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Chapters/Sections	Essential Knowledge	Required content for the AP Course	Illustrative examples covered in this textbook - teach at least one	Content not required for the AP Course
1. Introduction: Themes in the Study of Life				
1.1 The themes of this book make connections across different areas of biology				2-11
1.2 The Core Theme: Evolution accounts for the unity and diversity of life				11-18
1.3 In studying nature, scientists make observations and then form and test hypotheses				18-23
1.4 Science benefits from a cooperative approach and diverse viewpoints				23-25
2. The Chemical Context of Life				
2.1 Matter consists of chemical elements in pure form and in combination called compounds				31-32
2.2 An element's properties depends on the structure of its atoms				33-37
2.3 The formation and function of molecules depend on chemical bonding between atoms				38-42
2.4 Chemical reaction make and break chemical bonds				42-43
3. Water and Life				
3.1 Polar covalent bonds in water molecules result in hydrogen bonding	2.A.3 Organisms must exchange matter with the environment to grow, reproduce, and maintain organization	46-47	Cohesion 47, 774, 775; Adhesion 48, 775; High specific heat capacity 49, Universal solvent supports reactions 50, 51, 52, 53, 54, 55, Heat of vaporization 49; Heat of fusion; 501, Water's thermal conductivity 860; Root hairs: 739; Cells of the alveoli 582: Cells of the villi 887; Microvilli 99, 100, 117, 887, 888	

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Chapters/Sections	Essential Knowledge	Required content for the AP Course	Illustrative examples covered in this textbook - teach at least one	Content not required for the AP Course
3.2 Four emergent properties of water contribute to Earth's suitability for life	2.A.3 Organisms must exchange matter with the environment to grow, reproduce, and maintain organization	47-52	Cohesion: 47, 774, 775; Adhesion: 48, 775; High specific heat capacity: 49, Universal solvent supports reactions: 50, 51, 52, 53, 54, 55, Heat of vaporization: 49; Heat of fusion; 501, Water's thermal conductivity: 860; Root hairs: 739; Cells of the alveoli;: 582, Cells of the villi: 887; Microvilli: 99, 100, 117, 887, 888	
3.3 Acidic and basic conditions affect living organisms	2.A.3 Organisms must exchange matter with the environment to grow, reproduce, and maintain organization	52-56	Cohesion: 47, 774, 775; Adhesion: 48, 775; High specific heat capacity: 49, Universal solvent supports reactions: 50, 51, 52, 53, 54, 55, Heat of vaporization: 49; Heat of fusion; 501, Water's thermal conductivity: 860; Root hairs: 739; Cells of the alveoli;: 582, Cells of the villi: 887; Microvilli: 99, 100, 117, 887, 888	
4. Carbon and the Molecular Diversity of Life				
4.1 Organic Chemistry in the study of carbon compounds	1.D.1 There are several hypotheses about the natural origin of life on Earth, each with supporting evidence	58-59		
	2.A.3 Organisms must exchange matter with the environment to grow, reproduce, and maintain organization		Cohesion 47, 774, 775; Adhesion 48, 775; High specific heat capacity 49, Universal solvent supports reactions 50, 51, 52, 53, 54, 55, Heat of vaporization 49; Heat of fusion 501; Water's thermal conductivity 860; Root hairs 739; Cells of the alveoli 582; Cells of the villi 887; Microvilli 99, 100, 117, 887, 888	

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Chapters/Sections	Essential Knowledge	Required content for the AP Course	Illustrative examples covered in this textbook - teach at least one	Content not required for the AP Course
4.2 Carbon atoms can form diverse molecules by bonding to four other atoms	2.A.3 Organisms must exchange matter with the environment to grow, reproduce, and maintain organization	60-63	Cohesion 47, 60, 61, 62, 63, 774, 775; Adhesion 48, 775; High specific heat capacity 49; Universal solvent supports reactions 50, 51, 52, 53, 54, 55; Heat of vaporization 49; Heat of fusion 501; Water's thermal conductivity 860; Root hairs 739; Cells of the alveoli 582; Cells of the villi 887; Microvilli 99, 100, 117, 887, 888	
4.3 A few chemical groups are key to the functioning of biological molecules				63-66
5. The Structure and Function of Large Biological Molecules				
5.1 Macromolecules are polymers, built from monomers	4.A.1 The subcomponents of biological molecules and their sequence determine the properties of that molecule	68-69		
	4.C.1 Variations in molecular units provides cells with a wider range of functions		Different types of phospholipids in cell membranes 68, 69, 76, 77, 99, 126, 127, 128, 129; Different types of hemoglobin 83, 84, 437, 440, 912, 924; MHC proteins 937; Chlorophylls 186, 188, 190, 191, 192; Molecular diversity of antibodies in response to an antigen 935, 936, 937, 938, 941, 942; The antifreeze gene in fish 128	
	4.A.1 The subcomponents of biological molecules and their sequence determine the properties of that molecule			

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Chapters/Sections	Essential Knowledge	Required content for the AP Course	Illustrative examples covered in this textbook - teach at least one	Content not required for the AP Course
5.2 Carbohydrates serve as fuel and building material	4.C.1 Variations in molecular units provides cells with a wider range of functions	69-74	Different types of phospholipids in cell membranes 68, 69, 70, 71, 72, 76, 77, 99, 126, 127, 128, 129; Different types of hemoglobin 83, 84, 437, 440, 912, 924; MHC proteins 937; Chlorophylls 186, 188, 190, 191, 192; Molecular diversity of antibodies in response to an antigen 935, 936, 937, 938, 941, 942; The antifreeze gene in fish 128	
5.3 Lipids are a diverse group of hydrophobic molecules	4.A.1 The subcomponents of biological molecules and their sequence determine the properties of that molecule	74-77		
	4.C.1 Variations in molecular units provides cells with a wider range of functions		Different types of phospholipids in cell membranes: 68, 69, 75, 76, 77, 99, 126, 127, 128, 129; Different types of hemoglobin: 83, 84, 437, 440, 912, 924; MHC proteins, 937; Chlorophylls, 186, 188, 190, 191, 192; Molecular diversity of antibodies in response to an antigen, 935, 936, 937, 938, 941, 942; The antifreeze gene in fish 128	
	4.A.1 The subcomponents of biological molecules and their sequence determine the properties of that molecule			
	4.B.1 Interactions between molecules affect their structure and function			

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Chapters/Sections	Essential Knowledge	Required content for the AP Course	Illustrative examples covered in this textbook - teach at least one	Content not required for the AP Course
5.4 Proteins include diversity of structures, resulting in a wide range of functions	4.C.1 Variations in molecular units provides cells with a wider range of functions	77-86	Different types of phospholipids in cell membranes 68, 69, 76, 77, 78, 79, 80, 81, 82, 83, 86, 99, 126, 127, 128, 129; Different types of hemoglobin 83, 84, 437, 440, 912, 924; MHC proteins, 937; Chlorophylls 186, 188, 190, 191, 192; Molecular diversity of antibodies in response to an antigen 935, 936, 937, 938, 941, 942; The antifreeze gene in fish 128	
5.5 Nucleic acid store, transmit, and help express hereditary information	3.A.1 DNA, and in some cases RNA, is the primary source of heritable information	86-89	Addition of a poly-A tail 334, 335; Addition of a GTP cap 211; Excision of introns 318; Enzymatic reactions 319; Transport by proteins 307; Synthesis 314, 315, 316, 317; Degradation 363, 364; Electrophoresis 405; Plasmid-based transformation 306, 399; Restriction enzyme analysis of DNA 398; Polymerase Chain Reaction (PCR) 404 409; Genetically modified foods 397; Transgenic animals 419; Cloned animals 397, 399, 400, 402 413, 414; Pharmaceuticals, such as human insulin or factor X 412	
	4.A.1 The subcomponents of biological molecules and their sequence determine the properties of that molecule			

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Chapters/Sections	Essential Knowledge	Required content for the AP Course	Illustrative examples covered in this textbook - teach at least one	Content not required for the AP Course
	4.C.1 Variations in molecular units provides cells with a wider range of functions		Different types of phospholipids in cell membranes: 68, 69, 76, 77, 78, 79, 80, 81, 82, 83, 86, 87, 99, 126, 127, 128, 129; Different types of hemoglobin: 83, 84, 437, 440, 912, 924; MHC proteins, 937; Chlorophylls, 186, 188, 190, 191, 192; Molecular diversity of antibodies in response to an antigen, 935, 936, 937, 938, 941, 942; The antifreeze gene in fish 128	
6. A Tour of the Cell				
6.1 Biologists use microscopes and the tools of biochemistry to study cells				94-97
6.2 Eukaryotic cells have internal membranes that compartmentalize their functions	2.A.3 Organisms must exchange matter with the environment to grow, reproduce, and maintain organization	98-102	Cohesion: 47, 774, 775; Adhesion: 48, 775; High specific heat capacity: 49, Universal solvent supports reactions: 50, 51, 52, 53, 54, 55, Heat of vaporization: 49; Heat of fusion; 501, Water's thermal conductivity: 860; Root hairs: 739; Cells of the alveoli;: 582, Cells of the villi: 887; Microvilli: 99, 100, 117, 887, 888	
	2.B.3 Eukaryotic cells maintain internal membranes that partition the cell into specialized regions		Endoplasmic reticulum 100, 101, 103, 104, 106, 108, 109, 123, 131; Mitochondria 100, 101, 103, 104, 107, 109, 110, 111, 119, 123, 160, 167, 174, 175, 176, 179; Chloroplasts 100, 109, 111, 119, 123, 581; Golgi 100, 101, 103, 104, 106, 108, 109, 123, 131; Nuclear envelope 100, 101, 103, 104, 108, 109, 123	
	4.A.2 The structure and function of subcellular components, and their interactions, provide essential cellular			

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Chapters/Sections	Essential Knowledge	Required content for the AP Course	Illustrative examples covered in this textbook - teach at least one	Content not required for the AP Course
6.3 The eukaryotic cell's genetic instructions are housed in the nucleus and carried out by the ribosomes	2.B.3 Eukaryotic cells maintain internal membranes that partition the cell into specialized regions	102-104	Endoplasmic reticulum 100, 101, 103, 104, 106, 108, 109, 123, 131; Mitochondria 100, 101, 103, 104, 107, 109, 110, 111, 1119, 23, 160, 167, 174, 175, 176, 179; Chloroplasts 100, 109, 111, 119, 123, 581; Golgi 100, 101, 103, 104, 106, 108, 109, 123, 131; Nuclear envelope 100, 101, 103, 104, 108, 109, 123	
	4.A.2 The structure and function of subcellular components, and their interactions, provide essential cellular			
6.4 The endomembrane system regulates protein traffic and performs metabolic functions in the cell	2.B.3 Eukaryotic cells maintain internal membranes that partition the cell into specialized regions	104-109	Endoplasmic reticulum 100, 101, 103, 104, 106, 108, 109, 123, 131; Mitochondria 100, 101, 103, 104, 107, 109, 110, 111, 119, 123, 160, 167, 174, 175, 176, 179; Chloroplasts 100, 109, 111, 119, 123, 581; Golgi 100, 101, 103, 104, 106, 108, 109, 123, 131; Nuclear envelope 100, 101, 103, 104, 108, 109, 123	
	4.A.2 The structure and function of subcellular components, and their interactions, provide essential cellular			960, 961, 962, 963, 964, 966
	4.B.2 Cooperative interactions within organisms promote efficiency in the use of energy and matter		Exchange of gases 854, 897, 898, 916, 917, 918, 919, 921, 923, 924, 925; Circulation of fluids 107, 108, 853, 854, 899, 900, 901, 902, 903, 908; Digestion of food 107, 854, 880, 882, 883, 885, 887, 890; Excretion of wastes 108, 854, 898; Bacterial community in the rumen of animals 891; Bacterial community in and around deep sea vents 567	

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Chapters/Sections	Essential Knowledge	Required content for the AP Course	Illustrative examples covered in this textbook - teach at least one	Content not required for the AP Course
6.5 Mitochondria and chloroplasts change energy from one form to another	2.B.3 Eukaryotic cells maintain internal membranes that partition the cell into specialized regions	109-112	Endoplasmic reticulum 100, 101, 103, 104, 106, 108, 109, 123, 131; Mitochondria 100, 101, 103, 104, 107, 109, 110, 111, 123, 160, 167, 174, 175, 176, 179; Chloroplasts 100, 109, 111, 123, 581; Golgi 100, 101, 103, 104, 106, 108, 109, 123, 131; Nuclear envelope 100, 101, 103, 104, 108, 109, 123	
	4.A.2 The structure and function of subcellular components, and their interactions, provide essential cellular			
6.6 The cytoskeleton is a network of fibers that organizes structures and activities in the cell				112-118
6.7 Extracellar components and connections between cells help coordinate cellular activities				118-122

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Chapters/Sections	Essential Knowledge	Required content for the AP Course	Illustrative examples covered in this textbook - teach at least one	Content not required for the AP Course
7. Membrane Structure and Function				
7.1 Cellular membranes are fluid mosaics of lipids and proteins	2.B.1 Cell membranes are selectively permeable due to their structure	125-131		
7.2 Membranes structure results in selective permeability	2.B.1 Cell membranes are selectively permeable due to their structure	131-132		
7.3 Passive transport in diffusion of a substance across a membrane with no energy investment	2.B.2 Growth and dynamic homeostasis are maintained by the constant movement of molecules across membranes	132-135	Glucose transport 132; Na+/K+ transport 135, 136	
7.4 Active transport uses energy to move solutes against their gradients	2.B.2 Growth and dynamic homeostasis are maintained by the constant movement of molecules across membranes	135-138	Glucose transport 132; Na+/K+ transport 135, 136	
7.5 Bulk transport across the plasma membrane occurs by exocytosis and endocytosis	2.B.2 Growth and dynamic homeostasis are maintained by the constant movement of molecules across membranes	138	Glucose transport 132; Na+/K+ transport 135, 136	
8. An Introduction to Metabolism				

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Chapters/Sections	Essential Knowledge	Required content for the AP Course	Illustrative examples covered in this textbook - teach at least one	Content not required for the AP Course
8.1 An organism's metabolism transform matter and energy, of thermodynamics	2.A.1 All living systems require constant input of free energy	142-145	Krebs cycle 167, 168, 169, 170, 171, 175, 176, 178, 181; Glycolysis 167, 168, 169, 178, 181; Calvin cycle 194, 197, 198, 201, 202, 203; Fermentation 178, 179; Endothermy (the use of thermal energy generated by metabolism to maintain homeostatic body temperatures) 147, 149, 167, 168, 863, 864, 865, 866, 867, 868; Ectothermy (the use of external thermal energy to help regulate and maintain body temperature) 147, 148, 149, 165, 166, 167, 168, 863, 864, 865, 866, 867, 868; Life-history strategy (biennial plants, reproductive diapause) 1180, 1181; Change in the producer level can affect the number and size of other trophic levels 1202, 1203, 1204, 1205, 1206, 1220, 1221, 1222, 1226; Change in energy resources levels such as sunlight can affect the number and size of the trophic levels 1228-1229, 1230	

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Chapters/Sections	Essential Knowledge	Required content for the AP Course	Illustrative examples covered in this textbook - teach at least one	Content not required for the AP Course
8.2 The free-energy change of a reaction tells us whether or not the reaction occurs spontaneously	2.A.1 All living systems require constant input of free energy	146-149	Krebs cycle 167, 168, 169, 170, 171, 175, 176, 178, 181; Glycolysis 167, 168, 169, 178, 181; Calvin cycle 194, 197, 198, 201, 202, 203; Fermentation 178, 179; Endothermy (the use of thermal energy generated by metabolism to maintain homeostatic body temperatures) 147, 149, 167, 168, 863, 864, 865, 866, 867, 868; Ectothermy (the use of external thermal energy to help regulate and maintain body temperature) 147, 148, 149, 165, 166, 167, 168, 863, 864, 865, 866, 867, 868; Life-history strategy (biennial plants, reproductive diapause) 1180, 1181; Change in the producer level can affect the number and size of other trophic levels 1202, 1203, 1204, 1205, 1206, 1220, 1221, 1222, 1226; Change in energy resources levels such as sunlight can affect the number and size of the trophic levels 1228-1229, 1230	

