Pearson Campbell Biology
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Chapters/Sections	Essential Knowledge	Required content for the AP	Illustrative examples covered in this textbook - teach at least one	Content not required for the AP Course
1. Exploring Life				
1.1 Biologists explore life from the microscopic to the global scale				2-8
1.2 Biological systems are much more than the sun of their parts				9-12
1.3 Biologists explore life across its great diversity of species				12-15
1.4 Evolution accounts for life's unity and diversity				15-19
1.5 Biologists use various forms of inquiry to explore life				19-26
1.6 A set of themes connects the concepts of biology				26
2. The Chemical Context of Life				
2.1 Matter consists of chemical elements in pure form and in combination called compounds				32-34
2.2 An element's properties depends on the structure of its atoms				34-39
2.3 The formation and function of molecules depend on chemical bonding between atoms				39-44
2.4 Chemical reaction make and break chemical bonds				44-45
3. Water and the Fitness of the Environment				
3.1 The polarity of water molecules result in hydrogen bonding	2.A.3 Organisms must exchange matter with the environment to grow, reproduce, and maintain organization	47-48	Cohesion 48, 49, 747, 748| Adhesion 48, 747, 748 | Universal solvent supports reactions 51, 52 54 | Water's thermal conductivity 834| Root hairs | Cells of the alveoli 555 | Cells of the villi |860 Microvilli 100, 117, 860	
3.2 Four emergent properties of water contribute to Earth's fitness for life	2.A.3 Organisms must exchange matter with the environment to grow, reproduce, and maintain organization	48-53	Cohesion 48, 49, 747, 748| Adhesion 48, 747, 748 | Universal solvent supports reactions 51, 52 54 | Water's thermal conductivity 834| Root hairs | Cells of the alveoli 555 | Cells of the villi |860 Microvilli 100, 117, 860	
3.3 Dissociation of water molecules leads to acidic and basic conditions that affect living organisms	2.A.3 Organisms must exchange matter with the environment to grow, reproduce, and maintain organization	53-56	Cohesion 48, 49, 747, 748| Adhesion 48, 747, 748 | Universal solvent supports reactions 51, 52 54 | Water's thermal conductivity 834| Root hairs | Cells of the alveoli 555 | Cells of the villi |860 Microvilli 100, 117, 860	
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 scientific evidence	58-59		
	2.A.3 Organisms must exchange matter with the environment to grow, reproduce, and maintain organization		Cohesion 48, 49, 747, 748| Adhesion 48, 747, 748 | Universal solvent supports reactions 51, 52 54 | Water's thermal conductivity 834| Root hairs | Cells of the alveoli 555 | Cells of the villi |860 Microvilli 100, 117, 860	
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	59-63	Cohesion 48, 49, 747, 748| Adhesion 48, 747, 748 | Universal solvent supports reactions 51, 52 54 | Water's thermal conductivity 834| Root hairs | Cells of the alveoli 555 | Cells of the villi |860 Microvilli 100, 117, 860	
4.3 Functional groups are the parts of molecules involved in chemical reactions				63-66
5. The Structure and Function of Large Biological Molecules				
5.1 Most 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 Variation in molecular units provides cells with a wider range of functions		Different types of phospholipids in cell membranes 76 77, 99, 125, 126 | Different types of hemoglobin 83, 84, 329, 466, 377, 379, 556, 880, 881 | MHC proteins 905 | Chlorophylls 183, 185, 186, 187, 188, 189, 190 192, 193 | Molecular diversity of antibodies in response to an antigen 904, 905, 907, 908, 909	
	4.A.1 The subcomponents of biological molecules and their sequence determine the properties of that molecule			

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5.2 Carbohydrates serve as fuel and building material	4.C.1 Variation in molecular units provides cells with a wider range of functions	69-74	Different types of phospholipids in cell membranes 76 77, 99, 125, 126 | Different types of hemoglobin 83, 84, 329, 466, 377, 379, 556, 880, 881 | MHC proteins 905 | Chlorophylls 183, 185, 186, 187, 188, 189, 190 192, 193 | Molecular diversity of antibodies in response to an antigen 904, 905, 907, 908, 909	
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 Variation in molecular units provides cells with a wider range of functions		Different types of phospholipids in cell membranes 76 77, 99, 125, 126 | Different types of hemoglobin 83, 84, 329, 466, 377, 379, 556, 880, 881 | MHC proteins 905 | Chlorophylls 183, 185, 186, 187, 188, 189, 190 192, 193 | Molecular diversity of antibodies in response to an antigen 904, 905, 907, 908, 909	
5.4 Proteins have many structures, resulting in a wide range of functions	4.A.1 The subcomponents of biological molecules and their sequence determine the properties of that molecule	77-86		
	4.B.1 Interactions between molecules affect their structure and function			
	4.C.1 Variation in molecular units provides cells with a wider range of functions		Different types of phospholipids in cell membranes 76 77, 99, 125, 126 | Different types of hemoglobin 83, 84, 329, 466, 377, 379, 556, 880, 881 | MHC proteins 905 | Chlorophylls 183, 185, 186, 187, 188, 189, 190 192, 193 | Molecular diversity of antibodies in response to an antigen 904, 905, 907, 908, 909	
5.5 Nucleic acid store and transmit 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 317, 318 | Addition of a GTP cap 206 | Excision of introns | Enzymatic reactions 318, 319, | Transport by proteins 134 136 | Synthesis 302, 303, 304 | Degradation 369 370 | Electrophoresis 393 395 | Plasmid-based transformation 387 | Restriction enzyme analysis of DNA 386 | Polymerase Chain Reaction (PCR) 391 | Genetically modified foods 407 | Transgenic animals | Cloned animals 406 | Pharmaceuticals, such as human insulin or factor X 403	
	4.A.1 The subcomponents of biological molecules and their sequence determine the properties of that molecule			
	4.C.1 Variation in molecular units provides cells with a wider range of functions		Different types of phospholipids in cell membranes 76 77, 99, 125, 126 | Different types of hemoglobin 83, 84, 329, 466, 377, 379, 556, 880, 881 | MHC proteins 905 | Chlorophylls 183, 185, 186, 187, 188, 189, 190 192, 193 | Molecular diversity of antibodies in response to an antigen 904, 905, 907, 908, 909	
6. A Tour of the Cell				
6.1 To study cells, biologists use microscopes and the tools of biochemistry				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 48, 49, 747, 748| Adhesion 48, 747, 748 | Universal solvent supports reactions 51, 52 54 | Water's thermal conductivity 834| Root hairs | Cells of the alveoli 555 | Cells of the villi |860 Microvilli 100, 117, 860	
	2.B.3 Eukaryotic cells maintain internal membranes that partition the cell into specialized regions		Endoplasmic reticulum, 105, 106, 109, | Mitochondria, 107, 110, 111, 160, 168, 192, | Chloroplasts, 107, 108, 111, 160, 182, 183, 185, 198, 196, | Golgi, 106, 109, | Nuclear envelope, 103, 105, 109,	
	4.A.2 The structure and function of subcellular components, and their interactions, provide essential cellular processes			

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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, 105, 106, 109, | Mitochondria, 107, 110, 111, 160, 168, 192, | Chloroplasts, 107, 108, 111, 160, 182, 183, 185, 198, 196, | Golgi, 106, 109, | Nuclear envelope, 103, 105, 109	
	4.A.2 The structure and function of subcellular components, and their interactions, provide essential cellular processes			
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	104-108	Endoplasmic reticulum, 105, 106, 109, | Mitochondria, 107, 110, 111, 160, 168, 192, | Chloroplasts, 107, 108, 111, 160, 182, 183, 185, 198, 196, | Golgi, 106, 109, | Nuclear envelope, 103, 105, 109	
	4.A.2 The structure and function of subcellular components, and their interactions, provide essential cellular processes			
	4.B.2 Cooperative interactions within organisms promote efficiency in the use of energy and matter		Exchange of gases 660, 822, 884, 885, 886, 887, 888, 889, 891, 892, 893| Circulation of fluids 654, 821, 868, 869, 870, 872, 873, 875, 876, 877, 878, 879 | Digestion of food 827, 853, 854, 855, 856, 857, 858, 859, 860, 861, 863| Excretion of wastes 853| Bacterial community in the rumen of animals 858, 864	
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	109-111	Endoplasmic reticulum, 105, 106, 109, | Mitochondria, 107, 110, 111, 160, 168, 192, | Chloroplasts, 107, 108, 111, 160, 182, 183, 185, 198, 196, | Golgi, 106, 109, | Nuclear envelope, 103, 105, 109	
	4.A.2 The structure and function of subcellular components, and their interactions, provide essential cellular processes			
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				118-120
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	124-129		
7.2 Membranes structure results in selective permeability	2.B.1 Cell membranes are selectively permeable due to their structure	130		
7.3 Passive transport is 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	130-134	Glucose transport 164, 165, 173, 175, 356, 955, | Na+/K+ transport 135	
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	134-137	Glucose transport 164, 165, 173, 175, 356, 955, | Na+/K+ transport 135	
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	137	Glucose transport 164, 165, 173, 175, 356, 955, | Na+/K+ transport 135	
8. An Introduction to Metabolism				
8.1 An organism's metabolism transform matter and energy, subject to the laws of thermodynamics	2.A.1 All living systems require constant input of free energy	141-144	Krebs cycle 164, 165, 166, 167, 168, 169, 176, 177, 178 | Glycolysis 164, 165, 166, 167, 168, 169, 176, 177, 178 | Calvin cycle 185, 190, 193, 194, 196, 197, 198, | Fermentation 175, | Endothermy (the use of thermal energy generated by metabolism to maintain homeostatic body temperatures) 830, 831, 834, 835, 836, 837, 840 | Ectothermy (the use of external thermal energy to help regulate and maintain body temperature) 830, 831, 834, 835, 838, 839, |Life-history strategy (biennial plants and reproductive diapause) 1141, 1142 | Change in the producer level can affect the number and size of other trophic levels 1166, 1167, 1168, 1169, 1170, 1191, 1192, 1193, | Change in energy resources levels such as sunlight can affect the number and size of the trophic levels 1185, 1188	

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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	145-148	Krebs cycle 164, 165, 166, 167, 168, 169, 176, 177, 178 | Glycolysis 164, 165, 166, 167, 168, 169, 176, 177, 178 | Calvin cycle 185, 190, 193, 194, 196, 197, 198, | Fermentation 175, | Endothermy (the use of thermal energy generated by metabolism to maintain homeostatic body temperatures) 830, 831, 834, 835, 836, 837, 840 | Ectothermy (the use of external thermal energy to help regulate and maintain body temperature) 830, 831, 834, 835, 838, 839, |Life-history strategy (biennial plants and reproductive diapause) 1141, 1142 | Change in the producer level can affect the number and size of other trophic levels 1166, 1167, 1168, 1169, 1170, 1191, 1192, 1193, | Change in energy resources levels such as sunlight can affect the number and size of the trophic levels 1185, 1188	
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	148-150	Krebs cycle 164, 165, 166, 167, 168, 169, 176, 177, 178 | Glycolysis 164, 165, 166, 167, 168, 169, 176, 177, 178 | Calvin cycle 185, 190, 193, 194, 196, 197, 198, | Fermentation 175, | Endothermy (the use of thermal energy generated by metabolism to maintain homeostatic body temperatures) 830, 831, 834, 835, 836, 837, 840 | Ectothermy (the use of external thermal energy to help regulate and maintain body temperature) 830, 831, 834, 835, 838, 839, |Life-history strategy (biennial plants and reproductive diapause) 1141, 1142 | Change in the producer level can affect the number and size of other trophic levels 1166, 1167, 1168, 1169, 1170, 1191, 1192, 1193, | Change in energy resources levels such as sunlight can affect the number and size of the trophic levels 1185, 1188	
8.4 Enzymes speed up metabolic reactions by lowering energy barriers	4.B.1 Interactions between molecules affect their structure and function	150-155		
8.5 Regulation of enzyme activity helps control metabolism	4.B.1 Interactions between molecules affect their structure and function	156-157		
9. Cellular Respiration: Harvesting Chemical Energy				
9.1 Catabolic pathways yield energy by oxidizing organic fuels	2.A.1 All living systems require constant input of free energy	161-165	Krebs cycle 164, 165, 166, 167, 168, 169, 176, 177, 178 | Glycolysis 164, 165, 166, 167, 168, 169, 176, 177, 178 | Calvin cycle 185, 190, 193, 194, 196, 197, 198, | Fermentation 175, | Endothermy (the use of thermal energy generated by metabolism to maintain homeostatic body temperatures) 830, 831, 834, 835, 836, 837, 840 | Ectothermy (the use of external thermal energy to help regulate and maintain body temperature) 830, 831, 834, 835, 838, 839, |Life-history strategy (biennial plants and reproductive diapause) 1141, 1142 | Change in the producer level can affect the number and size of other trophic levels 1166, 1167, 1168, 1169, 1170, 1191, 1192, 1193, | Change in energy resources levels such as sunlight can affect the number and size of the trophic levels 1185, 1188	
	2.A.2 Organisms capture and store free energy for use in biological processes		NADP+ in photosynthesis 185, 190, 191, 193, 194 | Oxygen in cellular respiration 160, 162, 163, 164	

