthesis • Peptides and proteins: reactions o Sulfur linkage for cysteine and cystine o Peptide linkage: polypeptides and proteins o Hydrolysis • General Principles o 1° structure of proteins o 2° structure of proteins o 3° structure of proteins o Isoelectric point	Ch. 2 Protein Composition and Structure, pp. 29-64	Ch. 3 Amino Acids, pp. 37-45 Ch. 4 Protein Three-Dimensional Structure, pp. 49-68	3.4 Proteins	Ch. 4 Amino Acids, pp. 80-96	Ch. 2 Chemical Composition of the Body, pp. 45-52	Ch. 2 The Chemical Basis of Life, pp. 58-70	Ch. 1.3D, pp. 41-43	Ch. 11.1-11.7, pp. 95-124 Ch. 15.6, pp. 309-316
The Three-Dimensional Protein Structure (BC) • Conformational stability o Hydrophobic interactions o Solvation layer (entropy) • 4° structure • Denaturing and folding	Ch. 2 Protein Composition and Structure, pp. 52-62	Ch. 4 Protein Three-Dimensional Structure, pp. 62-67	3.4 Proteins	Ch. 6 Proteins: Three-Dimensional Structure, pp. 131-179	Ch. 2 Chemical Composition of the Body, pp. 45-52	Ch. 2 The Chemical Basis of Life, pp. 48-70		

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Content Category 5D: Structure, function, and reactivity of biologically-relevant molecules *(continued)*

Topic	*Biochemistry*	*Biochemistry: A Short Course*	*Biology, 2e*	*Fundamentals of Biochemistry*	*Human Physiology*	*Karp's Cell and Molecular Biology*	*Organic Chemistry With a Biological Emphasis, Vol. 1*	*Organic Chemistry With a Biological Emphasis, Vol. 2*
Nonenzymatic Protein Function (BC) • Binding • Immune system • Motor	Ch. 7 Hemoglobin, pp. 207-227 Ch. 35 Immune System, pp. 1119-1145 Ch. 36 Molecular Motors, pp. 1151-1168	Ch. 9 Hemoglobin, an Allosteric Protein, pp. 161-173		Ch. 7 Protein Function: Myoglobin and Hemoglobin, Muscle Contraction and Antibodies, pp. 180-220	Ch. 2 Chemical Composition of the Body, pp. 45-52	Ch. 2 The Chemical Basis of Life, pp. 73-76 Ch. 7 Interactions Between Cells and Their Environment, pp. 238-241 Ch. 9 The Cytoskeleton and Cell Motility, pp. 315-320		

Lipids (BC, OC)
• Types
• Storage
  ○ Triacyl glycerols
  ○ Free fatty acids: saponification
• Structural
  ○ Phospholipids and phosphatids
  ○ Sphingolipids
  ○ Waxes
• Signals/cofactors
  ○ Fat-soluble vitamins
  ○ Steroids
  ○ Prostaglandins
	Ch. 12
	Lipids and Cell Membranes,
	pp. 373-380
	Ch. 26
	The Biosynthesis of Membrane Lipids and Steroids,
	pp. 849-883
		Ch. 29
		Lipid Synthesis: Storage Lipids, Phospholipids and Cholesterol,
		pp. 577-601
			3.3
			Lipids
				Ch. 9
				Lipids and Biological Membranes,
				pp. 245-292
					Ch. 2
					Chemical Composition of the Body,
					pp. 40-45
					Ch. 4
					Metabolism,
					pp. 126-127
						Ch. 2
						The Chemical Basis of Life,
						pp. 46-49
						Ch. 4
						The Structure and Function of the Plasma Membrane,
						pp. 118-122
							Ch. 1.3A,
							pp. 35-39
								Ch. 11.6,
								pp. 116-121

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Content Category 5D: Structure, function, and reactivity of biologically-relevant molecules *(continued)*

