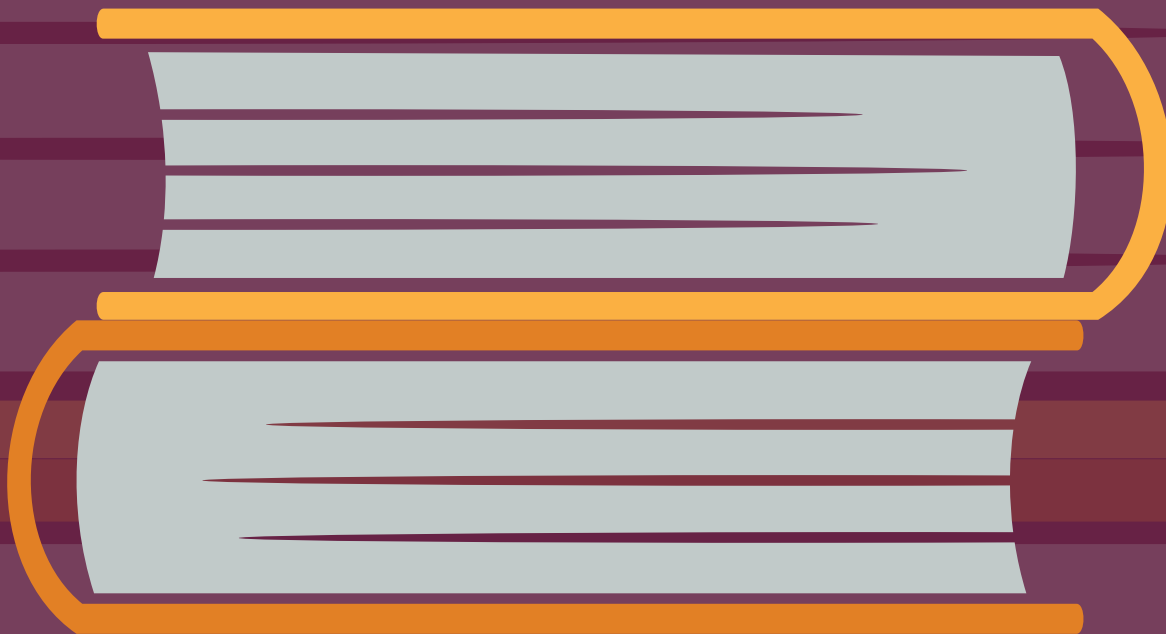




Tomorrow's Doctors, Tomorrow's Cures®

# A Road Map to MCAT® Content in Biochemistry Textbooks



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

## 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.

**A Road Map to MCAT® Content in Biochemistry Textbooks**
**Content Category 1A: Structure and function of proteins and their constituent amino acids**

Topic	<i>Biochemistry</i>	<i>Biochemistry: A Short Course</i>	<i>Biology, 2e</i>	<i>Fundamentals of Biochemistry</i>	<i>Human Physiology</i>	<i>Karp's Cell and Molecular Biology</i>	<i>Organic Chemistry With a Biological Emphasis, Vol. 1</i>	<i>Organic Chemistry With a Biological Emphasis, Vol. 2</i>
<b>Amino Acids (BC, OC)</b> Description <ul style="list-style-type: none"> <li>• Absolute configuration at the <math>\alpha</math> position</li> <li>• Amino acids as dipolar ions</li> <li>• Classifications               <ul style="list-style-type: none"> <li>◦ Acidic or basic</li> <li>◦ Hydrophobic or hydrophilic</li> </ul> </li> </ul> Reactions <ul style="list-style-type: none"> <li>• Sulfur linkage: cysteine and cysteine</li> <li>• Peptide linkage: polypeptides and proteins</li> <li>• Hydrolysis</li> </ul>	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
<b>Protein Structure (BIO, BC, OC)</b> Structure <ul style="list-style-type: none"> <li>• 1° structure of proteins</li> <li>• 2° structure of proteins</li> <li>• 3° structure of proteins; role of proline, cystine, hydrophobic bonding</li> <li>• 4° structure of proteins (BIO, BC)</li> </ul> Conformational stability <ul style="list-style-type: none"> <li>• Denaturing and folding</li> <li>• Hydrophobic interactions</li> <li>• Solvation layer (entropy) (BC)</li> </ul> Separation techniques <ul style="list-style-type: none"> <li>• Isoelectric point</li> <li>• Electrophoresis</li> </ul>	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	<u>Ch. 3.4 Proteins</u>	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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**A Road Map to MCAT® Content in Biochemistry Textbooks**
**Content Category 1A: Structure and function of proteins and their constituent amino acids (continued)**

Topic	<i>Biochemistry</i>	<i>Biochemistry: A Short Course</i>	<i>Biology, 2e</i>	<i>Fundamentals of Biochemistry</i>	<i>Human Physiology</i>	<i>Karp's Cell and Molecular Biology</i>	<i>Organic Chemistry With a Biological Emphasis, Vol. 1</i>	<i>Organic Chemistry With a Biological Emphasis, Vol. 2</i>
<b>Non-Enzymatic Protein Function (BIO, BC)</b> <ul style="list-style-type: none"> <li>• Binding</li> <li>• Immune system</li> <li>• Motors</li> </ul>	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	<a href="#">42.1 Innate Immune Response</a>	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		
<b>Enzyme Structure and Function (BIO, BC)</b> <ul style="list-style-type: none"> <li>• Function of enzymes in catalyzing biological reactions</li> <li>• Enzyme classification by reaction type</li> <li>• Reduction of activation energy</li> <li>• Substrates and enzyme specificity</li> <li>• Active Site Model</li> <li>• Induced-fit Model</li> <li>• Mechanism of catalysis               <ul style="list-style-type: none"> <li>◦ Cofactors</li> <li>◦ Coenzymes</li> <li>◦ Water-soluble vitamins</li> </ul> </li> <li>• Effects of local conditions on enzyme activity</li> </ul>	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	<a href="#">6.5 Enzymes</a>	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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**A Road Map to MCAT® Content in Biochemistry Textbooks**
**Content Category 1A: Structure and function of proteins and their constituent amino acids (continued)**

Topic	<i>Biochemistry</i>	<i>Biochemistry: A Short Course</i>	<i>Biology, 2e</i>	<i>Fundamentals of Biochemistry</i>	<i>Human Physiology</i>	<i>Karp's Cell and Molecular Biology</i>	<i>Organic Chemistry With a Biological Emphasis, Vol. 1</i>	<i>Organic Chemistry With a Biological Emphasis, Vol. 2</i>
<b>Control of Enzyme Activity (BIO, BC)</b> <ul style="list-style-type: none"> <li>• Kinetics               <ul style="list-style-type: none"> <li>◦ General (catalysis)</li> <li>◦ Michaelis-Menten</li> <li>◦ Cooperativity</li> </ul> </li> <li>• Feedback regulation</li> <li>• Inhibition — types               <ul style="list-style-type: none"> <li>◦ Competitive</li> <li>◦ Noncompetitive</li> <li>◦ Mixed (BC)</li> <li>◦ Uncompetitive (BC)</li> </ul> </li> <li>• Regulatory enzymes               <ul style="list-style-type: none"> <li>◦ Allosteric enzymes</li> <li>◦ Covalently modified enzymes</li> <li>◦ Zymogen</li> </ul> </li> </ul>	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	<u>6.5</u> <u>Enzymes</u>	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.

**A Road Map to MCAT® Content in Biochemistry Textbooks**
**Content Category 1B: Transmission of genetic information from the gene to the protein**

Topic	<i>Biochemistry</i>	<i>Biochemistry: A Short Course</i>	<i>Biology, 2e</i>	<i>Fundamentals of Biochemistry</i>	<i>Human Physiology</i>	<i>Karp's Cell and Molecular Biology</i>	<i>Organic Chemistry With a Biological Emphasis, Vol. 1</i>	<i>Organic Chemistry With a Biological Emphasis, Vol. 2</i>
<b>Nucleic Acid Structure and Function (BIO, OC, BC)</b> <ul style="list-style-type: none"> <li>Description</li> <li>Nucleotides and nucleosides               <ul style="list-style-type: none"> <li>Sugar phosphate backbone</li> <li>Pyrimidine, purine residues</li> </ul> </li> <li>Deoxyribonucleic acid (DNA): double helix, Watson-Crick model of DNA structure</li> <li>Base-pairing specificity: A with T, G with C</li> <li>Function in transmission of genetic information (BIO)</li> <li>DNA denaturation, reannealing, hybridization</li> </ul>	Ch. 4 DNA, RNA, and the Flow of Genetic Information, pp. 113-140	Ch. 33 The Structure of Informational Macromolecules pp. 673-690	<u>Ch. 14.2</u> <u>DNA Structure and Function</u>	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
<b>DNA Replication (BIO)</b> <ul style="list-style-type: none"> <li>Mechanism of replication: separation of strands, specific coupling of free nucleic acids</li> <li>Semi-conservative nature of replication</li> <li>Specific enzymes involved in replication</li> <li>Origins of replication, multiple origins in eukaryotes</li> <li>Replicating the ends of DNA molecules</li> </ul>	Ch. 29 DNA Replication, Repair, and Recombination, pp. 949-979	Ch. 34 DNA Replication, pp. 695-709	<u>Ch. 14.3</u> <u>Basics of DNA Replication</u> <u>Ch. 14.4</u> <u>DNA Replication in Prokaryotes</u> <u>Ch. 14.5</u> <u>DNA Replication in Eukaryotes</u>	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		
<b>Repair of DNA (BIO)</b> <ul style="list-style-type: none"> <li>Repair during replication</li> <li>Repair of mutations</li> </ul>	Ch. 29 DNA Replication, Repair, and Recombination, pp. 968-970	Ch. 35 DNA Repair and Replication, pp. 715-726	<u>Ch. 14.6</u> <u>DNA Repair</u>	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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**A Road Map to MCAT® Content in Biochemistry Textbooks**
**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
<b>Genetic Code (BIO)</b> <ul style="list-style-type: none"> <li>Central Dogma: DNA → RNA → protein</li> <li>The triplet code</li> <li>Codon-anticodon relationship</li> <li>Degenerate code, wobble pairing</li> <li>Missense, nonsense codons</li> <li>Initiation, termination codons</li> <li>Messenger RNA (mRNA)</li> </ul>	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	<a href="#">Ch. 15.1 The Genetic Code</a>	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		
<b>Transcription (BIO)</b> <ul style="list-style-type: none"> <li>Transfer RNA (tRNA); ribosomal RNA (rRNA)</li> <li>Mechanism of transcription</li> <li>mRNA processing in eukaryotes, introns, exons</li> <li>Ribozymes, spliceosomes, small nuclear ribonucleoproteins (snRNPs), small nuclear RNA (snRNAs)</li> <li>Functional and evolutionary importance of introns</li> </ul>	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	<a href="#">Ch. 15.2 Prokaryotic Transcription</a>  <a href="#">Ch. 15.3 Eukaryotic Transcription</a>  <a href="#">Ch. 15.4 RNA Processing in Eukaryotes</a>	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		
<b>Translation (BIO)</b> <ul style="list-style-type: none"> <li>Roles of mRNA, tRNA, rRNA</li> <li>Role and structure of ribosomes</li> <li>Initiation, termination co-factors</li> <li>Post-translational modification of proteins</li> </ul>	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	<a href="#">Ch. 15.5 Ribosomes and Protein Synthesis</a>	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	<i>Biochemistry</i>	<i>Biochemistry: A Short Course</i>	<i>Biology, 2e</i>	<i>Fundamentals of Biochemistry</i>	<i>Human Physiology</i>	<i>Karp's Cell and Molecular Biology</i>	<i>Organic Chemistry With a Biological Emphasis, Vol. 1</i>	<i>Organic Chemistry With a Biological Emphasis, Vol. 2</i>
<b>Eukaryotic Chromosome Organization (BIO)</b> <ul style="list-style-type: none"> <li>• Chromosomal proteins</li> <li>• Single copy vs. repetitive DNA</li> <li>• Supercoiling</li> <li>• Heterochromatin vs. euchromatin</li> <li>• Telomeres, centromeres</li> </ul>		Ch. 33 The Structure of Informational Macromolecules, pp. 685-690	<u>Ch. 14.2 DNA Structure and Sequencing</u>	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		
<b>Control of Gene Expression in Prokaryotes (BIO)</b> <ul style="list-style-type: none"> <li>• Operon Concept, Jacob-Monod Model</li> <li>• Gene repression in bacteria</li> <li>• Positive control in bacteria</li> </ul>	Ch. 32 The Control of Gene Expression in Prokaryotes, pp. 1057-1071	Ch. 36 RNA Synthesis and Regulation in Bacteria, pp. 733-746	<u>Ch. 16.1 Regulation of Gene Expression</u> <u>Ch. 16.2 Prokaryotic Gene Regulation</u>	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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**A Road Map to MCAT® Content in Biochemistry Textbooks**
**Content Category 1B: Transmission of genetic information from the gene to the protein (continued)**

