Principles of Life, First Edition

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Correlation to 2012 AP* Biology Course Description

	Essential Knowledge covered	Required content for the AP Course	Illustrative examples covered in this textbook - teach at least one	Content not required for the AP Course
1. Principles of Life				
1.1 Living organisms share common aspects of structure, functions, and energy flow	1.b.1 Organisms share many conserved core processes and features that evolved and are widely distributed among organisms today.; 1.b.2 Phylogenetic trees and cladograms are graphical representations (models) of evolutionary history that can be tested.; 1.d.1 There are several hypotheses about the natural origin of life on Earth, each with supporting scientific evidence. 1.d.2 Scientific evidence from many different disciplines supports models of the origin of life.	2-5	• Membrane-bound organelles (mitochondria and/or chloroplasts) p. 4	
1.2 Genetic systems control the flow, exchange, storage, and use of information				6
1.3 Organisms interact with and affect their environmnets				7-8
1.4 Evolution explains both the unity and diversity of life	1.a.1 Natural selection is a major mechanism of evolution	9-10		
1.5 Science is based on quantifiable observations and experiments				10-14
2. Life Chemistry and Energy				
2.1 Atomic structure is the basis for life's chemistry				17

2.2 Atoms interact and form molecules	2.a.3 Organisms must exchange matter with the environment to grow, reproduce, and maintain organization.	18-23		
2.3 Carbohydrates consist of sugar molecules				24-25
2.4 Lipids are hydrophobic molecules				26-28
2.5 Biochemical changes involve energy	2.a.1 All living systems require constant input of free energy.	29-30		
3. Nucleic Acids, Proteins, and Enzymes				
3.1 Nucleic acids are informational macromolecules	3.A.1: DNA, and in some cases RNA, is the primary source of heritable information. 4.A.1: The subcomponents of biological molecules and their sequence determine the properties of that molecule.	35-38		
3.2 Proteins are polymers with important structural and metabolic roles	3.A.1: DNA, and in some cases RNA, is the primary source of heritable information. 4.A.1: The subcomponents of biological molecules and their sequence determine the properties of that molecule.	39-45		

3.3 Some proteins act as enzymes to speed up biochemical reactions	1.d.2 Scientific evidence from many different disciplines supports models of the origin of life. 3.A.1: DNA, and in some cases RNA, is the primary source of heritable information. 4.A.1: The subcomponents of biological molecules and their sequence determine the properties of that molecule. 4.B.1: Interactions between molecules affect their structure and function.	46-48		
3.4 Regulation of metabolism occurs by regulation of enzymes	3.A.1: DNA, and in some cases RNA, is the primary source of heritable information. 4.A.1: The subcomponents of biological molecules and their sequence determine the properties of that molecule. 4.B.1: Interactions between molecules affect their structure and function.	49-52		
4. Cells: The Working Units of Life				
4.1 Cells provide compartments for biochemical reactions				57-58
4.2 Prokaryotic cells do not have a nucleus				59-60

4.3 Eukaryotic cells have a nucleus and other membrane-bound compartments	2.b.3 Eukaryotic cells maintain internal membranes that partition the cell into specialized regions. 4.A.2: The structure and function of subcellular components, and their interactions, provide essential cellular processes.	61-68	• Cytoskeleton (a network of structural proteins that facilitate cell movement, morphological integrity, organelle transport) p. 62 • Endomembrane systems, including the nuclear envelope p. 64 • Endoplasmic reticulum p. 62-66 • Mitochondria p. 62 • Chloroplasts p. 63 • Golgi p. 62-66 • Nuclear envelope p. 64	
4.4 The Cytoskeleton provides strength and movement	4.A.2: The structure and function of subcellular components, and their interactions, provide essential cellular processes.	69-72	• Cytoskeleton (a network of structural proteins that facilitate cell movement, morphological integrity, organelle transport) p. 69-72	
4.5 Extracellular structures allow cells to communicate with the external environment	3.D.2 Cells communicate with each other through direct contact with other cells or from a distance via chemical signaling.	73-74		
5. Cell Membranes and Signaling				
5.1 Biological membranes have a common structure and are fluid	2.b.1 Cell membranes are selectively permeable due to their structure. 4.C.1: Variation in molecular units provides cells with a wider range of functions.	79-82	• Phospholipids in membranes p. 79-80	
5.2 Some substances can cross the membrane by diffusion	2.b.2 Growth and dynamic homeostasis are maintained by the constant movement of molecules across membranes.	83-85	• Glucose transport p. 85	

5.3 Some substances require energy to cross the membrane	2.b.2 Growth and dynamic homeostasis are maintained by the constant movement of molecules across membranes.	86-87	• Glucose transport p. 87	
5.4 Large molecules cross the membrane via vesicles	2.b.2 Growth and dynamic homeostasis are maintained by the constant movement of molecules across membranes.	88-90		
5.5 The membrane plays a key role in a cell's response to environmental signals	3.B.2 A variety of intercellular and intracellular signal transmissions mediate gene expression. 3.D.1 Cell communication processes share common features that reflect a shared evolutionary history. 3.D.3. Signal transduction pathways link signal reception with cellular response.	91-93	• G-protein linked receptors p. 93-94	
5.6 Signal transduction allows the cell to respond to its environment	3.D.1 Cell communication processes share common features that reflect a shared evolutionary history. 3.D.3. Signal transduction pathways link signal reception with cellular response. 3.D.4. Changes in signal transduction pathways can alter cellular response.	94-97		
6. Pathways that Harvest and Store Chemical Energy				

