The Biology Compendium

A Field Guide to the Alabama Standards

AMSTI
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A+ COLLEGE READY
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HudsonAlpha
INSTITUTE FOR BIOTECHNOLOGY

The 2015 Biology Course of Study (COS)

Visit alex.state.al.us to view the *2015 Alabama Course of Study* online.

ALABAMA COURSE OF STUDY: SCIENCE
GENERAL INTRODUCTION

In response to our nation's declining competitiveness in the science, technology, engineering, and mathematics (STEM) fields, the National Research Council (NRC) published a research-based report on teaching and learning science in a 2012 document titled *A Framework for K-12 Science Education: Practices, Crosscutting Concepts, and Core Ideas*. This document proposes a new approach to K-12 science education through the integration of engineering design and engineering practices within the context of science content instruction. Supported by the NRC framework and our state's College- and Career-Readiness (CCR) Anchor Standards for Reading and for Writing (Appendix A), the goal of Alabama's K-12 science education standards is scientific and engineering literacy for all Alabama students. The 2015 *Alabama Course of Study: Science* defines the minimum required content that students should master to achieve this goal.

Since the present goal of Alabama's science education curriculum includes engineering literacy, it is important to define what is meant by the terms science, technology, and engineering. Science is the process of building a structured body of knowledge about the natural world delineated in the three traditional domains of physical, life, and earth and space sciences. Technology is defined as any modification of the natural world made to fulfill human needs or desires, thus expanding the interpretation of technology far beyond computers and electronic devices to include simple machines, steam engines, and musical instruments. Engineering, in a broad sense, involves engagement in a systematic practice of design in order to solve problems and generate products rising from human needs and wants. A major conceptual shift in K-12 science and engineering education includes a limited number of disciplinary core ideas in four domains that students explore with increasing rigor and depth over multiple years and the integration of such knowledge with the practices needed to engage in scientific inquiry and engineering design.

Scientific and engineering literacy enables students to become critical thinkers and informed decision makers in an increasingly technological society. While providing students with foundational knowledge of the core ideas of physical, life, and earth and space sciences, the 2015 *Alabama Course of Study: Science* will also help students develop competency in a specific set of engineering practices they can apply in everyday problem-solving situations. Developmentally appropriate engineering projects, beginning in kindergarten, provide a meaningful and relevant context in which students' knowledge and skills can be applied. Engineering projects should include all components of the engineering design process, including specific criteria for success and constraints on materials, time, and cost.

The structure of the Alabama course of study in science reflects the approach outlined by NRC's framework. The 2015 *Alabama Course of Study: Science* incorporates the three dimensions around which K-12 science and engineering education are built. These dimensions are scientific and engineering practices; crosscutting concepts that unify the study of science through their common application across all domains of science and engineering; and disciplinary core ideas in the physical, life, and earth and space sciences, and in engineering, technology, and applications of science.

Alabama's K-12 science program places emphasis on the importance of teaching science every day to every student in every grade. This document provides foundational knowledge and learning progressions that are coherent, vertically aligned, and increasingly rigorous in preparing scientifically literate citizens with the ability to evaluate the quality of science information and make informed personal choices, to gain an appreciation of science as a way of knowing about the world, and to be savvy science consumers. Effective implementation of the 2015 *Alabama Course of Study: Science* will help develop confident and capable graduates, the key to Alabama's economic productivity and our nation's competitiveness in the global marketplace.

ALABAMA'S K-12 SCIENCE CURRICULUM CONCEPTUAL FRAMEWORK

The goal of Alabama's K-12 science standards, as shown across the top of the conceptual framework graphic design on page 2, is the achievement of scientific and engineering literacy by all students. A scientifically literate person is one who has a foundation in scientific knowledge, a technological understanding of problem solving, and the ability to design scientific solutions. The correlation among these aspects of scientific literacy is depicted in the conceptual framework, which illustrates the three basic dimensions for establishing scientific and engineering literacy—scientific and engineering practices, crosscutting concepts, and disciplinary core ideas.