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Chapters/Sections	Essential Knowledge	Required content for the AP Course	Illustrative examples covered in this textbook - teach at least one	Content not required for the AP Course
8.3 ATP powers cellular work by coupling exergonic reactions to engergonic reactions	2.A.1 All living systems require constant input of free energy	149-151	Krebs cycle 167, 168, 169, 170, 171, 175, 176, 178, 181; Glycolysis 167, 168, 169, 178, 181; Calvin cycle 194, 197, 198, 201, 202, 203; Fermentation 178, 179; Endothermy (the use of thermal energy generated by metabolism to maintain homeostatic body temperatures) 147, 149, 167, 168, 863, 864, 865, 866, 867, 868; Ectothermy (the use of external thermal energy to help regulate and maintain body temperature) 147, 148, 149, 165, 166, 167, 168, 863, 864, 865, 866, 867, 868; Life-history strategy (biennial plants, reproductive diapause) 1180, 1181; Change in the producer level can affect the number and size of other trophic levels 1202, 1203, 1204, 1205, 1206, 1220, 1221, 1222, 1226; Change in energy resources levels such as sunlight can affect the number and size of the trophic levels 1228-1229, 1230	
8.4 Enzymes speed up metabolic reactions by lowering energy barriers	4.B.1 Interactions between molecules affect their structure and function	152-157		
8.5 Regulation of enzyme activity helps control metabolism	4.B.1 Interactions between molecules affect their structure and function	158-160		
9. Cellular Respiration and Fermentation				

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Chapters/Sections	Essential Knowledge	Required content for the AP Course	Illustrative examples covered in this textbook - teach at least one	Content not required for the AP Course
9.1 Catabolic pathways yield energy by oxidizing organic fuels	2.A.1 All living systems require constant input of free energy	164-168	Krebs cycle 167, 168, 169, 170, 171, 175, 176, 178, 181; Glycolysis 167, 168, 169, 178, 181; Calvin cycle 194, 197, 198, 201, 202, 203; Fermentation 178, 179; Endothermy (the use of thermal energy generated by metabolism to maintain homeostatic body temperatures) 147, 149, 167, 168, 863, 864, 865, 866, 867, 868; Ectothermy (the use of external thermal energy to help regulate and maintain body temperature) 147, 148, 149, 165, 166, 167, 168, 863, 864, 865, 866, 867, 868; Life-history strategy (biennial plants, reproductive diapause) 1180, 1181; Change in the producer level can affect the number and size of other trophic levels 1202, 1203, 1204, 1205, 1206, 1220, 1221, 1222, 1226; Change in energy resources levels such as sunlight can affect the number and size of the trophic levels 1228-1229, 1230	
	2.A.2 Organisms capture and store free energy for use in biological processes		NADP+ in photosynthesis 163, 166, 186, 188, 190, 191, 192, 193, 194, 195, 196, 197; Oxygen in cellular respiration 160, 165, 166, 167, 173, 203	

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Chapters/Sections	Essential Knowledge	Required content for the AP Course	Illustrative examples covered in this textbook - teach at least one	Content not required for the AP Course
9.2 Glycolysis harvests chemical energy by oxidizing glucose by pyruvate	2.A.1 All living systems require constant input of free energy	168-169	Krebs cycle 167, 168, 169, 170, 171, 175, 176, 178, 181; Glycolysis 167, 168, 169, 178, 181; Calvin cycle 194, 197, 198, 201, 202, 203; Fermentation 178, 179; Endothermy (the use of thermal energy generated by metabolism to maintain homeostatic body temperatures) 147, 149, 167, 168, 863, 864, 865, 866, 867, 868; Ectothermy (the use of external thermal energy to help regulate and maintain body temperature) 147, 148, 149, 165, 166, 167, 168, 863, 864, 865, 866, 867, 868; Life-history strategy (biennial plants, reproductive diapause) 1180, 1181; Change in the producer level can affect the number and size of other trophic levels 1202, 1203, 1204, 1205, 1206, 1220, 1221, 1222, 1226; Change in energy resources levels such as sunlight can affect the number and size of the trophic levels 1228-1229, 1230	
	2.A.2 Organisms capture and store free energy for use in biological processes		NADP+ in photosynthesis 163, 166, 186, 188, 190, 191, 192, 193, 194, 195, 196, 197; Oxygen in cellular respiration 160, 165, 166, 167, 173, 203	

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9.3 After pyruvate is oxidized, the citric acid cycle completes the energy-yielding oxidation of organic molecules	2.A.1 All living systems require constant input of free energy	170-172	Krebs cycle 167, 168, 169, 170, 171, 175, 176, 178, 181; Glycolysis 167, 168, 169, 178, 181; Calvin cycle 194, 197, 198, 201, 202, 203; Fermentation 178, 179; Endothermy (the use of thermal energy generated by metabolism to maintain homeostatic body temperatures) 147, 149, 167, 168, 863, 864, 865, 866, 867, 868; Ectothermy (the use of external thermal energy to help regulate and maintain body temperature) 147, 148, 149, 165, 166, 167, 168, 863, 864, 865, 866, 867, 868; Life-history strategy (biennial plants, reproductive diapause) 1180, 1181; Change in the producer level can affect the number and size of other trophic levels 1202, 1203, 1204, 1205, 1206, 1220, 1221, 1222, 1226; Change in energy resources levels such as sunlight can affect the number and size of the trophic levels 1228-1229, 1230	
	2.A.2 Organisms capture and store free energy for use in biological processes		NADP+ in photosynthesis 163, 166, 186, 188, 190, 191, 192, 193, 194, 195, 196, 197; Oxygen in cellular respiration 165, 167, 173, 203	

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Chapters/Sections	Essential Knowledge	Required content for the AP Course	Illustrative examples covered in this textbook - teach at least one	Content not required for the AP Course
9.4 During oxidative phosphorylation, chemiosmosis couples electron transport to ATP synthesis	2.A.1 All living systems require constant input of free energy	172-177	Krebs cycle 167, 168, 169, 170, 171, 175, 176, 178, 181; Glycolysis 167, 168, 169, 178, 181; Calvin cycle 194, 197, 198, 201, 202, 203; Fermentation 178, 179; Endothermy (the use of thermal energy generated by metabolism to maintain homeostatic body temperatures) 147, 149, 167, 168, 863, 864, 865, 866, 867, 868; Ectothermy (the use of external thermal energy to help regulate and maintain body temperature) 147, 148, 149, 165, 166, 167, 168, 863, 864, 865, 866, 867, 868; Life-history strategy (biennial plants, reproductive diapause) 1180, 1181; Change in the producer level can affect the number and size of other trophic levels 1202, 1203, 1204, 1205, 1206, 1220, 1221, 1222, 1226; Change in energy resources levels such as sunlight can affect the number and size of the trophic levels 1228-1229, 1230	
	2.A.2 Organisms capture and store free energy for use in biological processes		NADP+ in photosynthesis 163, 166, 186, 188, 190, 191, 192, 193, 194, 195, 196, 197; Oxygen in cellular respiration 165, 167, 173, 176, 203	

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Chapters/Sections	Essential Knowledge	Required content for the AP Course	Illustrative examples covered in this textbook - teach at least one	Content not required for the AP Course
9.5 Fermentation and anaerobic respiration enable cells to produce ATP without the use of oxygen	2.A.1 All living systems require constant input of free energy	177-179	Krebs cycle 167, 168, 169, 170, 171, 175, 176, 178, 181; Glycolysis 167, 168, 169, 178, 181; Calvin cycle 194, 197, 198, 201, 202, 203; Fermentation 178, 179; Endothermy (the use of thermal energy generated by metabolism to maintain homeostatic body temperatures) 147, 149, 167, 168, 863, 864, 865, 866, 867, 868; Ectothermy (the use of external thermal energy to help regulate and maintain body temperature) 147, 148, 149, 165, 166, 167, 168, 863, 864, 865, 866, 867, 868; Life-history strategy (biennial plants, reproductive diapause) 1180, 1181; Change in the producer level can affect the number and size of other trophic levels 1202, 1203, 1204, 1205, 1206, 1220, 1221, 1222, 1226; Change in energy resources levels such as sunlight can affect the number and size of the trophic levels 1228-1229, 1230	
	2.A.2 Organisms capture and store free energy for use in biological processes		NADP+ in photosynthesis 163, 166, 186, 188, 190, 191, 192, 193, 194, 195, 196, 197; Oxygen in cellular respiration 160, 165, 166, 167, 173, 203	
9.6 Glycolysis and the citric acid cycle connect to many other metabolic pathways				179-181

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Chapters/Sections	Essential Knowledge	Required content for the AP Course	Illustrative examples covered in this textbook - teach at least one	Content not required for the AP Course
10. Photosynthesis				
10.1 Photosynthesis converts light energy to the chemical energy of food	2.A.1 All living systems require constant input of free energy	186-189	Krebs cycle 167, 168, 169, 170, 171, 175, 176, 178, 181; Glycolysis 167, 168, 169, 178, 181; Calvin cycle 194, 197, 198, 201, 202, 203; Fermentation 178, 179; Endothermy (the use of thermal energy generated by metabolism to maintain homeostatic body temperatures) 147, 149, 167, 168, 863, 864, 865, 866, 867, 868; Ectothermy (the use of external thermal energy to help regulate and maintain body temperature) 147, 148, 149, 165, 166, 167, 168, 863, 864, 865, 866, 867, 868; Life-history strategy (biennial plants, reproductive diapause) 1180, 1181; Change in the producer level can affect the number and size of other trophic levels 1202, 1203, 1204, 1205, 1206, 1220, 1221, 1222, 1226; Change in energy resources levels such as sunlight can affect the number and size of the trophic levels 1228-1229, 1230	
	2.A.2 Organisms capture and store free energy for use in biological processes		NADP+ in photosynthesis 163, 166, 186, 188, 190, 191, 192, 193, 194, 195, 196, 197; Oxygen in cellular respiration 160, 165, 166, 167, 173, 203	

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Chapters/Sections	Essential Knowledge	Required content for the AP Course	Illustrative examples covered in this textbook - teach at least one	Content not required for the AP Course
10.2 The light reactions converts solar energy to the chemical energy of ATP and NADPH	2.A.1 All living systems require constant input of free energy	189-197	Krebs cycle 167, 168, 169, 170, 171, 175, 176, 178, 181; Glycolysis 167, 168, 169, 178, 181; Calvin cycle 194, 197, 198, 201, 202, 203; Fermentation 178, 179; Endothermy (the use of thermal energy generated by metabolism to maintain homeostatic body temperatures) 147, 149, 167, 168, 863, 864, 865, 866, 867, 868; Ectothermy (the use of external thermal energy to help regulate and maintain body temperature) 147, 148, 149, 165, 166, 167, 168, 863, 864, 865, 866, 867, 868; Life-history strategy (biennial plants, reproductive diapause) 1180, 1181; Change in the producer level can affect the number and size of other trophic levels 1202, 1203, 1204, 1205, 1206, 1220, 1221, 1222, 1226; Change in energy resources levels such as sunlight can affect the number and size of the trophic levels 1228-1229, 1230	
	2.A.2 Organisms capture and store free energy for use in biological processes		NADP+ in photosynthesis 163, 166, 186, 188, 190, 191, 192, 193, 194, 195, 196, 197; Oxygen in cellular respiration 165, 167, 173, 179, 203	

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Chapters/Sections	Essential Knowledge	Required content for the AP Course	Illustrative examples covered in this textbook - teach at least one	Content not required for the AP Course
10.3 The Calvin cycle uses the chemical energy of ATP and NADPH to reduce CO_2 to sugar	2.A.1 All living systems require constant input of free energy	198-199	Krebs cycle 167, 168, 169, 170, 171, 175, 176, 178, 181; Glycolysis 167, 168, 169, 178, 181; Calvin cycle 194, 197, 198, 201, 202, 203; Fermentation 178, 179; Endothermy (the use of thermal energy generated by metabolism to maintain homeostatic body temperatures) 147, 149, 167, 168, 863, 864, 865, 866, 867, 868; Ectothermy (the use of external thermal energy to help regulate and maintain body temperature) 147, 148, 149, 165, 166, 167, 168, 863, 864, 865, 866, 867, 868; Seasonal reproduction in animals and plants 497; Life-history strategy (biennial plants, reproductive diapause) 1180, 1181; Change in the producer level can affect the number and size of other trophic levels 1202, 1203, 1204, 1205, 1206, 1220, 1221, 1222, 1226; Change in energy resources levels such as sunlight can affect the number and size of the trophic levels 1220, 1221, 1222	
	2.A.2 Organisms capture and store free energy for use in biological processes		NADP+ in photosynthesis 163, 166, 186, 188, 190, 191, 192, 193, 194, 195, 196, 197; Oxygen in cellular respiration 160, 165, 166, 167, 173, 203	
10.4 Alternative mechanisms of carbon fixation have evolved in hot, arid climates				199-202
11. Cell Communications				

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Chapters/Sections	Essential Knowledge	Required content for the AP Course	Illustrative examples covered in this textbook - teach at least one	Content not required for the AP Course
	3.D.1 Cell communication processes share common features that reflect a shared evolutionary history		Use of chemical messengers by microbes to communicate with other nearby cells and to regulate specific pathways in response to population density (quorum sensing) 207; Use of pheromones to trigger reproduction and developmental pathways 211, 212, 213; Response to external signals by bacteria that influences cell movement 207, 209; Epinephrine stimulation of glycogen breakdown in mammals 209; Temperature determination of sex in some vertebrate organisms 999; DNA repair mechanisms 318	
	3.D.2 Cell communicate with each other through direct contact with other cells or from a distance via chemical signaling		Use of chemical messengers by microbes to communicate with other nearby cells and to regulate specific pathways in response to population density (quorum sensing) 208; Use of pheromones to trigger reproduction and developmental pathways 211, 212, 213; Response to external signals by bacteria that influences cell movement 207, 209; Epinephrine stimulation of glycogen breakdown in mammals 209, 219, 220, 977, 991, 1058, 986; DNA repair mechanisms 318	

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Chapters/Sections	Essential Knowledge	Required content for the AP Course	Illustrative examples covered in this textbook - teach at least one	Content not required for the AP Course
11.1 External signals are converted to responses within the cell	2.E.2 timing and coordination of physiological events are regulated by multiple mechanisms	206-210	Circadian rhythms, or the physiological cycle of about 24 hours that is present in all eukaryotes and persists even in the absence of external cues 838, 862, 1070, 1071; Diurnal/nocturnal and sleep/awake cycles 838, 1070; Jet lag in humans 862; Seasonal responses, such as hibernation, estivation, and migration 872, 1119, 1136; Release and reaction to pheromones 639, 1089, 1122; Visual displays in the reproductive cycle, 594, 595; Fruiting body formation in fungi, slime molds and certain types of bacteria 207, 594, 595, 637, 643, 644, 645, 646, 647, 649; Quorum sensing in bacteria 207	

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Chapters/Sections	Essential Knowledge	Required content for the AP Course	Illustrative examples covered in this textbook - teach at least one	Content not required for the AP Course
	3.B.2 A variety of intercellular and intracellular signal transmissions mediate gene expression		Cytokines regulate gene expression to allow for cell replication and division 230, 231, 233, 235, 236, 254-255; Mating pheromones in yeast trigger mating gene expression 207; Levels of cAMP regulate metabolic gene expression in bacteria 355; Expression of the SRY gene triggers the male sexual development pathway in animals 290; Ethylene levels cause changes in the production of different enzymes, allowing fruits to ripen 827, 833; Seed germination and gibberellin 827, 831; Mating pheromones in yeast trigger mating genes expression and sexual reproduction 207; Morphogens stimulate cell differentiation and development 372; Changes in p53 activity can result in cancer 375, 376; HOX genes and their role in development 446, 527	
11.2 Reception: A signaling molecule binds to a receptor protein, causing it to change shape	3.D.2 Cell communicate with each other through direct contact with other cells or from a distance via chemical signaling	201-214	Immune cells interact by cell-cell contact, antigen-presenting cells (APCs), helper T-cells and killer T-cells. [See also 2.D.4] 208, 209, 935, 936, 937, 938, 939, 940, 941, 942, 943, 944; Plasmodesmata between plant cells that allow material to be transported from cell to cell 120, 121; Neurotransmitters; Plant immune response 845, 847, 975, 1047, 1055; Quorum sensing in bacteria 207; Morphogens in embryonic development; Insulin 986; Human growth hormone 63; Thyroid hormones; Testosterone; Estrogen 63, 214, 1009	

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Chapters/Sections	Essential Knowledge	Required content for the AP Course	Illustrative examples covered in this textbook - teach at least one	Content not required for the AP Course
11.3 Transduction: Cascades of molecular interactions relay signals from receptors to target molecules in the cell	3.D.3 Signal transduction pathways link signal reception with cellular response	214-218	G-protein linked receptors 211, 213, 217, 220, 221; Receptor tyrosine kinases 212; Ligand-gated ion channels 213; Second messengers, such as cyclic GMP, cyclic AMP, calcium ions (Ca2+), and inositol triphosphate (IP3) 218, 1055	
	3.D.4 Changes in signal transduction pathways can alter cellular response		G-protein linked receptors 217, 220, 221; Receptor tyrosine kinases 212; Ligand-gated ion channels 213; Second messengers, such as cyclic GMP, cyclic AMP, calcium ions (Ca2+), and inositol triphosphate (IP3) 218, 1055	