6.1 ATP, reduced coenzymes, and chemiosmosis play important roles in biological energy metabolism	1.d.1 There are several hypotheses about the natural origin of life on Earth, each with supporting scientific evidence. 1.d.2 Scientific evidence from many different disciplines supports models of the origin of life. 2.a.1 All living systems require constant input of free energy. 2.a.2 Organisms capture and store free energy for use in biological processes.	101-105		
6.2 Carbohydrate catabolism in the presence of oxygen releases a large amount of energy	2.a.1 All living systems require constant input of free energy. 2.a.2 Organisms capture and store free energy for use in biological processes. 4.A.2: The structure and function of subcellular components, and their interactions, provide essential cellular processes.	106-109	• Glycolysis p. 106-108	
6.3 Carbohydrate catabolism in the absence of exygen releases a small amount of energy	2.a.1 All living systems require constant input of free energy. 2.a.2 Organisms capture and store free energy for use in biological processes.	110-111	• Fermentation p. 110-111 • Oxygen in cellular respiration p. 110	
6.4 Catabolic and anabolic pathways are integrated	2.a.1 All living systems require constant input of free energy.	111-112		

6.5 During photosynthesis, light energy is converted to chemical energy	2.a.1 All living systems require constant input of free energy. 4.A.2: The structure and function of subcellular components, and their interactions, provide essential cellular processes. 4.C.1: Variation in molecular units provides cells with a wider range of functions.	113-117	• Chlorophylls p. 114-117	
6.6 Photosynthetic organisms use chemical energy to convert CO2 to carbohydrates	2.a.1 All living systems require constant input of free energy.	118-120	• Calvin cycle p. 118-119 • Fermentation p. 120	
7. The Cell Cycle and Cell Division				
7.1 Different life cycles use different modes of cell reproduction	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.	125-126		
7.2 Both binary fission and mitosis produce genetically identical cells	2.c.1 Organisms use negative feedback mechanisms to maintain their internal environments and respond to external environmental changes. 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.	127-131	• Endomembrane systems, including the nuclear envelope p. 131	
7.3 Cell reproduction is under precise control	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.	132-134	• Cancer and cell cycle control p. 132-134	

7.4 Meiosis halves the nuclear chromosome content and generates diversity	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. 3.A.3 The chromosomal basis of inheritance provides an understanding of the pattern of passage (transmission) of genes from parent to offspring. 3.C.1 Changes in genotype can result in changes in phenotype. 3.C.2 Biological systems have multiple processes that increase genetic variation.	134-139	• Cell cycle checkpoints p. 134 • Down syndrome p. 139	
7.5 Programmed cell death is a necessary process in living organisms				140-142
8. Inheritance, Genes, and Chromosomes				
8.1 Genes are particulate and are inherited according to Mendel's laws	3.A.3 The chromosomal basis of inheritance provides an understanding of the pattern of passage (transmission) of genes from parent to offspring	145-151		
8.2 Alleles and genes interact to produce phenotypes	3.A.3 The chromosomal basis of inheritance provides an understanding of the pattern of passage (transmission) of genes from parent to offspring. 4.C.2: Environmental factors influence the expression of the genotype in an organism.	152-154		

8.3 Genes are carried on chromosomes	3.A.3 The chromosomal basis of inheritance provides an understanding of the pattern of passage (transmission) of genes from parent to offspring. 3.A.4 The inheritance pattern of many traits cannot be explained by simple Mendelian genetics.	155-160	• X-linked color blindness p. 160 • Sex-linked genes p. 158-159	
8.4 Prokaryotes can exchange genetic material	3.C.2 Biological systems have multiple processes that increase genetic variation. 3.C.3 Viral replication results in genetic variation, and viral infection can introduce genetic variation into the hosts.	161-162		
9. DNA and Its Role in Heredity				
9.1 DNA structure reflects its role as the genetic material	3.A.1: DNA, and in some cases RNA, is the primary source of heritable information. 3.C.3 Viral replication results in genetic variation, and viral infection can introduce genetic variation into the hosts. 4.A.1: The subcomponents of biological molecules and their sequence determine the properties of that molecule.	166-171		

9.2 DNA replicates semiconservatively	3.A.1: DNA, and in some cases RNA, is the primary source of heritable information. 3.C.2 Biological systems have multiple processes that increase genetic variation. 3.D.1 Cell communication processes share common features that reflect a shared evolutionary history.	172-178		
9.3 Mutations are heritable changes in DNA	3.A.1: DNA, and in some cases RNA, is the primary source of heritable information. 3.A.3 The chromosomal basis of inheritance provides an understanding of the pattern of passage (transmission) of genes from parent to offspring. 3.A.4 The inheritance pattern of many traits cannot be explained by simple Mendelian genetics. 3.C.1 Changes in genotype can result in changes in phenotype.	179-183	• Sickle cell anemia p. 181	
10. From DNA to Protein: Gene Expression				
10.1 Genetics shows that genes code for proteins	3.A.1: DNA, and in some cases RNA, is the primary source of heritable information.	188-189		
10.2 DNA expression begins with its transcription to RNA	3.A.1: DNA, and in some cases RNA, is the primary source of heritable information.	190-195	• Poly A tail p. 195 • Excision of introns p. 192-195	
10.3 The genetic code in RNA is translated into the amino acid sequences of proteins	3.A.1: DNA, and in some cases RNA, is the primary source of heritable information.	196-198		

10.4 Translation of the genetic code is mediated by tRNA and ribosomes	3.A.1: DNA, and in some cases RNA, is the primary source of heritable information.	199-203		
10.5 Proteins are modified after translation	3.A.1: DNA, and in some cases RNA, is the primary source of heritable information.	204-205		
11. Regulation of gene expression				
11.1 Several strategies are used to regulate gene expression	2.c.1 Organisms use negative feedback mechanisms to maintain their internal environments and respond to external environmental changes. 3.B.1 Gene regulation results in differential gene expression, leading to cell specialization.	209-211	• Promoter p. 210	
11.2 Many prokaryotic genes are regulated in operons	2.c.1 Organisms use negative feedback mechanisms to maintain their internal environments and respond to external environmental changes. 3.B.1 Gene regulation results in differential gene expression, leading to cell specialization. 4.C.2: Environmental factors influence the expression of the genotype in an organism.	212-215	• Operons in gene regulation p. 213-215	
11.3 Eukaryotic genes are regulated by transcription factors and DNA changes	3.B.1 Gene regulation results in differential gene expression, leading to cell specialization.	216-220	• Promoter p. 216-217 • Enhancer p. 216	
11.4 Eukaryotic gene expression can be regulated after transcription	3.B.1 Gene regulation results in differential gene expression, leading to cell specialization.	221-223		
12. Genomes				