To face the many challenges of a universal society, Alabama students should be provided every opportunity to achieve scientific and engineering literacy from a global perspective as indicated by the image of Earth to the right of the goal statement. The infusion of a global science perspective into Alabama's curriculum is accomplished through a study of the three dimensions of science—scientific and engineering practices, crosscutting concepts, and disciplinary core ideas. Scientific and engineering practices are a set of skills and tools used by students to investigate, construct models, design and build systems, and develop theories about the world in which they live. Crosscutting concepts are unifying themes that link scientific and engineering ideas across all domains of science. Disciplinary core ideas in the four domains of Physical Sciences; Life Sciences; Earth and Space Sciences; and Engineering Technology, and Applications of Science are broad concepts that provide students with foundational knowledge. The three dimensions are depicted on the arrows that flow from the globe to the image of the state of Alabama where they are incorporated into the four domains that form the organizational structure for the content standards in this document.

The domains of Earth and Space Sciences; Physical Sciences; Life Sciences; and Engineering, Technology, and Applications of Science are displayed in the four quadrants in the graphic of the state of Alabama. The domain of Earth and Space Sciences is represented by a rocket, the image of an atom characterizes the Physical Sciences domain, and the gulf coastal area of the state symbolizes the Life Sciences domain. In the fourth quadrant are gears representing the meshing of the Engineering, Technology, and Applications of Science domain into each of the other domains. Each of the domains addresses the specific disciplinary core ideas of Dimension 3 as identified on page 12 of this document. Core ideas are the organizers for the content in each grade or course. However, the core ideas for the domain of Engineering, Technology, and Applications of Science are integrated into the content standards of the other three domains. The four domains continue from kindergarten through high school with concepts increasing in depth and rigor as students focus on deeper understanding and application of content.

The resulting science standards contained in this document ensure that Alabama students, having completed the K-12 science study, are informed science citizens and prepared college- and career-ready graduates. Having met the goal of attaining scientific and engineering literacy, these students will be able to achieve success in the global society of the twenty-first century and make meaningful contributions to a dynamic world.

BIOLOGY

Biology is a required, inquiry-based course focused on providing all high school students with foundational life science content about the patterns, processes, and interactions among living organisms. The emphasis is on increased sophistication and rigor of a limited number of core ideas rather than on memorizing a breadth of factual content. Students use prior and new knowledge to build conceptual understandings based on evidence from their own and others' investigations. They use their own learning and experiences to support claims and engage in argument from evidence. The standards provide a depth of conceptual understanding to adequately prepare them for college, career, and citizenship with an appropriate level of scientific literacy. Resources specific to the local area as well as external resources, including evidenced-based literature found within scientific journals, should be used to extend and increase the complexity of the core ideas.

Content standards within this course are organized according to the disciplinary core ideas for the Life Science domain. The first core idea, From Molecules to Organisms: Structures and Processes, concentrates on the structure of cells and how their functions are necessary for supporting life, growth, behavior, and reproduction. The second core idea, Ecosystems: Interactions, Energy, and Dynamics, investigates the positive and negative interactions between living organisms and other biotic and abiotic factors. The third core idea, Heredity: Inheritance and Variation of Traits, centers on the formation of proteins that affect the trait expression, also known as the central dogma of molecular biology; the passing of distinguishing genetic information throughout generations; and how environmental factors and genetic errors can cause gene mutations. The fourth core idea, Unity and Diversity, examines the variation of traits within a population over a long period of time that results in diversity among organisms. Integrated within the disciplinary core ideas of Biology are the Engineering, Technology, and Applications of Science (ETS) core ideas, which are denoted with an asterisk (*). The ETS core ideas require students to use tools and materials to solve simple problems and to use representations to convey design solutions to a problem and determine which is most appropriate.

Students will:

From Molecules to Organisms: Structures and Processes

1. Use models to compare and contrast how the structural characteristics of carbohydrates, nucleic acids, proteins, and lipids define their function in organisms.

2. Obtain, evaluate, and communicate information to describe the function and diversity of organelles and structures in various types of cells (e.g., muscle cells having a large amount of mitochondria, plasmids in bacteria, chloroplasts in plant cells).

3. Formulate an evidence-based explanation regarding how the composition of deoxyribonucleic acid (DNA) determines the structural organization of proteins.
   a. Obtain and evaluate experiments of major scientists and communicate their contributions to the development of the structure of DNA and to the development of the central dogma of molecular biology.
   b. Obtain, evaluate, and communicate information that explains how advancements in genetic technology (e.g., Human Genome Project, **Enc**yclopedia **of** **D**NA **E**lements [ENCODE] project, 1000 Genomes Project) have contributed to the understanding as to how a genetic change at the DNA level may affect proteins and, in turn, influence the appearance of traits.
   c. Obtain information to identify errors that occur during DNA replication (e.g., deletion, insertion, translocation, substitution, inversion, frame-shift, point mutations).