Topic	*Biochemistry*	*Biochemistry: A Short Course*	*Biology, 2e*	*Fundamentals of Biochemistry*	*Human Physiology*	*Karp's Cell and Molecular Biology*	*Organic Chemistry With a Biological Emphasis, Vol. 1*	*Organic Chemistry With a Biological Emphasis, Vol. 2*
Carbohydrates (OC) • Description o Nomenclature and classification, common names o Absolute configuration o Cyclic structure and conformations of hexoses o Epimers and anomers • Hydrolysis of the glycoside linkage • Keto-enol tautomerism of monosaccharides • Disaccharides (BC) • Polysaccharides (BC)	Ch. 11 Carbohydrates, pp. 341-365	Ch. 10 Carbohydrates, pp. 181-201	3.2 Carbohydrates	Ch. 8 Carbohydrates, pp. 221-245	Ch. 2 Chemical Composition of the Body, pp. 36-40	Ch. 2 The Chemical Basis of Life, pp. 41-46	Ch. 1.3C, pp. 39-43 Ch. 3.2 pp. 137-146 Ch. 3.6, pp. 161-168 Ch. 3.8, pp. 171-173	Ch. 10.1-10.3, pp. 53-71 Ch. 12.2 A-B, pp. 153-157
Phenols (OC, BC) • Oxidation and reduction (e.g., hydroquinones, ubiquinones): biological 2e-redox centers				Ch.14 Introduction to Metabolism: Section 3. Oxidation-Reduction Reactions, pp. 461-466				Ch. 15.1-15.4, pp. 278-307
Polycyclic and Heterocyclic Aromatic Compounds (OC, BC) • Biological aromatic heterocycles				Ch. 3 Nucleotides, Nucleic Acids and Genetic Information: Section 1. Nucleotides, pp. 43				

Content Category 5E: Principles of chemical thermodynamics and kinetics

The processes that occur in living systems are dynamic, and they follow the principles of chemical thermo-dynamics and kinetics. The position of chemical equilibrium is dictated by the relative energies of products and reactants. The rate at which chemical equilibrium is attained is dictated by a variety of factors: concentration of reactants, temperature, and the amount of catalyst (if any).

Biological systems have evolved to harness energy and utilize it in very efficient ways to support all processes of life, including homeostasis and anabolism. Biological catalysts, known as enzymes, have evolved to allow all the relevant chemical reactions required to sustain life to occur both rapidly and efficiently, and under the narrow set of conditions required.

The content in this category covers all principles of chemical thermodynamics and kinetics including enzymatic catalysis.

Topic	*Biochemistry*	*Biochemistry: A Short Course*	*Biology, 2e*	*Fundamentals of Biochemistry*	*Human Physiology*	*Karp's Cell and Molecular Biology*	*Organic Chemistry With a Biological Emphasis, Vol. 1*	*Organic Chemistry With a Biological Emphasis, Vol. 2*
Enzymes (BC, BIO) • Classification by reaction type • Mechanism o Substrates and enzyme specificity o Active site model o Induced-fit model o Cofactors, coenzymes and vitamins • Kinetics o General (catalysis) o Michaelis-Menten o Cooperativity o Effects of local conditions on enzyme activity • Inhibition • Regulatory enzymes o Allosteric o Covalently modified	Ch. 8 Enzymes: Basic Concepts and Kinetics, pp. 223-264 Ch. 9 Catalytic Strategies, pp. 273-306 Ch. 10 Regulatory Strategies, pp. 303-335	Ch. 6 Basic Concepts of Enzyme Action, pp. 105-115 Ch. 7 Kinetics and Regulation, pp. 119-134 Ch. 8 Mechanisms and Inhibitors, pp. 143-156	6.5 Enzymes	Ch. 17 Enzyme Kinetics, Inhibition, and Control, pp. 346-401	Ch. 2 Chemical Composition of the Body, pp. 51-52 Ch. 4 Energy and Metabolism, pp. 102-106 Ch. 21 The Digestive System, pp. 762-763	Ch. 3 Bioenergetics, Enzymes, and Metabolism, pp. 89-100, 106, 109-110	Ch. 6.3-6.4, pp. 320-324	Ch. 16.5, pp. 355-360 Ch. 17.7-17.4, pp. 369-412

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Content Category 5E: Principles of chemical thermodynamics and kinetics *(continued)*