12.1 There are powerful methods for sequencing genomes and analyzing gene products				227-230
12.2 Prokaryotic genomes are relatively small and compace				231-234
12.3 Eukaryotic genomes are large and complex	3.C.3 Viral replication results in genetic variation, and viral infection can introduce genetic variation into the hosts.	235-239	• Transposons p. 238-239	
12.4 The human genome sequence has many applications	3.A.3 The chromosomal basis of inheritance provides an understanding of the pattern of passage (transmission) of genes from parent to offspring	239-241		
13. Biotechnology				
13.1 Recombinant DNA can be made in the laboratory	3.A.1: DNA, and in some cases RNA, is the primary source of heritable information.	245-247	• Electrophoresis p. 246-247 • Plasmid-based transformation p. 249	
13.2 DNA can genetically transform cells and organisms	3.A.1: DNA, and in some cases RNA, is the primary source of heritable information.	248-251	• Transgenic animals p. 249-250	
13.3 Genes and gene expression can be manipulated	3.A.1: DNA, and in some cases RNA, is the primary source of heritable information.	252-254	• Polymerase chain reaction p. 252-253	
13.4 Biotechnology has wide applications	3.A.1: DNA, and in some cases RNA, is the primary source of heritable information.	255-260		
14. Genes, Development, and Evolution				
14.1 Development involves distinct but overlapping processes	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.	264-268	• Cloned animals p. 266-267	

14.2 Changes in gene expression underlie cell differentiation in development	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. 4.A.3: Interactions between external stimuli and regulated gene expression result in specialization of cells, tissues and organs.	269-272		
14.3 Spatial differences in gene expression lead to morphogenesis	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. 3.B.2 A variety of intercellular and intracellular signal transmissions mediate gene expression. 3.D.2 Cells communicate with each other through direct contact with other cells or from a distance via chemical signaling. 4.A.3: Interactions between external stimuli and regulated gene expression result in specialization of cells, tissues and organs.	273-277	• Morphogens stimulate development p. 275-277 • HOX genes and development p. 277	
14.4 Gene expression pathways underlie the evolution of development				278-280
14.5 Developmental genes contribute to species evolution but also pose constraints				281-286
15. Mechanisms of Evolution				

15.1 Evolution is both factual and the basis of broader theory	1.a.1 Natural selection is a major mechanism of evolution; 1.a.2 Natural selection acts on phenotypic variations in populations; 1.a.4 Biological evolution is supported by scientific evidence from many disciplines, including mathematics.; 1.c.3 Populations of organisms continue to evolve.	289-291		
15.2 Mutation, selection, gene flow, genetic drift, and nonrandom mating result in evolution	1.a.1 Natural selection is a major mechanism of evolution; 1.a.2 Natural selection acts on phenotypic variations in populations; 1.a.4 Biological evolution is supported by scientific evidence from many disciplines, including mathematics.; 1.c.3 Populations of organisms continue to evolve.	292-296	• Artificial selection p. 293-294	
15.3 DNA evolution can be measured by changes in allele frequencies	1.a.1 Natural selection is a major mechanism of evolution; 1.a.2 Natural selection acts on phenotypic variations in populations; 1.a.4 Biological evolution is supported by scientific evidence from many disciplines, including mathematics.; 1.c.3 Populations of organisms continue to evolve. 4.C.3: The level of variation in a population affects population dynamics.	297-300	• Graphical analysis of allele frequencies in a population p. 297-298 • Application of Hardy-Weinberg Equation p. 298-300	

15.4 Selection can be stabilizing, directional, or disruptive	1.a.1 Natural selection is a major mechanism of evolution; 1.a.2 Natural selection acts on phenotypic variations in populations; 1.a.4 Biological evolution is supported by scientific evidence from many disciplines, including mathematics.; 1.c.3 Populations of organisms continue to evolve. 4.C.3: The level of variation in a population affects population dynamics.	300-301	• Observed directional phenotypic change in a population p. 300	
15.5 Genomes reveal both neutral and selective processes of evolution	1.a.1 Natural selection is a major mechanism of evolution; 1.a.2 Natural selection acts on phenotypic variations in populations; 1.a.4 Biological evolution is supported by scientific evidence from many disciplines, including mathematics.; 1.c.3 Populations of organisms continue to evolve.	302-307	• Observed directional phenotypic change in a population p. 301-302 • A eukaryotic example that describes evolution of a structure or process p. 307	
15.6 Recombination, lateral gene transfer, and gene duplication can result in new features	1.a.1 Natural selection is a major mechanism of evolution; 1.a.2 Natural selection acts on phenotypic variations in populations; 1.a.4 Biological evolution is supported by scientific evidence from many disciplines, including mathematics.; 1.c.3 Populations of organisms continue to evolve.	308-309		
15.7 Evolutionary theory has practical applications				310-313

16. Reconstructing and Using Phylogenies				
16.1 All of life is connected through its evolutionary history	1.a.4 Biological evolution is supported by scientific evidence from many disciplines, including mathematics.; 1.b.1 Organisms share many conserved core processes and features that evolved and are widely distributed among organisms today.; 1.b.2 Phylogenetic trees and cladograms are graphical representations (models) of evolutionary history that can be tested.	316-317	• Analysis of phylogenetic trees p. 316-317	
16.2 Phylogeny can be reconstructed from traits or organisms	1.a.4 Biological evolution is supported by scientific evidence from many disciplines, including mathematics.; 1.b.1 Organisms share many conserved core processes and features that evolved and are widely distributed among organisms today.; 1.b.2 Phylogenetic trees and cladograms are graphical representations (models) of evolutionary history that can be tested.	318-323	• Analysis of phylogenetic trees p. 320-321 • Construction of phylogenetic trees based on sequence data p. 318-320	