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4. Develop and use models to explain the role of the cell cycle during growth and maintenance in multicellular organisms (e.g., normal growth and/or uncontrolled growth resulting in tumors).

5. Plan and carry out investigations to explain feedback mechanisms (e.g., sweating and shivering) and cellular processes (e.g., active and passive transport) that maintain homeostasis.
    a. Plan and carry out investigations to explain how the unique properties of water (e.g., polarity, cohesion, adhesion) are vital to maintaining homeostasis in organisms.

6. Analyze and interpret data from investigations to explain the role of products and reactants of photosynthesis and cellular respiration in the cycling of matter and the flow of energy.
    a. Plan and carry out investigations to explain the interactions among pigments, absorption of light, and reflection of light.

Ecosystems: Interactions, Energy, and Dynamics

7. Develop and use models to illustrate examples of ecological hierarchy levels, including biosphere, biome, ecosystem, community, population, and organism.

8. Develop and use models to describe the cycling of matter (e.g., carbon, nitrogen, water) and flow of energy (e.g., food chains, food webs, biomass pyramids, ten percent law) between abiotic and biotic factors in ecosystems.

9. Use mathematical comparisons and visual representations to support or refute explanations of factors that affect population growth (e.g., exponential, linear, logistic).

10. Construct an explanation and design a real-world solution to address changing conditions and ecological succession caused by density-dependent and/or density-independent factors.*

Heredity: Inheritance and Variation of Traits

11. Analyze and interpret data collected from probability calculations to explain the variation of expressed traits within a population.
    a. Use mathematics and computation to predict phenotypic and genotypic ratios and percentages by constructing Punnett squares, including using both homozygous and heterozygous allele pairs.
    b. Develop and use models to demonstrate codominance, incomplete dominance, and Mendel's laws of segregation and independent assortment.
    c. Analyze and interpret data (e.g., pedigree charts, family and population studies) regarding Mendelian and complex genetic disorders (e.g., sickle-cell anemia, cystic fibrosis, type 2 diabetes) to determine patterns of genetic inheritance and disease risks from both genetic and environmental factors.

12. Develop and use a model to analyze the structure of chromosomes and how new genetic combinations occur through the process of meiosis.
    a. Analyze data to draw conclusions about genetic disorders caused by errors in meiosis (e.g., Down syndrome, Turner syndrome).

Unity and Diversity

13. Obtain, evaluate, and communicate information to explain how organisms are classified by physical characteristics, organized into levels of taxonomy, and identified by binomial nomenclature (e.g., taxonomic classification, dichotomous keys).
    a. Engage in argument to justify the grouping of viruses in a category separate from living things.

14. Analyze and interpret data to evaluate adaptations resulting from natural and artificial selection that may cause changes in populations over time (e.g., antibiotic-resistant bacteria, beak types, peppered moths, pest-resistant crops).

15. Engage in argument from evidence (e.g., mathematical models such as distribution graphs) to explain how the diversity of organisms is affected by overpopulation of species, variation due to genetic mutations, and competition for limited resources.

16. Analyze scientific evidence (e.g., DNA, fossil records, cladograms, biogeography) to support hypotheses of common ancestry and biological evolution.

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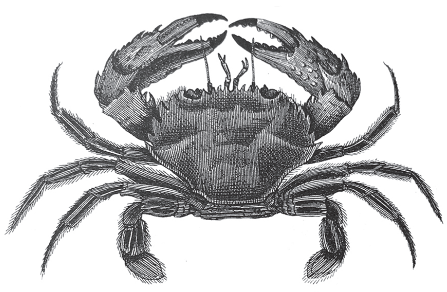

What are the building blocks of life?

In order to ground understanding of biological processes, it is necessary to be familiar with key chemical components, behaviors, and characteristics. Before students grasp structural concepts of proteins and lipids, they must understand key features of chemical bonding and the properties of water.

1 I can describe the particles that compose an atom and relate these particles to types of chemical bonding such as covalent, ionic, and hydrogen and describe Van der Waals forces.