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Chapters/Sections	Essential Knowledge	Required content for the AP Course	Illustrative examples covered in this textbook - teach at least one	Content not required for the AP Course
11.4 Response: Cell signaling leads to regulation of transcription or cytoplasmic activities	3.B.2 A variety of intercellular and intracellular signal transmissions mediate gene expression	219-223	Cytokines regulate gene expression to allow for cell replication and division 230, 233, 254-255; Mating pheromones in yeast trigger mating gene expression 207; Levels of cAMP regulate metabolic gene expression in bacteria; Expression of the SRY gene triggers the male sexual development pathway in animals 290, 1010; Ethylene levels cause changes in the production of different enzymes, allowing fruits to ripen 208, 827, 833; Seed germination and gibberellin 827, 831; Mating pheromones in yeast trigger mating genes expression and sexual reproduction 207; Morphogens stimulate cell differentiation and development 372; Changes in p53 activity can result in cancer 375, 376; HOX genes and their role in development 446, 527	
11.5 Apoptosis integrates multiple cell-signaling pathways				223-225
12. The Cell Cycle				
12.1 Most cell division results in genetically identical daughter cells	3.A.2 In eukaryotes, heritable information is passed to the next generation via processes that include the cell cycle and mitosis, or meiosis plus fertilization	229-230	Mitosis-promoting factor (MPF) 240; Action of platelet-derived growth factor (PDGF) 241; Cancer results from disruptions in cell cycle control 241, 242, 243	
12.2 The mitotic phase alternates with interphase in the cell cycle	3.A.2 In eukaryotes, heritable information is passed to the next generation via processes that include the cell cycle and mitosis, or meiosis plus fertilization	230-238	Mitosis-promoting factor (MPF) 240; Action of platelet-derived growth factor (PDGF) 241; Cancer results from disruptions in cell cycle control 241, 242, 243	
12.3 The eukaryotic cell cycle is regulated by a molecular control system	3.A.2 In eukaryotes, heritable information is passed to the next generation via processes that include the cell cycle and mitosis, or meiosis plus fertilization	238-243	Mitosis-promoting factor (MPF) 240; Action of platelet-derived growth factor (PDGF) 241; Cancer results from disruptions in cell cycle control 241, 242, 243	

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Chapters/Sections	Essential Knowledge	Required content for the AP Course	Illustrative examples covered in this textbook - teach at least one	Content not required for the AP Course
13. Meiosis and Sexual Life Cycle				
13.1 Offspring acquire genes from parents by inheriting chromosomes	3.A.2 In eukaryotes, heritable information is passed to the next generation via processes that include the cell cycle and mitosis, or meiosis plus fertilization	248-249	Mitosis-promoting factor (MPF) 240; Action of platelet-derived growth factor (PDGF) 241; Cancer results from disruptions in cell cycle control 241, 242, 243	
13.2 Fertilization and meiosis alternate in sexual life cycle	3.A.2 In eukaryotes, heritable information is passed to the next generation via processes that include the cell cycle and mitosis, or meiosis plus fertilization	250-253	Mitosis-promoting factor (MPF) 240; Action of platelet-derived growth factor (PDGF) 241; Cancer results from disruptions in cell cycle control 241, 242, 243	
13.3 Meiosis reduces the number of chromosomes sets from diploid to haploid	3.A.2 In eukaryotes, heritable information is passed to the next generation via processes that include the cell cycle and mitosis, or meiosis plus fertilization	253-257	Mitosis-promoting factor (MPF) 240; Action of platelet-derived growth factor (PDGF) 241; Cancer results from disruptions in cell cycle control 241, 242, 243	
13.4 Genetic variation produced in sexual life cycles contributes to evolution	3.C.2 Biological systems have multiple processes that increase genetic variation	257-260		
14. Mendel and the Gene Idea				
14.1 Mendel used the scientific approach to identify two laws of inheritance	3.A.3 The chromosomal basis of inheritance provides an understanding of the pattern of passage (transmission) of genes from parent to offspring	262-269	Sickle cell anemia 84; Tay-Sachs disease 280; Huntington's disease 278; X-linked color blindness 291; Trisomy 21/Down syndrome 250; Klinefelter's syndrome 298; Reproduction issues 250, 298	
14.2 The laws of probability govern Mendelian inheritance	3.A.3 The chromosomal basis of inheritance provides an understanding of the pattern of passage (transmission) of genes from parent to offspring	269-271	Sickle cell anemia 84; Tay-Sachs disease 280; Huntington's disease 278; X-linked color blindness 291; Trisomy 21/Down syndrome 250; Klinefelter's syndrome 298; Reproduction issues 270, 271, 298	

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Chapters/Sections	Essential Knowledge	Required content for the AP Course	Illustrative examples covered in this textbook - teach at least one	Content not required for the AP Course
14.3 Inheritance patterns are often more complex than predicted by simple Mendelian genetics	4.C.2 Environmental factors influence the expression of the genotype in an organism	271-275	Height and weight in humans 290; Flower color based on soil pH 274; Density of plant hairs as a function of herbivory 739; Effect of adding lactose to a Lac + bacterial culture 354; Presence of the opposite mating type on pheromones production in yeast and other fungi 157; Darker fur in cooler regions of the body in certain mammal species 292; Alterations in timing of flowering due to climate changes 274	
	3.A.3 The chromosomal basis of inheritance provides an understanding of the pattern of passage (transmission) of genes from parent to offspring		Sickle cell anemia 84; Tay-Sachs disease 280; Huntington's disease 278; X-linked color blindness 291; Trisomy 21/Down syndrome 250; Klinefelter's syndrome 298; Reproduction issues 250, 298	
	4.C.4 The diversity of species within an ecosystem may influence the stability of the ecosystem			
14.4 Many human traits follow Mendelian patterns of inheritance	3.A.3 The chromosomal basis of inheritance provides an understanding of the pattern of passage (transmission) of genes from parent to offspring	275-281	Sickle cell anemia 84; Tay-Sachs disease 280; Huntington's disease 278; X-linked color blindness 291; Trisomy 21/Down syndrome 250; Klinefelter's syndrome 298; Reproduction issues 250, 298; Civic issues such as ownership of genetic information, privacy, historical contexts, etc. 280	
15. The Chromosomal Basis of Inheritance				

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Chapters/Sections	Essential Knowledge	Required content for the AP Course	Illustrative examples covered in this textbook - teach at least one	Content not required for the AP Course
15.1 Mendel Ian inheritance has its physical basis in the behavior of chromosomes	3.A.4 The inheritance pattern of many traits cannot by explained by simple Medelian genetics	286-289	Sex-linked genes reside on sex chromosomes (X in humans) 289, 290, 992; In mammals and flies, the Y chromosome is very small and carries few genes 289, 290; In mammals and flies, females are XX and males are XY 289, 290, 992; as such, X-linked recessive traits are always expressed in males 289, 290, 992; Some traits are sex limited, and expression depends on the sex of the individual, such as milk production in female mammals and pattern baldness in males 291, 992	
15.2 Sex-linked genes exhibit unique patterns of inheritance	3.A.4 The inheritance pattern of many traits cannot by explained by simple Medelian genetics	289-292	Sex-linked genes reside on sex chromosomes (X in humans) 289, 290, 992; In mammals and flies, the Y chromosome is very small and carries few genes 289, 290; In mammals and flies, females are XX and males are XY 289, 290, 992; as such, X-linked recessive traits are always expressed in males 289, 290, 992; Some traits are sex limited, and expression depends on the sex of the individual, such as milk production in female mammals and pattern baldness in males 291, 992	

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Chapters/Sections	Essential Knowledge	Required content for the AP Course	Illustrative examples covered in this textbook - teach at least one	Content not required for the AP Course
15.3 Linked genes tend to be inherited together because they are located near each other on the same chromosome		292-297	Sex-linked genes reside on sex chromosomes (X in humans) 289, 290, 992; In mammals and flies, the Y chromosome is very small and carries few genes 289, 290; In mammals and flies, females are XX and males are XY 289, 290, 992; as such, X-linked recessive traits are always expressed in males 289, 290, 992; Some traits are sex limited, and expression depends on the sex of the individual, such as milk production in female mammals and pattern baldness in males 291, 992	
15.4 Alteration of chromosome number or structure cause some genetic disorder	3.C.1 Biological systems have multiple processes that increase genetic variation	297-300	Antibiotic resistance mutations 462; Pesticide resistance mutations 397; Sickle cell disorder and heterozygote advantage 8, 854	
15.5 Some inheritance patterns are exceptions to standard Mendel Ian inheritance	3.A.4 The inheritance pattern of many traits cannot by explained by simple Medelian genetics	300-302	Sex-linked genes reside on sex chromosomes (X in humans) 289, 290, 992; In mammals and flies, the Y chromosome is very small and carries few genes 289, 290; In mammals and flies, females are XX and males are XY 289, 290, 992; as such, X-linked recessive traits are always expressed in males 289, 290, 992; Some traits are sex limited, and expression depends on the sex of the individual, such as milk production in female mammals and pattern baldness in males 291, 992	
16. The Molecular Basis of Inheritance				

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Chapters/Sections	Essential Knowledge	Required content for the AP Course	Illustrative examples covered in this textbook - teach at least one	Content not required for the AP Course
16.1 DNA is the genetic material	3.A.1 DNA, and in some cases RNA, is the primary source of heritable information	305-310	Addition of a poly-A tail 334, 335; Addition of a GTP cap 211; Excision of introns 335, 336; Enzymatic reactions 319; Transport by proteins 307; Synthesis 314, 315, 316, 317; Degradation 364; Electrophoresis 405; Plasmid-based transformation 306, 399; Restriction enzyme analysis of DNA 398; Polymerase Chain Reaction (PCR) 404 409; Genetically modified foods 397, 413; Transgenic animals 419; Cloned animals 397, 399, 400, 402 413, 414; Pharmaceuticals, such as human insulin or factor X 412	
16.2 Many proteins work together in DNA replication and repair	3.A.1 DNA, and in some cases RNA, is the primary source of heritable information	311-319	Addition of a poly-A tail 334, 335; Addition of a GTP cap 211; Excision of introns 335, 336; Enzymatic reactions 319; Transport by proteins 307; Synthesis 314, 315, 316, 317; Degradation 364; Electrophoresis 405; Plasmid-based transformation 306, 399; Restriction enzyme analysis of DNA 398; Polymerase Chain Reaction (PCR) 404 409; Genetically modified foods 397, 413; Transgenic animals 419; Cloned animals 397, 399, 400, 402 413, 414; Pharmaceuticals, such as human insulin or factor X 412	
	3.C.1 Biological systems have multiple processes that increase genetic variation		Antibiotic resistance mutations 462; Pesticide resistance mutations 397; Sickle cell disorder and heterozygote advantage 8, 854	
16.3 A chromosome consists of a DNA molecule packed together with proteins				320-322

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Chapters/Sections	Essential Knowledge	Required content for the AP Course	Illustrative examples covered in this textbook - teach at least one	Content not required for the AP Course
17. From Gene to Protein				
17.1 Genes specify proteins via transcription and translation	3.A.1 DNA, and in some cases RNA, is the primary source of heritable information	325-331	Addition of a poly-A tail 334, 335; Addition of a GTP cap 211; Excision of introns 335, 336; Enzymatic reactions 319; Transport by proteins 307; Synthesis 314, 315, 316, 317; Degradation 364; Electrophoresis 405; Plasmid-based transformation 306, 399; Restriction enzyme analysis of DNA 398; Polymerase Chain Reaction (PCR) 404 409; Genetically modified foods 397, 413; Transgenic animals 419; Cloned animals 397, 399, 400, 402 413, 414; Pharmaceuticals, such as human insulin or factor X 412	
17.2 Transcription is the DNA-directed synthesis of RNA: *a closer look*	3.A.1 DNA, and in some cases RNA, is the primary source of heritable information	331-334	Addition of a poly-A tail 334, 335; Addition of a GTP cap 211; Excision of introns 335, 336; Enzymatic reactions 319; Transport by proteins 307; Synthesis 314, 315, 316, 317; Degradation 364; Electrophoresis 405; Plasmid-based transformation 306, 399; Restriction enzyme analysis of DNA 398; Polymerase Chain Reaction (PCR) 404 409; Genetically modified foods 397, 413; Transgenic animals 419; Cloned animals 397, 399, 400, 402 413, 414; Pharmaceuticals, such as human insulin or factor X 412	

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Chapters/Sections	Essential Knowledge	Required content for the AP Course	Illustrative examples covered in this textbook - teach at least one	Content not required for the AP Course
17.3 Eukaryotic cells modify RNA after transcription	3.A.1 DNA, and in some cases RNA, is the primary source of heritable information	334-336	Addition of a poly-A tail 334, 335; Addition of a GTP cap 211; Excision of introns 335, 336; Enzymatic reactions 319; Transport by proteins 307; Synthesis 314, 315, 316, 317; Degradation 364; Electrophoresis 405; Plasmid-based transformation 306, 399; Restriction enzyme analysis of DNA 398; Polymerase Chain Reaction (PCR) 404 409; Genetically modified foods 397, 413; Transgenic animals 419; Cloned animals 397, 399, 400, 402 413, 414; Pharmaceuticals, such as human insulin or factor X 412	
17.4 Translation is the RNA-directed synthesis of a polypeptide: *a closer look*	3.A.1 DNA, and in some cases RNA, is the primary source of heritable information	337-344	Addition of a poly-A tail 334, 335; Addition of a GTP cap 211; Excision of introns 335, 336; Enzymatic reactions 319; Transport by proteins 307; Synthesis 314, 315, 316, 317; Degradation 364; Electrophoresis 405; Plasmid-based transformation 306, 399; Restriction enzyme analysis of DNA 398; Polymerase Chain Reaction (PCR) 404 409; Genetically modified foods 397, 413; Transgenic animals 419; Cloned animals 397, 399, 400, 402 413, 414; Pharmaceuticals, such as human insulin or factor X 412	
17.5 Mutations of one or a few nucleotides can affect protein structure and function	3.C.1 Biological systems have multiple processes that increase genetic variation	344-346	Antibiotic resistance mutations 462; Pesticide resistance mutations 397; Sickle cell disorder and heterozygote advantage 8, 854	

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Chapters/Sections	Essential Knowledge	Required content for the AP Course	Illustrative examples covered in this textbook - teach at least one	Content not required for the AP Course
17.6 While gene expression differs among the domains of life, the concept of a gene is universal	2.E.1 Timing and coordination of specific events are necessary for the normal development of an organism, and these events are regulated by a variety of mechanisms	346-347	Morphogenesis of fingers and toes 367, 526, 527, 528; Immune function 930, 931, 932, 933, 934; *C. elegans* development 1036; Flower Development 755, 756	

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Chapters/Sections	Essential Knowledge	Required content for the AP Course	Illustrative examples covered in this textbook - teach at least one	Content not required for the AP Course
18. Regulation of Gene Expression				
18.1 Bacteria often respond to environmental change by regulating transcription	3.B.1 Gene regulation results in differential gene expression, leading to cell specialization	351-356	Promoters 332, 333, 353, 354, 355; Terminators 332; Enhancers 360, 361	
	3.B.2 A variety of intercellular and intracellular signal transmissions mediate gene expression		Cytokines regulate gene expression to allow for cell replication and division 230, 233, 254-255; Mating pheromones in yeast trigger mating gene expression 207; Levels of cAMP regulate metabolic gene expression in bacteria; Expression of the SRY gene triggers the male sexual development pathway in animals 290, 1010; Ethylene levels cause changes in the production of different enzymes, allowing fruits to ripen 208, 827, 833; Seed germination and gibberellin 827, 831; Mating pheromones in yeast trigger mating genes expression and sexual reproduction 207; Morphogens stimulate cell differentiation and development 372; Changes in p53 activity can result in cancer 375, 376; HOX genes and their role in development 446, 527	
	2.E.1 Timing and coordination of specific events are necessary for the normal development of an organism, and these events are regulated by a variety of mechanisms		Morphogenesis of fingers and toes 367, 526, 527, 528; Immune function 930, 931, 932, 933, 934; *C. elegans* development 1036; Flower Development 755, 756	
	3.B.1 Gene regulation results in differential gene expression, leading to cell specialization		Promoters 332, 333, 353, 354, 355; Terminators 332; Enhancers 360, 361	

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Chapters/Sections	Essential Knowledge	Required content for the AP Course	Illustrative examples covered in this textbook - teach at least one	Content not required for the AP Course
18.2 Eukaryotic gene expression is regulated at many stages	3.B.2 A variety of intercellular and intracellular signal transmissions mediate gene expression	356-364	Cytokines regulate gene expression to allow for cell replication and division 230, 233, 254-255; Mating pheromones in yeast trigger mating gene expression 207; Levels of cAMP regulate metabolic gene expression in bacteria; Expression of the SRY gene triggers the male sexual development pathway in animals 290, 1010; Ethylene levels cause changes in the production of different enzymes, allowing fruits to ripen 208, 827, 833; Seed germination and gibberellin 827, 831; Mating pheromones in yeast trigger mating genes expression and sexual reproduction 207; Morphogens stimulate cell differentiation and development 372; Changes in p53 activity can result in cancer 375, 376; HOX genes and their role in development 446, 527	
	2.E.1 Timing and coordination of specific events are necessary for the normal development of an organism, and these events are regulated by a variety of mechanisms		Morphogenesis of fingers and toes 367, 526, 527, 528; Immune function 930, 931, 932, 933, 934; *C. elegans* development 1036; Flower Development 755, 756	
	3.B.1 Gene regulation results in differential gene expression, leading to cell specialization		Promoters 332, 333, 353, 354, 355; Terminators 332; Enhancers 360, 361	