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9.2 Glycolysis harvests chemical energy by oxidizing glucose by pyruvate	2.A.1 All living systems require constant input of free energy	165	Krebs cycle 164, 165, 166, 167, 168, 169, 176, 177, 178 | Glycolysis 164, 165, 166, 167, 168, 169, 176, 177, 178 | Calvin cycle 185, 190, 193, 194, 196, 197, 198, | Fermentation 175, | Endothermy (the use of thermal energy generated by metabolism to maintain homeostatic body temperatures) 830, 831, 834, 835, 836, 837, 840 | Ectothermy (the use of external thermal energy to help regulate and maintain body temperature) 830, 831, 834, 835, 838, 839, |Life-history strategy (biennial plants and reproductive diapause) 1141, 1142 | Change in the producer level can affect the number and size of other trophic levels 1166, 1167, 1168, 1169, 1170, 1191, 1192, 1193, | Change in energy resources levels such as sunlight can affect the number and size of the trophic levels 1185, 1188	
	2.A.2 Organisms capture and store free energy for use in biological processes		NADP+ in photosynthesis 185, 190, 191, 193, 194 | Oxygen in cellular respiration 160, 162, 163, 164	
9.3 The citric acid cycle completes the energy-yielding oxidation of organic molecules	2.A.1 All living systems require constant input of free energy	168-170	Krebs cycle 164, 165, 166, 167, 168, 169, 176, 177, 178 | Glycolysis 164, 165, 166, 167, 168, 169, 176, 177, 178 | Calvin cycle 185, 190, 193, 194, 196, 197, 198, | Fermentation 175, | Endothermy (the use of thermal energy generated by metabolism to maintain homeostatic body temperatures) 830, 831, 834, 835, 836, 837, 840 | Ectothermy (the use of external thermal energy to help regulate and maintain body temperature) 830, 831, 834, 835, 838, 839, |Life-history strategy (biennial plants and reproductive diapause) 1141, 1142 | Change in the producer level can affect the number and size of other trophic levels 1166, 1167, 1168, 1169, 1170, 1191, 1192, 1193, | Change in energy resources levels such as sunlight can affect the number and size of the trophic levels 1185, 1188	
9.4 During oxidative phosphorylation, chemiosmosis couples electron transport to ATP synthesis	2.A.1 All living systems require constant input of free energy	170-174	Krebs cycle 164, 165, 166, 167, 168, 169, 176, 177, 178 | Glycolysis 164, 165, 166, 167, 168, 169, 176, 177, 178 | Calvin cycle 185, 190, 193, 194, 196, 197, 198, | Fermentation 175, | Endothermy (the use of thermal energy generated by metabolism to maintain homeostatic body temperatures) 830, 831, 834, 835, 836, 837, 840 | Ectothermy (the use of external thermal energy to help regulate and maintain body temperature) 830, 831, 834, 835, 838, 839, |Life-history strategy (biennial plants and reproductive diapause) 1141, 1142 | Change in the producer level can affect the number and size of other trophic levels 1166, 1167, 1168, 1169, 1170, 1191, 1192, 1193, | Change in energy resources levels such as sunlight can affect the number and size of the trophic levels 1185, 1188	
	2.A.2 Organisms capture and store free energy for use in biological processes		NADP+ in photosynthesis 185, 190, 191, 193, 194 | Oxygen in cellular respiration 160, 162, 163, 164	

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9.5 Fermentation enables some cells to produce ATP without the use of oxygen	2.A.1 All living systems require constant input of free energy	174-176	Krebs cycle 164, 165, 166, 167, 168, 169, 176, 177, 178 | Glycolysis 164, 165, 166, 167, 168, 169, 176, 177, 178 | Calvin cycle 185, 190, 193, 194, 196, 197, 198, | Fermentation 175, | Endothermy (the use of thermal energy generated by metabolism to maintain homeostatic body temperatures) 830, 831, 834, 835, 836, 837, 840 | Ectothermy (the use of external thermal energy to help regulate and maintain body temperature) 830, 831, 834, 835, 838, 839, |Life-history strategy (biennial plants and reproductive diapause) 1141, 1142 | Change in the producer level can affect the number and size of other trophic levels 1166, 1167, 1168, 1169, 1170, 1191, 1192, 1193, | Change in energy resources levels such as sunlight can affect the number and size of the trophic levels 1185, 1188	
	2.A.2 Organisms capture and store free energy for use in biological processes		NADP+ in photosynthesis 185, 190, 191, 193, 194 | Oxygen in cellular respiration 160, 162, 163, 164	
9.6 Glycolysis and the citric acid cycle connect to many other metabolic pathways				176-178

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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	182-185	Krebs cycle 164, 165, 166, 167, 168, 169, 176, 177, 178 | Glycolysis 164, 165, 166, 167, 168, 169, 176, 177, 178 | Calvin cycle 185, 190, 193, 194, 196, 197, 198, | Fermentation 175, | Endothermy (the use of thermal energy generated by metabolism to maintain homeostatic body temperatures) 830, 831, 834, 835, 836, 837, 840 | Ectothermy (the use of external thermal energy to help regulate and maintain body temperature) 830, 831, 834, 835, 838, 839, |Life-history strategy (biennial plants and reproductive diapause) 1141, 1142 | Change in the producer level can affect the number and size of other trophic levels 1166, 1167, 1168, 1169, 1170, 1191, 1192, 1193, | Change in energy resources levels such as sunlight can affect the number and size of the trophic levels 1185, 1188	
	2.A.2 Organisms capture and store free energy for use in biological processes		NADP+ in photosynthesis 185, 190, 191, 193, 194 | Oxygen in cellular respiration 160, 162, 163, 164	
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	186-193	Krebs cycle 164, 165, 166, 167, 168, 169, 176, 177, 178 | Glycolysis 164, 165, 166, 167, 168, 169, 176, 177, 178 | Calvin cycle 185, 190, 193, 194, 196, 197, 198, | Fermentation 175, | Endothermy (the use of thermal energy generated by metabolism to maintain homeostatic body temperatures) 830, 831, 834, 835, 836, 837, 840 | Ectothermy (the use of external thermal energy to help regulate and maintain body temperature) 830, 831, 834, 835, 838, 839, |Life-history strategy (biennial plants and reproductive diapause) 1141, 1142 | Change in the producer level can affect the number and size of other trophic levels 1166, 1167, 1168, 1169, 1170, 1191, 1192, 1193, | Change in energy resources levels such as sunlight can affect the number and size of the trophic levels 1185, 1188	
	2.A.2 Organisms capture and store free energy for use in biological processes		NADP+ in photosynthesis 185, 190, 191, 193, 194 | Oxygen in cellular respiration 160, 162, 163, 164	
10.3 The Calvin cycle uses ATP and NADPH to reduce CO_2 to sugar	2.A.1 All living systems require constant input of free energy	193-195	Krebs cycle 164, 165, 166, 167, 168, 169, 176, 177, 178 | Glycolysis 164, 165, 166, 167, 168, 169, 176, 177, 178 | Calvin cycle 185, 190, 193, 194, 196, 197, 198, | Fermentation 175, | Endothermy (the use of thermal energy generated by metabolism to maintain homeostatic body temperatures) 830, 831, 834, 835, 836, 837, 840 | Ectothermy (the use of external thermal energy to help regulate and maintain body temperature) 830, 831, 834, 835, 838, 839, |Life-history strategy (biennial plants and reproductive diapause) 1141, 1142 | Change in the producer level can affect the number and size of other trophic levels 1166, 1167, 1168, 1169, 1170, 1191, 1192, 1193, | Change in energy resources levels such as sunlight can affect the number and size of the trophic levels 1185, 1188	
	2.A.2 Organisms capture and store free energy for use in biological processes		NADP+ in photosynthesis 185, 190, 191, 193, 194 | Oxygen in cellular respiration 160, 162, 163, 164	
10.4 Alternative mechanisms of carbon fixation have evolved in hot, arid climates				195-197
11. Cell Communications				

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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	201-204	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 805, 1031| Diurnal/nocturnal and sleep/awake cycles 805, 1031 | Seasonal responses, such as hibernation, estivation, and migration 840, 1110| Release and reaction to pheromones 1111| Visual displays in the reproductive cycle 557, 559, 562, 565, 566, 569 | Fruiting body formation in fungi, slime molds, and certain types of bacteria 559, 562, 565, 566, 569 | Quorum sensing in bacteria 202	
	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 220, 221, 223, 225, 226, 244, 245, 246| Mating pheromones in yeast trigger mating gene expression 202| Levels of cAMP regulate metabolic gene expression in bacteria 356| Expression of the SRY gene triggers the male sexual development pathway in animals 282| Ethylene levels cause changes in the production of different enzymes, allowing fruits to ripen 203, 799, 800| Seed germination and gibberellin 780, 797, 798| Mating pheromones in yeast trigger mating genes expression and sexual reproduction 202| Morphogens stimulate cell differentiation and development 424| Changes in p53 activity can result in cancer 373| HOX genes and their role in development 432, 485, 486, 627, 675	
	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) 202, 203, 204, 208, 946; Use of pheromones to trigger reproduction and developmental pathways 611, 945, 946, 1049, 1111; Response to external signals by bacteria that influences cell movement; Epinephrine stimulation of glycogen breakdown in mammals 213, 947, 957; DNA repair mechanisms 305	
	3.D.2 Cells 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] 910, 911 ; Plasmodesmata between plant cells that allow material to be transported from cell to cell120; Neurotransmitters 1024, 1047; Plant immune response 813, 814, 815; Quorum sensing in bacteria 202; Morphogens in embryonic development 413, 424, 987, 1001, 1002, 1003; Insulin 105, 846, 955; Thyroid hormones 949, 953, 954; Testosterone 63, 205; Estrogen 958, 981	
	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) 202, 203, 204, 208, 946; Use of pheromones to trigger reproduction and developmental pathways 611, 945, 946, 1049, 1111; Response to external signals by bacteria that influences cell movement; Epinephrine stimulation of glycogen breakdown in mammals 213, 947, 957; DNA repair mechanisms 305	

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11.2 Reception: A signal molecule binds to a receptor protein, causing it to change shape	3.D.2 Cells communicate with each other through direct contact with other cells or from a distance via chemical signaling	204-218	Immune cells interact by cell-cell contact, antigen-presenting cells (APCs), helper T-cells and killer T-cells. [See also 2.D.4] 910, 911 ; Plasmodesmata between plant cells that allow material to be transported from cell to cell120; Neurotransmitters 1024, 1047; Plant immune response 813, 814, 815; Quorum sensing in bacteria 202; Morphogens in embryonic development 413, 424, 987, 1001, 1002, 1003; Insulin 105, 846, 955; Thyroid hormones 949, 953, 954; Testosterone 63, 205; Estrogen 958, 981	
	3.D.3 Signal transduction pathways link signal reception with cellular response		G-protein linked receptors 206, 211, 213, 1024, 1056 | Ligand-gated ion channels 208, 1017, 1022, 1023 | Receptor tyrosine kinases 207, | Ligand-gated ion channels 208 | Second messengers, such as cyclic GMP, cyclic AMP, calcium ions (Ca2+), and inositol triphosphate (IP3) 210, 211, 212, 790, 1022, 1056	
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	208-212	G-protein linked receptors 206, 211, 213, 1024, 1056 | Ligand-gated ion channels 208, 1017, 1022, 1023 | Receptor tyrosine kinases 207, | Ligand-gated ion channels 208 | Second messengers, such as cyclic GMP, cyclic AMP, calcium ions (Ca2+), and inositol triphosphate (IP3) 210, 211, 212, 790, 1022, 1056	
11.4 Response: Cell signaling leads to regulation of cytoplasmic activities or transcription	3.B.2 A variety of intercellular and intracellular signal transmissions mediate gene expression	212-215	Cytokines regulate gene expression to allow for cell replication and division 220, 221, 223, 225, 226, 244, 245, 246| Mating pheromones in yeast trigger mating gene expression 202| Levels of cAMP regulate metabolic gene expression in bacteria 356| Expression of the SRY gene triggers the male sexual development pathway in animals 282| Ethylene levels cause changes in the production of different enzymes, allowing fruits to ripen 203, 799, 800| Seed germination and gibberellin 780, 797, 798| Mating pheromones in yeast trigger mating genes expression and sexual reproduction 202| Morphogens stimulate cell differentiation and development 424| Changes in p53 activity can result in cancer 373| HOX genes and their role in development 432, 485, 486, 627, 675	
	3.D.4 Changes in signal transduction pathways can alter cellular response		Diabetes, heart disease, neurological disease, autoimmune disease, cancer, and cholera 232, 233, 340, 371, 372, 373, 883, 917 | Effects of neurotoxins, poisons, and pesticides 155, 156, 211, 535, 555| Drugs (Hypertensives, Anesthetics, Antihistamines, and Birth Control Drugs) 982	
12. The Cell Cycle				
12.1 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	219-220	Mitosis-promoting factor (MPF) 230 | Action of platelet-derived growth factor (PDGF) 231 | Cancer results from disruptions in cell cycle control 232, 233, 373	
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	221-228	Mitosis-promoting factor (MPF) 230 | Action of platelet-derived growth factor (PDGF) 231 | Cancer results from disruptions in cell cycle control 232, 233, 373	
12.3 The 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	228-233	Mitosis-promoting factor (MPF) 230 | Action of platelet-derived growth factor (PDGF) 231 | Cancer results from disruptions in cell cycle control 232, 233, 373	

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Chapters/Sections	Essential Knowledge	Required content for the AP	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	238-239	Mitosis-promoting factor (MPF) 230 | Action of platelet-derived growth factor (PDGF) 231 | Cancer results from disruptions in cell cycle control 232, 233, 373	
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	240-243	Mitosis-promoting factor (MPF) 230 | Action of platelet-derived growth factor (PDGF) 231 | Cancer results from disruptions in cell cycle control 232, 233, 373	
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	243-247	Mitosis-promoting factor (MPF) 230 | Action of platelet-derived growth factor (PDGF) 231 | Cancer results from disruptions in cell cycle control 232, 233, 373	
13.4 Genetic variation produced in sexual life cycles contributes to evolution	3.C.2 Biological systems have multiple processes that increase genetic variation	247-249		
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	251-258	Sickle cell anemia 466, 329, 393 | Tay-Sachs disease 263| Huntington's disease |403 X-linked color blindness 283 | Trisomy 21/Down syndrome 287 | Klinefelter's syndrome 286| Reproduction issues 261, 262, 263	
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	258-260	Sickle cell anemia 466, 329, 393 | Tay-Sachs disease 263| Huntington's disease |403 X-linked color blindness 283 | Trisomy 21/Down syndrome 287 | Klinefelter's syndrome 286| Reproduction issues 261, 262, 263	
14.3 Inheritance patterns are often more complex than predicted by simple Mendelian genetics	3.A.3 The chromosomal basis of inheritance provides an understanding of the pattern of passage (transmission) of genes from parent to offspring	260-264	Sickle cell anemia 466, 329, 393 | Tay-Sachs disease 263| Huntington's disease |403 X-linked color blindness 283 | Trisomy 21/Down syndrome 287 | Klinefelter's syndrome 286| Reproduction issues 261, 262, 263	
	4.C.2 Environmental factors influence the expression of the genotype in an organism		Height and weight in humans 484 | Flower color based on soil pH 264 | Effect of adding lactose to a Lac + bacterial culture 355 | Effect of increased UV on melanin production in animals 305, 306 | Presence of the opposite mating type on pheromones production in yeast and other fungi 202, 611 | Alterations in timing of flowering due to climate changes 807	
	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	265-270	Sickle cell anemia 466, 329, 393 | Tay-Sachs disease 263| Huntington's disease 403 | X-linked color blindness 283 | Trisomy 21/Down syndrome 287 | Klinefelter's syndrome 286| Reproduction issues 259, 260, 265	
15. The Chromosomal Basis of Inheritance				
15.1 Mendelian inheritance has its physical basis in the behavior of chromosomes	3.A.4 The inheritance pattern of many traits cannot be explained by simple Mendelian genetics	274-277	Sex-linked genes reside on sex chromosomes (X in humans) 282, 283| In mammals and flies, the Y chromosome is very small and carries few genes 282 | In mammals and flies, females are XX and males are XY; as such, X-linked recessive traits are always expressed in males 282 | 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 283, 284	