2 I can identify patterns in the elements that compose each macromolecule and the arrangement of monomer units in carbohydrates, proteins, nucleic acids, and lipids. (1)

3 I can conduct several short investigations to predict the unique properties of water. (5a)

4 I can build a model of a water molecule that illustrates hydrogen bonding. (5a)

5 I can use that model to illustrate how water molecules interact with each other and with other polar and nonpolar molecules, based on oppositely charged parts of the molecule. (5a)

6 I can design and conduct an experiment, including controls and variables, that provides data regarding a property of water. (5a)

7 I can communicate the results of my investigation in one or more modes. (5a)

8 I can use standard experimental tests to predict the macromolecular content of a given substance. (1)

9 Given a model, schematic, or diagram, I can differentiate macromolecules based on common characteristics. (1)

10 I can build a model of a carbohydrate and describe its role in biological processes, such as photosynthesis and cellular respiration. (1)

11 I can build a model of a lipid and describe its role in biological processes, such as cell membrane function and energy storage.(1)

12 I can build a model of a nucleic acid and describe its role in biological processes, such as transmission of hereditary information. (1)

13 I can build a model of a protein and describe its role in biological processes, such as enzyme function or structural functionality. (1)

14 I can compare and contrast the structure of each macromolecule and can predict the function of each from its structure. (1)

15 I can draw conclusions from evidence of matter cycling through living and nonliving components of an ecosystem. (8)

16 I can describe the term biogeochemical by breaking it into its root, prefix, and suffix. (8)

What are living things made of?

Cells are the basic unit of living things. Biology students develop mental constructs of cellular structures and functions. Students draw conclusions about the essential components of cells and cell organelles to explain a variety of cellular functions in unicellular and multicellular organisms. Students investigate cellular structures using microscopes, models, and diagrams. Within this content progression, students build a richer conceptual understanding of cell processes such as signaling, cell life cycles, and reproduction.

17 I can describe the cell theory and discuss the historical context of its develoment. (2)

18 I can distinguish biotic components from abiotic materials, using the scientifically accepted characteristics of living things. (2)

19 I can classify cells (prokaryotes and eukaryotes) based on the observation of internal structures and the complexity of the cell and can use those classifications to annotate a diagram of prokaryotic and eukaryotic cells. (2)

20 I can distinguish between common cellular organelles based on structure and function. (2)

21 I can classify cells after observing the presence or absence of organelles and I can draw conclusions about the function of the cell based on the abundance of organelles. (2)

22 I can compare and contrast different types of cells (plant, animal, bacterial, fungal, etc.) found in a variety of organisms. (2)

23 I can predict the role of an unfamiliar cell based on my knowledge of cellular components and their functions. (2)

24 Using knowledge of cell parts, I can design a cell that performs a specific function and can communicate the features of my designed cell. (2)

25 I can build a model of a phospholipid and compare the chemical characteristics of the two distinct parts of the molecule. (1)

26 I can build a model of a cell membrane and use the model to demonstrate how materials move across the membrane. (2, 5)

27 I can distinguish between solution types based on solute concentration (hypo-, hyper-, isotonic solutions). (5)

28 I can investigate how materials move across membranes and categorize the movements as active or passive transport. (5)

29 I can investigate cell membrane function using data collected from my investigation to explain a phenomenon related to movement across a membrane. (2, 5)

30 I can compare active and passive transport, provide examples of each, and describe the process for each. (2, 5)

31 I can relate multiple properties of water to impacts on cells and living systems, as well as the maintenance of homeostasis. (2, 5a)

32 I can describe the ways cells obtain information from nearby cells and the environment in the context of cell membrane composition. (2, 4)

33 I can modify a membrane model to explain the phenomenon of cell communication in terms of membrane composition. (2)

34 I can make calculations from a hands-on activity and illustrate the amount of time spent in each phase of the cell cycle by a cell. (4)

35 I can use a model to describe patterns in typical cell growth and relate those patterns to the mechanisms of cell reproduction for growth, differentiation, and repair. (4)

36 I can develop a model of chromosome movement and can use the model to explain the maintenance of chromosome number during mitosis. (4)

37 I can use chromosome models to illustrate mitosis and to explain the role of mitosis in maintaining populations of cells. (4)

38 I can use a model to demonstrate errors that may occur during cell division.(4)

39 I can identify the strengths and limitations of a model in representing the cell cycle and cell differentiation. (4)

40 I can use evidence to describe the internal and external factors that influence cell cycle control mechanisms. (4)

41 I can use a model to compare multiple pathways to tumor formation. (4)

How do living things get and use energy?