Topic	<i>Biochemistry</i>	<i>Biochemistry: A Short Course</i>	<i>Biology, 2e</i>	<i>Fundamentals of Biochemistry</i>	<i>Human Physiology</i>	<i>Karp's Cell and Molecular Biology</i>	<i>Organic Chemistry With a Biological Emphasis, Vol. 1</i>	<i>Organic Chemistry With a Biological Emphasis, Vol. 2</i>
<b>Control of Gene Expression in Eukaryotes (BIO)</b> <ul style="list-style-type: none"> <li>• Transcriptional regulation</li> <li>• DNA binding proteins, transcription factors</li> <li>• Gene amplification and duplication</li> <li>• Post-transcriptional control, basic concept of splicing (introns, exons)</li> <li>• Cancer as a failure of normal cellular controls, oncogenes, tumor-suppressor genes</li> <li>• Regulation of chromatin structure</li> <li>• DNA methylation</li> <li>• Role of noncoding RNAs</li> </ul>	Ch. 33 The Control of Gene Expression in Eukaryotes, pp. 1075-1094	Ch. 37 Gene Expression in Eukaryotes, pp. 751-763	<a href="#">Ch. 16.3 Eukaryotic Epigenetic Gene Regulation</a> <a href="#">Ch. 16.4 Eukaryotic Transcription Gene Regulation</a> <a href="#">Ch. 16.5 Eukaryotic Post-Transcriptional Gene Regulation</a> <a href="#">Ch. 16.6 Eukaryotic Translational and Post-Translational Gene Regulation</a> <a href="#">Ch. 16.7 Cancer and Gene Regulation</a>	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		

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**A Road Map to MCAT® Content in Biochemistry Textbooks**
**Content Category 1B: Transmission of genetic information from the gene to the protein (continued)**

Topic	<i>Biochemistry</i>	<i>Biochemistry: A Short Course</i>	<i>Biology, 2e</i>	<i>Fundamentals of Biochemistry</i>	<i>Human Physiology</i>	<i>Karp's Cell and Molecular Biology</i>	<i>Organic Chemistry With a Biological Emphasis, Vol. 1</i>	<i>Organic Chemistry With a Biological Emphasis, Vol. 2</i>
<b>Recombinant DNA and Biotechnology (BIO)</b> <ul style="list-style-type: none"> <li>• Gene cloning</li> <li>• Restriction enzymes</li> <li>• DNA libraries</li> <li>• Generation of cDNA</li> <li>• Hybridization</li> <li>• Expressing cloned genes</li> <li>• Polymerase chain reaction</li> <li>• Gel electrophoresis and Southern blotting</li> <li>• DNA sequencing</li> <li>• Analyzing gene expression</li> <li>• Determining gene function</li> <li>• Stem cells</li> <li>• Practical applications of DNA technology: medical applications, human gene therapy, pharmaceuticals, forensic evidence, nvironmental cleanup, agriculture</li> <li>• Safety and ethics of DNA technology</li> </ul>	Ch. 5 Exploring Genes and Genomes, pp. 145-180	Ch. 41 Recombinant DNA Techniques, pp. 827-847	<u>Ch. 17.1 Biotechnology</u> <u>Ch. 17.2 Mapping Genomes</u> <u>Ch. 17.3 Whole-Genome Sequencing</u> <u>Ch. 17.4 Applying Genomics</u> <u>Ch. 17.5 Genomics and Proteomics</u>	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	<i>Biochemistry</i>	<i>Biochemistry: A Short Course</i>	<i>Biology, 2e</i>	<i>Fundamentals of Biochemistry</i>	<i>Human Physiology</i>	<i>Karp's Cell and Molecular Biology</i>
Evidence that DNA is Genetic Material (BIO)			<a href="#">Ch. 14.1 Historical Basis of Modern Understanding</a>	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

(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
<b>Mendelian Concepts (BIO)</b> <ul style="list-style-type: none"> <li>• Phenotype and genotype</li> <li>• Gene</li> <li>• Locus</li> <li>• Allele: single and multiple</li> <li>• Homozygosity and heterozygosity</li> <li>• Wild-type</li> <li>• Recessiveness</li> <li>• Complete dominance</li> <li>• Co-dominance</li> <li>• Incomplete dominance, leakage, penetrance, expressivity</li> <li>• Hybridization: viability</li> <li>• Gene pool</li> </ul>			<u>Ch. 12.1</u> <u>Mendel's</u> <u>Experiments</u> <u>and the Laws</u> <u>of Probability</u>  <u>Ch. 12.2</u> <u>Characteristics</u> <u>and Traits</u>  <u>Ch. 12.3</u> <u>Laws of</u> <u>Inheritance</u>			Ch. 10 The Nature of the Gene and the Genome, pp. 366-373
<b>Meiosis and Other Factors Affecting Genetic Variability (BIO)</b> <ul style="list-style-type: none"> <li>• Significance of meiosis</li> <li>• Important differences between meiosis and mitosis</li> <li>• Segregation of genes               <ul style="list-style-type: none"> <li>◦ Independent assortment</li> <li>◦ Linkage</li> <li>◦ Recombination                   <ul style="list-style-type: none"> <li>◆ Single crossovers</li> <li>◆ Double crossovers</li> <li>◆ Synaptonemal complex</li> <li>◆ Tetrad</li> </ul> </li> <li>◦ Sex-linked characteristics</li> <li>◦ Very few genes on Y chromosome</li> <li>◦ Sex determination</li> <li>◦ Cytoplasmic/extranuclear inheritance</li> </ul> </li> <li>• Mutation               <ul style="list-style-type: none"> <li>◦ General concept of mutation — error in DNA sequence</li> <li>◦ Types of mutations: random, translation error, transcription error, base substitution, inversion, addition, deletion, translocation, mispairing</li> <li>◦ Advantageous vs. deleterious mutation</li> <li>◦ Inborn errors of metabolism</li> <li>◦ Relationship of mutagens to carcinogens</li> </ul> </li> <li>• Genetic drift</li> <li>• Synapsis or crossing-over mechanism for increasing genetic diversity</li> </ul>			<u>Ch. 11.1</u> <u>The Process</u> <u>of Meiosis</u>  <u>Ch. 11.2</u> <u>Sexual</u> <u>Reproduction</u>  <u>Ch. 13.1</u> <u>Chromosomal</u> <u>Theory and</u> <u>Genetic Linkage</u>  <u>Ch. 13.2</u> <u>Chromosomal</u> <u>Basis of</u> <u>Inherited</u> <u>Disorders</u>	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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**A Road Map to MCAT® Content in Biochemistry Textbooks**
**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
<b>Analytic Methods (BIO)</b> <ul style="list-style-type: none"> <li>• Hardy-Weinberg Principle</li> <li>• Test cross</li> <li>• Gene mapping: crossover frequencies</li> <li>• Biometry: statistical methods</li> </ul>			<a href="#">Ch. 19.1 Population Evolution</a> <a href="#">Ch. 19.2 Population Genetics</a> <a href="#">Ch. 19.3 Adaptive Evolution</a>			Ch. 10 The Nature of the Gene and the Genome, pp. 370-373
<b>Evolution (BIO)</b> <ul style="list-style-type: none"> <li>• Natural selection <ul style="list-style-type: none"> <li>◦ Fitness concept</li> <li>◦ Selection by differential reproduction</li> <li>◦ Concepts of natural and group selection</li> <li>◦ Evolutionary success as increase in percentage representation in the gene pool of the next generation</li> </ul> </li> <li>• Speciation <ul style="list-style-type: none"> <li>◦ Polymorphism</li> <li>◦ Adaptation and specialization</li> <li>◦ Inbreeding</li> <li>◦ Outbreeding</li> <li>◦ Bottlenecks</li> </ul> </li> <li>• Evolutionary time as measured by gradual random changes in genome</li> </ul>			<a href="#">Ch. 18.1 Understanding Evolution</a> <a href="#">Ch. 18.2 Formation of New Species</a> <a href="#">Ch. 18.3 Reconnection and Speciation Rates</a>	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
<b>Principles of Bioenergetics (BC, GC)</b> <ul style="list-style-type: none"> <li>• Bioenergetics/thermodynamics <ul style="list-style-type: none"> <li>◦ Free energy/<math>K_{eq}</math> <ul style="list-style-type: none"> <li>◆ Equilibrium constant</li> <li>◆ Relationship of the equilibrium constant and <math>\Delta G^\circ</math></li> </ul> </li> <li>◦ Concentration <ul style="list-style-type: none"> <li>◆ Le Châtelier's Principle</li> </ul> </li> <li>◦ Endothermic/exothermic reactions</li> <li>◦ Free energy: G</li> <li>◦ Spontaneous reactions and <math>\Delta G^\circ</math></li> </ul> </li> <li>• Phosphoryl group transfers and ATP <ul style="list-style-type: none"> <li>◦ ATP hydrolysis <math>\Delta G \ll 0</math></li> <li>◦ ATP group transfers</li> </ul> </li> <li>• Biological oxidation-reduction <ul style="list-style-type: none"> <li>◦ Half-reactions</li> <li>◦ Soluble electron carriers</li> </ul> </li> <li>• Flavoproteins</li> </ul>	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	<a href="#">6.1 Energy and Metabolism</a> <a href="#">6.2 Potential, Kinetic, Free, and Activation Energy</a> <a href="#">6.3 The Laws of Thermodynamics</a> <a href="#">6.4 ATP: Adenosine Triphosphate</a>	Ch. 12 Enzyme Kinetics, Inhibition, and Control, pp. 361-401	Ch. 4 Metabolism, pp. 100-113	Ch. 3 Bioenergetics, Enzymes, and Metabolism

