***Big Idea 1: The process of evolution drives the diversity and unity of life.***

**Enduring understanding 1.A: Change in the genetic make-up of a population over time is evolution.**

22.2: “Descent with modifications by natural selection explains the adaptation of organisms and the unity and diversity of life,” pp. 455 -- 460

22.3: “Evolution is supported by an overwhelming amount of scientific evidence,” pp. 460 -- 467

23.1: “Genetic variation makes evolution possible,” pp. 469 -- 471

23.2: “The Hardy-Weinberg equation can be used to test whether a population is evolving,” pp. 473 -- 476

23.3: “Natural selection, genetic drift, and gene flow can alter allele frequencies in a population,” pp. 476 -- 480

23.4: “Natural selection is the only mechanism that consistently causes adaptive evolution,” pp. 480 -- 485

**Enduring understanding 1.B: Organisms are linked by lines of descent from common ancestry.**

25.1: “Conditions on early Earth made the origin of life possible,” pp. 507 -- 510

25.3: “Key events in life’s history include the origins of single-celled and multicelled organisms and the colonization of land,” pp. 514 -- 519

26.1: “Phylogenies show evolutionary relationships,” pp. 537 -- 540

26.2: “Phylogenies are inferred from morphological and molecular data,” pp. 540 -- 542

26.3: “Shared characters are used to construct phylogenetic trees,” pp. 542 -- 548

**Enduring understanding 1.C: Life continues to evolve within a changing environment.**

24.1: “The biological species concept emphasizes reproductive isolation,” pp. 488 -- 492

24.2: “Speciation can take place with or without geographic separation,” pp. 493 -- 498

24.3: “Hybrid zones reveal factors that cause reproductive isolation,” pp. 498 -- 501

24.4: “Speciation can occur rapidly or slowly and can result from changes in few or many genes,” pp. 501 -- 504

25.2: “The fossil record documents the history of life,” pp. 510 -- 514

25.4: “The rise and fall of groups of organisms reflect differences in speciation and extinction rate,” pp. 519 -- 524

**Enduring understanding 1.D: The origin of living systems is explained by natural resources.**

4.1: “Organic chemistry in the study of carbon compounds,” pp. 58 -- 59

26.6: “New information continues to revise our understanding of the tree of life,” pp. 551 -- 553

***Big Idea 2: Biological systems utilize free energy and molecular building blocks to grow, to reproduce,
and to maintain dynamic homeostasis.***

**Enduring understanding 2.A: Growth, reproduction and maintenance of the organization of living systems require free energy and matter.**

3.1 “Polar covalent bonds in water molecules result in hydrogen bonding,” pp. 46 -- 47

3.2 “Four emergent properties of water contribute to Earth’s suitability for life,” pp. 47 -- 52

3.3 “Acidic and basic conditions affect living organisms,” pp. 52 -- 56

4.1 “Organic chemistry is the study of carbon compounds,” pp. 58 --59

4.2 “Carbon atoms can form diverse molecules by bonding to four other atoms,” pp. 60 -- 63

6.2 “Eukaryotic cells have internal membranes that compartmentalize their functions,” pp. 98 -- 102

8.1 “An organism’s metabolism transforms matter and energy, of thermodynamics,” pp. 142 -- 145

8.2 “The free-energy change of a reaction tells us whether or not the reaction occurs spontaneously,” pp. 146 -- 149

8.3 “ATP powers cellular work by coupling exergonic reactions to endergonic reactions,” pp. 149 -- 151

9.1 “Catabolic pathways yield energy by oxidizing organic fuels,” pp. 164 -- 168

9.2 “Glycolysis harvests chemical energy by oxidizing glucose by pyruvate,” pp. 168 -- 169

9.3 “After pyruvate is oxidized, the citric acid cycle completes the energy-yielding oxidation of organic molecules,” pp. 170 -- 172

9.4 “During oxidative phosphorylation, chemiosmosis couples electron transport to ATP synthesis,” pp. 172 -- 177

9.5 “Fermentation and anaerobic respiration enable cells to produce ATP without the use of oxygen,” pp. 177 -- 179