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Chapters/Sections	Essential Knowledge	Required content for the AP Course	Illustrative examples covered in this textbook - teach at least one	Content not required for the AP Course
18.3 Noncoding RNAs play multiple roles in controlling gene expression	3.B.2 A variety of intercellular and intracellular signal transmissions mediate gene expression	364-366	Cytokines regulate gene expression to allow for cell replication and division 230, 233, 254-255; Mating pheromones in yeast trigger mating gene expression 207; Levels of cAMP regulate metabolic gene expression in bacteria; Expression of the SRY gene triggers the male sexual development pathway in animals 290, 1010; Ethylene levels cause changes in the production of different enzymes, allowing fruits to ripen 208, 827, 833; Seed germination and gibberellin 827, 831; Mating pheromones in yeast trigger mating genes expression and sexual reproduction 207; Morphogens stimulate cell differentiation and development 372; Changes in p53 activity can result in cancer 375, 376; HOX genes and their role in development 446, 527	
	4.A.3 Interactions between external stimuli and regulated gene expression result in specializations of cells, tissues and organs			
	2.E.1 Timing and coordination of specific events are necessary for the normal development of an organism, and these events are regulated by a variety of mechanisms		Morphogenesis of fingers and toes 367, 526, 527, 528; Immune function 930, 931, 932, 933, 934; *C. elegans* development 1036; Flower Development 755, 756	

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Chapters/Sections	Essential Knowledge	Required content for the AP Course	Illustrative examples covered in this textbook - teach at least one	Content not required for the AP Course
18.4 A program of differential gene expression leads to the different cell types in a multicellular organism	3.B.2 A variety of intercellular and intracellular signal transmissions mediate gene expression	366-373	Cytokines regulate gene expression to allow for cell replication and division 230, 233, 254-255; Mating pheromones in yeast trigger mating gene expression 207; Levels of cAMP regulate metabolic gene expression in bacteria; Expression of the SRY gene triggers the male sexual development pathway in animals 290, 1010; Ethylene levels cause changes in the production of different enzymes, allowing fruits to ripen 208, 827, 833; Seed germination and gibberellin 827, 831; Mating pheromones in yeast trigger mating genes expression and sexual reproduction 207; Morphogens stimulate cell differentiation and development 372; Changes in p53 activity can result in cancer 375, 376; HOX genes and their role in development 446, 527	
18.5 Cancer results from genetic changes that affect cell cycle control				373-377
19. Viruses				
19.1 A virus consists of a nucleic acid surrounded by a protein coat	3.C.3 Viral replication results in genetic variation, and viral infection can introduce genetic variation into the hosts	381-384	Transduction in bacteria 384, 386, 562, 563; Transposons present in incoming DNA 385, 435, 436	

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Chapters/Sections	Essential Knowledge	Required content for the AP Course	Illustrative examples covered in this textbook - teach at least one	Content not required for the AP Course
19.2 Viruses replicate only in host cells	3.A.1 DNA, and in some cases RNA, is the primary source of heritable information	384-390	Addition of a poly-A tail 334, 335; Addition of a GTP cap 211; Excision of introns 318; Enzymatic reactions 319; Transport by proteins 307; Synthesis 314, 315, 316, 317; Degradation 363, 364; Electrophoresis 405; Plasmid-based transformation 306, 399; Restriction enzyme analysis of DNA 398; Polymerase Chain Reaction (PCR) 404 409; Genetically modified foods 397; Transgenic animals 419; Cloned animals 397, 399, 400, 402 413, 414; Pharmaceuticals, such as human insulin or factor X 412	
	3.C.3 Viral replication results in genetic variation, and viral infection can introduce genetic variation into the hosts		Transduction in bacteria 384, 386, 562, 563; Transposons present in incoming DNA 385, 435, 436	
19.3 Viruses, viroids, and prions are formidable pathogens in animals and plants				390-394
20. Biotechnology				
20.1 DNA cloning yields multiple copies of a gene or other DNA segment	3.A.1 DNA, and in some cases RNA, is the primary source of heritable information	396-404	Addition of a poly-A tail 334, 335; Addition of a GTP cap 211; Excision of introns 318; Enzymatic reactions 319; Transport by proteins 307; Synthesis 314, 315, 316, 317; Degradation 363, 364; Electrophoresis 405; Plasmid-based transformation 306, 399; Restriction enzyme analysis of DNA 398; Polymerase Chain Reaction (PCR) 404 409; Genetically modified foods 397; Transgenic animals 419; Cloned animals 397, 399, 400, 402 413, 414; Pharmaceuticals, such as human insulin or factor X 412	

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Chapters/Sections	Essential Knowledge	Required content for the AP Course	Illustrative examples covered in this textbook - teach at least one	Content not required for the AP Course
20.2 DNA technology allows us to study the sequence, expression, and function of a gene	3.A.1 DNA, and in some cases RNA, is the primary source of heritable information	405-412	Addition of a poly-A tail 334, 335; Addition of a GTP cap 211; Excision of introns 318; Enzymatic reactions 319; Transport by proteins 307; Synthesis 314, 315, 316, 317; Degradation 363, 364; Electrophoresis 405; Plasmid-based transformation 306, 399; Restriction enzyme analysis of DNA 398; Polymerase Chain Reaction (PCR) 404 409; Genetically modified foods 397; Transgenic animals 419; Cloned animals 397, 399, 400, 402 413, 414; Pharmaceuticals, such as human insulin or factor X 412	
20.3 Cloning organisms may lead to production of stem cells for research and other applications				412-416
20.4 The practical applications of DNA technology affects our lives in many ways				417-423
21. Genomes and Their Evolution				
21.1 New approaches have accelerated the pace of genome sequencing				427-429
21.2 Scientists use bioinformatics to analyze genomes and their functions	3.C.1 Biological systems have multiple processes that increase genetic variation	429-432	Antibiotic resistance mutations 462; Pesticide resistance mutations 397; Sickle cell disorder and heterozygote advantage 8, 854	
21.3 Genomes vary in size, number of genes, and gene density				432-434
21.4 Multicellular eukaryotes have much noncoding DNA and many multigene families				434-438

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Chapters/Sections	Essential Knowledge	Required content for the AP Course	Illustrative examples covered in this textbook - teach at least one	Content not required for the AP Course
21.5 Duplication, rearrangement, and mutation of DNA contribute to genome evolution	4.C.1 Variations in molecular units provides cells with a wider range of functions	438-442	Different types of phospholipids in cell membranes 68, 69, 70, 71, 72, 76, 77, 99, 126, 127, 128, 129; Different types of hemoglobin 83, 84, 437, 440, 912, 924; MHC proteins 937; Chlorophylls 186, 188, 190, 191, 192; Molecular diversity of antibodies in response to an antigen 935, 936, 937, 938, 941, 942; The antifreeze gene in fish 128	
21.6 Comparing genome sequences provides clues to evolution and development				442-447
22. Descent with Modification: A Darwinian View of Life				
22.1 The Darwinian revolution challenged traditional views of a young Earth inhabited by unchanging species				453-455
22.2 Descent with modifications by natural selection explains the adaptation of organisms and the unity and diversity of life	1.A.1 Natural selection is a major mechanism of evolution	455-460	Graphical analysis of allele frequencies in a population 457, 458, 459, 460, 474; Application of the Hardy-Weinberg equilibrium equation 475	
22.3 Evolution is supported by an overwhelming amount of scientific evidence	1.A.4 Biological evolution is supported by scientific evidence from many disciplines, including mathematics	460-467	Graphical analyses of allele frequencies in a population; 457, 458, 459, 460, 474; Analysis of sequence data sets 541; Analysis of phylogenetic trees 538, 539, 540; Construction of phylogenetic trees based on sequence data 542, 543, 544, 545, 546, 547	

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Chapters/Sections	Essential Knowledge	Required content for the AP Course	Illustrative examples covered in this textbook - teach at least one	Content not required for the AP Course
23. The Evolution of Populations				
23.1 Genetic variation makes evolution possible	1.A.2 Natural selection acts on phenotypic variations in populations	469-472	Flowering time in relation to global climate change 201, 839, 840; Sickle cell Anemia 84, 406, 484; DDT resistance in insects 470; Artificial selection 459; Loss of genetic diversity within a crop species 459 815; Overuse of antibiotics 462	
	4.C.3 The level of variation in a population affects population dynamics			470, 471, 472, 588, 650, 1184
23.2 The Hardy-Weinberg equation can be used to test whether a population is evolving	1.A.1 Natural selection is a major mechanism of evolution	473-476	Graphical analysis of allele frequencies in a population 457, 458, 459, 460, 474; Application of the Hardy-Weinberg equilibrium equation 475	
	4.C.3 The level of variation in a population affects population dynamics		Campbell Biology offers many examples for this area, such as the following: Prairie chickens 478; Potato blight causing the potato famine 588; Corn rust affects on agricultural crops 650; Not all individuals in a population in a disease outbreak are equally affected 470; some may not show symptoms, some may have mild symptoms, or some may be naturally immune and resistant to the disease 471	
	4.C.4 The diversity of species within an ecosystem may influence the stability of the ecosystem			

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Chapters/Sections	Essential Knowledge	Required content for the AP Course	Illustrative examples covered in this textbook - teach at least one	Content not required for the AP Course
23.3 Natural selection, genetic drift, and gene flow can alter allele frequencies in a population	1.A.3 Evolutionary change is also driven by random processes	476-480	Graphical analyses of allele frequencies in a population; 457, 458, 459, 460, 474; Analysis of sequence data sets 541; Analysis of phylogenetic trees 538, 539, 540; Construction of phylogenetic trees based on sequence data 542, 543, 544, 545, 546, 547	
	4.C.3 The level of variation in a population affects population dynamics		Campbell Biology offers many examples for this area, such as the following: Prairie chickens 478; Potato blight causing the potato famine 588; Corn rust affects on agricultural crops 650; Not all individuals in a population in a disease outbreak are equally affected 470; some may not show symptoms, some may have mild symptoms, or some may be naturally immune and resistant to the disease 471	
23.4 Natural selection is the only mechanism that consistently causes adaptive evolution	1.A.2 Natural selection acts on phenotypic variations in populations	480-485	Flowering time in relation to global climate change 201, 839, 840; Peppered moth; Sickle cell Anemia 84, 406, 484; DDT resistance in insects 470; Artificial selection 459; Loss of genetic diversity within a crop species 459, 815; Overuse of antibiotics 462	
	3.C.1 Biological systems have multiple processes that increase genetic variation		Antibiotic resistance mutations 462; Pesticide resistance mutations 397; Sickle cell disorder and heterozygote advantage 8, 854	

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Chapters/Sections	Essential Knowledge	Required content for the AP Course	Illustrative examples covered in this textbook - teach at least one	Content not required for the AP Course
24. The Origin of Species				
24.1 The biological species concept emphasizes reproductive isolation	1.C.2 Speciation may occur when two populations become reproductively isolated	488-492		
	2.E.2 timing and coordination of physiological events are regulated by multiple mechanisms		Circadian rhythms, or the physiological cycle of about 24 hours that is present in all eukaryotes and persists even in the absence of external cues 207, 208, 838, 839, 1071; Diurnal/nocturnal and sleep/awake cycles 209, 838, 840, 1070; Jet lag in humans 209, 839; Seasonal responses, such as hibernation, estivation, and migration 835, 836, 837, 872, 1089, 1119, 1136; Release and reaction to pheromones 639, 1089, 1122; Visual displays in the reproductive cycle, 594, 595; Fruiting body formation in fungi, slime molds and certain types of bacteria 207, 594, 595, 637, 643, 644, 645, 646, 647, 649; Quorum sensing in bacteria 207	
24.2 Speciation can take place with or without geographic separation	1.C.3 Populations of organisms continue to evolve	493-498	Chemical resistance (mutations for resistance to antibiotics, pesticides, herbicides or chemotherapy drugs occur in the absence of the chemical 344, 345); Emergent diseases; Observed directional phenotypic change in a population (Grants' observations of Darwin's finches in the Galapagos) 469; A eukaryotic example that describes evolution of a Structure or process such as heart chambers, limbs, the brain and the immune system 511, 517, 518	

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Chapters/Sections	Essential Knowledge	Required content for the AP Course	Illustrative examples covered in this textbook - teach at least one	Content not required for the AP Course
24.3 Hybrid zones reveal factors that cause reproductive isolation	1.C.1 Speciation and extinction have occurred throughout the Earth's history	498-501	Five major extinctions 521, 522, 523; Human impact on ecosystems and species extinction rates 1205, 1245	
24.4 Speciation can occur rapidly or slowly and can result from changes in few or many genes	1.C.1 Speciation and extinction have occurred throughout the Earth's history	501-504	Five major extinctions 521, 522, 523; Human impact on ecosystems and species extinction rates 1205, 1245	
25. The History of Life on Earth				
25.1 Conditions on early Earth made the origin of life possible	1.B.1 Organisms share many conserved core processes and features that evolved and are widely distributed among organisms today	507-510	Cytoskeleton (a network of structural proteins that facilitate cell movement, morphological integrity and organelle transport) 100, 101, 112, 113, 116; Membrane-bound organelles (mitochondria and/or chloroplasts) 100, 101, 109, 110, 111; Linear chromosomes 229, 230, 232-233; Endomembrane systems, including the nuclear envelope 100, 101, 103, 104, 106, 107, 108, 109	
	1.D.1 There are several hypotheses about the natural origin of life on Earth, each with supporting evidence			
25.2 The fossil record documents the history of life	1.A.4 Biological evolution is supported by scientific evidence from many disciplines, including mathematics	510-514	Graphical analyses of allele frequencies in a population; 457, 458, 459, 460, 474; Analysis of sequence data sets 541; Analysis of phylogenetic trees 538, 539, 540; Construction of phylogenetic trees based on sequence data 542, 543, 544, 545, 546, 547	
	1.C.1 Speciation and extinction have occurred throughout the Earth's history		Five major extinctions 521, 522, 523; Human impact on ecosystems and species extinction rates 1205, 1245	

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Chapters/Sections	Essential Knowledge	Required content for the AP Course	Illustrative examples covered in this textbook - teach at least one	Content not required for the AP Course
25.3 Key events in life's history include the origins of single-celled and multicelled organisms and the colonization of land	1.B.1 Organisms share many conserved core processes and features that evolved and are widely distributed among organisms today	514-519	Cytoskeleton (a network of structural proteins that facilitate cell movement, morphological integrity and organelle transport) 100, 101, 112, 113, 116; Membrane-bound organelles (mitochondria and/or chloroplasts) 100, 101, 109, 110, 111; Linear chromosomes 229, 230, 232-233; Endomembrane systems, including the nuclear envelope 100, 101, 103, 104, 106, 107, 108, 109	
	1.D.1 There are several hypotheses about the natural origin of life on Earth, each with supporting evidence			
25.4 The rise and fall of groups of organisms reflect differences in speciation and extinction rates	1.C.1 Speciation and extinction have occurred throughout the Earth's history	519-524	Five major extinctions 521, 522, 523; Human impact on ecosystems and species extinction rates 1205, 1245	
	4.B.3 Interaction between and within populations influence patterns of species distribution and abundance			
25.5 Major changes in body form can result from changes in the sequences and regulation of developmental genes	2.E.1 Timing and coordination of specific events are necessary for the normal development of an organism, and these events are regulated by a variety of mechanisms	525-529	Morphogenesis of fingers and toes 367, 526, 527, 528; Immune function 930, 931, 932, 933, 934; *C. elegans* development 1036; Flower Development 755, 756	
25.6 Evolution is not goal oriented				529-530
26. Phylogeny and the Tree of Life				
26.1 Phylogenies show evolutionary relationships	1.B.2 Phylogenetic trees and cladograms are graphical representations (models) of evolutionary history that can be tested	537-540	Number of heart chambers in animals 678, 679, 682, 687, 688, 899, 900, 901, 902, 903; Opposable thumbs 742, 746; Absence of legs in some sea mammals 725	