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Chapters/Sections	Essential Knowledge	Required content for the AP	Illustrative examples covered in this textbook - teach at least one	Content not required for the AP Course
15.2 Linked genes tend to be inherited together because they are located near each other on the same chromosome	3.A.4 The inheritance pattern of many traits cannot be explained by simple Mendelian genetics	277-282	Sex-linked genes reside on sex chromosomes (X in humans) 282, 283| In mammals and flies, the Y chromosome is very small and carries few genes 282 | In mammals and flies, females are XX and males are XY; as such, X-linked recessive traits are always expressed in males 282 | 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 283, 284	
15.3 Sex-linked genes exhibit unique patterns of inheritance	3.A.4 The inheritance pattern of many traits cannot be explained by simple Mendelian genetics	282-284	Sex-linked genes reside on sex chromosomes (X in humans) 282, 283| In mammals and flies, the Y chromosome is very small and carries few genes 282 | In mammals and flies, females are XX and males are XY; as such, X-linked recessive traits are always expressed in males 282 | 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 283, 284	
15.4 Alteration of chromosome number or structure cause some genetic disorder	3.C.1 Changes in genotype can result in changes in phenotype	285-288	Antibiotic resistance mutations 448 | Pesticide resistance mutations 385| Sickle cell disorder and heterozygote advantage 329, 330, 331, 393	
15.5 Some inheritance patterns are exceptions to the standard chromosome theory	3.A.4 The inheritance pattern of many traits cannot be explained by simple Mendelian genetics	288-290	Sex-linked genes reside on sex chromosomes (X in humans) 282, 283| In mammals and flies, the Y chromosome is very small and carries few genes 282 | In mammals and flies, females are XX and males are XY; as such, X-linked recessive traits are always expressed in males 282 | 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 283, 284	
16. The Molecular Basis of Inheritance				
16.1 DNA is the genetic material	3.A.1 DNA, and in some cases RNA, is the primary source of heritable information	293-298		
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	299-307	Addition of a poly-A tail 317, 318 | Addition of a GTP cap 206 | Excision of introns | Enzymatic reactions 318, 319, | Transport by proteins 134 136 | Synthesis 302, 303, 304 | Degradation 369 370 | Electrophoresis 393 395 | Plasmid-based transformation 387 | Restriction enzyme analysis of DNA 386 | Polymerase Chain Reaction (PCR) 391 | Genetically modified foods 407 | Transgenic animals | Cloned animals 406 | Pharmaceuticals, such as human insulin or factor X 403	
	3.C.1 Changes in genotype can result in changes in phenotype		Antibiotic resistance mutations 448 | Pesticide resistance mutations 385| Sickle cell disorder and heterozygote advantage 329, 330, 331, 393	
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	309-314	Addition of a poly-A tail 317, 318 | Addition of a GTP cap 206 | Excision of introns | Enzymatic reactions 318, 319, | Transport by proteins 134 136 | Synthesis 302, 303, 304 | Degradation 369 370 | Electrophoresis 393 395 | Plasmid-based transformation 387 | Restriction enzyme analysis of DNA 386 | Polymerase Chain Reaction (PCR) 391 | Genetically modified foods 407 | Transgenic animals | Cloned animals 406 | Pharmaceuticals, such as human insulin or factor X 403	

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Chapters/Sections	Essential Knowledge	Required content for the AP	Illustrative examples covered in this textbook - teach at least one	Content not required for the AP Course
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	315-317	Addition of a poly-A tail 317, 318 | Addition of a GTP cap 206 | Excision of introns | Enzymatic reactions 318, 319, | Transport by proteins 134 136 | Synthesis 302, 303, 304 | Degradation 369 370 | Electrophoresis 393 395 | Plasmid-based transformation 387 | Restriction enzyme analysis of DNA 386 | Polymerase Chain Reaction (PCR) 391 | Genetically modified foods 407 | Transgenic animals | Cloned animals 406 | Pharmaceuticals, such as human insulin or factor X 403	
17.3 Eukaryotic cells modify RNA after transcription	3.A.1 DNA, and in some cases RNA, is the primary source of heritable information	317-319	Addition of a poly-A tail 317, 318 | Addition of a GTP cap 206 | Excision of introns | Enzymatic reactions 318, 319, | Transport by proteins 134 136 | Synthesis 302, 303, 304 | Degradation 369 370 | Electrophoresis 393 395 | Plasmid-based transformation 387 | Restriction enzyme analysis of DNA 386 | Polymerase Chain Reaction (PCR) 391 | Genetically modified foods 407 | Transgenic animals | Cloned animals 406 | Pharmaceuticals, such as human insulin or factor X 403	
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	320-326	Addition of a poly-A tail 317, 318 | Addition of a GTP cap 206 | Excision of introns | Enzymatic reactions 318, 319, | Transport by proteins 134 136 | Synthesis 302, 303, 304 | Degradation 369 370 | Electrophoresis 393 395 | Plasmid-based transformation 387 | Restriction enzyme analysis of DNA 386 | Polymerase Chain Reaction (PCR) 391 | Genetically modified foods 407 | Transgenic animals | Cloned animals 406 | Pharmaceuticals, such as human insulin or factor X 403	
17.5 RNA plays multiple roles in the cell: *a review*				327
17.6 Comparing gene expression in prokaryotes and eukaryotes reveals key differences				327-328
17.7 Point mutations can affect protein structure and function	3.C.1 Changes in genotype can result in changes in phenotype	328-330	Antibiotic resistance mutations 448 | Pesticide resistance mutations 385| Sickle cell disorder and heterozygote advantage 329, 330, 331, 393	

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Chapters/Sections	Essential Knowledge	Required content for the AP	Illustrative examples covered in this textbook - teach at least one	Content not required for the AP Course
18. The Genetics of Viruses and Bacteria				
18.1 A virus has a genome but can reproduce only within a host cell	3.A.1 DNA, and in some cases RNA, is the primary source of heritable information	334-343	Addition of a poly-A tail 317, 318 | Addition of a GTP cap 206 | Excision of introns | Enzymatic reactions 318, 319, | Transport by proteins 134 136 | Synthesis 302, 303, 304 | Degradation 369 370 | Electrophoresis 393 395 | Plasmid-based transformation 387 | Restriction enzyme analysis of DNA 386 | Polymerase Chain Reaction (PCR) 391 | Genetically modified foods 407 | Transgenic animals | Cloned animals 406 | Pharmaceuticals, such as human insulin or factor X 403	
	3.C.3 Viral replication results in genetic variation, and viral infection can introduce genetic variation into the hosts		Transduction in bacteria 349 | Transposons present in incoming DNA 352, 375	
18.2 Viruses, viroids, and prions are formidable pathogens in animals and plants				343-346
18.3 Rapid reproduction, mutation, and genetic recombination contribute to the genetic diversity of bacteria	3.C.2 Biological systems have multiple processes that increase genetic variation	346-352		
18.4 Individual bacteria responds to environmental change by regulating their gene expression	3.B.1 Gene regulation results in differential gene expression, leading to cell specialization	352-356	Promoters 315, 316, 354, 355, 366, 367| Terminators 315 | Enhancers 365	
	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 220, 221, 223, 225, 226, 244, 245, 246| Mating pheromones in yeast trigger mating gene expression 202| Levels of cAMP regulate metabolic gene expression in bacteria 356| Expression of the SRY gene triggers the male sexual development pathway in animals 282| Ethylene levels cause changes in the production of different enzymes, allowing fruits to ripen 203, 799, 800| Seed germination and gibberellin 780, 797, 798| Mating pheromones in yeast trigger mating genes expression and sexual reproduction 202| Morphogens stimulate cell differentiation and development 424| Changes in p53 activity can result in cancer 373| HOX genes and their role in development 432, 485, 486, 627, 675	
19. Eukaryotic Genomes: Organization, Regulation, and Evolution				
19.1 Chromatin structure is based on successive levels of DNA packing				359-360
	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 413, 1001 | Immune function | C. elegans development 426, 427 | Flower Development 429	
	3.B.1 Gene regulation results in differential gene expression, leading to cell specialization		Promoters 315, 316, 354, 355, 366, 367| Terminators 315 | Enhancers 365	

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Chapters/Sections	Essential Knowledge	Required content for the AP	Illustrative examples covered in this textbook - teach at least one	Content not required for the AP Course
19.2 Gene expression can be regulated at any stage, but the key step is transcription	3.B.2 A variety of intercellular and intracellular signal transmissions mediate gene expression	362-370	Cytokines regulate gene expression to allow for cell replication and division 220, 221, 223, 225, 226, 244, 245, 246| Mating pheromones in yeast trigger mating gene expression 202| Levels of cAMP regulate metabolic gene expression in bacteria 356| Expression of the SRY gene triggers the male sexual development pathway in animals 282| Ethylene levels cause changes in the production of different enzymes, allowing fruits to ripen 203, 799, 800| Seed germination and gibberellin 780, 797, 798| Mating pheromones in yeast trigger mating genes expression and sexual reproduction 202| Morphogens stimulate cell differentiation and development 424| Changes in p53 activity can result in cancer 373| HOX genes and their role in development 432, 485, 486, 627, 675	
19.3 Cancer results from genetic changes that affect cell cycle control				370-374
19.4 Eukaryotic genomes can have many noncoding DNA sequences in addition to genes				374-378
19.5 Duplication, rearrangements, and mutations of DNA contribute to genome evolution	4.C.1 Variation in molecular units provides cells with a wider range of functions	378-381	Different types of phospholipids in cell membranes 76, 77, 125 | Different types of hemoglobin 369, 379, 450, 880, 881, 892 | MHC proteins 905, | Chlorophylls 182, 185, 187, 188, 189, 190| Molecular diversity of antibodies in response to an antigen 903, 904, 905, 907, 908, 913	
20. DNA Technology and Genomics				
20.1 DNA cloning permits production of multiple copies of a specific gene or other DNA segment	3.A.1 DNA, and in some cases RNA, is the primary source of heritable information	385-392	Addition of a poly-A tail 317, 318 | Addition of a GTP cap 206 | Excision of introns | Enzymatic reactions 318, 319, | Transport by proteins 134 136 | Synthesis 302, 303, 304 | Degradation 369 370 | Electrophoresis 393 395 | Plasmid-based transformation 387 | Restriction enzyme analysis of DNA 386 | Polymerase Chain Reaction (PCR) 391 | Genetically modified foods 407 | Transgenic animals | Cloned animals 406 | Pharmaceuticals, such as human insulin or factor X 403	
20.2 Restriction fragment analysis detests DNA differences that affect restriction sites	3.A.1 DNA, and in some cases RNA, is the primary source of heritable information	392-394	Addition of a poly-A tail 317, 318 | Addition of a GTP cap 206 | Excision of introns | Enzymatic reactions 318, 319, | Transport by proteins 134 136 | Synthesis 302, 303, 304 | Degradation 369 370 | Electrophoresis 393 395 | Plasmid-based transformation 387 | Restriction enzyme analysis of DNA 386 | Polymerase Chain Reaction (PCR) 391 | Genetically modified foods 407 | Transgenic animals | Cloned animals 406 | Pharmaceuticals, such as human insulin or factor X 403	

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Chapters/Sections	Essential Knowledge	Required content for the AP	Illustrative examples covered in this textbook - teach at least one	Content not required for the AP Course
20.3 Entire genomes can be mapped at the DNA level	3.A.1 DNA, and in some cases RNA, is the primary source of heritable information	394-398	Addition of a poly-A tail 317, 318 | Addition of a GTP cap 206 | Excision of introns | Enzymatic reactions 318, 319, | Transport by proteins 134 136 | Synthesis 302, 303, 304 | Degradation 369 370 | Electrophoresis 393 395 | Plasmid-based transformation 387 | Restriction enzyme analysis of DNA 386 | Polymerase Chain Reaction (PCR) 391 | Genetically modified foods 407 | Transgenic animals | Cloned animals 406 | Pharmaceuticals, such as human insulin or factor X 403	
20.4 Genome sequences provide clues to important biological questions				398-402
20.5 The practical applications of DNA technology affect our lives in many ways				402-408
21. The Genetic Basis of Development				
21.1 Embryonic development involves cell division, cell differentiation, and morphogenesis				412-415
21.2 Different cell types result from differential gene expression in cells with the same DNA	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	415-420	Morphogenesis of fingers and toes 413, 1001 | Immune function | C. elegans development 426, 427 | Flower Development 429	
	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 220, 221, 223, 225, 226, 244, 245, 246| Mating pheromones in yeast trigger mating gene expression 202| Levels of cAMP regulate metabolic gene expression in bacteria 356| Expression of the SRY gene triggers the male sexual development pathway in animals 282| Ethylene levels cause changes in the production of different enzymes, allowing fruits to ripen 203, 799, 800| Seed germination and gibberellin 780, 797, 798| Mating pheromones in yeast trigger mating genes expression and sexual reproduction 202| Morphogens stimulate cell differentiation and development 424| Changes in p53 activity can result in cancer 373| HOX genes and their role in development 432, 485, 486, 627, 675	
	4.A.3 Interactions between external stimuli and regulated gene expression result in specialization of cells, tissues and organs			
21.3 Pattern formation in animals and plants results from similar genetic and cellular mechanisms				421-431
21.4 Comparative studies help explain how the evolution of development leads to morphological diversity				431-433
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				438-441
22.2 In *The Origin of Species* , Darwin proposed that species change through natural selection	1.A.1 Natural selection is a major mechanism of evolution	441-446	Graphical analysis of allele frequencies in a population 456 | Application of the Hardy-Weinberg equilibrium equation 457	
22.3 Darwin's theory explains a wide range of observations	1.A.4 Biological evolution is supported by scientific evidence from many disciplines, including mathematics	446-451	Graphical analyses of allele frequencies in a population 456 | | Analysis of phylogenetic trees 491, 496, 497, Construction of phylogenetic trees based on |499, 500, 501, 502-503, 504	