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

Topic	<i>Biochemistry</i>	<i>Biochemistry: A Short Course</i>	<i>Biology, 2e</i>	<i>Fundamentals of Biochemistry</i>	<i>Human Physiology</i>	<i>Karp's Cell and Molecular Biology</i>
<b>Carbohydrates (BC, OC)</b> <ul style="list-style-type: none"> <li>• Description               <ul style="list-style-type: none"> <li>◦ Nomenclature and classification, common names</li> <li>◦ Absolute configuration</li> <li>◦ Cyclic structure and conformations of hexoses</li> <li>◦ Epimers and anomers</li> </ul> </li> <li>• Hydrolysis of the glycoside linkage</li> <li>• Monosaccharides</li> <li>• Disaccharides               <ul style="list-style-type: none"> <li>◦ Polysaccharides</li> </ul> </li> </ul>	Ch. 11 Carbohydrates, pp. 341-365	Ch. 10 Carbohydrates, pp. 181-201	<u>3.2</u> <u>Carbohydrates</u>	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	<i>Biochemistry</i>	<i>Biochemistry: A Short Course</i>	<i>Biology, 2e</i>	<i>Fundamentals of Biochemistry</i>	<i>Human Physiology</i>	<i>Karp's Cell and Molecular Biology</i>	<i>Organic Chemistry With a Biological Emphasis, Vol. 2</i>
<b>Glycolysis, Gluconeogenesis, and the Pentose Phosphate Pathway (BIO, BC)</b> <ul style="list-style-type: none"> <li>Glycolysis (aerobic), substrates and products               <ul style="list-style-type: none"> <li>Feeder pathways: glycogen, starch metabolism</li> </ul> </li> <li>Fermentation (anaerobic glycolysis)</li> <li>Gluconeogenesis (BC)</li> <li>Pentose phosphate pathway (BC)</li> <li>Net molecular and energetic results of respiration processes</li> </ul>	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	<u>7.2 Glycolysis</u> (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	
<b>Principles of Metabolic Regulation (BC)</b> <ul style="list-style-type: none"> <li>Regulation of metabolic pathways (BIO, BC)               <ul style="list-style-type: none"> <li>Maintenance of a dynamic steady state</li> </ul> </li> <li>Regulation of glycolysis and gluconeogenesis</li> <li>Metabolism of glycogen</li> <li>Regulation of glycogen synthesis and breakdown               <ul style="list-style-type: none"> <li>Allosteric and hormonal control</li> </ul> </li> <li>Analysis of metabolic control</li> </ul>	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	<u>7.7 Regulation of Cellular Respiration</u>	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	

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**A Road Map to MCAT® Content in Biochemistry Textbooks**
**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
<b>Citric Acid Cycle (BIO, BC)</b> <ul style="list-style-type: none"> <li>• Acetyl-CoA production (BC)</li> <li>• Reactions of the cycle, substrates and products</li> <li>• Regulation of the cycle</li> <li>• Net molecular and energetic results of respiration processes</li> </ul>	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	<u>7.3</u> <u>Oxidation of Pyruvate and the Citric Acid Cycle</u>	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
<b>Metabolism of Fatty Acids and Proteins (BIO, BC)</b> <ul style="list-style-type: none"> <li>• Description of fatty acids (BC)</li> <li>• Digestion, mobilization, and transport of fats</li> <li>• Oxidation of fatty acids <ul style="list-style-type: none"> <li>◦ Saturated fats</li> <li>◦ Unsaturated fats</li> </ul> </li> <li>• Ketone bodies (BC)</li> <li>• Anabolism of fats (BIO)</li> <li>• Nontemplate synthesis: biosynthesis of lipids and polysaccharides (BIO)</li> <li>• Metabolism of proteins (BIO)</li> </ul>	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
<b>Oxidative Phosphorylation (BIO, BC)</b> <ul style="list-style-type: none"> <li>• Electron transport chain and oxidative phosphorylation, substrates and products, general features of the pathway</li> <li>• Electron transfer in mitochondria <ul style="list-style-type: none"> <li>◦ NADH, NADPH</li> <li>◦ Flavoproteins</li> <li>◦ Cytochromes</li> </ul> </li> <li>• ATP synthase, chemiosmotic coupling <ul style="list-style-type: none"> <li>◦ Proton motive force</li> </ul> </li> <li>• Net molecular and energetic results of respiration processes</li> <li>• Regulation of oxidative phosphorylation</li> <li>• Mitochondria, apoptosis, oxidative stress (BC)</li> </ul>	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	<u>7.4</u> <u>Oxidative Phosphorylation</u>	Ch. 14 Introduction to Metabolism, pp. 442-477	Ch. 4 Metabolism, pp. 106-113	Ch. 5 Aerobic Respiration and the Mitochondrion, pp. 168-186	

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

Topic	<i>Biochemistry</i>	<i>Biochemistry: A Short Course</i>	<i>Biology, 2e</i>	<i>Fundamentals of Biochemistry</i>	<i>Human Physiology</i>	<i>Karp's Cell and Molecular Biology</i>	<i>Organic Chemistry With a Biological Emphasis, Vol. 2</i>
<b>Hormonal Regulation and Integration of Metabolism (BC)</b> <ul style="list-style-type: none"> <li>• Higher-level integration of hormone structure and function</li> <li>• Tissue-specific metabolism</li> <li>• Hormonal regulation of fuel metabolism</li> <li>• Obesity and regulation of body mass</li> </ul>	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.

**A Road Map to MCAT® Content in Biochemistry Textbooks**
**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
<b>Plasma Membrane (BIO, BC)</b> <ul style="list-style-type: none"> <li>• General function in cell containment</li> <li>• Composition of membranes               <ul style="list-style-type: none"> <li>◦ Lipid components (BIO, BC, OC)                   <ul style="list-style-type: none"> <li>◆ Phospholipids (and phosphatids)</li> <li>◆ Steroids</li> <li>◆ Waxes</li> </ul> </li> <li>◦ Protein components</li> <li>◦ Fluid mosaic model</li> </ul> </li> <li>• Membrane dynamics</li> <li>• Solute transport across membranes               <ul style="list-style-type: none"> <li>◦ Thermodynamic considerations</li> <li>◦ Osmosis                   <ul style="list-style-type: none"> <li>◆ Colligative properties; osmotic pressure (GC)</li> </ul> </li> <li>◦ Passive transport</li> <li>◦ Active transport                   <ul style="list-style-type: none"> <li>◆ Sodium/potassium pump</li> </ul> </li> </ul> </li> <li>• Membrane channels</li> <li>• Membrane potential</li> <li>• Membrane receptors</li> <li>• Exocytosis and endocytosis</li> <li>• Intercellular junctions (BIO)               <ul style="list-style-type: none"> <li>◦ Gap junctions</li> <li>◦ Tight junctions</li> <li>◦ Desmosomes</li> </ul> </li> </ul>	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	<u>4.6</u> <u>Connections</u> <u>Between Cells</u> <u>and Cellular</u> <u>Activities</u>  <u>5.1</u> <u>Components</u> <u>and Structure</u>  <u>5.2</u> <u>Passive Transport</u>  <u>5.3</u> <u>Active Transport</u>  <u>5.4</u> <u>Bulk Transport</u>	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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**A Road Map to MCAT® Content in Biochemistry Textbooks**
**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
<b>Membrane-Bound Organelles and Defining Characteristics of Eukaryotic Cells (BIO)</b> <ul style="list-style-type: none"> <li>Defining characteristics of eukaryotic cells: membrane-bound nucleus, presence of organelles, mitotic division</li> <li>Nucleus <ul style="list-style-type: none"> <li>Compartmentalization, storage of genetic information</li> <li>Nucleolus: location and function</li> <li>Nuclear envelope, nuclear pores</li> </ul> </li> <li>Mitochondria <ul style="list-style-type: none"> <li>Site of ATP production</li> <li>Inner and outer membrane structure (BIO, BC)</li> <li>Self-replication</li> </ul> </li> <li>Lysosomes: membrane-bound vesicles containing hydrolytic enzymes</li> <li>Endoplasmic reticulum <ul style="list-style-type: none"> <li>Rough and smooth components</li> <li>Rough endoplasmic reticulum site of ribosomes</li> <li>Double membrane structure</li> <li>Role in membrane biosynthesis</li> <li>Role in biosynthesis of secreted proteins</li> </ul> </li> <li>Golgi apparatus: general structure and role in packaging and secretion</li> <li>Peroxisomes: organelles that collect peroxides</li> </ul>		Ch. 1 Biochemistry and the Unity of Life, pp. 9-15  Ch. 20 The Electron Transport Chain, pp. 400-402	<u>4.3</u> 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	
<b>Cytoskeleton (BIO)</b> <ul style="list-style-type: none"> <li>General function in cell support and movement</li> <li>Microfilaments: composition and role in cleavage and contractility</li> <li>Microtubules: composition and role in support and transport</li> <li>Intermediate filaments, role in support</li> <li>Composition and function of cilia and flagella</li> <li>Centrioles, microtubule organizing centers</li> </ul>			<u>4.5</u> 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	<i>Biochemistry</i>	<i>Biochemistry: A Short Course</i>	<i>Biology, 2e</i>	<i>Fundamentals of Biochemistry</i>	<i>Human Physiology</i>	<i>Karp's Cell and Molecular Biology</i>	<i>Organic Chemistry With a Biological Emphasis, Vol. 1</i>
<b>Tissues Formed From Eukaryotic Cells (BIO)</b> <ul style="list-style-type: none"> <li>• Epithelial cells</li> <li>• Connective tissue cells</li> </ul>			<u>33.2</u> <u>Animal</u> <u>Primary Tissues</u>	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	<i>Biology, 2e</i>	<i>Fundamentals of Biochemistry</i>	<i>Karp's Cell and Molecular Biology</i>
<b>Cell Theory (BIO)</b> <ul style="list-style-type: none"> <li>• History and development</li> <li>• Impact on biology</li> </ul>		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
<b>Classification and Structure of Prokaryotic Cells (BIO)</b> <ul style="list-style-type: none"> <li>• Prokaryotic domains               <ul style="list-style-type: none"> <li>◦ Archaea</li> <li>◦ Bacteria</li> </ul> </li> <li>• Major classifications of bacteria by shape               <ul style="list-style-type: none"> <li>◦ Bacilli (rod-shaped)</li> <li>◦ Spirilli (spiral shaped)</li> <li>◦ Cocci (spherical)</li> </ul> </li> <li>• Lack of nuclear membrane and mitotic apparatus</li> <li>• Lack of typical eukaryotic organelles</li> <li>• Presence of cell wall in bacteria</li> <li>• Flagellar propulsion, mechanism</li> </ul>	<u>Ch. 22.1 Prokaryotic Diversity</u> <u>Ch. 22.2 Structure of Prokaryotes: Bacteria and Archaea</u>	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
<b>Growth and Physiology of Prokaryotic Cells (BIO)</b> <ul style="list-style-type: none"> <li>• Reproduction by fission</li> <li>• High degree of genetic adaptability, acquisition of antibiotic resistance</li> <li>• Exponential growth</li> <li>• Existence of anaerobic and aerobic variants</li> <li>• Parasitic and symbiotic</li> <li>• Chemotaxis</li> </ul>	<u>Ch. 22.3 Prokaryotic Metabolism</u> <u>Ch. 22.4 Bacterial Diseases in Humans</u> <u>Ch. 22.5 Beneficial Prokaryotes</u>	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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**A Road Map to MCAT® Content in Biochemistry Textbooks**
**Content Category 2B: The structure, growth, physiology, and genetics of prokaryotes and viruses (continued)**