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Chapters/Sections	Essential Knowledge	Required content for the AP Course	Illustrative examples covered in this textbook - teach at least one	Content not required for the AP Course
26.2 Phylogenies are inferred from morphological and molecular data	1.B.2 Phylogenetic trees and cladograms are graphical representations (models) of evolutionary history that can be tested	540-542	Number of heart chambers in animals 678, 679, 682, 687, 688, 899, 900, 901, 902, 903; Opposable thumbs 742, 746; Absence of legs in some sea mammals 725	
26.3 Shared characters are used to construct phylogenetic trees	1.B.2 Phylogenetic trees and cladograms are graphical representations (models) of evolutionary history that can be tested	542-548	Number of heart chambers in animals 678, 679, 682, 687, 688, 899, 900, 901, 902, 903; Opposable thumbs 742, 746; Absence of legs in some sea mammals 725	
26.4 An organism's evolutionary history is documented in its genome				548-549
26.5 Molecular clocks help track evolutionary time				549-551
26.6 New information continues to revise our understanding of the tree of life	1.D.2 Scientific evidence from many different disciplines supports models of the origin of life	551-553		

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Chapters/Sections	Essential Knowledge	Required content for the AP Course	Illustrative examples covered in this textbook - teach at least one	Content not required for the AP Course
27. Bacteria and Archaea				
27.1 Structure and functional adaptations contribute to prokaryotic success	3.A.1 DNA, and in some cases RNA, is the primary source of heritable information	556-560	Addition of a poly-A tail 334, 335; Addition of a GTP cap 211; Excision of introns 318; Enzymatic reactions 319; Transport by proteins 307; Synthesis 314, 315, 316, 317; Degradation 363, 364; Electrophoresis 405; Plasmid-based transformation 306, 399; Restriction enzyme analysis of DNA 398; Polymerase Chain Reaction (PCR) 404 409; Genetically modified foods 397; Transgenic animals 331, 419; Cloned animals 397, 399, 400, 402 413, 414; Pharmaceuticals, such as human insulin or factor X 412	
27.2 Rapid reproduction, mutation, and genetic recombination promote genetic diversity in prokaryotes	3.C.2 Biological systems have multiple processes that increase genetic variation	561-564		
27.3 Diverse nutritional and metabolic adaptations have evolved in prokaryotes				564-565
27.4 Molecular systematics is illuminating prokaryotic phylogeny				565-570
27.5 Prokaryotes play crucial roles in the biosphere				570-571
27.6 Prokaryotes have both beneficial and harmful impacts on humans				571-573
28. Protists				
28.1 Most eukaryotes are single-celled organisms				575-577
28.2 Excavates include protists with modified mitochondria and protists with unique flagella				580-581
28.3 Chromalveolates may have originated by secondary endosymbiosis				582-589
28.4 Rhizarians are a diverse group of protists defined by DNA similarities				589-590
28.5 Red algae and green algae are the closest relatives of land plants				590-592

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Chapters/Sections	Essential Knowledge	Required content for the AP Course	Illustrative examples covered in this textbook - teach at least one	Content not required for the AP Course
28.6 Unikonts include protists that are closely related to fungi and animals				593-597
29. Plant Diversity I: How Plants Colonized Land				
29.1 Land plants evolved from green algae				600-606
29.2 Mosses and other nonvascular plants have life cycles dominated by gametophytes				606-610
29.3 Ferns and other seedless vascular plants were the first plants to grow tall				610-615
30. Plant Diversity II: The Evolution of Seed Plants				
30.1 Seeds and pollen grains are key adaptations for life on land				618-621
30.2 Gymnosperms bear "naked" seeds, typically on				621-625
30.3 The reproductive adaptations of angiosperms include flowers and fruits				625-632
30.4 Human welfare depends greatly on seed plants				632-634
31. Fungi				
31.1 Fungi are heterotrophs that feed by absorption				636-638
31.2 Fungi produce sores through sexual or asexual life cycles				638-640
31.3 The ancestor of fungi was an aquatic, single-celled, flagellated protist				640-641
31.4 Fungi have radiated into a diverse set of lineages				641-648
31.5 Fungi play key roles in nutrient cycling, ecological interactions, and human welfare				648-652
32. An Overview of Animal Diversity				
32.1 Animals are multicellular heterotrophic eukaryotes with tissues that develop from embryonic layers				654-656
32.2 The history of animals spans more than half a billion years				656-658

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Chapters/Sections	Essential Knowledge	Required content for the AP Course	Illustrative examples covered in this textbook - teach at least one	Content not required for the AP Course
32.3 Animals can be characterized by "body plans"				658-661
32.4 New views of animal phylogen are emerging from molecular data				662-664
33. An Introduction to Invertebrates				
33.1 Sponges are basal animals that lack true tissues				670-671
33.2 Cnidarians are an ancient phylum of eumetazoans				671-673
33.3 Lophotrochozoans, a clade identified by molecular data, have the widest range of animal body forms				674-683
33.4 Ecdysozoans are the most species-rich animal group				683-692
33.5 Echinoderms and chordates are deuterostomes				692-694
34. The Origin and Evolution of Vertebrates				
34.1 Cordates have a notochord and a dorsal, hollow nerve cord				697-701
34.2 Craniates are chordates that have a head				701-702
34.3 Vertebrates are craniates that have a backbone				703-704
34.4 Cnatostomes are vertebrates that have jaws				704-709
34.5 Tetrapods are gnathostomes that have limbs				709-712
34.6 Amniotes are tetrapods that have a terrestrially adapted egg				713-720
34.7 Mammals are amniotes that have hair and produce milk				720-728
34.8 Humans are mammals that have a large brain and bipedal locomotion				728-733
35. Plant Structure, Growth, and Development				
35.1 Plants have a hierarchical organization consisting of organs, tissues, and cells				738-743
35.2 Meristems generate cells for primary and secondary growth				746-747
35.3 Primary growth lengthens roots and shoots				747-751
35.4 Secondary growth increases the diameter of stems and roots in woody plants				751-755

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Chapters/Sections	Essential Knowledge	Required content for the AP Course	Illustrative examples covered in this textbook - teach at least one	Content not required for the AP Course
35.5 Growth, morphogenesis, and cell differentiation produce the plant body				755-761
36. Resource Acquisition and Transport in Vascular Plants				
36.1 Adaptations for acquiring resources were key steps in the evolution of vascular plants				764-767
36.2 Different mechanisms transport substances over short or long distances				767-771
36.3 Transpiration drives the transport of water and minerals from roots to shoots via the xylem				772-776
36.4 The rate of transpiration is regulated by stomata				776-778
36.5 Sugars are transported from sources to sinks via the phloem				779-781
36.6 The symplast is highly dynamic				781-782
37. Soil and Plant Nutrition				
37.1 Soil containing a living, complex ecosystem				785-789
37.2 Plants require essential elements to complete their life cycle				789-792
37.3 Plant nutrition often involves relationships with other organisms				792-797

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Chapters/Sections	Essential Knowledge	Required content for the AP Course	Illustrative examples covered in this textbook - teach at least one	Content not required for the AP Course
38. Angiosperm Reproduction and Biotechnology				
38.1 Flowers, double fertilization, and fruits are unique features of the angiosperm life cycle	2.E.1 Timing and coordination of specific events are necessary for the normal development of an organism, and these events are regulated by a variety of mechanisms	801-811	Morphogenesis of fingers and toes 367, 526, 527, 528; Immune function 930, 931, 932, 933, 934; *C. elegans* development 1036; Flower Development 755, 756	
	2.E.2 timing and coordination of physiological events are regulated by multiple mechanisms		Circadian rhythms, or the physiological cycle of about 24 hours that is present in all eukaryotes and persists even in the absence of external cues 207, 208, 838, 839; Diurnal/nocturnal and sleep/awake cycles 209, 838, 840, 1070; Jet lag in humans 209, 839; Seasonal responses, such as hibernation, estivation, and migration 835, 836, 837, 872, 1089, 1119, 1136; Release and reaction to pheromones 639, 1089, 1122; Visual displays in the reproductive cycle, 594, 595; Fruiting body formation in fungi, slime molds and certain types of bacteria 207, 594, 595, 637, 643, 644, 645, 646, 647, 649; Quorum sensing in bacteria 207	
38.2 Flowering plants reproduce sexually, asexually, or both				812-815
38.3 Humans modify crops by breeding and genetic engineering				815-819
39. Plant Responses to Internal and External				

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Chapters/Sections	Essential Knowledge	Required content for the AP Course	Illustrative examples covered in this textbook - teach at least one	Content not required for the AP Course
39.1 Signals transduction pathways link signal reception to response	2.E.2 timing and coordination of physiological events are regulated by multiple mechanisms	821-824	Circadian rhythms, or the physiological cycle of about 24 hours that is present in all eukaryotes and persists even in the absence of external cues 207, 208, 838, 839, 1071; Diurnal/nocturnal and sleep/awake cycles 209, 838, 840, 1070; Jet lag in humans 209, 839; Seasonal responses, such as hibernation, estivation, and migration 835, 836, 837, 872, 1089, 1119, 1136; Release and reaction to pheromones 639, 1089, 1122; Visual displays in the reproductive cycle, 594, 595; Fruiting body formation in fungi, slime molds and certain types of bacteria 207, 594, 595, 637, 643, 644, 645, 646, 647, 649; Quorum sensing in bacteria 207	
39.2 Plant hormones help coordinate growth, development, and responses to stimuli	2.E.2 timing and coordination of physiological events are regulated by multiple mechanisms	824-835	Circadian rhythms, or the physiological cycle of about 24 hours that is present in all eukaryotes and persists even in the absence of external cues 207, 208, 838, 839, 1071; Diurnal/nocturnal and sleep/awake cycles 209, 838, 840, 1070; Jet lag in humans 209, 839; Seasonal responses, such as hibernation, estivation, and migration 835, 836, 837, 872, 1089, 1119, 1136; Release and reaction to pheromones 639, 1089, 1122; Visual displays in the reproductive cycle, 594, 595; Fruiting body formation in fungi, slime molds and certain types of bacteria 207, 594, 595, 637, 643, 644, 645, 646, 647, 649; Quorum sensing in bacteria 207	

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Chapters/Sections	Essential Knowledge	Required content for the AP Course	Illustrative examples covered in this textbook - teach at least one	Content not required for the AP Course
	2.E.3 Timing and coordination of behavior are regulated by various mechanisms and are important in natural selection		Availability of resources leading to fruiting body formation in fungi and certain types of bacteria 638, 639, 640, 649, 793, 794, 795; Niche and resource partitioning 1195, 1196; Mutualistic relationships (lichens; bacteria in digestive tracts of animals 797, 1199; and mycorrhizae) 571; Biology of pollination 572, 624, 625, 626, 627, 637, 645, 646, 647, 806, 807; Hibernation 872; Estivation 872; Migration 1119, 1136; Courtship 482, 483, 490-491, 1120, 1130, 1131, 1132	
39.3 Responses to light are critical for plant success	2.E.2 timing and coordination of physiological events are regulated by multiple mechanisms	835-841	Circadian rhythms, or the physiological cycle of about 24 hours that is present in all eukaryotes and persists even in the absence of external cues 207, 208, 838, 839, 1071; Diurnal/nocturnal and sleep/awake cycles 209, 838, 840, 1070; Jet lag in humans 209, 839; Seasonal responses, such as hibernation, estivation, and migration 835, 836, 837, 872, 1089, 1119, 1136; Release and reaction to pheromones 639, 1089, 1122; Visual displays in the reproductive cycle, 594, 595; Fruiting body formation in fungi, slime molds and certain types of bacteria 207, 594, 595, 637, 643, 644, 645, 646, 647, 649; Quorum sensing in bacteria 207	

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Chapters/Sections	Essential Knowledge	Required content for the AP Course	Illustrative examples covered in this textbook - teach at least one	Content not required for the AP Course
	2.E.3 Timing and coordination of behavior are regulated by various mechanisms and are important in natural selection		Availability of resources leading to fruiting body formation in fungi and certain types of bacteria 638, 639, 640, 649, 793, 794, 795; Niche and resource partitioning 1195, 1196; Mutualistic relationships (lichens; bacteria in digestive tracts of animals 797, 1199; and mycorrhizae) 571; Biology of pollination 572, 624, 625, 626, 627, 637, 645, 646, 647, 806, 807; Hibernation 872; Estivation 872; Migration 1119, 1136; Courtship 482, 483, 490-491, 1120, 1130, 1131, 1132	
39.4 Plants respond to a wide variety of stimuli other than light				841-845
39.5 Plants respond to attacks by herbivores and pathogens	2.D.4 Plants and animals have a variety of chemical defenses against infections that affect dynamic homeostasis	845-847	Invertebrate immune systems have nonspecific response mechanisms, but they lack pathogen-specific defense responses 845; Plant defenses against pathogens include molecular recognition systems with systemic responses; 847; infection triggers chemical responses that destroy infected and adjacent cells, thus localizing the effects 847; Vertebrate immune systems have nonspecific and nonheritable defense mechanisms against pathogens 934	
40. Basic Principles of Animal Form and Function				

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Chapters/Sections	Essential Knowledge	Required content for the AP Course	Illustrative examples covered in this textbook - teach at least one	Content not required for the AP Course
40.1 Animals form and function are correlated at all levels of organization	2.A.1 All living systems require constant input of free energy	852-860	Krebs cycle 167, 168, 169, 170, 171, 175, 176, 178, 181; Glycolysis 167, 168, 169, 178, 181; Calvin cycle 194, 197, 198, 201, 202, 203; Fermentation 178, 179; Endothermy (the use of thermal energy generated by metabolism to maintain homeostatic body temperatures) 147, 149, 167, 168, 863, 864, 865, 866, 867, 868; Ectothermy (the use of external thermal energy to help regulate and maintain body temperature) 147, 148, 149, 165, 166, 167, 168, 863, 864, 865, 866, 867, 868; Life-history strategy (biennial plants, reproductive diapause) 1180, 1181; Change in the producer level can affect the number and size of other trophic levels 1202, 1203, 1204, 1205, 1206, 1220, 1221, 1222, 1226; Change in energy resources levels such as sunlight can affect the number and size of the trophic levels 1228-1229, 1230	

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Chapters/Sections	Essential Knowledge	Required content for the AP Course	Illustrative examples covered in this textbook - teach at least one	Content not required for the AP Course
	4.B.2 Cooperative interactions within organisms promote efficiency in the use of energy and matter		Exchange of gases 854, 897, 898, 916, 917, 918, 919, 921, 923, 924, 925; Circulation of fluids 107, 108, 853, 854, 899, 900, 901, 902, 903, 908; Digestion of food 107, 854, 880, 882, 883, 885, 887, 890; Excretion of wastes 108, 854, 898; Bacterial community in the rumen of animals 891; Bacterial community in and around deep sea vents 567	

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Chapters/Sections	Essential Knowledge	Required content for the AP Course	Illustrative examples covered in this textbook - teach at least one	Content not required for the AP Course
	2.A.1 All living systems require constant input of free energy		Krebs cycle 167, 168, 169, 170, 171, 175, 176, 178, 181; Glycolysis 167, 168, 169, 178, 181; Calvin cycle 194, 197, 198, 201, 202, 203; Fermentation 178, 179; Endothermy (the use of thermal energy generated by metabolism to maintain homeostatic body temperatures) 147, 149, 167, 168, 863, 864, 865, 866, 867, 868; Ectothermy (the use of external thermal energy to help regulate and maintain body temperature) 147, 148, 149, 165, 166, 167, 168, 863, 864, 865, 866, 867, 868; Life-history strategy (biennial plants, reproductive diapause) 1180, 1181; Change in the producer level can affect the number and size of other trophic levels 1202, 1203, 1204, 1205, 1206, 1220, 1221, 1222, 1226; Change in energy resources levels such as sunlight can affect the number and size of the trophic levels 1228-1229, 1230	

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Chapters/Sections	Essential Knowledge	Required content for the AP Course	Illustrative examples covered in this textbook - teach at least one	Content not required for the AP Course
40.2 Feedback control maintains the internal environment in many animals	2.C.1 Organisms use feedback mechanisms to maintain their internal environments and respond to external environmental changes	860-862	Operons in gene regulation 353, 354, 355; Temperature regulation in animals 860; Plant responses to water limitations 779; Lactation in mammals 1015; Onset of labor in childbirth 1014, 1015; Ripening of fruit 626, 627; Diabetes mellitus in response to decreased insulin; 982; Dehydration in response to decreased antidiuretic hormone (ADH) 969; Graves' disease (hyperthyroidism) 987; Blood clotting 912	
	2.D.2 Homeostatic mechanism reflect both common ancestry and divergence due to adaptation in different environments		Gas exchange in aquatic and terrestrial plants 1229; Digestive mechanisms in animals such as food vacuoles, gastrovascular cavities, one-way digestive systems 80, 881, 882, 883, 885, 886, 887, 888, 889, 890; Respiratory systems of aquatic and terrestrial animals 916, 917, 918, 919, 921, 922, 923, 925; Nitrogenous waste production and elimination in aquatic and terrestrial animals 958, 959, 961; Excretory systems in flatworms, earthworms and vertebrates 8 960, 962-963, 964, 966; Osmoregulation in bacteria, fish and protests 133, 134, 135, 953, 955, 956, 957; Osmoregulation in aquatic and terrestrial plants 133, 134, 135; Circulatory systems in fish, amphibians and mammals 899, 900, 901, 902, 903, 904, 905, 908, 909; Thermoregulation in aquatic and terrestrial animals (countercurrent exchange mechanisms) 863, 864, 865, 866, 867, 868	