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Chapters/Sections	Essential Knowledge	Required content for the AP	Illustrative examples covered in this textbook - teach at least one	Content not required for the AP Course
23. The Evolution of Populations				
23.1 Population genetics provide a foundation for studying evolution	1.A.1 Natural selection is a major mechanism of evolution	454-458	Graphical analysis of allele frequencies in a population 456, 457, | Application of the Hardy-Weinberg equilibrium equation 457	
	4.C.3 The level of variation in a population affects population dynamics		Campbell Biology offers many examples for this area, such as: Potato blight causing the potato famine 558 | Corn rust affects on agricultural crops 622	
	4.C.4 The diversity of species within an ecosystem may influence the stability of the ecosystem			
23.2 Mutations sexual recombination produce the variation that makes evolution possible	1.A.2 Natural selection acts on phenotypic variations in populations	459-460	Flowering time in relation to global climate change 807 | Sickle cell Anemia 329 393, 466 | DDT resistance in insects 1202 | Artificial selection 445, 783, 249, 462, 463, 464, 1210 | Loss of genetic diversity within a crop species 407 | Overuse of antibiotics 448	
	4.C.3 The level of variation in a population affects population dynamics		Campbell Biology offers many examples for this area, such as: Potato blight causing the potato famine 558 | Corn rust affects on agricultural crops 622	
23.3 Natural selection, genetic drift, and gene flow can alter a population's genetic composition	1.A.3 Evolutionary change is also driven by random processes	460-462		
	4.C.3 The level of variation in a population affects population dynamics		Campbell Biology offers many examples for this area, such as: Potato blight causing the potato famine 558 | Corn rust affects on agricultural crops 622	
23.4 Natural selection is the primary mechanism of adaptive evolution	1.A.2 Natural selection acts on phenotypic variations in populations	462-470	Flowering time in relation to global climate change 807 | Sickle cell Anemia 329 393, 466 | DDT resistance in insects 1202 | Artificial selection 445, 783, 249, 462, 463, 464, 1210 | Loss of genetic diversity within a crop species 407 | Overuse of antibiotics 448	
	3.C.1 Changes in genotype can result in changes in phenotype		Antibiotic resistance mutations 448 | Pesticide resistance mutations 385| Sickle cell disorder and heterozygote advantage 329, 330, 331, 393	
24. The Origin of Species				
	1.C.2 Speciation may occur when two populations become reproductively isolated from each other			

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24.1 The biological species concept emphasizes reproductive isolation	2.E.2 Timing and coordination of physiological events are regulated by multiple mechanisms	473-476	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 805, 1031| Diurnal/nocturnal and sleep/awake cycles 805, 1031 | Seasonal responses, such as hibernation, estivation, and migration 840, 1110| Release and reaction to pheromones 1111| Visual displays in the reproductive cycle 557, 559, 562, 565, 566, 569 | Fruiting body formation in fungi, slime molds, and certain types of bacteria 559, 562, 565, 566, 569 | Quorum sensing in bacteria 202.	
24.2 Speciation can take place with or without geographic separation	1.C.1 Speciation and extinction have occurred throughout the Earth's history	476-482	Five major extinctions 518, 519, 520 | Human impact on ecosystems and species extinction rates 55, 1200, 1201, 1202, 1214	
	1.C.3 Populations of organisms continue to evolve		Chemical resistance (mutations for resistance to antibiotics, pesticides, herbicides or chemotherapy drugs occur in the absence of the chemical) 329, 330 | Observed directional phenotypic change in a Population (Grants' observations of Darwin's finches in the Galapagos) 443 | A eukaryotic example that describes evolution of a structure or process such as heart chambers, limbs, the brain and the immune system 413, 414, 416, 417, 422, 424, 428, 429	
24.3 Macroevolutionary changes can accumulate through many speciation events	1.C.1 Speciation and extinction have occurred throughout the Earth's history	482-488	Five major extinctions 518, 519, 520 | Human impact on ecosystems and species extinction rates 55, 1200, 1201, 1202, 1214	
25. Phylogeny and Systematics				
25.1 Phylogenies are based on common ancestries inferred from fossil, morphological, and molecular evidence	1.B.2 Phylogenetic trees and cladograms are graphical representations (models) of evolutionary history that can be tested	492-495	Number of heart chambers in animal 869, 870, 872| Opposable thumbs 697, 700, 701 | Absence of legs in some sea mammals 821	
25.2 Phylogenetic systematics connects classification with evolutionary history	1.B.2 Phylogenetic trees and cladograms are graphical representations (models) of evolutionary history that can be tested	495-497	Number of heart chambers in animal 869, 870, 872| Opposable thumbs 697, 700, 701 | Absence of legs in some sea mammals 821	
25.3 Phylogenetic systematics informs that construction of phylogenetic trees based on shared characters	1.B.2 Phylogenetic trees and cladograms are graphical representations (models) of evolutionary history that can be tested	497-504	Number of heart chambers in animal 869, 870, 872| Opposable thumbs 697, 700, 701 | Absence of legs in some sea mammals 821	
25.4 Much of an organism's evolutionary history is documented in its genome	4.B.4 Distribution of local and global ecosystems changes over time	504-506	Dutch elm disease 622 | Potato blight 559 | Small pox [historic example for Native Americans) 912 | El Nino 1171 | Continental drift 527, 528 | Meteor impact on dinosaurs 520	
25.5 Molecular clocks help track evolutionary time				506-508
26. The Tree of Life: An Introduction to Biological Diversity				
26.1 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	513-516	Cytoskeleton (a network of structural proteins that facilitate cell movement, morphological integrity and organelle transport) 112, 113, 116, 117 | Membrane-bound organelles (mitochondria and/or chloroplasts) 107, 110, 111, 160, 168, 192, | Linear chromosomes 244-245, 246, 248 | Endomembrane systems, including the nuclear envelope 100, 101, 103, 105, 109	
	1.D.1 There are several hypotheses about the natural origin of life on Earth, each with supporting scientific evidence			

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Chapters/Sections	Essential Knowledge	Required content for the AP	Illustrative examples covered in this textbook - teach at least one	Content not required for the AP Course
26.2 The fossil record chronicles life on Earth	1.A.4 Biological evolution is supported by scientific evidence from many disciplines, including mathematics	516-520	Graphical analyses of allele frequencies in a population 456 | Analysis of phylogenetic trees 491, 496, 497, Construction of phylogenetic trees based on |499, 500, 501, 502-503, 504	
	1.C.1 Speciation and extinction have occurred throughout the Earth's history		Five major extinctions 518, 519, 520 | Human impact on ecosystems and species extinction rates 55, 1200, 1201, 1202, 1214	
26.3 As prokaryotes evolved, they exploited and changed young Earth	1.B.1 Organisms share many conserved core processes and features that evolved and are widely distributed among organisms today	521-523	Cytoskeleton (a network of structural proteins that facilitate cell movement, morphological integrity and organelle transport) 112, 113, 116, 117 | Membrane-bound organelles (mitochondria and/or chloroplasts) 107, 110, 111, 160, 168, 192, | Linear chromosomes 244-245, 246, 248 | Endomembrane systems, including the nuclear envelope 100, 101, 103, 105, 109	
	1.D.1 There are several hypotheses about the natural origin of life on Earth, each with supporting scientific evidence			
26.4 Eukaryotic cells arose from symbioses and genetic exchanges between prokaryotes	1.B.1 Organisms share many conserved core processes and features that evolved and are widely distributed among organisms today	523-525	Cytoskeleton (a network of structural proteins that facilitate cell movement, morphological integrity and organelle transport) 112, 113, 116, 117 | Membrane-bound organelles (mitochondria and/or chloroplasts) 107, 110, 111, 160, 168, 192, | Linear chromosomes 244-245, 246, 248 | Endomembrane systems, including the nuclear envelope 100, 101, 103, 105, 109	
	1.D.1 There are several hypotheses about the natural origin of life on Earth, each with supporting scientific evidence			
26.5 Multicellular evolved several times in eukaryotes	1.B.1 Organisms share many conserved core processes and features that evolved and are widely distributed among organisms today	525-528	Cytoskeleton (a network of structural proteins that facilitate cell movement, morphological integrity and organelle transport) 112, 113, 116, 117 | Membrane-bound organelles (mitochondria and/or chloroplasts) 107, 110, 111, 160, 168, 192, | Linear chromosomes 244-245, 246, 248 | Endomembrane systems, including the nuclear envelope 100, 101, 103, 105, 109	
	1.D.1 There are several hypotheses about the natural origin of life on Earth, each with supporting scientific evidence			
26.6 New information has revised our understanding of the tree of life	1.D.2 Scientific evidence from many different disciplines supports models of the origin of life	529-531		

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Chapters/Sections	Essential Knowledge	Required content for the AP	Illustrative examples covered in this textbook - teach at least one	Content not required for the AP Course
27. Prokaryotes				
27.1 Structural and functional, and genetic adaptations contribute to prokaryotic success	3.A.1 DNA, and in some cases RNA, is the primary source of heritable information	534-538	Addition of a poly-A tail 317, 318 | Addition of a GTP cap 206 | Excision of introns | Enzymatic reactions 318, 319, | Transport by proteins 134 136 | Synthesis 302, 303, 304 | Degradation 369 370 | Electrophoresis 393 395 | Plasmid-based transformation 387 | Restriction enzyme analysis of DNA 386 | Polymerase Chain Reaction (PCR) 391 | Genetically modified foods 407 | Transgenic animals | Cloned animals 406 | Pharmaceuticals, such as human insulin or factor X 403	
27.2 A great diversity of nutritional and metabolic adaptations have evolved in prokaryotes				538-540
27.3 Molecular systematics is illuminating prokaryotic phylogeny				540-544
27.4 Prokaryotes play crucial roles in the biosphere				544-545
27.5 Prokaryotes have both harmful and beneficial impacts on humans				545-547
28. Protists				
28.1 Protists are an extremely diverse assortment of eukaryotes				549-551
28.2 Diplomonads and parabasalids have modified mitochondria				552-553
28.3 Euglenozoans have flagella with a unique internal structure				553-554
28.4 Alveolates have sacs beneath the plasma membrane				555-558
28.5 Stramenopiles have "hairy" and smooth flagella				558-562
28.6 Cerozoans and radiolarians have threadlike pseudopodia				563
28.7 Amochozoans have lobe-shaped pseudopodia				564-566
28.8 Red algae and green algae are the closest relatives of land plants				567-569
29. Plant Diversity I: How Plants Colonized Land				
29.1 Land plants evolved from green algae				573-574
29.2 Land plants possess a set of derived terrestrial adaptations				575-579
29.3 The life cycles of mosses and other bryophytes are dominated by the gametophyte stage				580-583
Ferns and other seedless vascular plants formed the first forests				584-588
30. Plant Diversity II: The Evolution of Seed Plants				
30.1 The reduced gametophytes of seed plants are protected in ovules and pollen grains				591-593
30.2 Gymnosperms bear "naked" seeds, typically on cones				593-596
30.3 The reproductive adaptations of angiosperms include flowers and fruits				598-604
30.4 Human welfare depends greatly on seed plants				605-606
31. Fungi				
31.1 Fungi are heterotrophs that feed by absorption				608-610
31.2 Fungi produce sores through sexual or asexual life cycles				610-612
31.3 Fungi descended from an aquatic, single-celled, flagellated protist				612
31.4 Fungi have radiated into a diverse set of lineages				612-619
31.5 Fungi have a powerful impact on ecosystems and human welfare				620-623
32. An Introduction to Animal Diversity				
32.1 Animals are multicellular, heterotrophic eukaryotes with tissues that develop from embryonic layers				626-628
32.2 The history of animals may spans more than half a billion years				628-630
32.3 Animals can be characterized by "body plans"				630-633
32.4 Leading hypotheses agree on major features of the animal phylogenetic tree				633-636
33. Invertebrates				
33.1 Sponges are sessile and have a porous body and choanocytes				642-643
33.2 Cnidarians have radial symmetry, a gastrovascular cavity, and cnidocytes				643-646
33.3 Most animals have bilateral symmetry				646-650

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Chapters/Sections	Essential Knowledge	Required content for the AP	Illustrative examples covered in this textbook - teach at least one	Content not required for the AP Course
33.4 Molluscs have a muscular foot, a visceral mass, and a mantle				650-653
33.5 Annelids are segmented worms				653-655
33.6 Nematodes are nonsegmented pseudocoelomates covered by a tough cuticle				655-656
33.7 Arthropods are segmented coelomates that have an exoskeleton and jointed appendages				656-665
33.8 Echinoderms and chordates are deuterostomes				665-667
34. Vertebrates				
34.1 Chordates have a notochord and a dorsal, hollow nerve cord				671-675
34.2 Craniates are chordates that have a head				675-677
34.3 Vertebrates are craniates that have a backbone				678-679
34.4 Gnatostomes are vertebrates that have jaws				679-684
34.5 Tetrapods are gnathostomes that have limbs and feet				684-687
34.6 Amniotes are tetrapods that have a terrestrially adapted egg				687-694
34.7 Mammals are amniotes that have hair and produce milk				694-701
34.8 Humans are bipedal hominoids with a large brain				701-707
35. Plant Structure, Growth, and Development				
35.1 The plant body has a hierarchy of organs, tissues, and cells				712-717
35.2 Meristems generate cells for new organs				720-721
35.3 Primary growth lengthens roots and shoots				721-725
35.4 Secondary growth adds grith to stems and roots in woody plants				725-728
35.5 Growth, morphogenesis, and cell differentiation produce the plant body				728-735
36. Transport in Vascular Plants				
36.1 Physical forces drive the transport of materials in plants over a range of distances				738-744
36.2 Roots absorb water and minerals from the soil				744-746
36.3 Water and minerals ascend from roots to shoots through the xylem				746-749
36.4 Stomata help regulate the rate of transpiration				749-751
36.5 organic nutrients are translocated through the phloem				751-753