Topic	<i>Biology, 2e</i>	<i>Fundamentals of Biochemistry</i>	<i>Karp's Cell and Molecular Biology</i>
<b>Genetics of Prokaryotic Cells (BIO)</b> <ul style="list-style-type: none"> <li>• Existence of plasmids, extragenomic DNA</li> <li>• Transformation: incorporation into bacterial genome of DNA fragments from external medium</li> <li>• Conjugation</li> <li>• Transposons (also present in eukaryotic cells)</li> </ul>		Ch. 1 Introduction to the Chemistry of Life, pp. 1-22	Ch. 12 Control of Gene Expression, pp. 455-460
<b>Virus Structure (BIO)</b> <ul style="list-style-type: none"> <li>• General structural characteristics (nucleic acid and protein, enveloped and nonenveloped)</li> <li>• Lack organelles and nucleus</li> <li>• Structural aspects of typical bacteriophage</li> <li>• Genomic content: RNA or DNA</li> <li>• Size relative to bacteria and eukaryotic cells</li> </ul>	<u>Ch. 21.1</u> <u>Viral Evolution, Morphology, and Classification</u>		Ch. 1 Introduction to the Study of Cell and Molecular Biology, pp. 23-25
<b>Viral Life Cycle (BIO)</b> <ul style="list-style-type: none"> <li>• Self-replicating biological units that must reproduce within specific host cell</li> <li>• Generalized phage and animal virus life cycles               <ul style="list-style-type: none"> <li>◦ Attachment to host, penetration of cell membrane or cell wall, and entry of viral genetic material</li> <li>◦ Use of host synthetic mechanism to replicate viral components</li> <li>◦ Self-assembly and release of new viral particles</li> </ul> </li> <li>• Transduction: transfer of genetic material by viruses</li> <li>• Retrovirus life cycle: integration into host DNA, reverse transcriptase, HIV</li> <li>• Prions and viroids: subviral particles</li> </ul>	<u>Ch. 21.2</u> <u>Virus Infections and Hosts</u>  <u>Ch. 21.3</u> <u>Prevention and Treatment of Viral Infections</u>  <u>Ch. 21.4</u> <u>Other Acellular Entities: Prions and Viroids</u>		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	<i>Biochemistry</i>	<i>Biochemistry: A Short Course</i>	<i>Biology, 2e</i>	<i>Fundamentals of Biochemistry</i>	<i>Human Physiology</i>	<i>Karp's Cell and Molecular Biology</i>
<b>Mitosis (BIO)</b> <ul style="list-style-type: none"> <li>• Mitotic process: prophase, metaphase, anaphase, telophase, interphase</li> <li>• Mitotic structures               <ul style="list-style-type: none"> <li>◦ Centrioles, asters, spindles</li> <li>◦ Chromatids, centromeres, kinetochores</li> <li>◦ Nuclear membrane breakdown and reorganization</li> <li>◦ Mechanisms of chromosome movement</li> </ul> </li> <li>• Phases of cell cycle: G<sub>0</sub>, G<sub>1</sub>, S, G<sub>2</sub>, M</li> <li>• Growth arrest</li> <li>• Control of cell cycle</li> <li>• Loss of cell-cycle controls in cancer cells</li> </ul>			<a href="#">10.2 The Cell Cycle</a> <a href="#">10.3 Control of the Cell Cycle</a> <a href="#">10.4 Cancer and the Cell Cycle</a>		Ch. 3 Cells, pp. 79-83	Ch. 14 Cell Division
<b>Biosignalling (BC)</b> <ul style="list-style-type: none"> <li>• Oncogenes, apoptosis</li> </ul>	Ch. 14 Signal-Transduction Pathways, pp. 455-457	Ch. 13 Signal-Transduction Pathways, pp. 245-261	<a href="#">9.3 Response to the Signal</a> <a href="#">10.4 Cancer and the Cell Cycle</a>	Ch. 13 Biochemical Signaling, pp. 402-441	Ch. 3 Cells, p. 82	Ch. 16 Cancer

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**A Road Map to MCAT® Content in Biochemistry Textbooks**
**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
<b>Reproductive System (BIO)</b> <ul style="list-style-type: none"> <li>• Gametogenesis by meiosis</li> <li>• Ovum and sperm               <ul style="list-style-type: none"> <li>◦ Differences in formation</li> <li>◦ Differences in morphology</li> <li>◦ Relative contribution to next generation</li> </ul> </li> <li>• Reproductive sequence: fertilization, implantation, development, birth</li> </ul>			11.1 <a href="#">The Process of Meiosis</a>  11.2 <a href="#">Sexual Reproduction</a>		Ch. 23 The Reproductive Systems, pp. 811-816, 823-827	Ch. 14 Cell Division, pp. 539-581
<b>Embryogenesis (BIO)</b> <ul style="list-style-type: none"> <li>• Stages of early development (order and general features of each)               <ul style="list-style-type: none"> <li>◦ Fertilization</li> <li>◦ Cleavage</li> <li>◦ Blastula formation</li> <li>◦ Gastrulation                   <ul style="list-style-type: none"> <li>◆ First cell movements</li> <li>◆ Formation of primary germ layers (endoderm, mesoderm, ectoderm)</li> </ul> </li> <li>◦ Neurulation</li> </ul> </li> <li>• Major structures arising out of primary germ layers</li> <li>• Neural crest</li> <li>• Environment-gene interaction in development</li> </ul>			43.6 <a href="#">Fertilization and Early Embryonic Development</a>		Ch. 23 The Reproductive Systems, pp. 840-851	
<b>Mechanisms of Development (BIO)</b> <ul style="list-style-type: none"> <li>• Cell specialization               <ul style="list-style-type: none"> <li>◦ Determination</li> <li>◦ Differentiation</li> <li>◦ Tissue types</li> </ul> </li> <li>• Cell-cell communication in development</li> <li>• Cell migration</li> <li>• Pluripotency: stem cells</li> <li>• Gene regulation in development</li> <li>• Programmed cell death</li> <li>• Existence of regenerative capacity in various species</li> <li>• Senescence and aging</li> </ul>					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
<b>Nervous System: Structure and Function (BIO)</b> <ul style="list-style-type: none"> <li>Major Functions               <ul style="list-style-type: none"> <li>High level control and integration of body systems</li> <li>Adaptive capability to external influences</li> </ul> </li> <li>Organization of vertebrate nervous system</li> <li>Sensor and effector neurons</li> <li>Sympathetic and parasympathetic nervous systems: antagonistic control</li> <li>Reflexes               <ul style="list-style-type: none"> <li>Feedback loop, reflex arc</li> <li>Role of spinal cord and supraspinal circuits</li> </ul> </li> <li>Integration with endocrine system: feedback control</li> </ul>					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
<b>Nerve Cell (BIO)</b> <ul style="list-style-type: none"> <li>Cell body: site of nucleus, organelles</li> <li>Dendrites: branched extensions of cell body</li> <li>Axon: structure and function</li> <li>Myelin sheath, Schwann cells, insulation of axon</li> <li>Nodes of Ranvier: propagation of nerve impulse along axon</li> <li>Synapse: site of impulse propagation between cells</li> <li>Synaptic activity: transmitter molecules</li> <li>Resting potential: electrochemical gradient</li> <li>Action potential               <ul style="list-style-type: none"> <li>Threshold, all-or-none</li> <li>Sodium/potassium pump</li> </ul> </li> <li>Excitatory and inhibitory nerve fibers: summation, frequency of firing</li> <li>Glial cells, neuroglia</li> </ul>			<a href="#">35.1 Neurons and Glial Cell</a>		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
<b>Biosignalling (BC)</b> <ul style="list-style-type: none"> <li>Gated ion channels               <ul style="list-style-type: none"> <li>Voltage gated</li> <li>Ligand gated</li> </ul> </li> <li>Receptor enzymes</li> <li>G protein-coupled receptors</li> </ul>	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	<a href="#">9.1 Signaling Molecules and Cellular Receptors</a>  <a href="#">9.2 Propagation of the Signal</a>	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
<b>Lipids (BC, OC)</b> <ul style="list-style-type: none"> <li>Description; structure               <ul style="list-style-type: none"> <li>Steroids</li> <li>Terpenes and terpenoids</li> </ul> </li> </ul>	Ch. 26 The Biosynthesis of Membrane Lipids and Steroids, pp. 858-882	Ch. 29 Lipid Synthesis: Storage Lipids, Phospholipids and Cholesterol, pp. 577-601	<u>3.3 Lipids</u>	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
<b>Endocrine System: Hormones and Their Sources (BIO)</b> <ul style="list-style-type: none"> <li>Function of endocrine system: specific chemical control at cell, tissue, and organ level</li> <li>Definitions of endocrine gland, hormone</li> <li>Major endocrine glands: names, locations, products</li> <li>Major types of hormones</li> <li>Neuroendocrinology — relation between neurons and hormonal systems</li> </ul>			<u>37.1 Types of Hormones</u>  <u>37.2 How Hormones Work</u>  <u>37.5 Endocrine Glands</u>		Ch. 13 The Endocrine System, pp. 448-456	
<b>Endocrine System: Mechanisms of Hormone Action (BIO)</b> <ul style="list-style-type: none"> <li>Cellular mechanisms of hormone action</li> <li>Transport of hormones: blood supply</li> <li>Specificity of hormones: target tissue</li> <li>Integration with nervous system: feedback control regulation by second messengers</li> </ul>			<u>37.3 Regulation of Body Processes</u>	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
<b>Respiratory System (BIO)</b> <ul style="list-style-type: none"> <li>• General function               <ul style="list-style-type: none"> <li>◦ Gas exchange, thermoregulation</li> <li>◦ Protection against disease: particulate matter</li> </ul> </li> <li>• Structure of lungs and alveoli</li> <li>• Breathing mechanisms               <ul style="list-style-type: none"> <li>◦ Diaphragm, rib cage, differential pressure</li> <li>◦ Resiliency and surface tension effects</li> </ul> </li> <li>• Thermoregulation: nasal and tracheal capillary beds; evaporation, panting</li> <li>• Particulate filtration: nasal hairs, mucus/cilia system in lungs</li> <li>• Alveolar gas exchange               <ul style="list-style-type: none"> <li>◦ Diffusion, differential partial pressure</li> <li>◦ Henry's Law (GC)</li> </ul> </li> <li>• pH control</li> <li>• Regulation by nervous control               <ul style="list-style-type: none"> <li>◦ CO<sub>2</sub> sensitivity</li> </ul> </li> </ul>		<a href="#">39.1 Systems of Gas Exchange</a> <a href="#">39.2 Gas Exchange across Respiratory Surfaces</a> <a href="#">39.3 Breathing</a> <a href="#">39.4 Transport of Gases in Human Bodily Fluids</a>	Ch. 18 The Respiratory System	Ch. 5 Aerobic Respiration and the Mitochondrion, p. 168  Ch. 9 The Cytoskeleton and Cell Motility, pp. 327-334