Energy is necessary for life processes. How living things get and use energy to power life processes is often challenging for introductory biology students. In focusing on bioenergetics, students build on chemistry and cellular concepts from previous instruction.

42 I can distinguish the components of a feedback loop and identify the function of each. (5)

43 I can predict the characteristics necessary for maintaining homeostasis and investigate factors that affect homeostasis in living organisms. (5)

44 I can develop an answerable scientific question and plan and carry out an investigation that provides data about homeostasis. (5)

45 I can use evidence from my investigation to explain how negative feedback mechanisms regulate and maintain a narrow range of internal conditions in living systems among a wide range of external conditions. (5)

46 I can revise my model of cell membrane function using evidence about active and passive transport and feedback loops. (5, 2)

47 I can use a model to illustrate the three-dimensional structure of a protein and relate that structure to the biological function of an enzyme. (1)

48 I can compare the activation energy of an uncatalyzed reaction with an enzyme-mediated reaction using a diagram. (1, 6)

49 I can investigate the factors that affect enzyme function and use that data to draw conclusions about the key components of enzyme functionality in living systems. (1, 6)

50 I can collect and analyze data to identify the reactants and products of photosynthesis and respiration. (6)

51 I can use evidence to describe the relationship between photosynthesis and respiration and illustrate that relationship. (6)

52 I can plan and carry out an investigation that provides data to support the premise that light energy is absorbed by pigments during photosynthesis. (6a)

53 I can formulate a scientific question about how energy is stored and/or released in living systems. (6, 6a, 8)

54 I can relate evidence from an experiment to light absorption and reflection in photosynthetic organisms. (6a)

55 I can analyze and interpret data from experiments related to photosynthesis to draw conclusions about the cycling of matter and energy. (6, 6a, 8)

56 I can build a model of AMP, ADP, and ATP and relate the amount of energy available to the number of phosphate bonds. (6)

57 I can collect and analyze data from an investigation to explain how energy is transferred and used in cells to power life processes. (6)

58 I can compare respiration strategies in terms of energy required and energy released. (6)

59 I can analyze and interpret data from experiments relating CO2 and O2 in order to develop a model summarizing the relationship between photosynthesis and respiration. (6)

How does DNA control traits in living things?

The traits of living things are ultimately determined by inherited sequences of DNA. In this content progression, students will investigate how the information encoded in DNA impacts the functionality of protein products formed. Explicit links between DNA sequences and traits of organisms are highlighted as well as more modern understandings of the complex nature of gene expression and regulation. This content progression also introduces common complex traits, those that are controlled by multiple genetic and environmental factors and complex interactions between those factors.

60 I can identify the structural components within a model of DNA including monomer units and hydrogen bonds. (1)

61 I can cite and evaluate evidence that supports Watson and Crick's model of the double helix structure of DNA. (3a)

62 I can annotate a diagram of the Central Dogma of Biology to include relevant discoveries and their implications on the understanding of the Central Dogma. (3a, 3b)

63 I can use models to demonstrate how information encoded in DNA leaves the nucleus.(3)

64 I can use a model to identify patterns in transcription and infer the impacts of any errors. (3)

65 I can compare and contrast the functionality of multiple types of RNA and relate that function to protein synthesis. (3,3b)

66 I can use a model to illustrate how mRNA serves as a template for building a polypeptide chain and how other types of RNA are utilized in the process. (3, 3b)

67 I can use a codon chart to determine the sequence of amino acids (polypeptide chains) that will be built from a given mRNA sequence. (3, 3b)

68 I can use a model to explain protein folding in terms of the rules of chemistry and physics to describe how the folding of the protein affects its function. (1, 3)

69 I can relate the levels of protein structure to the final three-dimensional shape and functionality of the protein. (1, 3)

70 I can use data to support the concept that changes in DNA impact protein function in predictable ways. (3, 3c)

71 I can categorize types of mutations and use a model to show how changes in DNA can result in changes in protein function. (3, 3c)