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Chapters/Sections	Essential Knowledge	Required content for the AP	Illustrative examples covered in this textbook - teach at least one	Content not required for the AP Course
37. Plant Nutrition				
37.1 Plants require certain chemical elements to complete their life cycle				758-759
37.2 Soil quality is a major determinant of plant distribution and growth				759-763
37.3 Nitrogen is often the mineral that has the greatest effect on plant growth				763-764
37.4 Plant nutritional adaptations often involve relationships with other organisms				764-767
38. Angiosperm Reproduction and Biotechnology				
38.1 Pollination enables gametes to come together within a flower	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	771-776	Morphogenesis of fingers and toes 413, 1001 | Immune function | C. elegans development 426, 427 | Flower Development 429	
	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 805, 1031| Diurnal/nocturnal and sleep/awake cycles 805, 1031 | Seasonal responses, such as hibernation, estivation, and migration 840, 1110| Release and reaction to pheromones 1111| Visual displays in the reproductive cycle 557, 559, 562, 565, 566, 569 | Fruiting body formation in fungi, slime molds, and certain types of bacteria 559, 562, 565, 566, 569 | Quorum sensing in bacteria(term 202	
38.2 After fertilization, ovules develop into seeds and ovaries into fruits	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	776-780	Morphogenesis of fingers and toes 413, 1001 | Immune function | C. elegans development 426, 427 | Flower Development 429	
	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 805, 1031| Diurnal/nocturnal and sleep/awake cycles 805, 1031 | Seasonal responses, such as hibernation, estivation, and migration 840, 1110| Release and reaction to pheromones 1111| Visual displays in the reproductive cycle 557, 559, 562, 565, 566, 569 | Fruiting body formation in fungi, slime molds, and certain types of bacteria 559, 562, 565, 566, 569 | Quorum sensing in bacteria(term 202	
38.3 Many flowering plants clone themselves by asexual reproduction				781-783
38.4 Plants biotechnology is transforming agriculture				783-786
39. Plant Responses to Internal and External Signals				
39.1 Signals transduction pathways link signal reception to response	2.E.2 timing and coordination of physiological events are regulated by multiple mechanisms	788-791	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 805, 1031| Diurnal/nocturnal and sleep/awake cycles 805, 1031 | Seasonal responses, such as hibernation, estivation, and migration 840, 1110| Release and reaction to pheromones 1111| Visual displays in the reproductive cycle 557, 559, 562, 565, 566, 569 | Fruiting body formation in fungi, slime molds, and certain types of bacteria 559, 562, 565, 566, 569 | Quorum sensing in bacteria(term 202	

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Chapters/Sections	Essential Knowledge	Required content for the AP	Illustrative examples covered in this textbook - teach at least one	Content not required for the AP Course
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	791-802	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 805, 1031| Diurnal/nocturnal and sleep/awake cycles 805, 1031 | Seasonal responses, such as hibernation, estivation, and migration 840, 1110| Release and reaction to pheromones 1111| Visual displays in the reproductive cycle 557, 559, 562, 565, 566, 569 | Fruiting body formation in fungi, slime molds, and certain types of bacteria 559, 562, 565, 566, 569 | Quorum sensing in bacteria(term 202	
	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 592, 614, 615, 616, 617, 618, 619, 620, 622| Niche and resource partitioning 1160, 1161 | Mutualistic relationships (lichens; bacteria in digestive tracts of animals; and mycorrhizae) 621 | Biology of pollination 592, 598, 599, 604, 772, 773, 774, 775, 776, 776, 778 | Hibernation 840 | Estivation 841 | Migration 1109, 1110 | Courtship 1106	
39.3 Responses to light are critical for plant success	2.E.2 Timing and coordination of physiological events are regulated by multiple mechanisms	802-808	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 805, 1031| Diurnal/nocturnal and sleep/awake cycles 805, 1031 | Seasonal responses, such as hibernation, estivation, and migration 840, 1110| Release and reaction to pheromones 1111| Visual displays in the reproductive cycle 557, 559, 562, 565, 566, 569 | Fruiting body formation in fungi, slime molds, and certain types of bacteria 559, 562, 565, 566, 569 | Quorum sensing in bacteria(term 202	
	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 592, 614, 615, 616, 617, 618, 619, 620, 622| Niche and resource partitioning 1160, 1161 | Mutualistic relationships (lichens; bacteria in digestive tracts of animals; and mycorrhizae) 621 | Biology of pollination 592, 598, 599, 604, 772, 773, 774, 775, 776, 776, 778 | Hibernation 840 | Estivation 841 | Migration 1109, 1110 | Courtship 1106	
39.4 Plants respond to a wide variety of stimuli other than light				808-812

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Chapters/Sections	Essential Knowledge	Required content for the AP	Illustrative examples covered in this textbook - teach at least one	Content not required for the AP Course
39.5 Plants defend themselves against herbivores and pathogens	2.D.4 Plants and animals have a variety of chemical defenses against infections that affect dynamic homeostasis	812-815	Invertebrate immune systems have nonspecific response mechanisms, but they lack pathogen-specific defense responses 899 | Plant defenses against pathogens include molecular recognition systems with systemic responses; infection triggers chemical responses that destroy infected and adjacent cells, thus localizing the effects 814, 815 | Vertebrate immune systems have nonspecific and nonheritable defense mechanisms against pathogens 901, 902, 903, 909, 910, 911, 912, 913	
40. Basic Principles of Animal Form and Function				
40.1 Physical laws and the environment constrain animal size and shape	2.A.1 All living systems require constant input of free energy	820-822	Krebs cycle 164, 165, 166, 167, 168, 169, 176, 177, 178 | Glycolysis 164, 165, 166, 167, 168, 169, 176, 177, 178 | Calvin cycle 185, 190, 193, 194, 196, 197, 198, | Fermentation 175, | Endothermy (the use of thermal energy generated by metabolism to maintain homeostatic body temperatures) 830, 831, 834, 835, 836, 837, 840 | Ectothermy (the use of external thermal energy to help regulate and maintain body temperature) 830, 831, 834, 835, 838, 839, |Life-history strategy (biennial plants and reproductive diapause) 1141, 1142 | Change in the producer level can affect the number and size of other trophic levels 1166, 1167, 1168, 1169, 1170, 1191, 1192, 1193, | Change in energy resources levels such as sunlight can affect the number and size of the trophic levels 1185, 1188	
	4.B.2 Cooperative interactions within organisms promote efficiency in the use of energy and matter		Exchange of gases 657, 659, 821, 822, 884, 885, 886, 887, 888, 889, 890, 891, 892, 893, 894 | Circulation of fluids 869, 870, 872, 873, 874, 875, 876, 877, 878, 879 | Digestion of food 853, 854, 855, 856, 857, 858, 859, 860, 861, 863, 864 | Excretion of wastes | Bacterial community in the rumen of animals 864 |	
40.2 Animals form and function are correlated at all levels of organization	2.A.1 All living systems require constant input of free energy	823-827	Krebs cycle 164, 165, 166, 167, 168, 169, 176, 177, 178 | Glycolysis 164, 165, 166, 167, 168, 169, 176, 177, 178 | Calvin cycle 185, 190, 193, 194, 196, 197, 198, | Fermentation 175, | Endothermy (the use of thermal energy generated by metabolism to maintain homeostatic body temperatures) 830, 831, 834, 835, 836, 837, 840 | Ectothermy (the use of external thermal energy to help regulate and maintain body temperature) 830, 831, 834, 835, 838, 839, |Life-history strategy (biennial plants and reproductive diapause) 1141, 1142 | Change in the producer level can affect the number and size of other trophic levels 1166, 1167, 1168, 1169, 1170, 1191, 1192, 1193, | Change in energy resources levels such as sunlight can affect the number and size of the trophic levels 1185, 1188	

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Chapters/Sections	Essential Knowledge	Required content for the AP	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 657, 659, 821, 822, 884, 885, 886, 887, 888, 889, 890, 891, 892, 893, 894 | Circulation of fluids 869, 870, 872, 873, 874, 875, 876, 877, 878, 879 | Digestion of food 853, 854, 855, 856, 857, 858, 859, 860, 861, 863, 864 | Excretion of wastes | Bacterial community in the rumen of animals 864 |	
40.3 Animals use the chemical energy in food to sustain form and function	2.A.1 All living systems require constant input of free energy	828-831	Krebs cycle 164, 165, 166, 167, 168, 169, 176, 177, 178 | Glycolysis 164, 165, 166, 167, 168, 169, 176, 177, 178 | Calvin cycle 185, 190, 193, 194, 196, 197, 198, | Fermentation 175, | Endothermy (the use of thermal energy generated by metabolism to maintain homeostatic body temperatures) 830, 831, 834, 835, 836, 837, 840 | Ectothermy (the use of external thermal energy to help regulate and maintain body temperature) 830, 831, 834, 835, 838, 839, |Life-history strategy (biennial plants and reproductive diapause) 1141, 1142 | Change in the producer level can affect the number and size of other trophic levels 1166, 1167, 1168, 1169, 1170, 1191, 1192, 1193, | Change in energy resources levels such as sunlight can affect the number and size of the trophic levels 1185, 1188	
40.4 Many animals regulate their internal environment within	2.A.1 All living systems require constant input of free energy		Krebs cycle 164, 165, 166, 167, 168, 169, 176, 177, 178 | Glycolysis 164, 165, 166, 167, 168, 169, 176, 177, 178 | Calvin cycle 185, 190, 193, 194, 196, 197, 198, | Fermentation 175, | Endothermy (the use of thermal energy generated by metabolism to maintain homeostatic body temperatures) 830, 831, 834, 835, 836, 837, 840 | Ectothermy (the use of external thermal energy to help regulate and maintain body temperature) 830, 831, 834, 835, 838, 839, |Life-history strategy (biennial plants and reproductive diapause) 1141, 1142 | Change in the producer level can affect the number and size of other trophic levels 1166, 1167, 1168, 1169, 1170, 1191, 1192, 1193, | Change in energy resources levels such as sunlight can affect the number and size of the trophic levels 1185, 1188	
	2.C.1 Organisms use feedback mechanisms to maintain their internal environments and respond to external environmental changes		Operons in gene regulation 354, 355 | | Lactation in mammals 698, 949, 950 | Onset of labor in childbirth 981 | Ripening of fruit | Diabetes mellitus in response to decreased insulin 385 | Dehydration in response to decreased antidiuretic hormone (ADH) 937, 945, 950| Graves' disease (hyperthyroidism) 953 | Blood clotting 882	

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Chapters/Sections	Essential Knowledge	Required content for the AP	Illustrative examples covered in this textbook - teach at least one	Content not required for the AP Course
40.4 Many animals regulate their internal environment within relatively narrow limits	2.D.2 Homeostatic mechanisms reflect both common ancestry and divergence due to adaptation in different environments	831-833	Gas exchange in aquatic and terrestrial plants 657, 659, 821, 822, 884, 885, 886, 887, 888, 889, 890, 891, 892, 893, 894, | Digestive mechanisms in animals such as food vacuoles, gastrovascular cavities, and one-way digestive systems 853, 854, 855, 856, 857, 858, 859, 860, 861, 863, 864 | Respiratory systems of aquatic and terrestrial animals 177, 886, 887, 888, 889,890, 891 | Nitrogenous waste production and elimination in aquatic and terrestrial animals 927, 930, 939 | Excretory systems in flatworms, earthworms, and vertebrates 932, 933, 935, 937 | Osmoregulation in bacteria, fish and protests 133, 922, 923, 924, 925, 926, | Osmoregulation in aquatic and terrestrial plants | Circulatory systems in fish, amphibians and mammals 886, 887, 888, 889,890, 891 | Thermoregulation in aquatic and terrestrial animals (countercurrent exchange mechanisms) 834, 835, 836, 837, 838, 839, 840	
	2.D.3 Biological systems are affected by disruptions to their dynamic homeostasis		Physiological responses to toxic substances 1202, 1204 | Dehydration 69, 136 | Immunological responses to pathogens, toxins, and allergens 916 | Invasive and/or eruptive species 1213| Human impact 1210, 1211, 1213, 1214 | Hurricanes, floods, earthquakes, volcanoes, and fires 1172, 1173 | Water limitation 761, 926, 937	
	2.A.1 All living systems require constant input of free energy		Krebs cycle 164, 165, 166, 167, 168, 169, 176, 177, 178 | Glycolysis 164, 165, 166, 167, 168, 169, 176, 177, 178 | Calvin cycle 185, 190, 193, 194, 196, 197, 198, | Fermentation 175, | Endothermy (the use of thermal energy generated by metabolism to maintain homeostatic body temperatures) 830, 831, 834, 835, 836, 837, 840 | Ectothermy (the use of external thermal energy to help regulate and maintain body temperature) 830, 831, 834, 835, 838, 839, |Life-history strategy (biennial plants and reproductive diapause) 1141, 1142 | Change in the producer level can affect the number and size of other trophic levels 1166, 1167, 1168, 1169, 1170, 1191, 1192, 1193, | Change in energy resources levels such as sunlight can affect the number and size of the trophic levels 1185, 1188	
	2.C.1 Organisms use feedback mechanisms to maintain their internal environments and respond to external environmental changes		Operons in gene regulation 354, 355 | | Lactation in mammals 698, 949, 950 | Onset of labor in childbirth 981 | Ripening of fruit | Diabetes mellitus in response to decreased insulin 385 | Dehydration in response to decreased antidiuretic hormone (ADH) 937, 945, 950| Graves' disease (hyperthyroidism) 953 | Blood clotting 882	

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Chapters/Sections	Essential Knowledge	Required content for the AP	Illustrative examples covered in this textbook - teach at least one	Content not required for the AP Course
40.5 Thermoregulation contributes to homeostasis and involves anatomy, physiology, and behavior	2.C.2 Organisms respond to changes in their external environments	833-841	Photoperiodism and phototropism in plants 807 | Hibernation and migration in animals 480, 1110 | Taxis and kinesis in animals 1110 | Chemotaxis in bacteria, sexual reproduction in fungi 536, 537 | Nocturnal and diurnal activity: circadian rhythms 805, 1031 | Shivering and sweating in humans 835	
	2.D.2 Homeostatic mechanisms reflect both common ancestry and divergence due to adaptation in different environments		Gas exchange in aquatic and terrestrial plants 657, 659, 821, 822, 884, 885, 886, 887, 888, 889, 890, 891, 892, 893, 894, | Digestive mechanisms in animals such as food vacuoles, gastrovascular cavities, and one-way digestive systems 853, 854, 855, 856, 857, 858, 859, 860, 861, 863, 864 | Respiratory systems of aquatic and terrestrial animals 177, 886, 887, 888, 889,890, 891 | Nitrogenous waste production and elimination in aquatic and terrestrial animals 927, 930, 939 | Excretory systems in flatworms, earthworms, and vertebrates 932, 933, 935, 937 | Osmoregulation in bacteria, fish and protests 133, 922, 923, 924, 925, 926, | Osmoregulation in aquatic and terrestrial plants | Circulatory systems in fish, amphibians and mammals 886, 887, 888, 889,890, 891 | Thermoregulation in aquatic and terrestrial animals (countercurrent exchange mechanisms) 834, 835, 836, 837, 838, 839, 840	
	2.D.3 Biological systems are affected by disruptions to their dynamic homeostasis		Physiological responses to toxic substances 1202, 1204 | Dehydration 69, 136 | Immunological responses to pathogens, toxins, and allergens 916 | Invasive and/or eruptive species 1213| Human impact 1210, 1211, 1213, 1214 | Hurricanes, floods, earthquakes, volcanoes, and fires 1172, 1173 | Water limitation 761, 926, 937	
41. Animal Nutrition				
41.1 Homeostatic mechanisms contribute to an animal's energy budget				844-849
41.1 An animal's diet must supply carbon skeletons and essential nutrients				849-852
41.2 The main stages of food processing are ingestion, digestion, absorption, and elimination				853-855
41.3 Each organs of the mammalian digestive system has specialized food-processing functions				855-862
41.4 Evolutionary adaptations of vertebrate digestive systems are often associated with diet				862-864
42. Circulation and Gas Exchange				
42.1 Circulatory systems reflect phylogeny				867-871
42.2 Double circulation in mammals depends on the anatomy and pumping cycle of the heart				871-874
42.3 Physical principles governs blood circulation				874-879
42.4 Blood is a connective tissue with cells suspended in plasma				879-883
42.5 Gas exchange occurs across specialized respiratory surfaces				884-888
42.6 Breathing ventilates the lungs				888-891
42.7 Respiratory pigments bind and transport gases				891-895
43. The Immune System				