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**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
<b>Circulatory System (BIO)</b> <ul style="list-style-type: none"> <li>• Functions: circulation of oxygen, nutrients, hormones, ions and fluids, removal of metabolic waste</li> <li>• Role in thermoregulation</li> <li>• Four-chambered heart: structure and function</li> <li>• Endothelial cells</li> <li>• Systolic and diastolic pressure</li> <li>• Pulmonary and systemic circulation</li> <li>• Arterial and venous systems (arteries, arterioles, venules, veins)               <ul style="list-style-type: none"> <li>◦ Structural and functional differences</li> <li>◦ Pressure and flow characteristics</li> </ul> </li> <li>• Capillary beds               <ul style="list-style-type: none"> <li>◦ Mechanisms of gas and solute exchange</li> <li>◦ Mechanism of heat exchange</li> <li>◦ Source of peripheral resistance</li> </ul> </li> <li>• Composition of blood               <ul style="list-style-type: none"> <li>◦ Plasma, chemicals, blood cells</li> <li>◦ Erythrocyte production and destruction; spleen, bone marrow</li> <li>◦ Regulation of plasma volume</li> </ul> </li> <li>• Coagulation, clotting mechanisms</li> <li>• Oxygen transport by blood               <ul style="list-style-type: none"> <li>◦ Hemoglobin, hematocrit</li> <li>◦ Oxygen content</li> <li>◦ Oxygen affinity</li> <li>◦ Oxygen transport by blood; modification of oxygen affinity</li> </ul> </li> <li>• Carbon dioxide transport and level in blood</li> <li>• Nervous and endocrine control</li> </ul>		<u>40.1 Overview of the Circulatory System</u> <u>40.2 Components of the Blood</u> <u>40.3 Mammalian Heart and Blood Vessels</u> <u>40.4 Blood Flow and Blood Pressure Regulation</u>	Ch. 14 The Cardiovascular System: The Heart  Ch. 15 The Cardiovascular System: Blood Vessels and Hemodynamics  Ch. 16 The Cardiovascular System: The Blood	
<b>Lymphatic System (BIO)</b> <ul style="list-style-type: none"> <li>• Structure of lymphatic system</li> <li>• Major functions               <ul style="list-style-type: none"> <li>◦ Equalization of fluid distribution</li> <li>◦ Transport of proteins and large glycerides</li> <li>◦ Production of lymphocytes involved in immune reactions</li> <li>◦ Return of materials to the blood</li> </ul> </li> </ul>			Ch. 17 The Immune System, pp. 613-615	Ch. 17 The Immune Response, pp. 688-691

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**A Road Map to MCAT® Content in Biochemistry Textbooks**
**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
<b>Immune System (BIO)</b> <ul style="list-style-type: none"> <li>• Innate (nonspecific) vs. adaptive (specific) immunity</li> <li>• Adaptive immune system cells               <ul style="list-style-type: none"> <li>◦ T-lymphocytes</li> <li>◦ B-lymphocytes</li> </ul> </li> <li>• Innate immune system cells               <ul style="list-style-type: none"> <li>◦ Macrophages</li> <li>◦ Phagocytes</li> </ul> </li> <li>• Concept of antigen and antibody</li> <li>• Antigen presentation</li> <li>• Clonal selection</li> <li>• Antigen-antibody recognition</li> <li>• Structure of antibody molecule</li> <li>• Recognition of self vs. nonself, autoimmune diseases</li> <li>• Major histocompatibility complex</li> </ul>	42.1 <a href="#">Innate Immune Response</a> 42.2 <a href="#">Adaptive Immune Response</a> 42.3 <a href="#">Antibodies</a> 42.4 <a href="#">Disruptions in the Immune System</a>		Ch. 17 The Immune System, pp. 615-645	Ch. 17 The Immune Response
<b>Digestive System (BIO)</b> <ul style="list-style-type: none"> <li>• Ingestion               <ul style="list-style-type: none"> <li>◦ Saliva as lubrication and source of enzymes</li> <li>◦ Ingestion; esophagus, transport function</li> </ul> </li> <li>• Liver               <ul style="list-style-type: none"> <li>◦ Structural relationship of liver within gastrointestinal system</li> <li>◦ Production of bile</li> <li>◦ Role in blood glucose regulation, detoxification</li> </ul> </li> <li>• Bile               <ul style="list-style-type: none"> <li>◦ Storage in gall bladder</li> <li>◦ Function</li> </ul> </li> <li>• Pancreas               <ul style="list-style-type: none"> <li>◦ Production of enzymes</li> <li>◦ Transport of enzymes to small intestine</li> </ul> </li> <li>• Small Intestine               <ul style="list-style-type: none"> <li>◦ Absorption of food molecules and water</li> <li>◦ Function and structure of villi</li> <li>◦ Production of enzymes, site of digestion</li> <li>◦ Neutralization of stomach acid</li> <li>◦ Structure (anatomic subdivisions)</li> </ul> </li> <li>• Large Intestine               <ul style="list-style-type: none"> <li>◦ Absorption of water</li> <li>◦ Bacterial flora</li> <li>◦ Structure (gross)</li> </ul> </li> </ul>		34.1 <a href="#">Digestive Systems</a> 34.2 <a href="#">Nutrition and Energy Production</a> 34.3 <a href="#">Digestive System Processes</a> 34.4 <a href="#">Digestive System Regulation</a>	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

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**A Road Map to MCAT® Content in Biochemistry Textbooks**
**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
<b>Digestive System (BIO)</b> <i>continued</i> <ul style="list-style-type: none"> <li>• Rectum: storage and elimination of waste, feces</li> <li>• Muscular control               <ul style="list-style-type: none"> <li>◦ Peristalsis</li> </ul> </li> <li>• Endocrine control               <ul style="list-style-type: none"> <li>◦ Hormones</li> <li>◦ Target tissues</li> </ul> </li> <li>• Nervous control: the enteric nervous system</li> </ul>				
<b>Excretory System (BIO)</b> <ul style="list-style-type: none"> <li>• Roles in homeostasis               <ul style="list-style-type: none"> <li>◦ Blood pressure</li> <li>◦ Osmoregulation</li> <li>◦ Acid-base balance</li> <li>◦ Removal of soluble nitrogenous waste</li> </ul> </li> <li>• Kidney structure               <ul style="list-style-type: none"> <li>◦ Cortex</li> <li>◦ Medulla</li> </ul> </li> <li>• Nephron structure               <ul style="list-style-type: none"> <li>◦ Glomerulus</li> <li>◦ Bowman's capsule</li> <li>◦ Proximal tubule</li> <li>◦ Loop of Henle</li> <li>◦ Distal tubule</li> <li>◦ Collecting duct</li> </ul> </li> <li>• Formation of urine               <ul style="list-style-type: none"> <li>◦ Glomerular filtration</li> <li>◦ Secretion and reabsorption of solutes</li> <li>◦ Concentration of urine</li> <li>◦ Counter-current multiplier mechanism</li> </ul> </li> <li>• Storage and elimination: ureter, bladder, urethra</li> <li>• Osmoregulation: capillary reabsorption of H<sub>2</sub>O, amino acids, glucose, ions</li> <li>• Muscular control: sphincter muscle</li> </ul>		<a href="#">41.1 Osmoregulation and Osmotic Balance</a> <a href="#">41.2 The Kidneys and Osmoregulatory Organs</a> <a href="#">41.3 Excretion Systems</a> <a href="#">41.4 Nitrogenous Wastes</a> <a href="#">41.5 Hormonal Control of Osmoregulatory Functions</a>	Ch. 19 The Urinary System Ch. 20 Fluid, Electrolyte, and Acid-Base Homeostasis	