72 Based on my understanding of the Central Dogma of Biology, I can predict how specific changes in DNA (both large scale and small) will impact protein function. (3, 3c)

73 I can interpret the impacts of DNA changes using lab techniques such as gel electrophoresis, PCR, or computer-based resources such as NCBI. (3, 3a, 3c)

74 I can evaluate the major findings of research projects such as the Human Genome Project, ENCODE, and the 1000 Genomes Project and modify my working definition of "a gene" based on the findings of those projects. (3b)

75 I can explain gene expression in terms of genes being "turned on or off" and in broad terms identify the factors that influence gene expression. (3b)

76 I can communicate the impact of modern genome research projects on our understanding of gene structure and function, using multiple modes. (3a, 3b)

77 I can explain common complex disease in terms of genetic and environmental interactions. (3b, 11c)

78 I can analyze multiple types of evidence to draw conclusions about an individual's risk for common complex disease. (11c)

How do living things pass traits to their offspring?

Building on a greater understanding of DNA structure and function, this content progression addresses the behavior of DNA before, during, and after meiosis and introduces Mendelian inheritance patterns. Many inheritance concepts were introduced in the study of molecular inheritance but are investigated in much greater detail here.

79 I can use a model to relate key features of DNA (antiparallel strands, complementary bases, and hydrogen bonding) to the mechanisms of DNA replication. (1, 3b)

80 I can use a model to investigate the process of semi-conservative replication and compare the leading strand to the lagging strand. (3, 4)

81 From that model, I can draw conclusions about errors that occur during replication. (3c)

82 I can develop a model of a replicated and non-replicated chromosome to compare their structure and use scientific vocabulary to describe chromosome structures. (4, 12)

83 I can compare and contrast mitosis and meiosis in terms of chromosome number and number of daughter cells and in comparison to the precursor cell. (12)

84 I can develop a model of chromosome movement at multiple points during meiosis and use the model to determine when cells are haploid and diploid. (12)

85 I can identify when crossing over occurs and can explain the significance of crossing over in genetic variation. (12)

86 I can compare and contrast the genetic makeup of cells before meiosis, after meiosis, and after fertilization. (12)

87 I can evaluate meiosis models, comparing them to the biological process, and identify strengths and weaknesses of the model. (12)

88 I can use meiosis models to explain the phenomena seen in a simple pedigree. (12)

89 I can describe the impacts of nondisjunction and relate the timing of nondisjunction to chromosome number in the gametes that form. (12)

90 I can use models to demonstrate a variety of chromosomal changes such as deletions, insertions, inversions, translocation, and nondisjunction. (3c, 12, 12a)

91 I can interpret karyotypes to identify chromosomal changes and related genetic disorders as well as describe the limitations of karyotyping. (12a)

92 I can differentiate genetic disorders in humans in terms of errors of meiosis, either large scale (chromosomal) or small scale (point mutations). (3c, 12, 11c)

93 I can summarize the investigations performed by Gregor Mendel and relate the importance of these experiments in the field of genetics. (11, 11b)

94 I can analyze trait data from multiple generations to support Mendel's conclusions about inheritance. (11, 11b)

95 I can use models, diagrams, and/or text to connect Mendel's laws of inheritance to the biological processes of meiosis. (11, 11b)

96 I can distinguish between homozygous and heterozygous allele pairs and relate these to phenotype. (11, 11b)

97 I can use a model to determine potential gametes from parental genotype and develop a Punnett square to predict inheritance outcomes. (11, 11b)

98 I can annotate a Punnett square, identifying maternal and paternal gametes, and use mathematics to explain the predicted outcomes. (11, 11a)

99 I can observe traits in offspring and use knowledge of inheritance patterns and Punnett squares to infer parental genotypes. (11, 11a)

100 I can use probability to predict the likelihood of specific offspring given parent traits and inheritance pattern. (11, 11a)

101 I can distinguish modes of inheritance by comparing parental and offspring traits and ratios. (11, 11c)

102 I can apply concepts of inheritance to explain patterns seen in pedigrees, offspring ratios, and trait prevalence in a population. (11, 11c)

103 I can analyze data to find inheritance patterns and explain those patterns in terms of incomplete dominance, co-dominance, multi-allelic, and polygenic traits. (11, 11b)

104 I can identify non-genetic factors that may impact expressed traits. (11c)

105 I can collect and analyze data on traits within a population to identify patterns within expressed traits in a population. (11)

106 I can mathematically calculate the probability of expressed traits of offspring, given parental traits and an understanding of inheritance patterns. (11)

How have living things changed over time?