Topic	*Biochemistry*	*Biochemistry: A Short Course*	*Biology, 2e*	*Fundamentals of Biochemistry*	*Human Physiology*	*Karp's Cell and Molecular Biology*	*Organic Chemistry With a Biological Emphasis, Vol. 1*	*Organic Chemistry With a Biological Emphasis, Vol. 2*
Principles of Bioenergetics (BC) • Bioenergetics/thermodynamics o Free energy/K_{eq} o Concentration • Phosphorylation/ATP o ATP hydrolysis $\Delta G << 0$ o ATP group transfers • Biological oxidation-reduction o Half-reactions o Soluble electron carriers o Flavoproteins	Ch. 8 Enzymes: Basic Concepts and Kinetics, pp. 236-239 Ch. 15 Metabolism: Basic Concepts and Design, pp. 463-475 Ch. 18 Oxidative Phosphorylation, pp. 576-582 Phosphorylation, pp. 576-582	Ch. 6 Basic Concepts of Enzyme Action, pp. 108-114 Ch. 15 Metabolism: Basic Concepts, pp. 286-292 Ch. 20 The Electron-Transport Chain, pp. 402-413	6.1 Energy and Metabolism 6.2 Potential, Kinetic, Free, and Activation Energy 6.3 The Laws of Thermodynamics	Ch. 18 Electron Transport and Oxidative hosphorylation, pp. 588-629	Ch. 4 Metabolism, pp. 100-113	Ch. 3 Bioenergetics, Enzymes, and Metabolism	Ch. 6.2-6.4, pp. 312-324	Ch. 9.1-9.6, pp. 4-32 Ch. 15.1-15.2, pp. 278-287 Ch. 15.4B, pp. 303-307

Foundational Concept 6

Biological, psychological, and sociocultural factors influence the ways that individuals perceive, think about, and react to the world.

Content Category 6A: Sensing the environment

Psychological, sociocultural, and biological factors affect sensation and perception of the world. All sensory processing begins with first detecting a stimulus in the environment through sensory cells, receptors, and biological pathways.

After collecting sensory information, we then interpret and make sense of it. Although sensation and perception are distinct functions, they are both influenced by psychological, social, and biological factors and therefore become almost indistinguishable in practice. This complexity is illuminated by examining human sight, hearing, touch, taste, and smell.

The content in this category covers sensation and perception across all five human senses.

Topic	*Biochemistry*	*Biology, 2e*	*Human Physiology*

Sensory Processing (PSY, BIO)
• Sensation
  ○ Thresholds
  ○ Weber's Law (PSY)
  ○ Signal detection theory (PSY)
  ○ Sensory adaptation
• Sensory receptors
  ○ Sensory pathways
  ○ Types of sensory receptors
		36.1
		Sensory Processes
			Ch. 9
			Sensory Systems,
			pp. 281-306

Vision (PSY, BIO)
• Structure and function of the eye
• Visual processing
  ○ Visual pathways in the brain
  ○ Parallel processing (PSY)
  ○ Feature detection (PSY)
		36.5
		Vision
			Ch. 9
			Sensory Systems,
			pp. 314-333

Hearing (PSY, BIO) • Auditory processing ○ Auditory pathways in the brain • Sensory reception by hair cells (PSY)		36.4 Hearing and Vestibular Sensation	Ch. 9 Sensory Systems, pp. 333-345

(continued)

Content Category 6A: Sensing the environment *(continued)*

Topic	*Biochemistry*	*Biology, 2e*	*Human Physiology*

Other Senses (PSY, BIO)
• Somatosensation
  ○ Pain perception (PSY)
• Taste
  ○ Taste buds/ chemoreceptors that detect specific chemicals
• Smell
  ○ Olfactory cells/chemoreceptors that detect specific chemicals
  ○ Pheromones (BIO)
  ○ Olfactory pathways in the brain (BIO)
• Kinesthetic sense (PSY)
• Vestibular sense
	Ch. 34
	Sensory Systems,
	pp. 1087-1114
	(online chapter)
		36.2
		Somatosensation
		36.3
		Taste and Smell
			Ch. 9
			Sensory Systems,
			pp. 292-314, 345-347

Content Category 6B: Making sense of the environment

The way we think about the world depends on our awareness, thoughts, knowledge, and memories. It is also influenced by our ability to solve problems, make decisions, form judgments, and communicate. Psychological, sociocultural, and biological influences determine the development and use of these different yet convergent processes.