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**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
<b>Reproductive System (BIO)</b> <ul style="list-style-type: none"> <li>• Male and female reproductive structures and their functions</li> <li>• Gonads</li> <li>• Genitalia</li> <li>• Differences between male and female structures</li> <li>• Hormonal control of reproduction</li> <li>• Male and female sexual development</li> <li>• Female reproductive cycle</li> <li>• Pregnancy, parturition, lactation</li> <li>• Integration with nervous control</li> </ul>		<u>43.3 Human Reproductive Anatomy and Gametogenesis</u> <u>43.4 Hormonal Control of Human Reproduction</u> <u>43.5 Human Pregnancy and Birth</u>	Ch. 23 The Reproductive Systems	
<b>Muscle System (BIO)</b> <ul style="list-style-type: none"> <li>• Important functions               <ul style="list-style-type: none"> <li>◦ Support: mobility</li> <li>◦ Peripheral circulatory assistance</li> <li>◦ Thermoregulation (shivering reflex)</li> </ul> </li> <li>• Structure of three basic muscle types: striated, smooth, cardiac</li> <li>• Muscle structure and control of contraction               <ul style="list-style-type: none"> <li>◦ T-tubule system</li> <li>◦ Contractile apparatus</li> <li>◦ Sarcoplasmic reticulum</li> <li>◦ Fiber type</li> <li>◦ Contractile velocity of different muscle types</li> </ul> </li> <li>• Regulation of cardiac muscle contraction</li> <li>• Oxygen debt: fatigue</li> <li>• Nervous control               <ul style="list-style-type: none"> <li>◦ Motor neurons</li> <li>◦ Neuromuscular junction, motor end plates</li> <li>◦ Sympathetic and parasympathetic innervation</li> <li>◦ Voluntary and involuntary muscles</li> </ul> </li> </ul>		<u>38.4 Muscle Contraction and Locomotion</u>	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
<b>Specialized Cell-Muscle Cell (BIO)</b> <ul style="list-style-type: none"> <li>• Structural characteristics of striated, smooth, and cardiac muscle</li> <li>• Abundant mitochondria in red muscle cells: ATP source</li> <li>• Organization of contractile elements: actin and myosin filaments, crossbridges, sliding filament model</li> <li>• Sarcomeres: "I" and "A" bands, "M" and "Z" lines, "H" zone</li> <li>• Presence of troponin and tropomyosin</li> <li>• Calcium regulation of contraction</li> </ul>		<u>38.4 Muscle Contraction and Locomotion</u>	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
<b>Skeletal System (BIO)</b> <ul style="list-style-type: none"> <li>• Functions               <ul style="list-style-type: none"> <li>◦ Structural rigidity and support</li> <li>◦ Calcium storage</li> <li>◦ Physical protection</li> </ul> </li> <li>• Skeletal structure               <ul style="list-style-type: none"> <li>◦ Specialization of bone types, structures</li> <li>◦ Joint structures</li> <li>◦ Endoskeleton vs. exoskeleton</li> </ul> </li> <li>• Bone structure               <ul style="list-style-type: none"> <li>◦ Calcium/protein matrix</li> <li>◦ Cellular composition of bone</li> </ul> </li> <li>• Cartilage: structure and function</li> <li>• Ligaments, tendons</li> <li>• Endocrine control</li> </ul>		38.1 <a href="#">Types of Skeletal Systems</a> 38.2 <a href="#">Bone</a> 38.3 <a href="#">Joints and Skeletal Movement</a>	Ch. 13 The Endocrine System, pp. 459-462, 489-492	
<b>Skin System (BIO)</b> <ul style="list-style-type: none"> <li>• Structure               <ul style="list-style-type: none"> <li>◦ Layer differentiation, cell types</li> <li>◦ Relative impermeability to water</li> </ul> </li> <li>• Functions in homeostasis and osmoregulation</li> <li>• Functions in thermoregulation               <ul style="list-style-type: none"> <li>◦ Hair, erectile musculature</li> <li>◦ Fat layer for insulation</li> <li>◦ Sweat glands, location in dermis</li> <li>◦ Vasoconstriction and vasodilation in surface capillaries</li> </ul> </li> <li>• Physical protection               <ul style="list-style-type: none"> <li>◦ Nails, calluses, hair</li> <li>◦ Protection against abrasion, disease organisms</li> </ul> </li> <li>• Hormonal control: sweating, vasodilation, and vasoconstriction</li> </ul>			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	<i>Biology, 2e</i>	<i>Human Physiology</i>
<b>Circulatory System (BIO)</b> • Arterial and venous systems; pressure and flow characteristics	40.3 <a href="#">Mammalian Heart and Blood Vessels</a> 40.4 <a href="#">Blood Flow and Blood Pressure Regulation</a>	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	<i>Biology, 2e</i>	<i>Human Physiology</i>	<i>Karp's Cell and Molecular Biology</i>
<b>Specialized Cell — Nerve Cell (BIO)</b> <ul style="list-style-type: none"> <li>• Myelin sheath, Schwann cells, insulation of axon</li> <li>• Nodes of Ranvier: propagation of nerve impulse along axon</li> </ul>	<u>35.1</u> 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
<b>Acid/Base Equilibria (GC, BC)</b> <ul style="list-style-type: none"> <li>Bronsted-Lowry definition of acid, base</li> <li>Ionization of water               <ul style="list-style-type: none"> <li><math>K_w</math>, its approximate value (<math>K_w = [H^+][OH^-] = 10^{-14}</math> at 25°C, 1 atm)</li> <li>Definition of pH: pH of pure water</li> </ul> </li> <li>Conjugate acids and bases (e.g., <math>NH_4^+</math> and <math>NH_3</math>)</li> <li>Strong acids and bases (e.g., nitric, sulfuric)</li> <li>Weak acids and bases (e.g., acetic, benzoic)               <ul style="list-style-type: none"> <li>Dissociation of weak acids and bases with or without added salt</li> <li>Hydrolysis of salts of weak acids or bases</li> <li>Calculation of pH of solutions of salts of weak acids or bases</li> </ul> </li> <li>Equilibrium constants <math>K_a</math> and <math>K_b</math>: <math>pK_a</math>, <math>pK_b</math></li> <li>Buffers               <ul style="list-style-type: none"> <li>Definition and concepts (common buffer systems)</li> <li>Influence on titration curves</li> </ul> </li> </ul>	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	<u>2.2 Water</u>	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
<b>Ions in Solutions (GC, BC)</b> <ul style="list-style-type: none"> <li>Anion, cation: common names, formulas and charges for familiar ions (e.g., <math>NH_4^+</math> ammonium, <math>PO_4^{3-}</math> phosphate, <math>SO_4^{2-}</math> sulfate)</li> <li>Hydration, the hydronium ion</li> </ul>		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	<i>Organic Chemistry With a Biological Emphasis, Vol. 1</i>
<b>Covalent Bond (GC)</b> <ul style="list-style-type: none"> <li>• Lewis Electron Dot formulas               <ul style="list-style-type: none"> <li>◦ Resonance structures</li> <li>◦ Formal charge</li> <li>◦ Lewis acids and bases</li> </ul> </li> <li>• Partial ionic character               <ul style="list-style-type: none"> <li>◦ Role of electronegativity in determining charge distribution</li> <li>◦ Dipole Moment</li> </ul> </li> <li>• <math>\sigma</math> and <math>\pi</math> bonds               <ul style="list-style-type: none"> <li>◦ Hybrid orbitals: <math>sp^3</math>, <math>sp^2</math>, <math>sp</math> and respective geometries</li> <li>◦ Valence shell electron pair repulsion and the prediction of shapes of molecules (e.g., <math>NH_3</math>, <math>H_2O</math>, <math>CO_2</math>)</li> <li>◦ Structural formulas for molecules involving H, C, N, O, F, S, P, Si, Cl</li> <li>◦ Delocalized electrons and resonance in ions and molecules</li> </ul> </li> <li>• Multiple bonding               <ul style="list-style-type: none"> <li>◦ Effect on bond length and bond energies</li> <li>◦ Rigidity in molecular structure</li> </ul> </li> <li>• Stereochemistry of covalently bonded molecules (OC)               <ul style="list-style-type: none"> <li>◦ Isomers                   <ul style="list-style-type: none"> <li>◆ Structural isomers</li> <li>◆ Stereoisomers (e.g., diastereomers, enantiomers, cis/trans isomers)</li> <li>◆ Conformational isomers</li> </ul> </li> <li>◦ Polarization of light, specific rotation</li> <li>◦ Absolute and relative configuration                   <ul style="list-style-type: none"> <li>◆ Conventions for writing <i>R</i> and <i>S</i> forms</li> <li>◆ Conventions for writing <i>E</i> and <i>Z</i> forms</li> </ul> </li> </ul> </li> </ul>	Ch. 1.1-3.9, pp. 5-173
<b>Liquid Phase — Intermolecular Forces (GC)</b> <ul style="list-style-type: none"> <li>• Hydrogen bonding</li> <li>• Dipole Interactions</li> <li>• Van der Waals' Forces (London dispersion forces)</li> </ul>	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	<i>Biochemistry</i>	<i>Biochemistry: A Short Course</i>	<i>Fundamentals of Biochemistry</i>	<i>Karp's Cell and Molecular Biology</i>
<b>Separations and Purifications (OC, BC)</b> <ul style="list-style-type: none"> <li>• Extraction: distribution of solute between two immiscible solvents</li> <li>• Distillation</li> <li>• Chromatography               <ul style="list-style-type: none"> <li>◦ Basic principles involved in separation process                   <ul style="list-style-type: none"> <li>◆ Column chromatography, gas-liquid chromatography</li> <li>◆ High pressure liquid chromatography</li> </ul> </li> <li>◦ Paper chromatography</li> <li>◦ Thin-layer chromatography</li> </ul> </li> <li>• Separation and purification of peptides and proteins (BC)               <ul style="list-style-type: none"> <li>◦ Electrophoresis</li> <li>◦ Quantitative analysis</li> <li>◦ Chromatography                   <ul style="list-style-type: none"> <li>◆ Size-exclusion</li> <li>◆ Ion-exchange</li> <li>◆ Affinity</li> </ul> </li> </ul> </li> <li>• Racemic mixtures, separation of enantiomers (OC)</li> </ul>	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	<i>Biochemistry</i>	<i>Biochemistry: A Short Course</i>	<i>Biology, 2e</i>	<i>Fundamentals of Biochemistry</i>	<i>Human Physiology</i>	<i>Karp's Cell and Molecular Biology</i>	<i>Organic Chemistry With a Biological Emphasis, Vol. 1</i>	<i>Organic Chemistry With a Biological Emphasis, Vol. 2</i>
<b>Nucleotides and Nucleic Acids (OC, BC, BIO)</b> <ul style="list-style-type: none"> <li>• Nucleotides and nucleosides: composition               <ul style="list-style-type: none"> <li>◦ Sugar phosphate backbone</li> <li>◦ Pyrimidine, purine residues</li> </ul> </li> <li>• Deoxyribonucleic acid: DNA; double helix</li> <li>• Chemistry (OC, BC)</li> <li>• Other functions (OC, BC)</li> </ul>	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 <u>Nucleic Acids</u>	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	<i>Biochemistry</i>	<i>Biochemistry: A Short Course</i>	<i>Biology, 2e</i>	<i>Fundamentals of Biochemistry</i>	<i>Human Physiology</i>	<i>Karp's Cell and Molecular Biology</i>	<i>Organic Chemistry With a Biological Emphasis, Vol. 1</i>	<i>Organic Chemistry With a Biological Emphasis, Vol. 2</i>
<b>Amino Acids, Peptides, Proteins (OC, BC)</b> <ul style="list-style-type: none"> <li>• Amino acids: description               <ul style="list-style-type: none"> <li>◦ Absolute configuration at the <math>\alpha</math> position</li> <li>◦ Dipolar ions</li> <li>◦ Classification                   <ul style="list-style-type: none"> <li>◊ Acidic or basic</li> <li>◊ Hydrophilic or hydrophobic</li> </ul> </li> <li>◦ Synthesis of <math>\alpha</math>-amino acids (OC)                   <ul style="list-style-type: none"> <li>◊ Strecker Synthesis</li> <li>◊ Gabriel Synthesis</li> </ul> </li> </ul> </li> <li>• Peptides and proteins: reactions               <ul style="list-style-type: none"> <li>◦ Sulfur linkage for cysteine and cystine</li> <li>◦ Peptide linkage: polypeptides and proteins</li> <li>◦ Hydrolysis</li> </ul> </li> <li>• General Principles               <ul style="list-style-type: none"> <li>◦ 1° structure of proteins</li> <li>◦ 2° structure of proteins</li> <li>◦ 3° structure of proteins</li> <li>◦ Isoelectric point</li> </ul> </li> </ul>	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	<u>3.4</u> 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
<b>The Three-Dimensional Protein Structure (BC)</b> <ul style="list-style-type: none"> <li>• Conformational stability               <ul style="list-style-type: none"> <li>◦ Hydrophobic interactions</li> <li>◦ Solvation layer (entropy)</li> </ul> </li> <li>• 4° structure</li> <li>• Denaturing and folding</li> </ul>	Ch. 2 Protein Composition and Structure, pp. 52-62	Ch. 4 Protein Three- Dimensional Structure, pp. 62-67	<u>3.4</u> 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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**A Road Map to MCAT® Content in Biochemistry Textbooks**
**Content Category 5D: Structure, function, and reactivity of biologically-relevant molecules (continued)**