16.3 Phylogeny makes biology comparative and predicitive	1.a.4 Biological evolution is supported by scientific evidence from many disciplines, including mathematics.; 1.b.1 Organisms share many conserved core processes and features that evolved and are widely distributed among organisms today.; 1.b.2 Phylogenetic trees and cladograms are graphical representations (models) of evolutionary history that can be tested.	324-327		
16.4 Phylogeny is the basis of biological classification	1.a.4 Biological evolution is supported by scientific evidence from many disciplines, including mathematics.; 1.b.1 Organisms share many conserved core processes and features that evolved and are widely distributed among organisms today.; 1.b.2 Phylogenetic trees and cladograms are graphical representations (models) of evolutionary history that can be tested.	328-329		
17. Speciation				
17.1 Species are reproductively isolated lineages on the tree of life	1.c.1 Speciation and extinction have occurred throughout the Earth’s history.	333-334		

17.2 Speciation is a natural consequence of population subdivision	1.c.1 Speciation and extinction have occurred throughout the Earth’s history.; 1.c.2 Speciation may occur when two populations become reproductively isolated from each other.	335-336		
17.3 Speciation may occur through geographic isolation or in sympatry	1.c.1 Speciation and extinction have occurred throughout the Earth’s history.; 1.c.2 Speciation may occur when two populations become reproductively isolated from each other.	337-339		
17.4 Reproductive isolation is reinforced when diverging species come into contact	1.c.1 Speciation and extinction have occurred throughout the Earth’s history.; 1.c.3 Populations of organisms continue to evolve.	340-344		
18. The History of Life on Earth				
18.1 Events in Earth's history can be dated	1.a.4 Biological evolution is supported by scientific evidence from many disciplines, including mathematics.; 1.c.1 Speciation and extinction have occurred throughout the Earth’s history.	348-349		
18.2 Changes in Earth's physical environmnet have affected the evolution of life	1.a.4 Biological evolution is supported by scientific evidence from many disciplines, including mathematics.; 1.c.1 Speciation and extinction have occurred throughout the Earth’s history.	350-355	• Five major extinctions p. 351, 353	

18.3 Major events in the evolution of life can be read in the fossil record	1.a.4 Biological evolution is supported by scientific evidence from many disciplines, including mathematics.; 1.c.1 Speciation and extinction have occurred throughout the Earth's history.	356-363	• Five major extinctions p. 358, 362, 363	
19. Bacteria, Archaea, and Viruses				
19.1 Life consists of three domains that share a common ancestor	1.b.1 Organisms share many conserved core processes and features that evolved and are widely distributed among organisms today.; 1.b.2 Phylogenetic trees and cladograms are graphical representations (models) of evolutionary history that can be tested.	367-370		
19.2 Prokaryote diversity reflects the ancient origins of life				371-377
19.3 Ecological communities depend on prokaryotes				378-382
19.4 Viruses have evolved many times				383-386
20. The Origin and Diversification of Eukaryotes				
20.1 Eukaryotes acquired features from both archaea and bacteria				389-391
20.2 Major lineages of eukaryotes diversified in the Precambrian	1.b.2 Phylogenetic trees and cladograms are graphical representations (models) of evolutionary history that can be tested.	392-394	• Cells of alveoli p. 392-394	394-400
20.3 Protists reproduce sexually and asexually				401
20.4 Protists are critical components of many ecosystems				402-405
21. The Evolution of Plants				
21.1 Primary endosymbiosis produced the first photosynthetic eukaryotes	1.b.2 Phylogenetic trees and cladograms are graphical representations (models) of evolutionary history that can be tested.	408-409		410
21.2 Key adaptations premitted plants to colonize land				411-414

21.3 Vascular tissues led to rapid diversification of land plants				415-419
21.4 Seeds protect plant embyos				420-425
21.5 Flowers and fruits increase the reproductive success of angiosperms				426-435
22. The Evolution and Diversity of Fungi				
22.1 Fungi live by absorptive heterotrophy				438
22.2 Fungi can be saprobic, parasitic, predatory, or mutualistic				439-443
22.3 Major groups of fungi differ in their life cycles	1.b.2 Phylogenetic trees and cladograms are graphical representations (models) of evolutionary history that can be tested.	444		445-451
22.4 Fungi can be sensitive indicators of environmental change				452-454
23. Animal Origins and Diversity				
23.1 Distinct body plans evolved among the animals	1.b.2 Phylogenetic trees and cladograms are graphical representations (models) of evolutionary history that can be tested.	457	• Absence of legs in some sea mammals p. 461	458-460
23.2 Some animal groups fall outsiede the bilateria				461-464
23.3 There are two major groups of protostomes				465-475
23.4 Arthropods are diverse and abundant animals				476-482
23.5 Deuterostomes include echinoderms, hemichordates, and chordates				483-489
23.6 Life on land contributed to vertebrate diversification	1.b.2 Phylogenetic trees and cladograms are graphical representations (models) of evolutionary history that can be tested.	493	• Absence of legs in some sea mammals p. 490	490-492, 494-498
23.7 Humans evolved among the primates				499-502
24. Plant Form and Function				
24.1 The plant body is organized and constructed in a distinctive way	4.A.4: Organisms exhibit complex properties due to interactions between their constituent parts.	507-510		

24.2 Meristems build roots, stems, and leaves	4.A.4: Organisms exhibit complex properties due to interactions between their constituent parts.	511-517	• Plant vascular and leaf p. 515-516 • Root, stem and leaf p. 512-517	
24.3 Domestication has altered plant form	4.A.4: Organisms exhibit complex properties due to interactions between their constituent parts.	518-521		
25. Plant Nutrition and Transport				
25.1 Plants acquire mineral nutrients from the soil	2.a.3 Organisms must exchange matter with the environment to grow, reproduce, and maintain organization.	522-524		
25.2 Soil organisms contribute to plant nutrition	2.a.3 Organisms must exchange matter with the environment to grow, reproduce, and maintain organization.		• Root hairs p. 526-527	525-528
25.3 Water and solutes are transported in the xylem by transpiration-cohesion-tension				529-534
25.4 Solutes are transported in the phloem by pressure flow				535-537
26. Plant Growth and Development				
26.1 Plants develop in response to the environment	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. 3.B.2 A variety of intercellular and intracellular signal transmissions mediate gene expression.	540-541		