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Chapters/Sections	Essential Knowledge	Required content for the AP Course	Illustrative examples covered in this textbook - teach at least one	Content not required for the AP Course
	2.D.3 Biological systems are affected by disruptions to their dynamic homeostatis		Physiological responses to toxic substances 1256, 1257; Dehydration; Immunological responses to pathogens, toxins, and allergens; Invasive and/or eruptive species 1242; Human impact 1239, 1240, 1243, 1244, 1254, 1255, 1256, 1259; Hurricanes, floods, earthquakes, volcanoes, and fires 1153-1156; Water limitation 793, 794, 795; Salination 793, 794, 795;	

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Chapters/Sections	Essential Knowledge	Required content for the AP Course	Illustrative examples covered in this textbook - teach at least one	Content not required for the AP Course
	2.C.2 Organisms respond to changes in their external environment		Physiological responses to toxic substances 1256, 1257; Dehydration; Immunological responses to pathogens, toxins, and allergens; Invasive and/or eruptive species 1242; Human impact 1239, 1240, 1243, 1244, 1254, 1255, 1256, 1259; Hurricanes, floods, earthquakes, volcanoes, and fires 1153-1156; Water limitation 793, 794, 795; Salination 793, 794, 795;	
	2.A.1 All living systems require constant input of free energy		Krebs cycle 167, 168, 169, 170, 171, 175, 176, 178, 181; Glycolysis 167, 168, 169, 178, 181; Calvin cycle 194, 197, 198, 201, 202, 203; Fermentation 178, 179; Endothermy (the use of thermal energy generated by metabolism to maintain homeostatic body temperatures) 147, 149, 167, 168, 863, 864, 865, 866, 867, 868; Ectothermy (the use of external thermal energy to help regulate and maintain body temperature) 147, 148, 149, 165, 166, 167, 168, 863, 864, 865, 866, 867, 868; Life-history strategy (biennial plants, reproductive diapause) 1180, 1181; Change in the producer level can affect the number and size of other trophic levels 1202, 1203, 1204, 1205, 1206, 1220, 1221, 1222, 1226; Change in energy resources levels such as sunlight can affect the number and size of the trophic levels 1228-1229, 1230	

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Chapters/Sections	Essential Knowledge	Required content for the AP Course	Illustrative examples covered in this textbook - teach at least one	Content not required for the AP Course
40.3 Homeostatic processes for thermoregulation involve form, function, and behavior	2.C.1 Organisms use feedback mechanisms to maintain their internal environments and respond to external environmental changes	862-868	Operons in gene regulation 353, 354, 355; Temperature regulation in animals 860; Plant responses to water limitations 779; Lactation in mammals 1015; Onset of labor in childbirth 1014, 1015; Ripening of fruit 626, 627; Diabetes mellitus in response to decreased insulin; 982; Dehydration in response to decreased antidiuretic hormone (ADH) 969; Graves' disease (hyperthyroidism) 987; Blood clotting 912	

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Chapters/Sections	Essential Knowledge	Required content for the AP Course	Illustrative examples covered in this textbook - teach at least one	Content not required for the AP Course
	2.D.2 Homeostatic mechanism reflect both common ancestry and divergence due to adaptation in different environments		Gas exchange in aquatic and terrestrial plants 1229; Digestive mechanisms in animals such as food vacuoles, gastrovascular cavities, one-way digestive systems 80, 881, 882, 883, 885, 886, 887, 888, 889, 890; Respiratory systems of aquatic and terrestrial animals 916, 917, 918, 919, 921, 922, 923, 925; Nitrogenous waste production and elimination in aquatic and terrestrial animals 958, 959, 961; Excretory systems in flatworms, earthworms and vertebrates 8 960, 962-963, 964, 966; Osmoregulation in bacteria, fish and protests 133, 134, 135, 953, 955, 956, 957; Osmoregulation in aquatic and terrestrial plants 133, 134, 135; Circulatory systems in fish, amphibians and mammals 899, 900, 901, 902, 903, 904, 905, 908, 909; Thermoregulation in aquatic and terrestrial animals (countercurrent exchange mechanisms) 863, 864, 865, 866, 867, 868	
	2.D.3 Biological systems are affected by disruptions to their dynamic homeostatis		Physiological responses to toxic substances 1256, 1257; Dehydration; Immunological responses to pathogens, toxins, and allergens; Invasive and/or eruptive species 1242; Human impact 1239, 1240, 1243, 1244, 1254, 1255, 1256, 1259; Hurricanes, floods, earthquakes, volcanoes, and fires 1153-1156; Water limitation 793, 794, 795; Salination 793, 794, 795;	

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Chapters/Sections	Essential Knowledge	Required content for the AP Course	Illustrative examples covered in this textbook - teach at least one	Content not required for the AP Course
40.4 Energy requirements are related to animal size, activity, and environment	2.A.1 All living systems require constant input of free energy	868-872	Krebs cycle 167, 168, 169, 170, 171, 175, 176, 178, 181; Glycolysis 167, 168, 169, 178, 181; Calvin cycle 194, 197, 198, 201, 202, 203; Fermentation 178, 179; Endothermy (the use of thermal energy generated by metabolism to maintain homeostatic body temperatures) 147, 149, 167, 168, 863, 864, 865, 866, 867, 868; Ectothermy (the use of external thermal energy to help regulate and maintain body temperature) 147, 148, 149, 165, 166, 167, 168, 863, 864, 865, 866, 867, 868; Life-history strategy (biennial plants, reproductive diapause) 1180, 1181; Change in the producer level can affect the number and size of other trophic levels 1202, 1203, 1204, 1205, 1206, 1220, 1221, 1222, 1226; Change in energy resources levels such as sunlight can affect the number and size of the trophic levels 1228-1229, 1230	
41. Animal Nutrition				
41.1 An animal's diet must supply chemical energy, organic molecules, and essential nutrients				875-880
41.2 The main stages of food processing are ingestion, digestion, absorption, and elimination				880-883
41.3 Organs specialized for sequential stages of food processing form the mammalian digestive system				883-889
41.4 Evolutionary adaptations of vertebrate digestive systems correlate with diet				889-891

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Chapters/Sections	Essential Knowledge	Required content for the AP Course	Illustrative examples covered in this textbook - teach at least one	Content not required for the AP Course
41.5 Feedback circuits regulate digestion, energy storage, and appetite				891-895
42. Circulation and Gas Exchange				
42.1 Circulatory systems link exchange surfaces with cells throughout the body				897-902
42.2 Coordinated cycles of heart contraction drive double circulation in mammals				902-904
42.3 Patterns of blood pressure and flow reflect the structure and arrangement of blood vessels				905-910
42.4 Blood components function in exchange, transport, and defense				910-915
42.5 Gas exchange occurs across specialized respiratory surfaces				915-920
42.6 Breathing ventilates the lungs				920-922
42.7 Adaptations for gas exchange include pigments that bind and transport gases				923-926
43 The Immune System				
43.1 In innate immunity, recognition and response rely on traits common to groups of pathogens	2.D.4 Plants and animals have a variety of chemical defenses against infections that affect dynamic homeostasis	930-935	Invertebrate immune systems have nonspecific response mechanisms, but they lack pathogen-specific defense responses 845; Plant defenses against pathogens include molecular recognition systems with systemic responses; 847; infection triggers chemical responses that destroy infected and adjacent cells, thus localizing the effects 847; Vertebrate immune systems have nonspecific and nonheritable defense mechanisms against pathogens 934	

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Chapters/Sections	Essential Knowledge	Required content for the AP Course	Illustrative examples covered in this textbook - teach at least one	Content not required for the AP Course
43.2 In adaptive immunity, receptors provide pathogen-specific recognition	2.D.4 Plants and animals have a variety of chemical defenses against infections that affect dynamic homeostasis	935-940	Invertebrate immune systems have nonspecific response mechanisms, but they lack pathogen-specific defense responses 845; Plant defenses against pathogens include molecular recognition systems with systemic responses; 847; infection triggers chemical responses that destroy infected and adjacent cells, thus localizing the effects 847; Vertebrate immune systems have nonspecific and nonheritable defense mechanisms against pathogens 934	
43.3 Adaptive immunity defends against infection of body fluids and body cells	2.D.4 Plants and animals have a variety of chemical defenses against infections that affect dynamic homeostasis	940-946	Invertebrate immune systems have nonspecific response mechanisms, but they lack pathogen-specific defense responses 845; Plant defenses against pathogens include molecular recognition systems with systemic responses; 847; infection triggers chemical responses that destroy infected and adjacent cells, thus localizing the effects 847; Vertebrate immune systems have nonspecific and nonheritable defense mechanisms against pathogens 934	

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Chapters/Sections	Essential Knowledge	Required content for the AP Course	Illustrative examples covered in this textbook - teach at least one	Content not required for the AP Course
43.4 Disruptions in immune system function can elicit or exacerbate disease	2.D.4 Plants and animals have a variety of chemical defenses against infections that affect dynamic homeostasis	946-950	Invertebrate immune systems have nonspecific response mechanisms, but they lack pathogen-specific defense responses 845; Plant defenses against pathogens include molecular recognition systems with systemic responses; 847; infection triggers chemical responses that destroy infected and adjacent cells, thus localizing the effects 847; Vertebrate immune systems have nonspecific and nonheritable defense mechanisms against pathogens 934	
44. Osmoregulation and Excretion				
44.1 Osmoregulation balances the uptake and loss of water and solutes				953-958
44.2 An animal's nitrogenous wastes reflect its phylogeny and habitat				958-959
44.3 Diverse excretory systems are variations on a tubular theme				960-963
44.4 The nephron is organized for stepwise processing of blood filtrate				963-968
44.5 Hormonal circuits link kidney function, water balance, and blood pressure				968-971

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Chapters/Sections	Essential Knowledge	Required content for the AP Course	Illustrative examples covered in this textbook - teach at least one	Content not required for the AP Course
45. Hormones and the Endocrine System				
45.1 Hormones and other signaling molecules bind to target receptors, triggering specific response pathways	3.B.2 A variety of intercellular and intracellular signal transmissions mediate gene expression	975-980	Cytokines regulate gene expression to allow for cell replication and division 230, 233, 254-255; Mating pheromones in yeast trigger mating gene expression 207; Levels of cAMP regulate metabolic gene expression in bacteria; Expression of the SRY gene triggers the male sexual development pathway in animals 290, 1010; Ethylene levels cause changes in the production of different enzymes, allowing fruits to ripen 208, 827, 833; Seed germination and gibberellin 827, 831; Mating pheromones in yeast trigger mating genes expression and sexual reproduction 207; Morphogens stimulate cell differentiation and development 372; Changes in p53 activity can result in cancer 375, 376; HOX genes and their role in development 446, 527	

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Chapters/Sections	Essential Knowledge	Required content for the AP Course	Illustrative examples covered in this textbook - teach at least one	Content not required for the AP Course
	3.D.2 Cell communicate with each other through direct contact with other cells or from a distance via chemical signaling		Immune cells interact by cell-cell contact, antigen-presenting cells (APCs), helper T-cells and killer T-cells. [See also 2.D.4] 208, 209, 935, 936, 937, 938, 939, 940, 941, 942, 943, 944; Plasmodesmata between plant cells that allow material to be transported from cell to cell 120, 121; Neurotransmitters; Plant immune response 845, 847, 975, 1047, 1055; Quorum sensing in bacteria 207; Morphogens in embryonic development; Insulin 986; Human growth hormone 63; Thyroid hormones; Testosterone; Estrogen 63, 214, 1009	
	3.D.1 Cell communication processes share common features that reflect a shared evolutionary history		Use of chemical messengers by microbes to communicate with other nearby cells and to regulate specific pathways in response to population density (quorum sensing) 208; Use of pheromones to trigger reproduction and developmental pathways 211, 212, 213; Response to external signals by bacteria that influences cell movement 207, 209; Epinephrine stimulation of glycogen breakdown in mammals 209; Temperature determination of sex in some vertebrate organisms 999; DNA repair mechanisms 318	

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Chapters/Sections	Essential Knowledge	Required content for the AP Course	Illustrative examples covered in this textbook - teach at least one	Content not required for the AP Course
45.2 Feedback regulation and antagonistic hormone pairs are common in endocrine systems	2.C.1 Organisms use feedback mechanisms to maintain their internal environments and respond to external environmental changes	981-984	Operons in gene regulation 353, 354, 355; Temperature regulation in animals 860; Plant responses to water limitations 779; Lactation in mammals 1015; Onset of labor in childbirth 1014, 1015; Ripening of fruit 626, 627; Diabetes mellitus in response to decreased insulin; 982; Dehydration in response to decreased antidiuretic hormone (ADH) 969; Graves' disease (hyperthyroidism) 987; Blood clotting 912	
	3.B.2 A variety of intercellular and intracellular signal transmissions mediate gene expression		Cytokines regulate gene expression to allow for cell replication and division 230, 233, 254-255; Mating pheromones in yeast trigger mating gene expression 207; Levels of cAMP regulate metabolic gene expression in bacteria; Expression of the SRY gene triggers the male sexual development pathway in animals 290, 1010; Ethylene levels cause changes in the production of different enzymes, allowing fruits to ripen 208, 827, 833; Seed germination and gibberellin 827, 831; Mating pheromones in yeast trigger mating genes expression and sexual reproduction 207; Morphogens stimulate cell differentiation and development 372; Changes in p53 activity can result in cancer 375, 376; HOX genes and their role in development 446, 527	

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Chapters/Sections	Essential Knowledge	Required content for the AP Course	Illustrative examples covered in this textbook - teach at least one	Content not required for the AP Course
	3.D.2 Cell communicate with each other through direct contact with other cells or from a distance via chemical signaling		Immune cells interact by cell-cell contact, antigen-presenting cells (APCs), helper T-cells and killer T-cells. [See also 2.D.4] 208, 209, 935, 936, 937, 938, 939, 940, 941, 942, 943, 944; Plasmodesmata between plant cells that allow material to be transported from cell to cell 120, 121; Neurotransmitters; Plant immune response 845, 847, 975, 1047, 1055; Quorum sensing in bacteria 207; Morphogens in embryonic development; Insulin 986; Human growth hormone 63; Thyroid hormones; Testosterone; Estrogen 63, 214, 1009	
45.3 The hypothalamus and pituitary are central to endocrine regulation				984-989
45.4 Endocrine glands respond to diverse stimuli in regulating homeostasis, development, and behavior				989-993
46. Animal Reproduction				
46.1 Both asexual and sexual reproduction occurs in the animal kingdom				996-999
46.2 Fertilization depends on mechanisms that bring together sperm and eggs of the same species				999-1002
46.3 Reproductive organs produce and transport gametes				1002-1008
46.4 The interplay of tropic and sex hormones regulates mammalian reproduction				1008-1011
46.5 In placental mammals, an embryo develops fully within the mother's uterus				1011-1018
47. Animal Development				
47.1 Fertilization and cleavage initiate embryonic development				1022-1027

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Chapters/Sections	Essential Knowledge	Required content for the AP Course	Illustrative examples covered in this textbook - teach at least one	Content not required for the AP Course
47.2 Morphogenesis in animals involves specific changes in cell shape, position, and survival				1027-1035
47.3 Cytoplasmic determinants and inductive signals contribute to cell fate specification	2.E.1 Timing and coordination of specific events are necessary for the normal development of an organism, and these events are regulated by a variety of mechanisms	1035-1042	Morphogenesis of fingers and toes 367, 526, 527, 528; Immune function 930, 931, 932, 933, 934; *C. elegans* development 1036; Flower Development 625, 839, 840	
48. Neurons, Synapses, and Signaling				
48.1 Neurons organization and structure reflect function in information transfer	3.E.2 Animals have nervous systems that detest external and internal signals, transmit and integrate information, and produce responses	1045-1047	Acetylcholine 1058; Epinephrine 986, 991; Norepinephrine 991, 1058; Dopamine 1058; Serotonin 1059; GABA 1058; Vision Hearing 1069, 1070, 1074, 1095, 1096-1097, 1098, 1099, 1100, 1101; Muscle movement 1064, 1104, 1105, 1108, 1110, 1111; Abstract thought and emotions 1071; Neuro-hormone production 975, 985; Forebrain (cerebrum), midbrain (brainstem), and hindbrain (cerebellum) 1068-1069; Right and left cerebral hemispheres in humans 1070, 1074	
48.2 Ion pumps and ion channels establish the resting potential of a neuron	3.E.2 Animals have nervous systems that detest external and internal signals, transmit and integrate information, and produce responses	1048-1050	Acetylcholine 1058; Epinephrine 986, 991; Norepinephrine 991, 1058; Dopamine 1058; Serotonin 1059; GABA 1058; Vision Hearing 1069, 1070, 1074, 1095, 1096-1097, 1098, 1099, 1100, 1101; Muscle movement 1064, 1104, 1105, 1108, 1110, 1111; Abstract thought and emotions 1071; Neuro-hormone production 975, 985; Forebrain (cerebrum), midbrain (brainstem), and hindbrain (cerebellum) 1068-1069; Right and left cerebral hemispheres in humans 1070, 1074	