Topic	<i>Biochemistry</i>	<i>Biochemistry: A Short Course</i>	<i>Biology, 2e</i>	<i>Fundamentals of Biochemistry</i>	<i>Human Physiology</i>	<i>Karp's Cell and Molecular Biology</i>	<i>Organic Chemistry With a Biological Emphasis, Vol. 1</i>	<i>Organic Chemistry With a Biological Emphasis, Vol. 2</i>
<b>Nonenzymatic Protein Function (BC)</b> <ul style="list-style-type: none"> <li>• Binding</li> <li>• Immune system</li> <li>• Motor</li> </ul>	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		
<b>Lipids (BC, OC)</b> <ul style="list-style-type: none"> <li>• Types</li> <li>• Storage               <ul style="list-style-type: none"> <li>◦ Triacyl glycerols</li> <li>◦ Free fatty acids: saponification</li> </ul> </li> <li>• Structural               <ul style="list-style-type: none"> <li>◦ Phospholipids and phosphatids</li> <li>◦ Sphingolipids</li> <li>◦ Waxes</li> </ul> </li> <li>• Signals/cofactors               <ul style="list-style-type: none"> <li>◦ Fat-soluble vitamins</li> <li>◦ Steroids</li> <li>◦ Prostaglandins</li> </ul> </li> </ul>	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	<a href="#">3.3 Lipids</a>	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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## A Road Map to MCAT® Content in Biochemistry Textbooks

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

Topic	<i>Biochemistry</i>	<i>Biochemistry: A Short Course</i>	<i>Biology, 2e</i>	<i>Fundamentals of Biochemistry</i>	<i>Human Physiology</i>	<i>Karp's Cell and Molecular Biology</i>	<i>Organic Chemistry With a Biological Emphasis, Vol. 1</i>	<i>Organic Chemistry With a Biological Emphasis, Vol. 2</i>
<b>Carbohydrates (OC)</b> <ul style="list-style-type: none"> <li>• Description               <ul style="list-style-type: none"> <li>◦ Nomenclature and classification, common names</li> <li>◦ Absolute configuration</li> <li>◦ Cyclic structure and conformations of hexoses</li> <li>◦ Epimers and anomers</li> </ul> </li> <li>• Hydrolysis of the glycoside linkage</li> <li>• Keto-enol tautomerism of monosaccharides</li> <li>• Disaccharides (BC)</li> <li>• Polysaccharides (BC)</li> </ul>	Ch. 11 Carbohydrates, pp. 341-365	Ch. 10 Carbohydrates, pp. 181-201	<u>3.2</u> <u>Carbohydrates</u>	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
<b>Phenols (OC, BC)</b> <ul style="list-style-type: none"> <li>• Oxidation and reduction (e.g., hydroquinones, ubiquinones): biological 2e-redox centers</li> </ul>				Ch.14 Introduction to Metabolism: Section 3. Oxidation- Reduction Reactions, pp. 461-466				Ch. 15.1-15.4, pp. 278-307
<b>Polycyclic and Heterocyclic Aromatic Compounds (OC, BC)</b> <ul style="list-style-type: none"> <li>• Biological aromatic heterocycles</li> </ul>				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	<i>Biochemistry</i>	<i>Biochemistry: A Short Course</i>	<i>Biology, 2e</i>	<i>Fundamentals of Biochemistry</i>	<i>Human Physiology</i>	<i>Karp's Cell and Molecular Biology</i>	<i>Organic Chemistry With a Biological Emphasis, Vol. 1</i>	<i>Organic Chemistry With a Biological Emphasis, Vol. 2</i>
<b>Enzymes (BC, BIO)</b> <ul style="list-style-type: none"> <li>• Classification by reaction type</li> <li>• Mechanism               <ul style="list-style-type: none"> <li>◦ Substrates and enzyme specificity</li> <li>◦ Active site model</li> <li>◦ Induced-fit model</li> <li>◦ Cofactors, coenzymes and vitamins</li> </ul> </li> <li>• Kinetics               <ul style="list-style-type: none"> <li>◦ General (catalysis)</li> <li>◦ Michaelis-Menten</li> <li>◦ Cooperativity</li> <li>◦ Effects of local conditions on enzyme activity</li> </ul> </li> <li>• Inhibition</li> <li>• Regulatory enzymes               <ul style="list-style-type: none"> <li>◦ Allosteric</li> <li>◦ Covalently modified</li> </ul> </li> </ul>	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 <u>Enzymes</u>	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
<b>Principles of Bioenergetics (BC)</b> <ul style="list-style-type: none"> <li>• Bioenergetics/thermodynamics               <ul style="list-style-type: none"> <li>◦ Free energy/<math>K_{eq}</math></li> <li>◦ Concentration</li> </ul> </li> <li>• Phosphorylation/ATP               <ul style="list-style-type: none"> <li>◦ ATP hydrolysis <math>\Delta G \ll 0</math></li> <li>◦ ATP group transfers</li> </ul> </li> <li>• Biological oxidation-reduction               <ul style="list-style-type: none"> <li>◦ Half-reactions</li> <li>◦ Soluble electron carriers</li> <li>◦ Flavoproteins</li> </ul> </li> </ul>	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	<u>6.1</u> <u>Energy and</u> <u>Metabolism</u>  <u>6.2</u> <u>Potential,</u> <u>Kinetic, Free,</u> <u>and Activation</u> <u>Energy</u>  <u>6.3</u> <u>The Laws of</u> <u>Thermodynamics</u>	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
<b>Sensory Processing (PSY, BIO)</b> <ul style="list-style-type: none"> <li>• Sensation               <ul style="list-style-type: none"> <li>◦ Thresholds</li> <li>◦ Weber's Law (PSY)</li> <li>◦ Signal detection theory (PSY)</li> <li>◦ Sensory adaptation</li> </ul> </li> <li>• Sensory receptors               <ul style="list-style-type: none"> <li>◦ Sensory pathways</li> <li>◦ Types of sensory receptors</li> </ul> </li> </ul>		<u>36.1</u> <u>Sensory Processes</u>	Ch. 9 Sensory Systems, pp. 281-306
<b>Vision (PSY, BIO)</b> <ul style="list-style-type: none"> <li>• Structure and function of the eye</li> <li>• Visual processing               <ul style="list-style-type: none"> <li>◦ Visual pathways in the brain</li> <li>◦ Parallel processing (PSY)</li> <li>◦ Feature detection (PSY)</li> </ul> </li> </ul>		<u>36.5</u> <u>Vision</u>	Ch. 9 Sensory Systems, pp. 314-333
<b>Hearing (PSY, BIO)</b> <ul style="list-style-type: none"> <li>• Auditory processing               <ul style="list-style-type: none"> <li>◦ Auditory pathways in the brain</li> </ul> </li> <li>• Sensory reception by hair cells (PSY)</li> </ul>		<u>36.4</u> <u>Hearing and Vestibular Sensation</u>	Ch. 9 Sensory Systems, pp. 333-345

(continued)