10.1 “Photosynthesis converts light energy to the chemical energy of food,” pp. 186 -- 189

10.2 “The light reactions converts solar energy to the chemical energy of ATP and NADPH,” pp. 189 -- 197

10.3 “The Calvin cycle uses the chemical energy of ATP and NADPH to reduce CO2 to sugar,” pp. 198 -- 199

40.1 “Animal form and function is correlated at all levels of organization,” pp. 852 -- 860

40.2 “Feedback control maintains the internal environment in many animals,” pp. 860 -- 862

40.3 “Homeostatic processes for thermoregulation involve form, function, and behavior,” pp. 862 -- 868

51.3 “Selection for individual survival and reproductive success can explain most behaviors,” pp. 1128 -- 1134

53.3 “The logistic model describes how a population grows more slowly as it nears its carrying capacity,” pp. 1177 -- 1179

53.4 “Life history traits are products of natural selection,” pp. 1179 -- 1181

55.1 “Physical laws govern energy flow and chemical cycling in ecosystems,” pp. 1219 -- 1220

55.2 “Energy and other limiting factors control primary production in ecosystems,” pp. 1220 -- 1225

55.3 “Energy transfer between trophic levels is typically only 10% efficient,” pp. 1225 -- 1226

55.4 “Biological and geochemical processes cycle nutrients and water in ecosystems,” pp. 1227 -- 1232

**Enduring understanding 2.B: Growth, reproduction and dynamic homeostasis require that cells create and maintain internal environments that are different from their external environments.**

6.3 “The eukaryotic cell’s genetic instructions are housed in the nucleus and carried out by the ribosomes,” pp. 102 -- 104

6.4 “The endomembrane system regulates protein traffic and performs metabolic functions in the cell,” pp. 104 -- 109

6.5 “Mitochondria and chloroplasts change energy from one form to another,” pp. 109 -- 112

7.1 “Cellular membranes are fluid mosaics of lipids and proteins,” pp. 125 -- 131

7.2 “Membranes structure results in selective permeability,” pp. 131 -- 132

7.3 “Passive transport in diffusion of a substance across a membrane with no energy investment,” pp. 132 -- 135

7.4 “Active transport uses energy to move solutes against gradients,” pp. 135 -- 138

7.5 “Bulk transport across the plasma membrane occurs by exocytosis and endocytosis,” p. 138

**Enduring understanding 2.C: Organisms use feedback mechanisms to regulate growth and reproduction, and to maintain dynamic homeostasis.**

45.2 “Feedback regulation and antagonistic hormone pairs are common in endocrine systems,” pp. 981 -- 984

**Enduring understanding 2.D: Growth and dynamic homeostasis of a biological system are influenced by changes in the system’s environment.**

39.5 “Plants respond to attacks by herbivores and pathogens,” pp. 845 -- 847

40.4 “Energy requirements are related to animal size, activity, and environment,” pp. 868 -- 872

43.1 “In innate immunity, recognition and response rely on traits common to groups of pathogens,” pp. 930 -- 935

43.2 “In adaptive immunity, receptors provide pathogen-specific recognition,” pp. 935 -- 940

43.3 “Adaptive immunity defends against infection of body fluids and body cells,” pp. 940 -- 946

43.4 “Disruptions in immune system function can elicit or exacerbate disease,” pp. 946 -- 950

52.2 “The structure and distribution of terrestrial biomes are controlled by climate and disturbance,” pp. 1150 -- 1152

53.1 “Dynamic biological processes influence population density, dispersion, and demographics,” pp. 1170 -- 1175

53.2 “The exponential model describes population growth in an idealized, unlimited environment,” pp. 1175 -- 1177

53.5 “Many factors that regulate population growth are density dependent,” pp. 1182 -- 1187

54.1 “Community interactions are classified by whether they help, harm, or have no effect on the species involved,” pp. 1194 -- 1200

54.2 “Diversity and trophic structure characterize biological communities,” 1200 -- 1206

54.3 “Disturbance influences species diversity and composition,” pp. 1207 -- 1210