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Chapters/Sections	Essential Knowledge	Required content for the AP Course	Illustrative examples covered in this textbook - teach at least one	Content not required for the AP Course
48.3 Action potentials are the signals conducted by axons	3.E.2 Animals have nervous systems that detest external and internal signals, transmit and integrate information, and produce responses	1050-1055	Acetylcholine 1058; Epinephrine 986, 991; Norepinephrine 991, 1058; Dopamine 1058; Serotonin 1059; GABA 1058; Vision Hearing 1069, 1070, 1074, 1095, 1096-1097, 1098, 1099, 1100, 1101; Muscle movement 1064, 1104, 1105, 1108, 1110, 1111; Abstract thought and emotions 1071; Neuro-hormone production 975, 985; Forebrain (cerebrum), midbrain (brainstem), and hindbrain (cerebellum) 1068-1069; Right and left cerebral hemispheres in humans 1070, 1074	
48.4 Neurons communicate with other cells at synapses	4.A.4 Organisms exhibit complex properties due to interactions between their constituent parts	1055-1060	Stomach and small intestines, 884, 885, 886, 887, 888; Kidney and bladder 962, 963, 964 969; Root, stem and leaf 773, 774, 775; Respiratory and circulatory 780, 781; Nervous and muscular 1104, 1105, 1108, 1110, 1111; Plant vascular and leaf 765, 769, 770, 771	
	3.E.2 Animals have nervous systems that detest external and internal signals, transmit and integrate information, and produce responses		Acetylcholine 1058; Epinephrine 986, 991; Norepinephrine 991, 1058; Dopamine 1058; Serotonin 1059; GABA 1058; Vision Hearing 1069, 1070, 1074, 1095, 1096-1097, 1098, 1099, 1100, 1101; Muscle movement 1064, 1104, 1105, 1108, 1110, 1111; Abstract thought and emotions 1071; Neuro-hormone production 975, 985; Forebrain (cerebrum), midbrain (brainstem), and hindbrain (cerebellum) 1068-1069; Right and left cerebral hemispheres in humans 1070, 1074	
49. Nervous System				

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Chapters/Sections	Essential Knowledge	Required content for the AP Course	Illustrative examples covered in this textbook - teach at least one	Content not required for the AP Course
49.1 Nervous system consists of curcuits of neurons and supporting cells				1062-1067
49.2 The vertebrates brain is regionally specialized	3.E.2 Animals have nervous systems that detest external and internal signals, transmit and integrate information, and produce responses	1067-1072	Acetylcholine 1058; Epinephrine 986, 991; Norepinephrine 991, 1058; Dopamine 1058; Serotonin 1059; GABA 1058; Vision Hearing 1069, 1070, 1074, 1095, 1096-1097, 1098, 1099, 1100, 1101; Muscle movement 1064, 1104, 1105, 1108, 1110, 1111; Abstract thought and emotions 1071; Neuro-hormone production 975, 985; Forebrain (cerebrum), midbrain (brainstem), and hindbrain (cerebellum) 1068-1069; Right and left cerebral hemispheres in humans 1070, 1074	
49.3 The cerebral cortex controls voluntary movement and cognitive functions				1072-1076
49.4 Changes in synaptic connections underlie memory and learning				1076-1079
49.5 Many nervous system disorder can be explained in molecular terms				1079-1082
50. Sensory and Motor Mechanisms				
50.1 Sensory receptors transduce stimulus energy and transmit signals to the central nervous system				1085-1090
50.2 The mechanoreceptors responsible for hearing and equilibrium detest moving fluid or settling particles				1090-1094
50.3 Visual receptors in diverse animals depends on light-absorbing pigments				1095-1101
50.4 The senses of taste and smell rely on similar sets of sensory receptors				1101-1103
50.5 The physical interaction of protein filaments is required for muscle function				1103-1110
50.6 Skeletal systems transform muscle contraction into locomotion				1110-1115

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Chapters/Sections	Essential Knowledge	Required content for the AP Course	Illustrative examples covered in this textbook - teach at least one	Content not required for the AP Course

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Chapters/Sections	Essential Knowledge	Required content for the AP Course	Illustrative examples covered in this textbook - teach at least one	Content not required for the AP Course
51. Animal Behavior				
51.1 Discrete sensory inputs can stimulate both simple and complex behaviors	3.E.1 Individuals can act on information and communicate it to others		Fight or flight response 206, 207; Predator warning 1127, 1139; Protection of young; Plant-plant interactions due to herbivory 1198; Avoidance responses 1125, 1126; Herbivory responses 1198; Territorial marking in mammals 1184; Coloration in flowers 761; Bee dances 1121; Birds songs 1134; Pack behavior in animals 1119; Herd, flock, and schooling behavior in animals 1119; Predator warning 1127; Colony and swarming behavior in insects 1124; Coloration 1197; Parent and offspring interactions 1124, 1127; Migration patterns 1119; Courtship and mating behaviors 482, 483, 490-491, 1120, 1130, 1131, 1132, 1134; Foraging in bees and other animals 1121; Avoidance behavior to electric fences, poisons, or traps 1125, 1126	
	2.E.3 Timing and coordination of behavior are regulated by various mechanisms and are important in natural selection		Availability of resources leading to fruiting body formation in fungi and certain types of bacteria 638, 639, 640, 649, 793, 794, 795; Niche and resource partitioning 1195, 1196; Mutualistic relationships (lichens; bacteria in digestive tracts of animals 797, 1199; and mycorrhizae) 571; Biology of pollination 572, 624, 625, 626, 627, 637, 645, 646, 647, 806, 807; Hibernation 872; Estivation 872; Migration 1119, 1136; Courtship 482, 483, 490-491, 1120, 1130, 1131, 1132	

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Chapters/Sections	Essential Knowledge	Required content for the AP Course	Illustrative examples covered in this textbook - teach at least one	Content not required for the AP Course
51.2 Learning establishes specific links between experience and behavior	2.E.3 Timing and coordination of behavior are regulated by various mechanisms and are important in natural selection	1123-1128	Availability of resources leading to fruiting body formation in fungi and certain types of bacteria 638, 639, 640, 649, 793, 794, 795; Niche and resource partitioning 1195, 1196; Mutualistic relationships (lichens; bacteria in digestive tracts of animals 797, 1199; and mycorrhizae) 571; Biology of pollination 572, 624, 625, 626, 627, 637, 645, 646, 647, 806, 807; Hibernation 872; Estivation 872; Migration 1119, 1136; Courtship 482, 483, 490-491, 1120, 1130, 1131, 1132	

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Chapters/Sections	Essential Knowledge	Required content for the AP Course	Illustrative examples covered in this textbook - teach at least one	Content not required for the AP Course
	2.A.1 All living systems require constant input of free energy	1128-1134	Krebs cycle 167, 168, 169, 170, 171, 175, 176, 178, 181; Glycolysis 167, 168, 169, 178, 181; Calvin cycle 194, 197, 198, 201, 202, 203; Fermentation 178, 179; Endothermy (the use of thermal energy generated by metabolism to maintain homeostatic body temperatures) 147, 149, 167, 168, 863, 864, 865, 866, 867, 868; Ectothermy (the use of external thermal energy to help regulate and maintain body temperature) 147, 148, 149, 165, 166, 167, 168, 863, 864, 865, 866, 867, 868; Life-history strategy (biennial plants, reproductive diapause) 1180, 1181; Change in the producer level can affect the number and size of other trophic levels 1202, 1203, 1204, 1205, 1206, 1220, 1221, 1222, 1226; Change in energy resources levels such as sunlight can affect the number and size of the trophic levels 1228-1229, 1230	
51.3 Selection for individual survival and reproductive success can explain most behaviors	1.A.1 Natural selection is a major mechanism of evolution		Graphical analyses of allele frequencies in a population; 457, 458, 459, 460, 474; Analysis of sequence data sets 541; Analysis of phylogenetic trees 538, 539, 540; Construction of phylogenetic trees based on sequence data 542, 543, 544, 545, 546, 547	

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Chapters/Sections	Essential Knowledge	Required content for the AP Course	Illustrative examples covered in this textbook - teach at least one	Content not required for the AP Course
	1.A.2 Natural selection acts on phenotypic variations in populations		Flowering time in relation to global climate change 201, 839, 840; Sickle cell Anemia 84, 406, 484; DDT resistance in insects 470; Artificial selection 459; Loss of genetic diversity within a crop species 459 815; Overuse of antibiotics 462	
	1.A.3 Evolutionary change is also driven by random processes		Graphical analyses of allele frequencies in a population; 457, 458, 459, 460, 474; Analysis of sequence data sets 541; Analysis of phylogenetic trees 538, 539, 540; Construction of phylogenetic trees based on sequence data 542, 543, 544, 545, 546, 547	
	1.A.4 Biological evolution is supported by scientific evidence from many disciplines, including mathematics		Graphical analyses of allele frequencies in a population; 457, 458, 459, 460, 474; Analysis of sequence data sets 541; Analysis of phylogenetic trees 538, 539, 540; Construction of phylogenetic trees based on sequence data 542, 543, 544, 545, 546, 547	
	1.A.1 Natural selection is a major mechanism of evolution		Graphical analysis of allele frequencies in a population 457, 458, 459, 460, 474; Application of the Hardy-Weinberg equilibrium equation 475	
	1.A.2 Natural selection acts on phenotypic variations in populations		Flowering time in relation to global climate change 201, 839, 840; Sickle cell Anemia 84, 406, 484; DDT resistance in insects 470; Artificial selection 459; Loss of genetic diversity within a crop species 459 815; Overuse of antibiotics 462	

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Chapters/Sections	Essential Knowledge	Required content for the AP Course	Illustrative examples covered in this textbook - teach at least one	Content not required for the AP Course
51.4 Inclusive fitness can account for the evolution of behavior, including altrusim	1.A.3 Evolutionary change is also driven by random processes	1134-1139	Graphical analyses of allele frequencies in a population; 457, 458, 459, 460, 474; Analysis of sequence data sets 541; Analysis of phylogenetic trees 538, 539, 540; Construction of phylogenetic trees based on sequence data 542, 543, 544, 545, 546, 547	
	1.A.4 Biological evolution is supported by scientific evidence from many disciplines, including mathematics		Graphical analyses of allele frequencies in a population; 457, 458, 459, 460, 474; Analysis of sequence data sets 541; Analysis of phylogenetic trees 538, 539, 540; Construction of phylogenetic trees based on sequence data 542, 543, 544, 545, 546, 547	
	2.E.3 Timing and coordination of behavior are regulated by various mechanisms and are important in natural selection		Availability of resources leading to fruiting body formation in fungi and certain types of bacteria 638, 639, 640, 642, 643, 645, 646, 647, 649, 793, 794, 795; Niche and resource partitioning 1195, 1196; Mutualistic relationships (lichens; bacteria in digestive tracts of animals 649; and mycorrhizae) 571; Biology of pollination 572, 624, 625, 626, 627, 637, 645, 646, 647, 806, 807; Hibernation 872; Estivation 872; Migration 1119, 1194; Courtship 482, 483, 490-491, 1120, 1130, 1131, 1132	
52. An Introduction to Ecology and the Biosphere				
52.1 Earth's climate varies by latitude and season and is changing rapidly				1144-1150

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Chapters/Sections	Essential Knowledge	Required content for the AP Course	Illustrative examples covered in this textbook - teach at least one	Content not required for the AP Course
52.2 The structure and distribution of terrestrial biomes are controlled by climate and disturbance	2.D.1 All biological systems from cells and organisms to populations, communities, and ecosystems are affected by complex biotic and abiotic interactions involving exchange of matter and free energy	1150-1152	Cell density 1178, 1179; Biofilms 207, 565; Temperature 1157, 1158; Water availability 778; Sunlight 1157, 1223; Symbiosis (mutualism, commensalism, parasitism) 571, 648, 649; Predator–prey relationships 1129, 1135, 1165, 1197, 1205; Water and nutrient availability, temperature, salinity, pH 793, 794, 795; Water and nutrient availability 1183; Availability of nesting materials and sites 1153-1156; Food chains and food webs 1202, 1203, 1204; Species diversity 1201; Population density 1171, 1172, 1173, 1182, 1183, 1184, 1185; Algal blooms 1223	
52.3 Aquatic biomes are diverse and dynamic systems that cover most of Earth				
52.4 Interaction between organisms and the environment limits the distribution of species				1163-1167
53. Population Ecology				
53.1 Dynamic biological processes influence population density, dispersion, and demographics	2.D.1 All biological systems from cells and organisms to populations, communities, and ecosystems are affected by complex biotic and abiotic interactions involving exchange of matter and free energy	1170-1175	Cell density 1178, 1179; Biofilms 207, 565; Temperature 1157, 1158; Water availability 778; Sunlight 1157, 1223; Symbiosis (mutualism, commensalism, parasitism) 571, 648, 649; Predator–prey relationships 1129, 1135, 1165, 1197, 1205; Water and nutrient availability, temperature, salinity, pH 793, 794, 795; Water and nutrient availability 1183; Availability of nesting materials and sites 1153-1156; Food chains and food webs 1202, 1203, 1204; Species diversity 1201; Population density 1171, 1172, 1173, 1182, 1183, 1184, 1185; Algal blooms 1223	
	4.A.5 Communities are composed of populations of organisms that interact in complex ways			

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Chapters/Sections	Essential Knowledge	Required content for the AP Course	Illustrative examples covered in this textbook - teach at least one	Content not required for the AP Course
53.2 The exponential model describes population growth in an idealized, unlimited environment	2.D.1 All biological systems from cells and organisms to populations, communities, and ecosystems are affected by complex biotic and abiotic interactions involving exchange of matter and free energy	1175-1177	Cell density 1178, 1179; Biofilms 207, 565; Temperature 1157, 1158; Water availability 778; Sunlight 1157, 1223; Symbiosis (mutualism, commensalism, parasitism) 571, 648, 649; Predator–prey relationships 1129, 1135, 1165, 1197, 1205; Water and nutrient availability, temperature, salinity, pH 793, 794, 795; Water and nutrient availability 1183; Availability of nesting materials and sites 1153-1156; Food chains and food webs 1202, 1203, 1204; Species diversity 1201; Population density 1171, 1172, 1173, 1182, 1183, 1184, 1185; Algal blooms 1223	
	4.A.5 Communities are composed of populations of organisms that interact in complex ways			

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Chapters/Sections	Essential Knowledge	Required content for the AP Course	Illustrative examples covered in this textbook - teach at least one	Content not required for the AP Course
53.3 The logistic model describes how a population grows more slowly as it nears its carrying capacity	2.A.1 All living systems require constant input of free energy	1177-1179	Krebs cycle 167, 168, 169, 170, 171, 175, 176, 178, 181; Glycolysis 167, 168, 169, 178, 181; Calvin cycle 194, 197, 198, 201, 202, 203; Fermentation 178, 179; Endothermy (the use of thermal energy generated by metabolism to maintain homeostatic body temperatures) 147, 149, 167, 168, 863, 864, 865, 866, 867, 868; Ectothermy (the use of external thermal energy to help regulate and maintain body temperature) 147, 148, 149, 165, 166, 167, 168, 863, 864, 865, 866, 867, 868; Life-history strategy (biennial plants, reproductive diapause) 1180, 1181; Change in the producer level can affect the number and size of other trophic levels 1202, 1203, 1204, 1205, 1206, 1220, 1221, 1222, 1226; Change in energy resources levels such as sunlight can affect the number and size of the trophic levels 1228-1229, 1230	
	2.D.1 All biological systems from cells and organisms to populations, communities, and ecosystems are affected by complex biotic and abiotic interactions involving exchange of matter and free energy		Cell density 1178, 1179; Biofilms 207, 565; Temperature 1157, 1158; Water availability 778; Sunlight 1157, 1223; Symbiosis (mutualism, commensalism, parasitism) 571, 648, 649; Predator–prey relationships 1129, 1135, 1165	