Biological factors underlie the mental processes that create our reality, shape our perception of the world, and influence the way we perceive and react to every aspect of our lives. The content in this category covers critical aspects of cognition — including consciousness, cognitive development, problem solving and decision making, intelligence, memory, and language.

Topic	*Human Physiology*

Cognition (PSY)
• Information-processing model
• Cognitive development
  ○ Piaget's stages of cognitive development
  ○ Cognitive changes in late adulthood
  ○ Role of culture in cognitive development
  ○ Influence of heredity and environment on cognitive development
• Biological factors that affect cognition (PSY, BIO)
• Problem solving and decision making (PSY, BIO)
  ○ Types of problem solving
  ○ Barriers to effective problem solving
  ○ Approaches to problem solving
  ○ Heuristics, biases, intuition, and emotion
  ◆ Overconfidence and belief perseverance
• Intellectual functioning
  ○ Multiple definitions of intelligence
  ○ Influence of heredity and environment on intelligence
  ○ Variations in intellectual ability
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Consciousness (PSY)
• States of consciousness
  ○ Alertness (PSY, BIO)
  ○ Sleep
  ◆ Stages of sleep
  ◆ Sleep cycles and changes to sleep cycles
  ◆ Sleep and circadian rhythms (PSY, BIO)
  ◆ Dreaming
  ◆ Sleep disorders
  ○ Hypnosis and meditation
• Consciousness altering drugs
  ○ Types of consciousness altering drugs and their effects on the nervous system and behavior
  ○ Drug addiction and the reward pathway in the brain
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(continued)

Content Category 6B: Making sense of the environment *(continued)*

Topic	*Human Physiology*

Memory (PSY)
• Encoding
  ○ Process of encoding information
  ○ Processes that aid in encoding memories
• Storage
  ○ Types of memory storage (i.e., sensory, working, long-term)
  ○ Semantic networks and spreading activation
• Retrieval
  ○ Recall, recognition, and relearning
  ○ Retrieval cues
  ○ The role of emotion in retrieving memories
• Forgetting
  ○ Aging and memory
  ○ Memory dysfunctions (e.g., Alzheimer's disease, Korsakoff's syndrome)
  ○ Decay
  ○ Interference
  ○ Memory construction and source monitoring
• Changes in synaptic connections underlie memory and learning (PSY, BIO)
  ○ Neural plasticity
  ○ Memory and learning
  ○ Long-term potentiation
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Language (PSY) • Theories of language development (e.g., learning, Nativist, Interactionist) • Influence of language on cognition • Different brain areas control language and speech (PSY, BIO)	Ch. 8 The Central Nervous System, pp. 269-270

Foundational Concept 7

Biological, psychological, and sociocultural factors influence behavior and behavior change.

Content Category 7A: Individual influences on behavior

A complex interplay of psychological and biological factors shapes behavior. Biological structures and processes serve as the pathway by which bodies carry out activities. They also affect predispositions to behave in certain ways, shape personalities, and influence the likelihood of developing psychological disorders. Psychological factors also affect behavior, and consequently, health and well-being.

The content in this category covers biological bases of behavior, including the effect of genetics and how the nervous and endocrine systems affect behavior. It also addresses how personality, psychological disorders, motivation, and attitudes affect behavior. Some of these topics are learned in the context of non-human animal species.