54.4 “Biogeographic factors affect community diversity,” pp. 1211 -- 1213

54.5 “Pathogens alter community structure locally and globally,” pp. 1213 -- 1215

56.1 “Human activities threaten Earth’s biodiversity,” pp. 1239 -- 1244

**Enduring understanding 2.E: Many biological processes involved in growth, reproduction and dynamic homeostasis include temporal regulation and coordination.**

11.1 “External signals are converted to responses within the cell,” pp. 206 -- 210

17.6 “While gene expression differs among the domains of life, the concept of a gene is universal,” pp. 346 -- 347

18.2 “Eukaryotic gene expression is regulated at many stages,” pp. 356 -- 364

18.3 “Noncoding RNAs play multiple roles in controlling gene expression,” pp. 364 -- 366

18.4 “A program of differential gene expression leads to the different cell types in a multicellular organism,” pp. 366 -- 373

24.1 “The biological species concept emphasizes reproductive isolation,” pp. 488 -- 492

25.5 “Major changes in body form can result from changes in the sequences and regulation of developmental genes,” pp. 525 -- 529

38.1 “Flowers, double fertilization, and fruits are unique features of the angiosperm life cycle,” pp. 801 -- 811

39.1 “Signal transduction pathways link signal reception to response,” pp. 821 -- 824

39.2 “Plant hormones help coordinate growth, development, and responses to stimuli,” pp. 824 -- 835

39.3 “Responses to light are critical for plant success,” pp. 835 -- 841

47.3 “Cytoplasmic determinants and inductive signals contribute to cell fate specification,” pp. 1035 -- 1042

51.1 “Discrete sensory inputs can stimulate both simple and complex behaviors,” pp.

51.2 “Learning establishes specific links between experience and behavior,” pp. 1123 -- 1128

***Big Idea 3: Living systems store, retrieve, transmit, and respond to information essential to life proceses.***

**Enduring understanding 3.A: Heritable information provides for continuity of life.**

5.5 “Nucleic acids store, transmit, and help express hereditary information,” pp. 86 -- 89

12.1 “Most cell division results in genetically identical daughter cells,” pp. 229 -- 230

12.2 “The mitotic phase alternates with interphase in the cell cycle,” pp. 230 -- 238

12.3 “The eukaryotic cell cycle is regulated by a molecular control system,” pp. 238 -- 243

13.1 “Offspring acquire genes from parents by inheriting chromosomes,” pp. 248 -- 249

13.2 “Fertilization and meiosis alternate in sexual life cycle,” pp. 250 -- 253

13.3 “Meiosis reduces the number of chromosome sets from diploid to haploid,” pp. 253 - 257

14.1 “Mendel used the scientific approach to identify two laws of inheritance,” pp. 262 -- 269

14.2 “The laws of probability govern Mendelian inheritance,” pp. 269 -- 271

14.3 “Inheritance patterns are often more complex than predicted by simple Mendelian genetics,” pp. 271 -- 275

14.4 “Many human traits follow Mendelian patterns of inheritance,” pp. 275 -- 281

15.1 “Mendelian inheritance has its physical basis in the behavior or chromosomes,” pp. 286 -- 289

15.2 “Sex-linked genes exhibit unique patterns of inheritance,” pp. 289 -- 292

15.3 “Linked genes tend to be inherited together because they are located near each other on the same chromosome,” pp. 292 -- 297

15.5 “Some inheritance patterns are exceptions to standard Mendelian inheritance,” pp. 300 -- 302

16.1 “DNA is the genetic material,” pp. 305 -- 310

16.2 “Many proteins work together in DNA replication and repair,” pp. 311 -- 319

17.1 “Genes specify proteins via transcription and translation,” pp. 325 -- 331

17.2 “Transcription is the DNA-directed synthesis of RNA: *a closer look*,” pp. 331 -- 334

17.3 “Eukaryotic cells modify RNA after transcription,” pp. 334 -- 336

17.4 “Translation is the RNA-directed synthesis of a polypeptide: *a closer look*,” pp. 337 -- 344