DNA sequences determine both the unity and diversity found in life on planet earth. The many ways that variation is introduced and maintained in populations of organisms was investigated in previous content progressions. This content progression addresses how groups of organisms respond to changing environmental conditions and biological evolution.

107 I can collect and analyze data to identify patterns in survival and trait frequency in a population of organisms. (14)

108 I can develop an argument about which traits in a population will confer an adaptive advantage while going through changing conditions. (14)

109 I can define variation and categorize the processes (mutation and sexual recombination) that lead to variation. (11,15)

110 I can postulate how an environmental change could influence selection, driving changes in traits in a species that will persist in the population. (14,15)

111 I can describe and provide illustrative examples of the main ideas behind natural selection (overproduction of offspring, competition for limited resources, inherited variation in phenotypes, and differential survival/reproduction). (15)

112 I can use mathematical models to test the concept that organisms with favorable adaptations are more likely to survive and reproduce. (11,15)

113 I can compare and contrast natural and artificial selection and predict how artificial selection will impact the traits of an organism. (14)

114 I can analyze and interpret data to evaluate the impact of human intervention in determining the traits of agriculturally important plants and animals. (14)

115 I can develop a logical argument for a proposed mechanism of evolution, including necessary adaptations, mutations, and environmental changes. (15)

116 I can compare historical explanations for the diversity of life on earth to modern explanations by placing both in a historical context. (15)

117 I can analyze data, including fossil records, to support the premise that organisms have changed over time and that only a small fraction of the species that have previously existed currently survive on earth. (16)

118 I can identify patterns of biogeography that are significant to Darwin's theory. (16)

119 I can describe homologous structures and explain how these structures are used as lines of evidence to support biological evolution. (16)

120 I can identify patterns in embryologic development among diverse organisms and explain how these patterns are used as lines of evidence to support biological evolution. (16)

121 I can describe vestigial structures and explain how these structures are used as lines of evidence to support biological evolution. (16)

122 I can interpret similarities in the genetic code to provide evidence of common descent (genetic conservation). (16)

123 I can create a cladogram of related objects or organisms and interpret cladograms to draw conclusions about the relatedness of organisms. (16)

124 I can evaluate a wide variety of evidence to explain how organisms have changed over geologic time. (16)

125 I can evaluate a wide variety of evidence to draw conclusions regarding the role of natural selection in the formation of new species. (14, 16)

126 I can make inferences about the diversity of life on earth using examples and evidence of co-evolution, divergent, and convergent evolution. (16)

127 I can organize items based on physical characteristics and communicate my reasoning to others. (13)

128 I can create a dichotomous key that will allow others to classify objects. (13)

129 I can use major features to classify unfamiliar organisms using accepted classification schemes and can justify my classification. (13)

130 I can use binomial nomenclature and tools such as dichotomous keys to classify an unfamiliar organism and determine where it fits into accepted taxonomic schemes. (13)

131 I can distinguish biotic from abiotic materials, using the scientifically accepted characteristics of life. (13a)

132 I can describe viral structures and life cycles and compare these to the structures and life cycles of multicellular or unicellular organisms. (13a)

133 I can compare viruses to other infectious agents such as pathogenic bacteria and prions. (13a)

134 I can create a logical argument, based on evidence and reasoning, to support the premise that viruses are not living things. (13a)

How do living things interact with each other and the environment?

Introductory Biology culminates in the study of how organisms interact with each other and the nonliving components of their environment. This content progression addresses ecosystem dynamics and patterns of population growth. One critical feature of this content progression is the opportunity provided for students to investigate and propose a solution for a real-world problem using their understanding of these complex ecological systems.