26.2 Gibberellins and auxin have diverse effects but a similar mechanism of action	2.e.2 Timing and coordination of physiological events are regulated by multiple mechanisms. 3.B.2 A variety of intercellular and intracellular signal transmissions mediate gene expression.	542-548	• Ethylene and fruit ripening p. 542-543 • Seed germination and gibberellin p. 542-544, 547-548	
26.3 Other plant hormones have diverse effects on plant development	3.B.2 A variety of intercellular and intracellular signal transmissions mediate gene expression.	548-550	• Ethylene and fruit ripening p. 549	
26.4 Photoreceptors initiate developmental responses to light				551-554
27. Reproduction of Flowering Plants				
27.1 Most angiosperms reproduce sexually				557-561
27.2 Hormones and signaling determine the transition from the vegetative to the reproductive state	2.c.2 Organisms respond to changes in their external environments. 2.e.2 Timing and coordination of physiological events are regulated by multiple mechanisms.	562-567	• Photoperiodism in plants p. 563-566	
27.3 Angiosperms can reproduce asexually				568-570
28. Plantes in the Environment				
28.1 Plants have constitutive and induced responses to pathogens	2.d.4 Plants and animals have a variety of chemical defenses against infections that affect dynamic homeostasis. 3.D.2 Cells communicate with each other through direct contact with other cells or from a distance via chemical signaling. 4.C.3: The level of variation in a population affects population dynamics.	573-575	• Plant defenses against pathogens p. 573-575 • Plant immune response p. 573-575	
28.2 Plants have mechanical and chemical defenses against herbivores	3.E.1**.** Individuals can act on information and communicate it to others.	576-579		

28.3 Plants adapt to environmental stresses	2.c.1 Organisms use negative feedback mechanisms to maintain their internal environments and respond to external environmental changes. 2.d.3 Biological systems are affected by disruptions to their dynamic homeostasis. 4.C.3: The level of variation in a population affects population dynamics.	580-586	• Plant responses to toxins, water stress and salinity p, 580-584 • Water limitation p. 582 • Wheat rust p. 585-586	
29. Physiology, Homeostasis, and Temberature Regulation				
29.1 Multicellular animals require a stable internal environment	2.b.2 Growth and dynamic homeostasis are maintained by the constant movement of molecules across membranes. 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. 4.B.2: Cooperative interactions within organisms promote efficiency in the use of energy and matter.	589-590	• Temperature regulation in animals p. 589-590	
29.2 Physiological regulation achieves homeostasis of the internal environment	2.c.1 Organisms use negative feedback mechanisms to maintain their internal environments and respond to external environmental changes.	591-592		

29.3 Living systems are temperature-sensitive	2.c.2 Organisms respond to changes in their external environments. 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	592-593		
29.4 Animals control body temperature by altering rates of heat gain and loss	2.a.3 Organisms must exchange matter with the environment to grow, reproduce, and maintain organization. 2.d.2 Homeostatic mechanisms reflect both common ancestry and divergence due to adaptation in different environments.	594-598	• Ectothermy p. 594, 598 • Endothermy 593-598 • Behavioral thermoregulation p. 598 • Shivering and sweating in humans p. 595 • Thermoregulation in animals (countercurrent) p. 598	
29.5 A thermostat in the brain regulates mammalian body temperature	2.c.2 Organisms respond to changes in their exterr		• Hibernation and migration in animals p. 600, 601	599
30. Animal Hormones				
30.1 Hormones are chemical messengers	3.D.2 Cells communicate with each other through direct contact with other cells or from a distance via chemical signaling.	604-606		
30.2 Hormones act by binding to receptors	3.E.1**.** Individuals can act on information and communicate it to others.	607-608	• Fight or flight response p. 607-608	
30.3 The pituitary gland links the nervous and endocrine systems	2.c.1 Organisms use negative feedback mechanisms to maintain their internal environments and respond to external environmental changes.	609-612		

30.4 Hormones regulate mammalian physiological systems	2.e.2 Timing and coordination of physiological events are regulated by multiple mechanisms. 3.A.4 The inheritance pattern of many traits cannot be explained by simple Mendelian genetics. 3.B.2 A variety of intercellular and intracellular signal transmissions mediate gene expression.	613-617		
31. Immunology: Animal Defense Systems				
31.1 Animals use innate and adaptive mechanisms to defend themselves against pathogens	2.d.3 Biological systems are affected by disruptions to their dynamic homeostasis. 2.d.4 Plants and animals have a variety of chemical defenses against infections that affect dynamic homeostasis.	621	• Immune response p. 621 • Animal nonspecific defenses and specific defenses p. 621	
31.2 Innate defenses are nonspecific	2.d.3 Biological systems are affected by disruptions to their dynamic homeostasis. 2.d.4 Plants and animals have a variety of chemical defenses against infections that affect dynamic homeostasis.	622-624	• Immune response p. 622-624 • Animal nonspecific defenses and specific defenses p. 622-624	
31.3 The adaptive immune response is specific	2.d.3 Biological systems are affected by disruptions to their dynamic homeostasis. 2.d.4 Plants and animals have a variety of chemical defenses against infections that affect dynamic homeostasis.	625-628	• Immune response p. 625-628 • Animal nonspecific defenses and specific defenses p. 625-628	

31.4 The adaptive humoral immune response involves specific antibodies	2.d.3 Biological systems are affected by disruptions to their dynamic homeostasis. 3.D.2 Cells communicate with each other through direct contact with other cells or from a distance via chemical signaling. 4.C.1: Variation in molecular units provides cells with a wider range of functions.B32	629-632	• Immune response p. 629-632	
31.5 The adaptive cellular immune response involves T cells and their receptors	2.d.3 Biological systems are affected by disruptions to their dynamic homeostasis. 2.d.4 Plants and animals have a variety of chemical defenses against infections that affect dynamic homeostasis. 3.D.2 Cells communicate with each other through direct contact with other cells or from a distance via chemical signaling.	633-635	• Immune response p. 633-635 • Mammalian cellular and humoral immunity, antibodies p. 633-635	
32. Animal Reproduction				
32.1 Reproduction can be sexual or asexual	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. 3.D.4. Changes in signal transduction pathways can alter cellular response.	639		