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Chapters/Sections	Essential Knowledge	Required content for the AP	Illustrative examples covered in this textbook - teach at least one	Content not required for the AP Course
43.1 Innate immunity provides broad defenses against infection	2.D.4 Plants and animals have a variety of chemical defenses against infections that affect dynamic homeostasis	898-903	Invertebrate immune systems have nonspecific response mechanisms, but they lack pathogen-specific defense responses 899 | Plant defenses against pathogens include molecular recognition systems with systemic responses; infection triggers chemical responses that destroy infected and adjacent cells, thus localizing the effects 814, 815 | Vertebrate immune systems have nonspecific and nonheritable defense mechanisms against pathogens 901, 902, 903, 909, 910, 911, 912, 913	
43.2 In acquired immunity, lymphocyte provide specific defenses against infection	2.D.4 Plants and animals have a variety of chemical defenses against infections that affect dynamic homeostasis	903-908	Invertebrate immune systems have nonspecific response mechanisms, but they lack pathogen-specific defense responses 899 | Plant defenses against pathogens include molecular recognition systems with systemic responses; infection triggers chemical responses that destroy infected and adjacent cells, thus localizing the effects 814, 815 | Vertebrate immune systems have nonspecific and nonheritable defense mechanisms against pathogens 901, 902, 903, 909, 910, 911, 912, 913	
43.3 Humoral and cell-mediated immunity defend against different types of threats	2.D.4 Plants and animals have a variety of chemical defenses against infections that affect dynamic homeostasis	908-914	Invertebrate immune systems have nonspecific response mechanisms, but they lack pathogen-specific defense responses 899 | Plant defenses against pathogens include molecular recognition systems with systemic responses; infection triggers chemical responses that destroy infected and adjacent cells, thus localizing the effects 814, 815 | Vertebrate immune systems have nonspecific and nonheritable defense mechanisms against pathogens 901, 902, 903, 909, 910, 911, 912, 913	
43.4 The immune system's ability to distinguish self from nonself limits tissue transplantation	2.D.4 Plants and animals have a variety of chemical defenses against infections that affect dynamic homeostasis	915-916	Invertebrate immune systems have nonspecific response mechanisms, but they lack pathogen-specific defense responses 899 | Plant defenses against pathogens include molecular recognition systems with systemic responses; infection triggers chemical responses that destroy infected and adjacent cells, thus localizing the effects 814, 815 | Vertebrate immune systems have nonspecific and nonheritable defense mechanisms against pathogens 901, 902, 903, 909, 910, 911, 912, 913	
43.5 Exaggerated, self-directed, or diminished immune responses can cause disease	2.D.4 Plants and animals have a variety of chemical defenses against infections that affect dynamic homeostasis	916-918	Invertebrate immune systems have nonspecific response mechanisms, but they lack pathogen-specific defense responses 899 | Plant defenses against pathogens include molecular recognition systems with systemic responses; infection triggers chemical responses that destroy infected and adjacent cells, thus localizing the effects 814, 815 | Vertebrate immune systems have nonspecific and nonheritable defense mechanisms against pathogens 901, 902, 903, 909, 910, 911, 912, 913	

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Chapters/Sections	Essential Knowledge	Required content for the AP	Illustrative examples covered in this textbook - teach at least one	Content not required for the AP Course
44. Osmoregulation and Excretion				
44.1 Osmoregulation balances the uptake and loss of water and solutes				922-927
44.2 An animal's nitrogenous wastes reflect its phylogeny and habitat				927-928
44.3 Diverse excretory systems are variations on a tubular theme				928-931
44.4 Nephrons and associated blood vessels are the functional units of the mommalian kidney				931-934
44.5 The mammalian kidney's ability to conserve water is a key terrestrial adaptation				934-938
44.6 Diverse adaptations of the vertebrate kidney have evolved in different environments				938
45. Hormones and the Endocrine System				
45.1 The endocrine system and the nervous system act individually and together in regulating an animal's physiology	3.B.2 A variety of intercellular and intracellular signal transmissions mediate gene expression	943-944	Cytokines regulate gene expression to allow for cell replication and division 220, 221, 223, 225, 226, 244, 245, 246| Mating pheromones in yeast trigger mating gene expression 202| Levels of cAMP regulate metabolic gene expression in bacteria 356| Expression of the SRY gene triggers the male sexual development pathway in animals 282| Ethylene levels cause changes in the production of different enzymes, allowing fruits to ripen 203, 799, 800| Seed germination and gibberellin 780, 797, 798| Mating pheromones in yeast trigger mating genes expression and sexual reproduction 202| Morphogens stimulate cell differentiation and development 424| Changes in p53 activity can result in cancer 373| HOX genes and their role in development 432, 485, 486, 627, 675	
	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] 910, 911 ; Plasmodesmata between plant cells that allow material to be transported from cell to cell120; Neurotransmitters 1024, 1047; Plant immune response 813, 814, 815; Quorum sensing in bacteria 202; Morphogens in embryonic development 413, 424, 987, 1001, 1002, 1003; Insulin 105, 846, 955; Thyroid hormones 949, 953, 954; Testosterone 63, 205; Estrogen 958, 981	
	2.C.1 Organisms use feedback mechanisms to maintain their internal environments and respond to external environmental changes		Operons in gene regulation 354, 355 | | Lactation in mammals 698, 949, 950 | Onset of labor in childbirth 981 | Ripening of fruit | Diabetes mellitus in response to decreased insulin 385 | Dehydration in response to decreased antidiuretic hormone (ADH) 937, 945, 950| Graves' disease (hyperthyroidism) 953 | Blood clotting 882	

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Chapters/Sections	Essential Knowledge	Required content for the AP	Illustrative examples covered in this textbook - teach at least one	Content not required for the AP Course
45.2 Hormones and other chemical signals bind to target cell receptors, initiating pathways that culminate in specific cell responses	3.D.1 Cell communication processes share common features that reflect a shared evolutionary history	945-948	Use of chemical messengers by microbes to communicate with other nearby cells and to regulate specific pathways in response to population density (quorum sensing) 202, 203, 204, 208, 946; Use of pheromones to trigger reproduction and developmental pathways 611, 945, 946, 1049, 1111; Response to external signals by bacteria that influences cell movement; Epinephrine stimulation of glycogen breakdown in mammals 213, 947, 957; DNA repair mechanisms 305	
	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 220, 221, 223, 225, 226, 244, 245, 246| Mating pheromones in yeast trigger mating gene expression 202| Levels of cAMP regulate metabolic gene expression in bacteria 356| Expression of the SRY gene triggers the male sexual development pathway in animals 282| Ethylene levels cause changes in the production of different enzymes, allowing fruits to ripen 203, 799, 800| Seed germination and gibberellin 780, 797, 798| Mating pheromones in yeast trigger mating genes expression and sexual reproduction 202| Morphogens stimulate cell differentiation and development 424| Changes in p53 activity can result in cancer 373| HOX genes and their role in development 432, 485, 486, 627, 675	
	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] 910, 911 ; Plasmodesmata between plant cells that allow material to be transported from cell to cell120; Neurotransmitters 1024, 1047; Plant immune response 813, 814, 815; Quorum sensing in bacteria 202; Morphogens in embryonic development 413, 424, 987, 1001, 1002, 1003; Insulin 105, 846, 955; Thyroid hormones 949, 953, 954; Testosterone 63, 205; Estrogen 958, 981	
	2.C.1 Organisms use feedback mechanisms to maintain their internal environments and respond to external environmental changes		Operons in gene regulation 354, 355 | | Lactation in mammals 698, 949, 950 | Onset of labor in childbirth 981 | Ripening of fruit | Diabetes mellitus in response to decreased insulin 385 | Dehydration in response to decreased antidiuretic hormone (ADH) 937, 945, 950| Graves' disease (hyperthyroidism) 953 | Blood clotting 882	
45.3 The hypothalamus and pituitary integrate many functions of the vertebrate endocrine systems				948-952
45.4 Nonpituitary hormones help regulate metabolism, homeostasis, development, and behavior				953-959
45.5 Invertebrate regulatory system also involve endocrine and nervous system interactions				959-961
46. Animal Reproduction				
46.1 Both asexual and sexual reproduction occurs in the animal kingdom				964-966

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Chapters/Sections	Essential Knowledge	Required content for the AP	Illustrative examples covered in this textbook - teach at least one	Content not required for the AP Course
46.2 Fertilization depends on mechanisms that help sperm meet eggs of the same species				967-969
46.3 Reproductive organs produce and transport gametes: focus on humans				969-973
46.4 In humans and other mammals, a complex interplay of hormones regulates gametogenesis				973-978
46.5 In humans and other placental mammals, an embryo grows into a newborn in the mother's uterus				978-984
47. Animal Development				
47.1 After fertilization, embryonic development proceeds through cleavage, gastrulation, and organogenesis				988-1001
47.2 Morphogenesis in animals involves specific changes in cell shape, position, and adhesion				1001-1003
47.3 The developmental fate of cells depends on their history and on inductive signals	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	1003-1008	Morphogenesis of fingers and toes 413, 1001 | Immune function | C. elegans development 426, 427 | Flower Development 429	

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Chapters/Sections	Essential Knowledge	Required content for the AP	Illustrative examples covered in this textbook - teach at least one	Content not required for the AP Course
48. Nervous System				
48.1 Nervous system consists of circuits of neurons and supporting cells	3.E.2 Animals have nervous systems that detect external and internal signals, transmit and integrate information, and produce responses	1012-1015	Acetylcholine | Epinephrine 947, 957 | Norepinephrine 957, 1024 | Dopamine | Serotonin 1024 | GABA 1024 | Vision 1027, 1029, 1032, 1033| Hearing | Muscle movement 1013, 1027 | Abstract thought and emotions 1035 | Neuro-hormone production 945, 946, 951| Forebrain (cerebrum), midbrain (brainstem), and hindbrain (cerebellum) 1028 | Right and left cerebral hemispheres in humans 1033	
48.2 Ion pumps and ion channels maintain the resting potential of a neuron	3.E.2 Animals have nervous systems that detect external and internal signals, transmit and integrate information, and produce responses	1015-1017	Acetylcholine | Epinephrine 947, 957 | Norepinephrine 957, 1024 | Dopamine | Serotonin 1024 | GABA 1024 | Vision 1027, 1029, 1032, 1033| Hearing | Muscle movement 1013, 1027 | Abstract thought and emotions 1035 | Neuro-hormone production 945, 946, 951| Forebrain (cerebrum), midbrain (brainstem), and hindbrain (cerebellum) 1028 | Right and left cerebral hemispheres in humans 1033	
48.3 Action potentials are the signals conducted by axons	3.E.2 Animals have nervous systems that detect external and internal signals, transmit and integrate information, and produce responses	1017-1021	Acetylcholine | Epinephrine 947, 957 | Norepinephrine 957, 1024 | Dopamine | Serotonin 1024 | GABA 1024 | Vision 1027, 1029, 1032, 1033| Hearing | Muscle movement 1013, 1027 | Abstract thought and emotions 1035 | Neuro-hormone production 945, 946, 951| Forebrain (cerebrum), midbrain (brainstem), and hindbrain (cerebellum) 1028 | Right and left cerebral hemispheres in humans 1033	
48.4 Neurons communicate with other cells at synapses	3.E.2 Animals have nervous systems that detect external and internal signals, transmit and integrate information, and produce responses	1021-1025	Acetylcholine | Epinephrine 947, 957 | Norepinephrine 957, 1024 | Dopamine | Serotonin 1024 | GABA 1024 | Vision 1027, 1029, 1032, 1033| Hearing | Muscle movement 1013, 1027 | Abstract thought and emotions 1035 | Neuro-hormone production 945, 946, 951| Forebrain (cerebrum), midbrain (brainstem), and hindbrain (cerebellum) 1028 | Right and left cerebral hemispheres in humans 1033	
	4.A.4 Organisms exhibit complex properties due to interactions between their constituent parts		Stomach and small intestines 855, 857, 858, 859, 860, 861, 863| Kidney and bladder 932, 933| Root, stem and leaf 576, 577, 713, 714, 715, 720, 721, 723, 724, 725, 726, 727 | Respiratory and circulatory 822, 868, 869, 870, 872, 873, 875, 876, 878, 879, 883, 886, 887, 888, 889, 891, 892, 893, 894| Nervous and muscular 1013, 1014, 1033| Plant vascular and leaf 578, 584, 585, 586, 715, 717, 718, 719, 720, 721, 722, 733, 747, 748, 750	
48.5 The vertebrate nervous system is regionally specialized	3.E.2 Animals have nervous systems that detect external and internal signals, transmit and integrate information, and produce responses	1026-1032	Acetylcholine | Epinephrine 947, 957 | Norepinephrine 957, 1024 | Dopamine | Serotonin 1024 | GABA 1024 | Vision 1027, 1029, 1032, 1033| Hearing | Muscle movement 1013, 1027 | Abstract thought and emotions 1035 | Neuro-hormone production 945, 946, 951| Forebrain (cerebrum), midbrain (brainstem), and hindbrain (cerebellum) 1028 | Right and left cerebral hemispheres in humans 1033	