135 I can categorize organisms in an ecosystem based on evidence of how they obtain energy. (8)

136 I can construct a food chain that differentiates between producers, primary, secondary, and tertiary consumers and integrate multiple food chains into a food web (model of feeding relationships). (8)

137 I can use relationships between organisms to develop a food web and use my developed model to demonstrate flow of energy and predict the impacts of population changes. (8)

138 I can construct a pyramid of biomass, given population data about organisms in the ecosystem, and can make calculations using data from the pyramid. (8)

139 I can use mathematical examples, such as the 10% law, to explain why there is less energy available at each level of an energy pyramid. (8)

140 I can explain the phenomenon of biomagnification using my developed trophic level and pyramid models. (8)

141 I can analyze data to identify patterns in the cycling of carbon, nitrogen, and water in ecosystems. (8)

142 I can use the patterns identified in the cycling of carbon, nitrogen, and water to build models of matter cycling through ecosystems. (8)

143 I can predict the effect of a reduction in the population of nitrogen-fixing bacteria on the nitrogen cycle. (8)

144 I can describe the impact of various biotic and abiotic components on each ecological level and can explore the interrelationships of these factors. (7,8)

145 I can use my observations to develop a model that illustrates ecological hierarchies and can compare my developed models to hierarchies existing in nature. (7,8)

146 I can use models to investigate the role of different environmental factors within the hierarchy. (7)

147 I can develop a model depicting the ecological hierarchy of a novel ecosystem and can communicate the dynamics of the hierarchy. (7)

148 I can investigate biomes, using a variety of sources, to compare and contrast the characteristics of each. (7)

149 I can use evidence to classify major geographical regions into biomes, based on climate and dominant life forms. (7)

150 I can create graphs representing exponential, linear, and logistic growth and use those graphs to calculate doubling time for a population. (9)

151 I can use mathematical or computer models to investigate the factors affecting population growth in an ecosystem. (9)

152 I can identify patterns in the characteristics of population growth that distinguish exponential growth from linear growth from logistic growth. (9)

153 I can interpret a population pyramid graph and use the information contained to predict the results of a change in birth rate or death rate. (9)

154 I can use evidence and data to describe trends in human population growth. (9)

155 I can investigate factors that impact population growth and make predictions of how changing environmental conditions will affect population growth. (9)

156 I can use growth curves of predators and prey to evaluate the impact of one species on another. (9)

157 I can analyze data on population growth to identify limiting factors, both biotic and abiotic. (8, 10)

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How do living things interact with each other and the environment?

158 I can analyze data to find patterns that distinguish density-dependent from density-independent limiting factors. (10)

159 I can use evidence and reasoning to define the carrying capacity of a specific ecosystem. (9)

160 I can distinguish between primary and secondary ecological succession and show that an ecosystem responds to such a disturbance in a predictable manner. (10)

161 I can use models to explain ecosystem recovery after disturbance. (10)

162 I can analyze historical data to find patterns in an ecosystem's response to disturbance and use this analysis to draw conclusions about how the ecosystem will respond to additional disturbance. (10)

163 I can categorize human activities that affect ecosystems and can predict the impact of these actions. (10)

164 I can describe an ecological cascade and explain the impacts on organisms in the ecosystem. (7,10)

165 I can design a solution to changing environmental conditions that accounts for density-dependent and independent factors. (10)

166 I can synthesize data and reasoning to evaluate potential solutions to an environmental problem. (10)

167 I can communicate my proposed solution and support my conclusions with evidence and reasoning. (10)

Learning Targets

135 I can categorize organisms in an ecosystem based on evidence of how they obtain energy. (8)

136 I can construct a food chain that differentiates between producers, primary, secondary, and tertiary consumers and integrate multiple food chains into a food web (model of feeding relationships). (8)

137 I can use relationships between organisms to develop a food web and use my developed model to demonstrate flow of energy and predict the impacts of population changes. (8)

138 I can construct a pyramid of biomass, given population data about organisms in the ecosystem, and can make calculations using data from the pyramid. (8)

139 I can use mathematical examples, such as the 10% law, to explain why there is less energy available at each level of an energy pyramid. (8)

140 I can explain the phenomenon of biomagnification using my developed trophic level and pyramid models. (8)

Teacher Tips

At this time teachers can introduce or emphasize the overarching theme of "Interconnectedness:" everything in an ecosystem is connected to everything else, either directly or indirectly.

This standard demands the development and use of models. However, those models need not be physical constructions. Student-developed food web diagrams are representations of conceptual models that can and should be used to meet the standard if students are able to use those models to predict future impacts. For example, if students could use a self-created food web diagram to predict the impact of removing one member on other members of the food web, it would be "developing and using a model" whereas if students only create a static diagram the standard would not be met.

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