32.2 Gametogenesis produces haploid gametes	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. 3.D.4. Changes in signal transduction pathways can alter cellular response.	640-641		
32.3 Fertilization is the union of sperm and ovum	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.	642-644		
32.4 Human reproduction is hormonally controlled	2.c.1 Organisms use negative feedback mechanisms to maintain their internal environments and respond to external environmental changes. 2.e.2 Timing and coordination of physiological events are regulated by multiple mechanisms.	645-650		
32.5 Humans use a variety of methods to control fertility				651-653
33. Animal Development				
33.1 Fertilization activates development	4.A.3: Interactions between external stimuli and regulated gene expression result in specialization of cells, tissues and organs.	656		
33.2 Cleavage repackages the cytoplasm of the zygote				657-659
33.3 Gastrulation creates three tissue layers	3.B.2 A variety of intercellular and intracellular signal transmissions mediate gene expression.	660-664		
33.4 Neurulation creates the nervous system				665-667

33.5 Extraembryonic membranes nourish the growing embryo				668-670
34. Neurons and Nervous Systems				
34.1 Nervous systems consist of neurons and glia	3.E.2. Animals have nervous systems that detect external and internal signals, transmit and integrate information, and produce responses.	673-674		
34.2 Neurons generate and transmit electical signals	2.b.1 Cell membranes are selectively permeable due to their structure. 3.E.2. Animals have nervous systems that detect external and internal signals, transmit and integrate information, and produce responses.	675-680		
34.3 Neurons communicate with other cells at synapses	3.D.2 Cells communicate with each other through direct contact with other cells or from a distance via chemical signaling. 3.E.2. Animals have nervous systems that detect external and internal signals, transmit and integrate information, and produce responses.	681-684	• Neurotransmitters p. 682-684 • Acetylcholine p. 681-682 • Serotonin p. 683 • GABA p. 682	
34.4 The vertebrate nervous system has many interacting components	3.E.2. Animals have nervous systems that detect external and internal signals, transmit and integrate information, and produce responses. 4.B.2: Cooperative interactions within organisms promote efficiency in the use of energy and matter.	684-689	• Forebrain, midbrain and hindbrain p. 687-688 • Right and left cerebral hemispheres p. 688-689	

34.5 Specific brain areas underlie the complex abilities of humans	2.e.2 Timing and coordination of physiological events are regulated by multiple mechanisms.	690-692		
35. Sensors				
35.1 Sensory systems convert stimuli into action potentials	2.c.2 Organisms respond to changes in their external environments. 3.E.2. Animals have nervous systems that detect external and internal signals, transmit and integrate information, and produce responses.	696-697		
35.2 Chemoreceptors detect specific molecules or ions	2.c.2 Organisms respond to changes in their external environments. 2.e.2 Timing and coordination of physiological events are regulated by multiple mechanisms. 3.E.2. Animals have nervous systems that detect external and internal signals, transmit and integrate information, and produce responses.	697-699	• Release and reaction to pheromones p. 698	
35.3 Mechanoreceptors detect physical forces	2.c.2 Organisms respond to changes in their external environments. 3.E.2. Animals have nervous systems that detect external and internal signals, transmit and integrate information, and produce responses.	700-704		

35.4 Photoreceptors detect light	2.c.2 Organisms respond to changes in their external environments. 3.E.2. Animals have nervous systems that detect external and internal signals, transmit and integrate information, and produce responses.	705-709		
36. Musculoskeletal Systems				
36.1 Cycles of protein-protein interactions cause muscles to contract	3.E.2. Animals have nervous systems that detect external and internal signals, transmit and integrate information, and produce responses. 4.A.4: Organisms exhibit complex properties due to interactions between their constituent parts.	713-719	• Acetylcholine p. 718-719	
36.2 The characteristics of muscle cells determine muscle performance	3.E.2. Animals have nervous systems that detect external and internal signals, transmit and integrate information, and produce responses. 4.B.2: Cooperative interactions within organisms promote efficiency in the use of energy and matter.	720-722		
36.3 Muscles pull on skeletal elements to generate force and cause movement	3.E.2. Animals have nervous systems that detect external and internal signals, transmit and integrate information, and produce responses. 4.A.4: Organisms exhibit complex properties due to interactions between their constituent parts.	723-725		
37. Gas exchnage in animals				
37.1 Fick's Law of Diffusion governs respiratory gas exchange				730-731

37.2 Respiratory systems have evolved to maximize partial pressure gradients	2.a.3 Organisms must exchange matter with the environment to grow, reproduce, and maintain organization. 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. 2.d.2 Homeostatic mechanisms reflect both common ancestry and divergence due to adaptation in different environments. 4.B.2: Cooperative interactions within organisms promote efficiency in the use of energy and matter.	732-737	• Cells of alveoli p. 736-737 • Respiratory systems of aquatic and terrestrial animals p. 732-735	
37.3 The mammalian lung is ventilated by pressure changes				737-738
37.4 Respiration is under negative feedback control by the nervous system	2.c.1 Organisms use negative feedback mechanisms to maintain their internal environments and respond to external environmental changes.	739-740		
37.5 Respiratory gasses are transported in the blood				741-744
38. Circulatory Systems				
38.1 Circulatory systems can be open or closed	2.d.3 Biological systems are affected by disruptions to their dynamic homeostasis.	747		747