Topic	*Human Physiology*

Biological Bases of Behavior (PSY, BIO)
• The nervous system
  ○ Neurons
  ◆ The reflex arc
  ○ Neurotransmitters
  ○ Peripheral nervous system
  ○ Central nervous system
  ◆ The brain
  • The brainstem
  • The cerebellum
  • The diencephalon (BIO)
  • The cerebrum
  • Control of voluntary movement in the cerebral
  • Information processing in the cerebral cortex
  • Lateralization of cortical functions
• Neurons communicate and influence behavior (PSY)
• Influence of neurotransmitters on behavior (PSY)
• The endocrine system
  ○ Components of the endocrine system
  ○ Effects of the endocrine system on behavior
• Behavioral genetics
• Genes, temperament, heredity
• Adaptive value of traits and behaviors
• Interaction between heredity and environmental influences
(continued)
	Ch. 7
	The Nervous System and Neuronal Excitability
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	Ch. 12
	Control of Body Movement,
	pp. 426-437
	Ch. 13
	The Endocrine System,
	pp. 448-456
	Ch. 23
	The Reproductive Systems,
	pp. 839-850

(continued)

Content Category 7A: Individual influences on behavior *(continued)*

Topic	*Human Physiology*

Biological Bases of Behavior (PSY, BIO) *(continued)*
• Genetic and environmental factors contribute to the development of behaviors
  ○ Experience and behavior (PSY)
  ○ Regulatory genes and behavior (BIO)
  ○ Genetically based behavioral variation in natural populations
• Human physiological development (PSY)
  ○ Prenatal development
  ○ Motor development
  ○ Developmental changes in adolescence	

Psychological Disorders (PSY)
• Understanding psychological disorders
  ○ Biomedical vs. biopsychosocial approaches
  ○ Classifying psychological disorders
  ○ Rates of psychological disorders
• Types of psychological disorders
  ○ Anxiety disorders
  ○ Somatoform disorders
  ○ Mood disorders
  ○ Schizophrenia
  ○ Dissociative disorder
  ○ Personality disorders
• Biological bases of nervous system disorders (PSY, BIO)
  ○ Schizophrenia
  ○ Depression
  ○ Alzheimer's disease
  ○ Parkinson's disease
  ○ Stem cell-based therapy to regenerate neurons in CNS (BIO)
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	The Nervous System and Neuronal Excitability,
	p. 236
	Ch. 8
	The Central Nervous System,
	p. 275
	Ch. 12
	Control of Body Movement,
	p. 441

Motivation (PSY)
• Factors that influence motivation
  ○ Instinct
  ○ Arousal
  ○ Drives
  ◆ Negative feedback systems (PSY, BIO)
  ○ Needs
• Theories that explain how motivation affects human behavior
  ○ Drive reduction theory
  ○ Incentive theory
  ○ Other: Cognitive and need-based theories
• Application of theories of motivation to understand behaviors (e.g., eating, sexual, drug and alcohol use)
  ○ Biological factors in regulation of these motivational processes
  ○ Sociocultural factors in regulation of these motivational processes
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Content Category 7C: Attitude and behavior change

Learning is a relatively permanent change in behavior brought about by experience. There are a number of different types of learning, which include habituation as well as associative, observational, and social learning.

Although people can learn new behaviors and change their attitudes, psychological, environmental, and biological factors influence whether those changes will be short-term or long-term. Understanding how people learn new behaviors and change their attitudes and the conditions that affect learning helps us understand behavior and our interactions with others.

The content in this category covers learning and theories of attitude and behavior change. This includes the elaboration likelihood model and social cognitive theory.

Topic	*Human Physiology*

Associative Learning (PSY)
• Classical conditioning (PSY, BIO)
  ○ Neutral, conditioned, and unconditioned stimuli
  ○ Conditioned and unconditioned response
  ○ Processes: acquisition, extinction, spontaneous recovery, generalization, discrimination
• Operant conditioning (PSY, BIO)
  ○ Processes of shaping and extinction
  ○ Types of reinforcement: positive, negative, primary, conditional
  ○ Reinforcement schedules: fixed-ratio, variable-ratio, fixed-interval, variable-interval
  ○ Punishment
  ○ Escape and avoidance learning
• Cognitive processes that affect associative learning
• Biological factors that affect associative learning
  ○ Innate behaviors are developmentally fixed
  ○ Learned behaviors are modified based on experiences
  ○ Development of learned behaviors (PSY, BIO)
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	pp. 273-275

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