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Chapters/Sections	Essential Knowledge	Required content for the AP	Illustrative examples covered in this textbook - teach at least one	Content not required for the AP Course
48.6 The cerebral cortex controls voluntary movement and cognitive functions				1032-1037
48.7 CNS injuries and diseases are the focus of much research				1037-1041
49. Sensory and Motor Mechanisms				
49.1 Sensory receptors transduce stimulus energy and transmit signals to the central nervous system				1046-1049
49.2 The mechanoreceptors involved with hearing and equilibrium detest settling particles or moving fluid				1050-1054
49.3 The senses of taste and smell are closely related in most animals				1054-1057
49.4 Similar mechanisms underlie vision throughout the animal kingdom				1057-1063
49.5 Animal skeletons function in support, protection, and movement				1063-1066
49.6 Muscles move skeletal parts by contracting				1066-1072
49.7 Locomotion requires energy to overcome friction and gravity				1073-1074
50. An Introduction to Ecology and the Biosphere				
50.1 Ecology is the study of interactions between organisms and the environment				1080-1083
50.2 Interactions between organisms and the environment limit the distribution of species	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	1083-1092	Cell density 202, 203 206-207, 208, | Biofilms 539 | Temperature 805 | Water availability 805 | Sunlight 789, 790, 792, 803, 805 807 1088, 1089 | Symbiosis (mutualism, commensalism, and parasitism) 525, 545, 620, 621, 864, 1164 | Predator–prey relationships 467, 1150, 1151, 1152, | Water and nutrient availability, temperature, salinity, and pH 761 805 | Water and nutrient availability | Availability of nesting materials and sites 1115 | Food chains and food webs 1166, 1167, 1169, 1192, 1193, 1195 | Species diversity 1165, 1210, 1222| Population density 1137, 1138, 1148, 1149 | Algal blooms 555, 1189	
50.3 Abiotic and biotic factors influence the structure and dynamics of aquatic biomes				1092-1098
50.4 Climate largely determines the distribution and structure of terrestrial biomes				1098-1104
51. Behavioral Ecology				
51.1 Behavioral ecologists distinguish between proximate and ultimate causes of behavior	2.E.3 Timing and coordination of behavior are regulated by various mechanisms and are important in natural selection	1106-1109	Availability of resources leading to fruiting body formation in fungi and certain types of bacteria 592, 614, 615, 616, 617, 618, 619, 620, 622| Niche and resource partitioning 1160, 1161 | Mutualistic relationships (lichens; bacteria in digestive tracts of animals; and mycorrhizae) 621 | Biology of pollination 592, 598, 599, 604, 772, 773, 774, 775, 776, 776, 778 | Hibernation 840 | Estivation 841 | Migration 1109, 1110 | Courtship 1106	
	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 592, 614, 615, 616, 617, 618, 619, 620, 622| Niche and resource partitioning 1160, 1161 | Mutualistic relationships (lichens; bacteria in digestive tracts of animals; and mycorrhizae) 621 | Biology of pollination 592, 598, 599, 604, 772, 773, 774, 775, 776, 776, 778 | Hibernation 840 | Estivation 841 | Migration 1109, 1110 | Courtship 1106	

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Chapters/Sections	Essential Knowledge	Required content for the AP	Illustrative examples covered in this textbook - teach at least one	Content not required for the AP Course
51.2 Many behaviors have a strong genetic component	3.E.1 Individuals can act on information and communicate it to others	1109-1113	Fight or flight response 947 | Predator warnings 467, 1119, 1132 | Protection of young | Territorial marking in mammals 1149 | Coloration in flowers | Birds songs 1112 | Territorial marking in mammals | Pack behavior in animals | Herd, flock, and schooling behavior in animals 1118, 1130 | Predator warning 1132 |Coloration | Parent and offspring interactions 1109, 1119, 1130 1142 | Migration patterns 1121 | Courtship and mating behaviors 1124, 1125 1131 | Foraging in bees and other animals 1122 | Avoidance behavior to electric fences, poisons, or traps 1117	
51.3 Environment, interacting with an animal's genetic makeup, influences the development of behaviors	2.A.1 All living systems require constant input of free energy	1113-1118	Krebs cycle 164, 165, 166, 167, 168, 169, 176, 177, 178 | Glycolysis 164, 165, 166, 167, 168, 169, 176, 177, 178 | Calvin cycle 185, 190, 193, 194, 196, 197, 198, | Fermentation 175, | Endothermy (the use of thermal energy generated by metabolism to maintain homeostatic body temperatures) 830, 831, 834, 835, 836, 837, 840 | Ectothermy (the use of external thermal energy to help regulate and maintain body temperature) 830, 831, 834, 835, 838, 839, |Life-history strategy (biennial plants and reproductive diapause) 1141, 1142 | Change in the producer level can affect the number and size of other trophic levels 1166, 1167, 1168, 1169, 1170, 1191, 1192, 1193, | Change in energy resources levels such as sunlight can affect the number and size of the trophic levels 1185, 1188	
	3.E.1 Individuals can act on information and communicate it to others		Fight or flight response 947 | Predator warnings 467, 1119, 1132 | Protection of young | Territorial marking in mammals 1149 | Coloration in flowers | Birds songs 1112 | Territorial marking in mammals | Pack behavior in animals | Herd, flock, and schooling behavior in animals 1118, 1130 | Predator warning 1132 |Coloration | Parent and offspring interactions 1109, 1119, 1130 1142 | Migration patterns 1121 | Courtship and mating behaviors 1124, 1125 1131 | Foraging in bees and other animals 1122 | Avoidance behavior to electric fences, poisons, or traps 1117	
51.4 Behavioral traits can evolve by natural selection	1.A.1 Natural selection is a major mechanism of evolution	1118-1121	Graphical analysis of allele frequencies in a population 456 | Application of the Hardy-Weinberg equilibrium equation 457	
	1.A.2 Natural selection acts on phenotypic variations in populations		Flowering time in relation to global climate change 807 | Sickle cell Anemia 329 393, 466 | DDT resistance in insects 1202 | Artificial selection 445, 783, 249, 462, 463, 464, 1210 | Loss of genetic diversity within a crop species 407 | Overuse of antibiotics 448	

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Chapters/Sections	Essential Knowledge	Required content for the AP	Illustrative examples covered in this textbook - teach at least one	Content not required for the AP Course
	1.A.3 Evolutionary change is also driven by random processes		Graphical analyses of allele frequencies in a population 456 | Analysis of phylogenetic trees 491, 496, 497, Construction of phylogenetic trees based on |499, 500, 501, 502-503, 504	
	1.A.4 Biological evolution is supported by scientific evidence from many disciplines, including mathematics		Graphical analyses of allele frequencies in a population 456 | Analysis of phylogenetic trees 491, 496, 497, Construction of phylogenetic trees based on |499, 500, 501, 502-503, 504	
51.5 Natural selection favors behaviors that increase survival and reproductive success	1.A.1 Natural selection is a major mechanism of evolution	1121-1128	Graphical analysis of allele frequencies in a population 456 | Application of the Hardy-Weinberg equilibrium equation 457	
	1.A.2 Natural selection acts on phenotypic variations in populations		Flowering time in relation to global climate change 807 | Sickle cell Anemia 329 393, 466 | DDT resistance in insects 1202 | Artificial selection 445, 783, 249, 462, 463, 464, 1210 | Loss of genetic diversity within a crop species 407 | Overuse of antibiotics 448	
	1.A.3 Evolutionary change is also driven by random processes		Graphical analyses of allele frequencies in a population 456 | Analysis of phylogenetic trees 491, 496, 497 | Construction of phylogenetic trees based on 499, 500, 501, 502-503, 504	
	1.A.4 Biological evolution is supported by scientific evidence from many disciplines, including mathematics		Graphical analyses of allele frequencies in a population 456 | Analysis of phylogenetic trees 491, 496, 497 | Construction of phylogenetic trees based on 499, 500, 501, 502-503, 504	
51.6 The concept of inclusive fitness can account for most altruistic social behavior	1.A.1 Natural selection is a major mechanism of evolution	1128-1133	Graphical analysis of allele frequencies in a population 456 | Application of the Hardy-Weinberg equilibrium equation 457	
	1.A.2 Natural selection acts on phenotypic variations in populations		Flowering time in relation to global climate change 807 | Sickle cell Anemia 329 393, 466 | DDT resistance in insects 1202 | Artificial selection 445, 783, 249, 462, 463, 464, 1210 | Loss of genetic diversity within a crop species 407 | Overuse of antibiotics 448	
	1.A.3 Evolutionary change is also driven by random processes		Graphical analyses of allele frequencies in a population 456 | Analysis of phylogenetic trees 491, 496, 497 | Construction of phylogenetic trees based on 499, 500, 501, 502-503, 504	
	1.A.4 Biological evolution is supported by scientific evidence from many disciplines, including mathematics		Graphical analyses of allele frequencies in a population 456 | Analysis of phylogenetic trees 491, 496, 497 | Construction of phylogenetic trees based on 499, 500, 501, 502-503, 504	
52. Population Ecology				

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Chapters/Sections	Essential Knowledge	Required content for the AP	Illustrative examples covered in this textbook - teach at least one	Content not required for the AP Course
52.1 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	1136-1141	Cell density 202, 203 206-207, 208, | Biofilms 539 | Temperature 805 | Water availability 805 | Sunlight 789, 790, 792, 803, 805 807 1088, 1089 | Symbiosis (mutualism, commensalism, and parasitism) 525, 545, 620, 621, 864, 1164 | Predator–prey relationships 467, 1150, 1151, 1152, | Water and nutrient availability, temperature, salinity, and pH 761 805 | Water and nutrient availability | Availability of nesting materials and sites 1115 | Food chains and food webs 1166, 1167, 1169, 1192, 1193, 1195 | Species diversity 1165, 1210, 1222| Population density 1137, 1138, 1148, 1149 | Algal blooms 555, 1189	
	4.A.5 Communities are composed of populations of organisms that interact in complex ways		Symbiotic relationship 525, 545, 620, 621, 864, 1164 | Introduction of species 1213 | Global climate change models 1092, 1204, 1205, 1206	
52.2 Life history traits are products of natural selection	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	1141-1143	Cell density 202, 203 206-207, 208, | Biofilms 539 | Temperature 805 | Water availability 805 | Sunlight 789, 790, 792, 803, 805 807 1088, 1089 | Symbiosis (mutualism, commensalism, and parasitism) 525, 545, 620, 621, 864, 1164 | Predator–prey relationships 467, 1150, 1151, 1152, | Water and nutrient availability, temperature, salinity, and pH 761 805 | Water and nutrient availability | Availability of nesting materials and sites 1115 | Food chains and food webs 1166, 1167, 1169, 1192, 1193, 1195 | Species diversity 1165, 1210, 1222| Population density 1137, 1138, 1148, 1149 | Algal blooms 555, 1189	
	2.A.1 All living systems require constant input of free energy		Krebs cycle 164, 165, 166, 167, 168, 169, 176, 177, 178 | Glycolysis 164, 165, 166, 167, 168, 169, 176, 177, 178 | Calvin cycle 185, 190, 193, 194, 196, 197, 198, | Fermentation 175, | Endothermy (the use of thermal energy generated by metabolism to maintain homeostatic body temperatures) 830, 831, 834, 835, 836, 837, 840 | Ectothermy (the use of external thermal energy to help regulate and maintain body temperature) 830, 831, 834, 835, 838, 839, |Life-history strategy (biennial plants and reproductive diapause) 1141, 1142 | Change in the producer level can affect the number and size of other trophic levels 1166, 1167, 1168, 1169, 1170, 1191, 1192, 1193, | Change in energy resources levels such as sunlight can affect the number and size of the trophic levels 1185, 1188	

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Chapters/Sections	Essential Knowledge	Required content for the AP	Illustrative examples covered in this textbook - teach at least one	Content not required for the AP Course
52.3 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	1143-1145	Cell density 202, 203 206-207, 208, | Biofilms 539 | Temperature 805 | Water availability 805 | Sunlight 789, 790, 792, 803, 805 807 1088, 1089 | Symbiosis (mutualism, commensalism, and parasitism) 525, 545, 620, 621, 864, 1164 | Predator–prey relationships 467, 1150, 1151, 1152, | Water and nutrient availability, temperature, salinity, and pH 761 805 | Water and nutrient availability | Availability of nesting materials and sites 1115 | Food chains and food webs 1166, 1167, 1169, 1192, 1193, 1195 | Species diversity 1165, 1210, 1222| Population density 1137, 1138, 1148, 1149 | Algal blooms 555, 1189	
	4.A.5 Communities are composed of populations of organisms that interact in complex ways		Symbiotic relationship 525, 545, 620, 621, 864, 1164 | Introduction of species 1213 | Global climate change models 1092, 1204, 1205, 1206	
52.4 The logistic growth model includes the concept of carrying capacity	2.A.1 All living systems require constant input of free energy	1145-1147	Krebs cycle 164, 165, 166, 167, 168, 169, 176, 177, 178 | Glycolysis 164, 165, 166, 167, 168, 169, 176, 177, 178 | Calvin cycle 185, 190, 193, 194, 196, 197, 198, | Fermentation 175, | Endothermy (the use of thermal energy generated by metabolism to maintain homeostatic body temperatures) 830, 831, 834, 835, 836, 837, 840 | Ectothermy (the use of external thermal energy to help regulate and maintain body temperature) 830, 831, 834, 835, 838, 839, |Life-history strategy (biennial plants and reproductive diapause) 1141, 1142 | Change in the producer level can affect the number and size of other trophic levels 1166, 1167, 1168, 1169, 1170, 1191, 1192, 1193, | Change in energy resources levels such as sunlight can affect the number and size of the trophic levels 1185, 1188	
	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 202, 203 206-207, 208, | Biofilms 539 | Temperature 805 | Water availability 805 | Sunlight 789, 790, 792, 803, 805 807 1088, 1089 | Symbiosis (mutualism, commensalism, and parasitism) 525, 545, 620, 621, 864, 1164 | Predator–prey relationships 467, 1150, 1151, 1152, | Water and nutrient availability, temperature, salinity, and pH 761 805 | Water and nutrient availability | Availability of nesting materials and sites 1115 | Food chains and food webs 1166, 1167, 1169, 1192, 1193, 1195 | Species diversity 1165, 1210, 1222| Population density 1137, 1138, 1148, 1149 | Algal blooms 555, 1189	
	4.A.5 Communities are composed of populations of organisms that interact in complex ways		Symbiotic relationship 525, 545, 620, 621, 864, 1164 | Introduction of species 1213 | Global climate change models 1092, 1204, 1205, 1206	