38.2 Circulatory systems may have separate pulmonary and systemic circuits	1.b.1 Organisms share many conserved core processes and features that evolved and are widely distributed among organisms today. 2.d.2 Homeostatic mechanisms reflect both common ancestry and divergence due to adaptation in different environments. 2.d.3 Biological systems are affected by disruptions to their dynamic homeostasis.	748-749	• Circulatory systems in animals p. 748-749	
38.3 A beating heart propels the blood	2.d.3 Biological systems are affected by disruptions to their dynamic homeostasis. 2.e.2 Timing and coordination of physiological events are regulated by multiple mechanisms.	750-754		
38.4 Blood consists of cells suspended in plasma	2.d.3 Biological systems are affected by disruptions to their dynamic homeostasis.	755-756		
38.5 Blood circulates through arteries, capillaries, and veins	2.a.3 Organisms must exchange matter with the environment to grow, reproduce, and maintain organization. 2.d.3 Biological systems are affected by disruptions to their dynamic homeostasis.	757-760		
38.6 Circulation is regulated by autoregulation, nerves, and hormones	2.c.1 Organisms use negative feedback mechanisms to maintain their internal environments and respond to external environmental changes. 2.d.3 Biological systems are affected by disruptions to their dynamic homeostasis.	761-762		

39. Nutrition, Digestion, and Absorption				
39.1 Food provides energy and nutrients	2.a.1 All living systems require constant input of free energy. 2.a.2 Organisms capture and store free energy for use in biological processes. 2.a.3 Organisms must exchange matter with the environment to grow, reproduce, and maintain organization. 2.d.3 Biological systems are affected by disruptions to their dynamic homeostasis. 4.C.2: Environmental factors influence the expression of the genotype in an organism.	766-769		
39.2 Digestive systems bread down macromolecules	2.d.2 Homeostatic mechanisms reflect both common ancestry and divergence due to adaptation in different environments. 2.d.3 Biological systems are affected by disruptions to their dynamic homeostasis.	770-772	• Cells of villi p. 771 • Microvilli p. 771 • Digestive mechanisms in animals 770-772	
39.3 The vertebrate digestive system is a tubular gut with accessory glands	2.a.3 Organisms must exchange matter with the environment to grow, reproduce, and maintain organization. 2.d.3 Biological systems are affected by disruptions to their dynamic homeostasis. 4.A.4: Organisms exhibit complex properties due to interactions between their constituent parts.	773-777	• Stomach and small intestines p. 773-777	

39.4 Food intake and metabolism are regulated	2.c.1 Organisms use negative feedback mechanisms to maintain their internal environments and respond to external environmental changes. 2.d.3 Biological systems are affected by disruptions to their dynamic homeostasis. 4.B.2: Cooperative interactions within organisms promote efficiency in the use of energy and matter.	778-780	• Diabetes mellitus p. 780 • Digestion of food p. 778-780	
40. Salt and Water Balance and Nitrogen Excertion				
40.1 Excretory systems maintain homeostasis of the extracellular fluid				785-786
40.2 Excretory systems eliminate nitrogenous wastes	2.d.2 Homeostatic mechanisms reflect both common ancestry and divergence due to adaptation in different environments.	787	• Excretory systems in animals 787	
40.3 Excretory systems produce urine by filtration, reabsorption, and secretion	2.b.1 Cell membranes are selectively permeable due to their structure.	788-790		
40.4 The mammalian kidney produces concentrated urine				791-794
40.5 The kidney is regulated to maintain blood pressure, blood volume, and blood composition	2.b.1 Cell membranes are selectively permeable due to their structure.	795-796		
41. Animal Behavior				
41.1 Behavior has proximate and ultimate causes	3.E.1**.** Individuals can act on information and communicate it to others.	800-801		

41.2 Behaviors can have genetic determinants	3.A.3 The chromosomal basis of inheritance provides an understanding of the pattern of passage (transmission) of genes from parent to offspring. 3.E.1. Individuals can act on information and communicate it to others.	801-803	• Courtship and mating behaviors p. 802	
41.3 Developmental processes shape behavior	2.e.2 Timing and coordination of physiological events are regulated by multiple mechanisms. 3.E.1. Individuals can act on information and communicate it to others.	804-805	• Parent-offspring interactions p. 805 • Bird songs p. 805	
41.4 Physiological mechanisms underlie behavior	2.c.2 Organisms respond to changes in their external environments. 2.E.3: Timing and coordination of behavior are regulated by various mechanisms and are important in natural selection. 3.D.2 Cells communicate with each other through direct contact with other cells or from a distance via chemical signaling. 3.E.1. Individuals can act on information and communicate it to others.	806-811	• Circadian rhythms p. 806-808 • Courtship and mating behaviors p. 811	
41.5 Individual behavior is shaped by natural selection	3.E.1. Individuals can act on information and communicate it to others.		• Territorial marking p. 812-813	
41.6 Social Behavior and social systems are shaped by natrual selection	3.E.1. Individuals can act on information and communicate it to others.	814-817		
42. Organisms in Their Environment				

42.1 Ecological systems vary in space and over time	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. 4.B.2: Cooperative interactions within organisms promote efficiency in the use of energy and matter. 4.B.4: Distribution of local and global ecosystems changes over time.	823-824		
42.2 Climate and topography shape Earth's physical environments	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. 4.B.4: Distribution of local and global ecosystems changes over time.	825-829		
42.3 Physical geography provides the template for biogeography	2.c.2 Organisms respond to changes in their external environments. 4.B.4: Distribution of local and global ecosystems changes over time.	830-833		

42.4 Geological history has shaped the distributions of organisms	1.b.2 Phylogenetic trees and cladograms are graphical representations (models) of evolutionary history that can be tested. ; 1.c.2 Speciation may occur when two populations become reproductively isolated from each other. 4.B.4: Distribution of local and global ecosystems changes over time.	834-837	• Continental drift p. 832, 835, 837	
42.5 Human activities affect ecological systems on a global scale	4.B.4: Distribution of local and global ecosystems changes over time. 4.C.4: The diversity of species within an ecosystem may influence the stability of the ecosystem.	838-839	• Impacts of human land use p. 838-839	
42.6 Ecological investigation depends on natural history knowledge and modeling				839-840
43. Populations				
43.1 Populations are patchy in space and dynamic over time	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. 4.A.5: Communities are composed of populations of organisms that interact in complex ways. 4.B.3: Interactions between and within populations influence patterns of species distribution and abundance.	843		