## A Road Map to MCAT® Content in Biochemistry Textbooks

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

Topic	Biochemistry	Biology, 2e	Human Physiology
<b>Other Senses (PSY, BIO)</b> <ul style="list-style-type: none"> <li>• Somatosensation               <ul style="list-style-type: none"> <li>◦ Pain perception (PSY)</li> </ul> </li> <li>• Taste               <ul style="list-style-type: none"> <li>◦ Taste buds/ chemoreceptors that detect specific chemicals</li> </ul> </li> <li>• Smell               <ul style="list-style-type: none"> <li>◦ Olfactory cells/chemoreceptors that detect specific chemicals</li> <li>◦ Pheromones (BIO)</li> <li>◦ Olfactory pathways in the brain (BIO)</li> </ul> </li> <li>• Kinesthetic sense (PSY)</li> <li>• Vestibular sense</li> </ul>	Ch. 34 Sensory Systems, pp. 1087-1114 (online chapter)	<u>36.2</u> <u>Somatosensation</u>  <u>36.3</u> <u>Taste and Smell</u>	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	<i>Human Physiology</i>
<b>Cognition (PSY)</b> <ul style="list-style-type: none"> <li>• Information-processing model</li> <li>• Cognitive development               <ul style="list-style-type: none"> <li>◦ Piaget’s stages of cognitive development</li> <li>◦ Cognitive changes in late adulthood</li> <li>◦ Role of culture in cognitive development</li> <li>◦ Influence of heredity and environment on cognitive development</li> </ul> </li> <li>• Biological factors that affect cognition (PSY, BIO)</li> <li>• Problem solving and decision making (PSY, BIO)               <ul style="list-style-type: none"> <li>◦ Types of problem solving</li> <li>◦ Barriers to effective problem solving</li> <li>◦ Approaches to problem solving</li> <li>◦ Heuristics, biases, intuition, and emotion                   <ul style="list-style-type: none"> <li>◆ Overconfidence and belief perseverance</li> </ul> </li> </ul> </li> <li>• Intellectual functioning               <ul style="list-style-type: none"> <li>◦ Multiple definitions of intelligence</li> <li>◦ Influence of heredity and environment on intelligence</li> <li>◦ Variations in intellectual ability</li> </ul> </li> </ul>	Ch. 8 The Central Nervous System, pp. 273-276
<b>Consciousness (PSY)</b> <ul style="list-style-type: none"> <li>• States of consciousness               <ul style="list-style-type: none"> <li>◦ Alertness (PSY, BIO)</li> <li>◦ Sleep                   <ul style="list-style-type: none"> <li>◆ Stages of sleep</li> <li>◆ Sleep cycles and changes to sleep cycles</li> <li>◆ Sleep and circadian rhythms (PSY, BIO)</li> <li>◆ Dreaming</li> <li>◆ Sleep disorders</li> </ul> </li> <li>◦ Hypnosis and meditation</li> </ul> </li> <li>• Consciousness altering drugs               <ul style="list-style-type: none"> <li>◦ Types of consciousness altering drugs and their effects on the nervous system and behavior</li> <li>◦ Drug addiction and the reward pathway in the brain</li> </ul> </li> </ul>	Ch. 8 The Central Nervous System, pp. 266-269

(continued)

**A Road Map to MCAT® Content in Biochemistry Textbooks**
**Content Category 6B: Making sense of the environment** *(continued)*

Topic	Human Physiology
<p><b>Memory (PSY)</b></p> <ul style="list-style-type: none"> <li>• Encoding               <ul style="list-style-type: none"> <li>◦ Process of encoding information</li> <li>◦ Processes that aid in encoding memories</li> </ul> </li> <li>• Storage               <ul style="list-style-type: none"> <li>◦ Types of memory storage (i.e., sensory, working, long-term)</li> <li>◦ Semantic networks and spreading activation</li> </ul> </li> <li>• Retrieval               <ul style="list-style-type: none"> <li>◦ Recall, recognition, and relearning</li> <li>◦ Retrieval cues</li> <li>◦ The role of emotion in retrieving memories</li> </ul> </li> <li>• Forgetting               <ul style="list-style-type: none"> <li>◦ Aging and memory</li> <li>◦ Memory dysfunctions (e.g., Alzheimer’s disease, Korsakoff’s syndrome)</li> <li>◦ Decay</li> <li>◦ Interference</li> <li>◦ Memory construction and source monitoring</li> </ul> </li> <li>• Changes in synaptic connections underlie memory and learning (PSY, BIO)               <ul style="list-style-type: none"> <li>◦ Neural plasticity</li> <li>◦ Memory and learning</li> <li>◦ Long-term potentiation</li> </ul> </li> </ul>	<p>Ch. 8 The Central Nervous System, pp. 273-276</p>
<p><b>Language (PSY)</b></p> <ul style="list-style-type: none"> <li>• Theories of language development (e.g., learning, Nativist, Interactionist)</li> <li>• Influence of language on cognition</li> <li>• Different brain areas control language and speech (PSY, BIO)</li> </ul>	<p>Ch. 8 The Central Nervous System, pp. 269-270</p>

## 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
<p><b>Biological Bases of Behavior (PSY, BIO)</b></p> <ul style="list-style-type: none"> <li>• The nervous system                             <ul style="list-style-type: none"> <li>◦ Neurons                                     <ul style="list-style-type: none"> <li>◆ The reflex arc</li> </ul> </li> <li>◦ Neurotransmitters</li> <li>◦ Peripheral nervous system</li> <li>◦ Central nervous system                                     <ul style="list-style-type: none"> <li>◆ The brain   <ul style="list-style-type: none"> <li>• The brainstem</li> <li>• The cerebellum</li> <li>• The diencephalon (BIO)</li> <li>• The cerebrum</li> <li>• Control of voluntary movement in the cerebral</li> <li>• Information processing in the cerebral cortex</li> <li>• Lateralization of cortical functions</li> </ul> </li> </ul> </li> </ul> </li> <li>• Neurons communicate and influence behavior (PSY)</li> <li>• Influence of neurotransmitters on behavior (PSY)</li> <li>• The endocrine system                             <ul style="list-style-type: none"> <li>◦ Components of the endocrine system</li> <li>◦ Effects of the endocrine system on behavior</li> </ul> </li> <li>• Behavioral genetics</li> <li>• Genes, temperament, heredity</li> <li>• Adaptive value of traits and behaviors</li> <li>• Interaction between heredity and environmental influences</li> </ul> <p style="text-align: right;"><i>(continued)</i></p>	<p>Ch. 7 The Nervous System and Neuronal Excitability</p> <p>Ch. 8 The Central Nervous System</p> <p>Ch. 12 Control of Body Movement, pp. 426-437</p> <p>Ch. 13 The Endocrine System, pp. 448-456</p> <p>Ch. 23 The Reproductive Systems, pp. 839-850</p>

*(continued)*

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

Topic	Human Physiology
<p><b>Biological Bases of Behavior (PSY, BIO)</b> (continued)</p> <ul style="list-style-type: none"> <li>• Genetic and environmental factors contribute to the development of behaviors               <ul style="list-style-type: none"> <li>◦ Experience and behavior (PSY)</li> <li>◦ Regulatory genes and behavior (BIO)</li> <li>◦ Genetically based behavioral variation in natural populations</li> </ul> </li> <li>• Human physiological development (PSY)               <ul style="list-style-type: none"> <li>◦ Prenatal development</li> <li>◦ Motor development</li> <li>◦ Developmental changes in adolescence</li> </ul> </li> </ul>	
<p><b>Psychological Disorders (PSY)</b></p> <ul style="list-style-type: none"> <li>• Understanding psychological disorders               <ul style="list-style-type: none"> <li>◦ Biomedical vs. biopsychosocial approaches</li> <li>◦ Classifying psychological disorders</li> <li>◦ Rates of psychological disorders</li> </ul> </li> <li>• Types of psychological disorders               <ul style="list-style-type: none"> <li>◦ Anxiety disorders</li> <li>◦ Somatoform disorders</li> <li>◦ Mood disorders</li> <li>◦ Schizophrenia</li> <li>◦ Dissociative disorder</li> <li>◦ Personality disorders</li> </ul> </li> <li>• Biological bases of nervous system disorders (PSY, BIO)               <ul style="list-style-type: none"> <li>◦ Schizophrenia</li> <li>◦ Depression</li> <li>◦ Alzheimer’s disease</li> <li>◦ Parkinson’s disease</li> <li>◦ Stem cell-based therapy to regenerate neurons in CNS (BIO)</li> </ul> </li> </ul>	<p>Ch. 7 The Nervous System and Neuronal Excitability, p. 236</p> <p>Ch. 8 The Central Nervous System, p. 275</p> <p>Ch. 12 Control of Body Movement, p. 441</p>
<p><b>Motivation (PSY)</b></p> <ul style="list-style-type: none"> <li>• Factors that influence motivation               <ul style="list-style-type: none"> <li>◦ Instinct</li> <li>◦ Arousal</li> <li>◦ Drives                   <ul style="list-style-type: none"> <li>◆ Negative feedback systems (PSY, BIO)</li> </ul> </li> <li>◦ Needs</li> </ul> </li> <li>• Theories that explain how motivation affects human behavior               <ul style="list-style-type: none"> <li>◦ Drive reduction theory</li> <li>◦ Incentive theory</li> <li>◦ Other: Cognitive and need-based theories</li> </ul> </li> <li>• Application of theories of motivation to understand behaviors (e.g., eating, sexual, drug and alcohol use)               <ul style="list-style-type: none"> <li>◦ Biological factors in regulation of these motivational processes</li> <li>◦ Sociocultural factors in regulation of these motivational processes</li> </ul> </li> </ul>	<p>Ch. 8 The Central Nervous System, pp. 271-273</p>

## 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	<i>Human Physiology</i>
<b>Associative Learning (PSY)</b> <ul style="list-style-type: none"> <li>• Classical conditioning (PSY, BIO)               <ul style="list-style-type: none"> <li>◦ Neutral, conditioned, and unconditioned stimuli</li> <li>◦ Conditioned and unconditioned response</li> <li>◦ Processes: acquisition, extinction, spontaneous recovery, generalization, discrimination</li> </ul> </li> <li>• Operant conditioning (PSY, BIO)               <ul style="list-style-type: none"> <li>◦ Processes of shaping and extinction</li> <li>◦ Types of reinforcement: positive, negative, primary, conditional</li> <li>◦ Reinforcement schedules: fixed-ratio, variable-ratio, fixed-interval, variable-interval</li> <li>◦ Punishment</li> <li>◦ Escape and avoidance learning</li> </ul> </li> <li>• Cognitive processes that affect associative learning</li> <li>• Biological factors that affect associative learning               <ul style="list-style-type: none"> <li>◦ Innate behaviors are developmentally fixed</li> <li>◦ Learned behaviors are modified based on experiences</li> <li>◦ Development of learned behaviors (PSY, BIO)</li> </ul> </li> </ul>	Ch. 8 The Central Nervous System, pp. 273-275



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