19.2 “Viruses replicate only in host cells,” pp. 384 -- 390

20.1 “DNA cloning yields multiple copies of a gene or other DNA segment,” pp. 396 -- 404

20.2 “DNA technology allows us to study the sequence, expression, and function of a gene,” pp. 405 -- 412

27.1 “Structure and functional adaptations contribute to prokaryotic success,” pp. 556 -- 560

**Enduring understanding 3.B: Expression of genetic information involves cellular and molecular mechanisms.**

18.1 “Bacteria often respond to environmental change by regulating transcription,” pp. 351 -- 356

18.2 “Eukaryotic gene expression is regulated at many stages,” pp. 356 -- 364

18.3 “Noncoding RNAs play multiple roles in controlling gene expression,” pp. 364 -- 366

18.4 “A program of differential gene expression leads to the different cell types in a multicellular organism,” pp. 366 -- 373

45.1 “Hormones and other signaling molecules bind to target receptors, triggering specific response pathways,” pp. 975 -- 980

**Enduring understanding 3.C: The processing of genetic information is imperfect and is a source of genetic variation.**

13.4 “Genetic variation produced in sexual life cycles contributes to evolution,” pp. 257 -- 260

15.4 “Alteration of chromosome number or structure causes some genetic disorders,” pp. 297 -- 300

17.5 “Mutations of one or a few nucleotides can effect protein structure and function,” pp. 344 -- 346

19.1 “A virus consists of a nucleic acid surrounded by a protein coat,” pp. 381 -- 384

21.2 “Scientists use bioinformatics to analyze genomes and their functions,” pp. 429 -- 432

27.2 “Rapid reproduction, mutation, and genetic recombination promote genetic diversity in prokaryotes,” pp. 561 -- 564

**Enduring understanding 3.D: Cells communicate by generating, transmitting and receiving chemical signals.**

11.1 “External signals are converted to responses within the cell,” pp. 206 -- 210

11.2 “Reception: A signaling molecule binds to a receptor protein, causing it to change shape,” pp. 201 -- 214

11.3 “Transduction: Cascades of molecular interactions relay signals from receptors to target molecules in the cell,” pp. 214 -- 218

11.4 “Response: Cell signaling leads to regulation of transcription or cytoplasmic activities,” pp. 219 -- 223

**Enduring understanding 3.E: Transmission of information results in changes within and between biological systems.**

48.1 “Neuron organization and structure reflects function in information transfer,” pp. 1045 -- 1047

48.2 “Ion pumps and ion channels establish the resting potential of a neuron,” pp. 1048 -- 1050

48.3 “Action potentials are the signals conducted by axons,” pp. 1050 -- 1055

48.4 “Neurons communicate with other cells at synapses,” pp. 1055 -- 1060

49.2 “The vertebrate brain is regionally specialized,” pp. 1067 -- 1072

***Big Idea 4: Biological systems interact, and these systems and their interactions possess complex
properties.***

**Enduring understanding 4.A: Interactions within biological systems lead to complex properties.**

5.1 “Macromolecules are polymers, built from monomers,” pp. 68 -- 69

5.2 “Carbohydrates serve as fuel and building material,” pp. 69 -- 74

5.3 “Lipids are a diverse group of hydrophobic molecules,” pp. 74 -- 77

5.4 “Proteins include diversity of structures, resulting in a wide range of functions,” pp. 77 -- 86

54.2 “Diversity and trophic structure characterize biological communities,” pp. 1200 -- 1206

55.5 “Restoration ecologists help return degraded ecosystems to a more natural state,” pp. 1232 -- 1233

**Enduring understanding 4.B: Competition and cooperation are important aspects of biological systems.**

8.4 “Enzymes speed up metabolic reactions by lowering energy barriers,” pp. 152 -- 157

8.5 “Regulation of enzyme activity helps control metabolism,” pp. 158 -- 160

56.4 “Earth is changing rapidly as a result of human actions,” pp. 1254 -- 1260

**Enduring understanding 4.C: Naturally occurring diversity among and between components within biological systems affects interactions with the environment.**

21.5 “Duplication, rearrangement, and mutation of DNA contribute to genome evolution,” pp 438 -- 442