43.2 Births increase and deaths decrease population size	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. 4.A.5: Communities are composed of populations of organisms that interact in complex ways. 4.A.6: Interactions among living systems and with their environment result in the movement of matter and energy.	844		
43.3 Life histories determine population growth rates	2.a.1 All living systems require constant input of free energy. 2.a.3 Organisms must exchange matter with the environment to grow, reproduce, and maintain organization. 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. 4.A.5: Communities are composed of populations of organisms that interact in complex ways.	845-849	• Life history strategy p. 845-849	

43.4 Populations grow multiplicatively, but not for long	1.a.1 Natural selection is a major mechanism of evolution. 2.d.3 Biological systems are affected by disruptions to their dynamic homeostasis. 4.A.5: Communities are composed of populations of organisms that interact in complex ways. 4.B.3: Interactions between and within populations influence patterns of species distribution and abundance.	850-853		
43.5 Extinction and recolonization affect population dynamics	1.c.1 Speciation and extinction have occurred throughout the Earth's history. 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. 4.B.3: Interactions between and within populations influence patterns of species distribution and abundance.	854	• Loss of keystone species p. 854	
43.6 Ecology provides tools for managing populations	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	855-856		
44. Ecological and Evolutionary Consequences of Species Interactions				

44.1 Interactions between species may be positive, negative, or neutral	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. 4.A.5: Communities are composed of populations of organisms that interact in complex ways. 4.B.3: Interactions between and within populations influence patterns of species distribution and abundance.	860-861	• Predator-prey relationships p. 860-861	
44.2 Interspecific interactions affect population dynamics and species distributions	1.c.1 Speciation and extinction have occurred throughout the Earth's history. 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. 4.A.5: Communities are composed of populations of organisms that interact in complex ways. 4.B.3: Interactions between and within populations influence patterns of species distribution and abundance.	862-864		

44.3 Interactions affect individual fitness and can result in evolution	1.a.2 Natural selection acts on phenotypic variations in populations; 1.c.3 Populations of organisms continue to evolve. 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. 4.A.5: Communities are composed of populations of organisms that interact in complex ways. 4.B.3: Interactions between and within populations influence patterns of species distribution and abundance.	865-868	• Predator-prey relationships p. 865	
44.4 Introduced species alter interspecific interactions	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. 2.d.3 Biological systems are affected by disruptions to their dynamic homeostasis. 4.A.5: Communities are composed of populations of organisms that interact in complex ways. 4.B.3: Interactions between and within populations influence patterns of species distribution and abundance.	869-870	• Invasive species p. 869 • Introduction of species p. 869-870 • Effects of introduced species p. 869-870	
45. Ecological Communities				

45.1 Communities contain species that colonize and persist	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. 4.A.5: Communities are composed of populations of organisms that interact in complex ways. 4.B.3: Interactions between and within populations influence patterns of species distribution and abundance.	874		
45.2 Communities change over space and time	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. 4.A.5: Communities are composed of populations of organisms that interact in complex ways. 4.B.3: Interactions between and within populations influence patterns of species distribution and abundance. 4.B.4: Distribution of local and global ecosystems changes over time.	875-876		

45.3 Trophic interactions determine how energy and materials move through communities	2.a.1 All living systems require constant input of free energy. 2.a.2 Organisms capture and store free energy for use in biological processes. 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. 4.A.5: Communities are composed of populations of organisms that interact in complex ways. 4.A.6: Interactions among living systems and with their environment result in the movement of matter and energy. 4.B.3: Interactions between and within populations influence patterns of species distribution and abundance.	877-880	• Change in primary production affects higher trophic levels p. 878 • Change in each trophic level affects higher trophic levels p. 878 • Food chains and food webs p. 878-879	

45.4 Species diversity affects community function	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. 4.A.5: Communities are composed of populations of organisms that interact in complex ways. 4.B.3: Interactions between and within populations influence patterns of species distribution and abundance. 4.C.4: The diversity of species within an ecosystem may influence the stability of the ecosystem.	881		
45.5 Diversity patterns provide clues to determinants of diversity	2.d.1 All biological systems from cells and organisms to populations, communities, and ecosystems are affected by complex biotic and abiotic interactions involving exchange of matter and free energy. 2.d.3 Biological systems are affected by disruptions to their dynamic homeostasis. 4.A.5: Communities are composed of populations of organisms that interact in complex ways. 4.B.3: Interactions between and within populations influence patterns of species distribution and abundance.	882-884		

45.6 Community ecology suggests strategies for conserving community function	1.c.1 Speciation and extinction have occurred throughout the Earth's history. 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. 4.A.5: Communities are composed of populations of organisms that interact in complex ways. 4.B.3: Interactions between and within populations influence patterns of species distribution and abundance.	885-888	• Human impact on ecosystems and species extinction rates p. 888 • Food chains and food webs p. 888	
46. The Global Ecosystem				
46.1 Climate and nutrients affect ecosystem function				893-895
46.2 Biological, geological, and chemical processes move materials through ecosystems	2.a.2 Organisms capture and store free energy for use in biological processes. 2.a.3 Organisms must exchange matter with the environment to grow, reproduce, and maintain organization. 4.A.6: Interactions among living systems and with their environment result in the movement of matter and energy.	893-895		
46.3 Certain biogeochemical cycles are especially critical for ecosystems	2.a.3 Organisms must exchange matter with the environment to grow, reproduce, and maintain organization.	896		
46.4 Biogeochemical cycles affect global climate	4.B.4: Distribution of local and g	902-903	• Impacts of climate change p. 902-903	

46.5 Rapid climate change affects species and communities	4.B.4: Distribution of local and global ecosystems changes over time. 4.C.4: The diversity of species within an ecosystem may influence the stability of the ecosystem.	904-906	• Global climate change models p. 904-906 • Volcanic eruption p. 905 • Impacts of climate change 904-905	
46.6 Ecological challenges can be addressed through science and international cooperation				907-908