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Chapters/Sections	Essential Knowledge	Required content for the AP Course	Illustrative examples covered in this textbook - teach at least one	Content not required for the AP Course
	4.A.5 Communities are composed of populations of organisms that interact in complex ways		Predator–prey relationships 1129, 1159, 1169, 1197, 1205; Water and nutrient availability, temperature, salinity, pH 793, 794, 795; Water and nutrient availability 1183; Availability of nesting materials and sites 1153-1156; Food chains and food webs 1202, 1203, 1204; Species diversity 1201; Population density 1171, 1172, 1173, 1182, 1183, 1184, 1185; Algal blooms 1223	
53.4 Life history traits are products of natural selection	2.A.1 All living systems require constant input of free energy	1179-1181	Krebs cycle 167, 168, 169, 170, 171, 175, 176, 178, 181; Glycolysis 167, 168, 169, 178, 181; Calvin cycle 194, 197, 198, 201, 202, 203; Fermentation 178, 179; Endothermy (the use of thermal energy generated by metabolism to maintain homeostatic body temperatures) 147, 149, 167, 168, 863, 864, 865, 866, 867, 868; Ectothermy (the use of external thermal energy to help regulate and maintain body temperature) 147, 148, 149, 165, 166, 167, 168, 863, 864, 865, 866, 867, 868; Seasonal reproduction in animals and plants 489, 490-491, 492, 493, 494, 495, 497; Life-history strategy (biennial plants, reproductive diapause) 174; Change in the producer level can affect the number and size of other trophic levels 1202, 1203, 1204, 1205, 1206, 1220, 1221, 1222, 1226; Change in energy resources levels such as sunlight can affect the number and size of the trophic levels 1228-1229, 1230	

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Chapters/Sections	Essential Knowledge	Required content for the AP Course	Illustrative examples covered in this textbook - teach at least one	Content not required for the AP Course
	2.D.1 All biological systems from cells and organisms to populations, communities, and ecosystems are affected by complex biotic and abiotic interactions involving exchange of matter and free energy		Cell density 1178, 1179; Biofilms 207, 565; Temperature 1157, 1158; Water availability 778; Sunlight 1157, 1223; Symbiosis (mutualism, commensalism, parasitism) 571, 648, 649; Predator–prey relationships 1129, 1135, 1165, 1197, 1205; Water and nutrient availability, temperature, salinity, pH 793, 794, 795; Water and nutrient availability 1183; Availability of nesting materials and sites 1153-1156; Food chains and food webs 1202, 1203, 1204; Species diversity 1201; Population density 1171, 1172, 1173, 1182, 1183, 1184, 1185; Algal blooms 1223	
53.5 Many factors that regulate population growth are density dependent	2.D.1 All biological systems from cells and organisms to populations, communities, and ecosystems are affected by complex biotic and abiotic interactions involving exchange of matter and free energy	1182-1187		
	4.A.5 Communities are composed of populations of organisms that interact in complex ways		Predator/prey relationships spreadsheet model 1129, 1135, 1165, 1197, 1205; Symbiotic relationship 571, 649, 801, 1199; Graphical representation of field data 1174, 1175; Introduction of species 1165; Global climate change models 1146, 1147	
53.6 The human population is no longer growing exponentially but is still increasing rapidly	4.A.5 Communities are composed of populations of organisms that interact in complex ways	1187-1191	Predator/prey relationships spreadsheet model 1129, 1135, 1165, 1197, 1205; Symbiotic relationship 571, 649, 801, 1199; Graphical representation of field data 1174, 1175; Introduction of species 1165; Global climate change models 1146, 1147	
54. Community Ecology				
	4.B.3 Interactions between and within populations influence patterns of species distribution and abundance		Loss of keystone species; Kudzu; Dutch elm disease	

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Chapters/Sections	Essential Knowledge	Required content for the AP Course	Illustrative examples covered in this textbook - teach at least one	Content not required for the AP Course
54.1 Community interactions are classified by whether they help, harm, or have no effect on the species involved	2.D.1 All biological systems from cells and organisms to populations, communities, and ecosystems are affected by complex biotic and abiotic interactions involving exchange of matter and free energy	1194-1200	Cell density 1178, 1179; Biofilms 207, 565; Temperature 1157, 1158; Water availability 778; Sunlight 1157, 1223; Symbiosis (mutualism, commensalism, parasitism) 571, 648, 649; Predator–prey relationships 1129, 1135, 1165, 1197, 1205; Water and nutrient availability, temperature, salinity, pH 793, 794, 795; Water and nutrient availability 1183; Availability of nesting materials and sites 1153-1156; Food chains and food webs 1202, 1203, 1204; Species diversity 1201; Population density 1171, 1172, 1173, 1182, 1183, 1184, 1185; Algal blooms 1223	
	2.E.3 Timing and coordination of behavior are regulated by various mechanisms and are important in natural selection			
	4.A.5 Communities are composed of populations of organisms that interact in complex ways		Predator/prey relationships spreadsheet model 1129, 1135, 1165, 1197, 1205; Symbiotic relationship 571, 649, 801, 1199; Graphical representation of field data 1174, 1175; Introduction of species 1165; Global climate change models 1146, 1147	
	2.D.1 All biological systems from cells and organisms to populations, communities, and ecosystems are affected by complex biotic and abiotic interactions involving exchange of matter and free energy		Cell density 1178, 1179; Biofilms 207, 565; Temperature 1157, 1158; Water availability 778; Sunlight 1157, 1223; Symbiosis (mutualism, commensalism, parasitism) 571, 648, 649; Predator–prey relationships 1129, 1135, 1165, 1197, 1205; Water and nutrient availability, temperature, salinity, pH 793, 794, 795; Water	

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Chapters/Sections	Essential Knowledge	Required content for the AP Course	Illustrative examples covered in this textbook - teach at least one	Content not required for the AP Course
54.2 Diversity and trophic structure characterize biological communities	4.A.5 Communities are composed of populations of organisms that interact in complex ways	1200-1206	and nutrient availability 1183; Availability of nesting materials and sites 1153-1156; Food chains and food webs 1202, 1203, 1204; Species diversity 1201; Population density 1171, 1172, 1173, 1182, 1183, 1184, 1185; Algal blooms 1223	
	4.A.6 Interactions among living systems and with their environment result in the movement of matter and energy		There illustrations go along with 4.A.5: Predator/prey relationships spreadsheet model 1129, 1135, 1165, 1197, 1205; Symbiotic relationship 571, 649, 801, 1199; Graphical representation of field data 1174, 1175; Introduction of species 1165; Global climate change models 1146, 1147	
	4.C.4 The diversity of species within an ecosystem may influence the stability of the ecosystem			
54.3 Disturbance influences species diversity and composition	2.D.1 All biological systems from cells and organisms to populations, communities, and ecosystems are affected by complex biotic and abiotic interactions involving exchange of matter and free energy	1207-1210	Cell density 1178, 1179; Biofilms 207, 565; Temperature 1157, 1158; Water availability 778; Sunlight 1157, 1223; Symbiosis (mutualism, commensalism, parasitism) 571, 648, 649; Predator–prey relationships 1129, 1135, 1165, 1197, 1205; Water and nutrient availability, temperature, salinity, pH 793, 794, 795; Water and nutrient availability 1183; Availability of nesting materials and sites 1153-1156; Food chains and food webs 1202, 1203, 1204; Species diversity 1201; Population density 1171, 1172, 1173, 1182, 1183, 1184, 1185; Algal blooms 1223	
54.4 Biogeographic factors affect community diversity	2.D.1 All biological systems from cells and organisms to populations, communities, and ecosystems are affected by complex biotic and abiotic interactions involving exchange of matter and free energy	1211-1213		

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Chapters/Sections	Essential Knowledge	Required content for the AP Course	Illustrative examples covered in this textbook - teach at least one	Content not required for the AP Course
54.5 Pathogens alter community structure locally and globally	2.D.1 All biological systems from cells and organisms to populations, communities, and ecosystems are affected by complex biotic and abiotic interactions involving exchange of matter and free energy	1213-1215	Cell density 1178, 1179; Biofilms 207, 565; Temperature 1157, 1158; Water availability 778; Sunlight 1157, 1223; Symbiosis (mutualism, commensalism, parasitism) 571, 648, 649; Predator–prey relationships 1129, 1135, 1165, 1197, 1205; Water and nutrient availability, temperature, salinity, pH 793, 794, 795; Water and nutrient availability 1183; Availability of nesting materials and sites 1153-1156; Food chains and food webs 1202, 1203, 1204; Species diversity 1201; Population density 1171, 1172, 1173, 1182, 1183, 1184, 1185; Algal blooms 1223	
55. Ecosystems and Restoration Ecology				

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Chapters/Sections	Essential Knowledge	Required content for the AP Course	Illustrative examples covered in this textbook - teach at least one	Content not required for the AP Course
55.1 Physical laws govern energy flow and chemical cycling in ecosystems	2.A.1 All living systems require constant input of free energy	1219-1220	Krebs cycle 167, 168, 169, 170, 171, 175, 176, 178, 181; Glycolysis 167, 168, 169, 178, 181; Calvin cycle 194, 197, 198, 201, 202, 203; Fermentation 178, 179; Endothermy (the use of thermal energy generated by metabolism to maintain homeostatic body temperatures) 147, 149, 167, 168, 863, 864, 865, 866, 867, 868; Ectothermy (the use of external thermal energy to help regulate and maintain body temperature) 147, 148, 149, 165, 166, 167, 168, 863, 864, 865, 866, 867, 868; Life-history strategy (biennial plants, reproductive diapause) 1180, 1181; Change in the producer level can affect the number and size of other trophic levels 1202, 1203, 1204, 1205, 1206, 1220, 1221, 1222, 1226; Change in energy resources levels such as sunlight can affect the number and size of the trophic levels 1228-1229, 1230	
	2.D.1 All biological systems from cells and organisms to populations, communities, and ecosystems are affected by complex biotic and abiotic interactions involving exchange of matter and free energy		Cell density 1178, 1179; Biofilms 207, 565; Temperature 1157, 1158; Water availability 778; Sunlight 1157, 1223; Symbiosis (mutualism, commensalism, parasitism) 571, 648, 649;	

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Chapters/Sections	Essential Knowledge	Required content for the AP Course	Illustrative examples covered in this textbook - teach at least one	Content not required for the AP Course
	4.A.6 Interactions among living systems and with their environment result in the movement of matter and energy		Predator–prey relationships 1129, 1135, 1165, 1197, 1205; Water and nutrient availability, temperature, salinity, pH 793, 794, 795; Water and nutrient availability 1183; Availability of nesting materials and sites 1153-1156; Food chains and food webs 1202, 1203, 1204; Species diversity 1201; Population density 1171, 1172, 1173, 1182, 1183, 1184, 1185; Algal blooms 1223	
55.2 Energy and other limiting factors control primary production in ecosystems	2.A.1 All living systems require constant input of free energy	1220-1225	Krebs cycle 167, 168, 169, 170, 171, 175, 176, 178, 181; Glycolysis 167, 168, 169, 178, 181; Calvin cycle 194, 197, 198, 201, 202, 203; Fermentation 178, 179; Endothermy (the use of thermal energy generated by metabolism to maintain homeostatic body temperatures) 147, 149, 167, 168, 863, 864, 865, 866, 867, 868; Ectothermy (the use of external thermal energy to help regulate and maintain body temperature) 147, 148, 149, 165, 166, 167, 168, 863, 864, 865, 866, 867, 868; Life-history strategy (biennial plants, reproductive diapause) 1180, 1181; Change in the producer level can affect the number and size of other trophic levels 1202, 1203, 1204, 1205, 1206, 1220, 1221, 1222, 1226; Change in energy resources levels such as sunlight can affect the number and size of the trophic levels 1228-1229, 1230	

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Chapters/Sections	Essential Knowledge	Required content for the AP Course	Illustrative examples covered in this textbook - teach at least one	Content not required for the AP Course
	2.D.1 All biological systems from cells and organisms to populations, communities, and ecosystems are affected by complex biotic and abiotic interactions involving exchange of matter and free energy		Cell density 1178, 1179; Biofilms 207, 565; Temperature 1157, 1158; Water availability 778; Sunlight 1157, 1223; Symbiosis (mutualism, commensalism, parasitism) 571, 648, 649; Predator–prey relationships 1129, 1135, 1165, 1197, 1205; Water and nutrient availability, temperature, salinity, pH 793, 794, 795; Water and nutrient availability 1183; Availability of nesting materials and sites 1153-1156; Food chains and food webs 1202, 1203, 1204; Species diversity 1201; Population density 1171, 1172, 1173, 1182, 1183, 1184, 1185; Algal blooms 1223	
55.3 Energy transfer between trophic levels is typically only 10% efficient	2.A.1 All living systems require constant input of free energy	1225-1226		
	2.D.1 All biological systems from cells and organisms to populations, communities, and ecosystems are affected by complex biotic and abiotic interactions involving exchange of matter and free energy		Cell density 1178, 1179; Biofilms 207, 565; Temperature 1157, 1158; Water availability 778; Sunlight 1157, 1223; Symbiosis (mutualism, commensalism, parasitism) 571, 648, 649; Predator–prey relationships 1129, 1135, 1165, 1197, 1205; Water and nutrient availability, temperature, salinity, pH 793, 794, 795; Water and nutrient availability 1183; Availability of nesting materials and sites 1153-1156; Food chains and food webs 1202, 1203, 1204; Species diversity 1201; Population density 1171, 1172, 1173, 1182, 1183, 1184, 1185; Algal blooms 1223	
	4.A.6 Interactions among living systems and with their environment result in the movement of matter and energy			

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Chapters/Sections	Essential Knowledge	Required content for the AP Course	Illustrative examples covered in this textbook - teach at least one	Content not required for the AP Course
55.4 Biological and geochemical processes cycle nutrients and water in ecosystems	2.D.1 All biological systems from cells and organisms to populations, communities, and ecosystems are affected by complex biotic and abiotic interactions involving exchange of matter and free energy	1227-1232	Cell density 1178, 1179; Biofilms 207, 565; Temperature 1157, 1158; Water availability 778; Sunlight 1157, 1223; Symbiosis (mutualism, commensalism, parasitism) 571, 648, 649; Predator–prey relationships 1129, 1135, 1165, 1197, 1205; Water and nutrient availability, temperature, salinity, pH 793, 794, 795; Water and nutrient availability 1183; Availability of nesting materials and sites 1153-1156; Food chains and food webs 1202, 1203, 1204; Species diversity 1201; Population density 1171, 1172, 1173, 1182, 1183, 1184, 1185; Algal blooms 1223	
	4.A.6 Interactions among living systems and with their environment result in the movement of matter and energy			
55.5 Restoration ecologists help return degraded ecosystems to a more natural state	4.A.6 Interactions among living systems and with their environment result in the movement of matter and energy	1232-1233		

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Chapters/Sections	Essential Knowledge	Required content for the AP Course	Illustrative examples covered in this textbook - teach at least one	Content not required for the AP Course
56. Conservation Biology and Global Change				
56.1 Human activities threaten Earth's biodiversity	2.D.2 Homeostatic mechanism reflect both common ancestry and divergence due to adaptation in different environments	1239-1244	Gas exchange in aquatic and terrestrial plants 1229; Digestive mechanisms in animals such as food vacuoles, gastrovascular cavities, one-way digestive systems 80, 881, 882, 883, 885, 886, 887, 888, 889, 890; Respiratory systems of aquatic and terrestrial animals 916, 917, 918, 919, 921, 922, 923, 925; Nitrogenous waste production and elimination in aquatic and terrestrial animals 958, 959, 961; Excretory systems in flatworms, earthworms and vertebrates 8 960, 962-963, 964, 966; Osmoregulation in bacteria, fish and protests 133, 134, 135, 953, 955, 956, 957; Osmoregulation in aquatic and terrestrial plants 133, 134, 135; Circulatory systems in fish, amphibians and mammals 899, 900, 901, 902, 903, 904, 905, 908, 909; Thermoregulation in aquatic and terrestrial animals (countercurrent exchange mechanisms) 863, 864, 865, 866, 867, 868	
	2.D.3 Biological systems are affected by disruptions to their dynamic homeostatis		Physiological responses to toxic substances 1255, 1256, 1257; Dehydration; 69; Immunological responses to pathogens, toxins, and allergen 947; Invasive and/or eruptive species 1242; Human impact 1239, 1240, 1243, 1244, 1254, 1255, 1256, 1259; Hurricanes, floods, earthquakes, volcanoes, and fires 1152, 1208, 1209; Water limitation 966; Salination 134	

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Chapters/Sections	Essential Knowledge	Required content for the AP Course	Illustrative examples covered in this textbook - teach at least one	Content not required for the AP Course
	4.B.4 Distribution of local and global ecosystems change over time		Dutch elm disease 650; Potato blight 588; Small pox [historic example for Native Americans] 944; Continental drift 520; Meteor impact on dinosaurs 521, 522	
	4.C.4 The diversity of species within an ecosystem may influence the stability of the ecosystem			
56.2 Population conservation focuses on population size, genetic diversity, an critical habitat				1244-1249
56.3 Landscape and regional conservation help sustain biodiversity				1249-1254
56.4 Earth is changing rapidly as a result of human actions	4.B.4 Distribution of local and global ecosystems change over time	1254-1260	Dutch elm disease 650; Potato blight 588; Small pox [historic example for Native Americans] 944; Continental drift 520; Meteor impact on dinosaurs 521, 522	
56.5 Sustainable development can improve human lives while conserving biodiversity				1260-1261