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Chapters/Sections	Essential Knowledge	Required content for the AP	Illustrative examples covered in this textbook - teach at least one	Content not required for the AP Course
52.5 Populations are regulated by a complex interaction of biotic and abiotic influences	4.A.5 Communities are composed of populations of organisms that interact in complex ways	1148-1152	Symbiotic relationship 525, 545, 620, 621, 864, 1164 | Introduction of species 1213 | Global climate change models 1092, 1204, 1205, 1206	
	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 202, 203 206-207, 208, | Biofilms 539 | Temperature 805 | Water availability 805 | Sunlight 789, 790, 792, 803, 805 807 1088, 1089 | Symbiosis (mutualism, commensalism, and parasitism) 525, 545, 620, 621, 864, 1164 | Predator–prey relationships 467, 1150, 1151, 1152, | Water and nutrient availability, temperature, salinity, and pH 761 805 | Water and nutrient availability | Availability of nesting materials and sites 1115 | Food chains and food webs 1166, 1167, 1169, 1192, 1193, 1195 | Species diversity 1165, 1210, 1222| Population density 1137, 1138, 1148, 1149 | Algal blooms 555, 1189	
52.6 The human population growth has slowed after centuries of exponential increase	4.A.5 Communities are composed of populations of organisms that interact in complex ways	1152-1156	Symbiotic relationship 525, 545, 620, 621, 864, 1164 | Introduction of species 1213 | Global climate change models 1092, 1204, 1205, 1206	
53. Community Ecology				
53.1 A community's interactions include competition, predation, herbivory, symbiosis, and disease	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	1159-1165	Cell density 202, 203 206-207, 208, | Biofilms 539 | Temperature 805 | Water availability 805 | Sunlight 789, 790, 792, 803, 805 807 1088, 1089 | Symbiosis (mutualism, commensalism, and parasitism) 525, 545, 620, 621, 864, 1164 | Predator–prey relationships 467, 1150, 1151, 1152, | Water and nutrient availability, temperature, salinity, and pH 761 805 | Water and nutrient availability | Availability of nesting materials and sites 1115 | Food chains and food webs 1166, 1167, 1169, 1192, 1193, 1195 | Species diversity 1165, 1210, 1222| Population density 1137, 1138, 1148, 1149 | Algal blooms 555, 1189	
	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		Symbiotic relationship 525, 545, 620, 621, 864, 1164 | Introduction of species 1213 | Global climate change models 1092, 1204, 1205, 1206	
	4.B.3 Interactions between and within populations influence patterns of species distribution and abundance		Loss of keystone species 1168, 1169 | Kudzu 1213 | Dutch elm disease 622	

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Chapters/Sections	Essential Knowledge	Required content for the AP	Illustrative examples covered in this textbook - teach at least one	Content not required for the AP Course
53.2 Dominant and keystone species exert strong controls on community structure	2.A.1 All living systems require constant input of free energy	1165-1171	Krebs cycle 164, 165, 166, 167, 168, 169, 176, 177, 178 | Glycolysis 164, 165, 166, 167, 168, 169, 176, 177, 178 | Calvin cycle 185, 190, 193, 194, 196, 197, 198, | Fermentation 175, | Endothermy (the use of thermal energy generated by metabolism to maintain homeostatic body temperatures) 830, 831, 834, 835, 836, 837, 840 | Ectothermy (the use of external thermal energy to help regulate and maintain body temperature) 830, 831, 834, 835, 838, 839, |Life-history strategy (biennial plants and reproductive diapause) 1141, 1142 | Change in the producer level can affect the number and size of other trophic levels 1166, 1167, 1168, 1169, 1170, 1191, 1192, 1193, | Change in energy resources levels such as sunlight can affect the number and size of the trophic levels 1185, 1188	
	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 202, 203 206-207, 208, | Biofilms 539 | Temperature 805 | Water availability 805 | Sunlight 789, 790, 792, 803, 805 807 1088, 1089 | Symbiosis (mutualism, commensalism, and parasitism) 525, 545, 620, 621, 864, 1164 | Predator–prey relationships 467, 1150, 1151, 1152, | Water and nutrient availability, temperature, salinity, and pH 761 805 | Water and nutrient availability | Availability of nesting materials and sites 1115 | Food chains and food webs 1166, 1167, 1169, 1192, 1193, 1195 | Species diversity 1165, 1210, 1222| Population density 1137, 1138, 1148, 1149 | Algal blooms 555, 1189	
	4.A.5 Communities are composed of populations of organisms that interact in complex ways		Symbiotic relationship 525, 545, 620, 621, 864, 1164 | Introduction of species 1213 | Global climate change models 1092, 1204, 1205, 1206	
	4.A.6 Interactions among living systems and with their environment result in the movement of matter and energy			
	4.C.4 The diversity of species within an ecosystem may influence the stability of the ecosystem			
53.3 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	1171-1175	Cell density 202, 203 206-207, 208, | Biofilms 539 | Temperature 805 | Water availability 805 | Sunlight 789, 790, 792, 803, 805 807 1088, 1089 | Symbiosis (mutualism, commensalism, and parasitism) 525, 545, 620, 621, 864, 1164 | Predator–prey relationships 467, 1150, 1151, 1152, | Water and nutrient availability, temperature, salinity, and pH 761 805 | Water and nutrient availability | Availability of nesting materials and sites 1115 | Food chains and food webs 1166, 1167, 1169, 1192, 1193, 1195 | Species diversity 1165, 1210, 1222| Population density 1137, 1138, 1148, 1149 | Algal blooms 555, 1189	

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Chapters/Sections	Essential Knowledge	Required content for the AP	Illustrative examples covered in this textbook - teach at least one	Content not required for the AP Course
53.4 Biogeographic factors affect community biodiversity	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	1175-1178	Cell density 202, 203 206-207, 208, | Biofilms 539 | Temperature 805 | Water availability 805 | Sunlight 789, 790, 792, 803, 805 807 1088, 1089 | Symbiosis (mutualism, commensalism, and parasitism) 525, 545, 620, 621, 864, 1164 | Predator–prey relationships 467, 1150, 1151, 1152, | Water and nutrient availability, temperature, salinity, and pH 761 805 | Water and nutrient availability | Availability of nesting materials and sites 1115 | Food chains and food webs 1166, 1167, 1169, 1192, 1193, 1195 | Species diversity 1165, 1210, 1222| Population density 1137, 1138, 1148, 1149 | Algal blooms 555, 1189	
53.5 Contrasting views of community structure are the subject of continuing debate	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	1178-1180	Cell density 202, 203 206-207, 208, | Biofilms 539 | Temperature 805 | Water availability 805 | Sunlight 789, 790, 792, 803, 805 807 1088, 1089 | Symbiosis (mutualism, commensalism, and parasitism) 525, 545, 620, 621, 864, 1164 | Predator–prey relationships 467, 1150, 1151, 1152, | Water and nutrient availability, temperature, salinity, and pH 761 805 | Water and nutrient availability | Availability of nesting materials and sites 1115 | Food chains and food webs 1166, 1167, 1169, 1192, 1193, 1195 | Species diversity 1165, 1210, 1222| Population density 1137, 1138, 1148, 1149 | Algal blooms 555, 1189	
54. Ecosystems				
54.1 Ecosystem ecology emphasizes energy flow and chemical cycling	2.A.1 All living systems require constant input of free energy	1184-1186	Krebs cycle 164, 165, 166, 167, 168, 169, 176, 177, 178 | Glycolysis 164, 165, 166, 167, 168, 169, 176, 177, 178 | Calvin cycle 185, 190, 193, 194, 196, 197, 198, | Fermentation 175, | Endothermy (the use of thermal energy generated by metabolism to maintain homeostatic body temperatures) 830, 831, 834, 835, 836, 837, 840 | Ectothermy (the use of external thermal energy to help regulate and maintain body temperature) 830, 831, 834, 835, 838, 839, |Life-history strategy (biennial plants and reproductive diapause) 1141, 1142 | Change in the producer level can affect the number and size of other trophic levels 1166, 1167, 1168, 1169, 1170, 1191, 1192, 1193, | Change in energy resources levels such as sunlight can affect the number and size of the trophic levels 1185, 1188	
	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 202, 203 206-207, 208, | Biofilms 539 | Temperature 805 | Water availability 805 | Sunlight 789, 790, 792, 803, 805 807 1088, 1089 | Symbiosis (mutualism, commensalism, and parasitism) 525, 545, 620, 621, 864, 1164 | Predator–prey relationships 467, 1150, 1151, 1152, | Water and nutrient availability, temperature, salinity, and pH 761 805 | Water and nutrient availability | Availability of nesting materials and sites 1115 | Food chains and food webs 1166, 1167, 1169, 1192, 1193, 1195 | Species diversity 1165, 1210, 1222| Population density 1137, 1138, 1148, 1149 | Algal blooms 555, 1189	

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Chapters/Sections	Essential Knowledge	Required content for the AP	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			
54.2 Physical and chemical factors limit primary production 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	1186-1191	Cell density 202, 203 206-207, 208, | Biofilms 539 | Temperature 805 | Water availability 805 | Sunlight 789, 790, 792, 803, 805 807 1088, 1089 | Symbiosis (mutualism, commensalism, and parasitism) 525, 545, 620, 621, 864, 1164 | Predator–prey relationships 467, 1150, 1151, 1152, | Water and nutrient availability, temperature, salinity, and pH 761 805 | Water and nutrient availability | Availability of nesting materials and sites 1115 | Food chains and food webs 1166, 1167, 1169, 1192, 1193, 1195 | Species diversity 1165, 1210, 1222| Population density 1137, 1138, 1148, 1149 | Algal blooms 555, 1189	
54.3 Energy transfer between trophic levels is usually less than 20% efficient	2.A.1 All living systems require constant input of free energy	1191-1194	Krebs cycle 164, 165, 166, 167, 168, 169, 176, 177, 178 | Glycolysis 164, 165, 166, 167, 168, 169, 176, 177, 178 | Calvin cycle 185, 190, 193, 194, 196, 197, 198, | Fermentation 175, | Endothermy (the use of thermal energy generated by metabolism to maintain homeostatic body temperatures) 830, 831, 834, 835, 836, 837, 840 | Ectothermy (the use of external thermal energy to help regulate and maintain body temperature) 830, 831, 834, 835, 838, 839, |Life-history strategy (biennial plants and reproductive diapause) 1141, 1142 | Change in the producer level can affect the number and size of other trophic levels 1166, 1167, 1168, 1169, 1170, 1191, 1192, 1193, | Change in energy resources levels such as sunlight can affect the number and size of the trophic levels 1185, 1188	
	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 202, 203 206-207, 208, | Biofilms 539 | Temperature 805 | Water availability 805 | Sunlight 789, 790, 792, 803, 805 807 1088, 1089 | Symbiosis (mutualism, commensalism, and parasitism) 525, 545, 620, 621, 864, 1164 | Predator–prey relationships 467, 1150, 1151, 1152, | Water and nutrient availability, temperature, salinity, and pH 761 805 | Water and nutrient availability | Availability of nesting materials and sites 1115 | Food chains and food webs 1166, 1167, 1169, 1192, 1193, 1195 | Species diversity 1165, 1210, 1222| Population density 1137, 1138, 1148, 1149 | Algal blooms 555, 1189	
	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	Illustrative examples covered in this textbook - teach at least one	Content not required for the AP Course
54.4 Biological and geochemical processes move nutrients between organic and inorganic parts of an ecosystem	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	1195-1199	Cell density 202, 203 206-207, 208, | Biofilms 539 | Temperature 805 | Water availability 805 | Sunlight 789, 790, 792, 803, 805 807 1088, 1089 | Symbiosis (mutualism, commensalism, and parasitism) 525, 545, 620, 621, 864, 1164 | Predator–prey relationships 467, 1150, 1151, 1152, | Water and nutrient availability, temperature, salinity, and pH 761 805 | Water and nutrient availability | Availability of nesting materials and sites 1115 | Food chains and food webs 1166, 1167, 1169, 1192, 1193, 1195 | Species diversity 1165, 1210, 1222| Population density 1137, 1138, 1148, 1149 | Algal blooms 555, 1189	
	4.A.6 Interactions among living systems and with their environment result in the movement of matter and energy			
54.5 The human population is disrupting chemical cycles throughout the biosphere	4.B.4 Distribution of local and global ecosystems changes over time	1200-1206	Dutch elm disease 622 | Potato blight 559 | Small pox [historic example for Native Americans) 912 | El Nino 1171 | Continental drift 527, 528 | Meteor impact on dinosaurs 520	
55. Conservation Biology and Restoration Ecology				
55.1 Human activities threaten Earth's biodiversity	2.D.2 Homeostatic mechanisms reflect both common ancestry and divergence due to adaptation in different environments	1209-1215	Gas exchange in aquatic and terrestrial plants 657, 659, 821, 822, 884, 885, 886, 887, 888, 889, 890, 891, 892, 893, 894, | Digestive mechanisms in animals such as food vacuoles, gastrovascular cavities, and one-way digestive systems 853, 854, 855, 856, 857, 858, 859, 860, 861, 863, 864 | Respiratory systems of aquatic and terrestrial animals 177, 886, 887, 888, 889,890, 891 | Nitrogenous waste production and elimination in aquatic and terrestrial animals 927, 930, 939 | Excretory systems in flatworms, earthworms, and vertebrates 932, 933, 935, 937 | Osmoregulation in bacteria, fish and protests 133, 922, 923, 924, 925, 926, | Osmoregulation in aquatic and terrestrial plants | Circulatory systems in fish, amphibians and mammals 886, 887, 888, 889,890, 891 | Thermoregulation in aquatic and terrestrial animals (countercurrent exchange mechanisms) 834, 835, 836, 837, 838, 839, 840	
	2.D.3 Biological systems are affected by disruptions to their dynamic homeostasis		Physiological responses to toxic substances 1202, 1204 | Dehydration 69, 136 | Immunological responses to pathogens, toxins, and allergens 916 | Invasive and/or eruptive species 1213| Human impact 1210, 1211, 1213, 1214 | Hurricanes, floods, earthquakes, volcanoes, and fires 1172, 1173 | Water limitation 761, 926, 937	
	4.B.4 Distribution of local and global ecosystems changes over time		Dutch elm disease 622 | Potato blight 559 | Small pox [historic example for Native Americans) 912 | El Nino 1171 | Continental drift 527, 528 | Meteor impact on dinosaurs 520	
	4.C.4 The diversity of species within an ecosystem may influence the stability of the ecosystem			
55.2 Population conservation focuses on population size, genetic diversity, and critical habitat				1215-1220
55.3 Landscape and regional conservation help sustain entire biotas				1220-1224

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55.4 Restoration ecology attempts to restore 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	1224-1225		
55.5 Sustainable development seeks to improve the human condition while conserving biodiversity				1228-1229