South Carolina Academic Standards and Performance Indicators for Science 2014

Instructional Unit Resource

Biology

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As support for implementing the *South Carolina Academic Standards and Performance Indicators for Science 2014*, the standards for Biology have been grouped into possible units. In the Overview of Units below, the titles for those possible units are listed in columns. Refer to the Overview document to note these unit titles and how Standards, Conceptual Understandings, Performance Indicators, Science and Engineering Practices, and Crosscutting Concepts align. Following the Overview of Units, an Instructional Unit document is provided that delivers guidance and possible resources in teaching our new *South Carolina Academic Standards and Performance Indicators for Science 2014*. The purpose of this document is to provide guidance as to how all the standards in this grade may be grouped into units and how those units might look. Since this document is merely guidance, districts should implement the standards in a manner that addresses the district curriculum and the needs of students. This document is a living document and instructional leaders from around the state will continuously update and expand these resource documents. These documents will be released throughout the 2016-2017 school year with the intentionality of staying ahead of instruction. Teachers should also note that links to the Standards document, A Framework for K-12 Science Education: Practices, Crosscutting Concepts, and Core Ideas, the SEP Support Document, and the Support Document 2.0 are embedded throughout the Instructional Unit format for reference.

Acknowledgments

Jean Baptiste Massieu, famous deaf educator, made a statement that is now considered a French proverb. “Gratitude is the memory of the heart. Indeed, appreciation comes when you feel grateful from the depths of your heart. The head keeps an account of all the benefits you received and gave. But the heart records the feelings of appreciation, humility, and generosity that one feels when someone showers you with kindness.” It is with sincere appreciation that we humbly acknowledge the dedication, hard work and generosity of time provided by teachers and instructional leaders across the state that have made and are continuing to make the Instructional Unit Resources possible.

Biology 1 Overview of Units

Unit 1				**Unit 2**	**Unit 3**			
Cells as a System				Energy Transfer	Heredity - Inheritance and Variation of Traits			
Standard				**Standard**	**Standard**			
H.B.2				H.B.3	H.B.4			
Conceptual Understanding				**Conceptual Understanding**	**Conceptual Understanding**			
H.B.2A	H.B.2B	H.B.2C	H.B.2D	H.B.3A	H.B.4A	H.B.4B	H.B.4C	H.B.4D
Performance Indicators	**Performance Indicators**	**Performance Indicators**	**Performance Indicators**	**Performance Indicators**	**Performance Indicators**	**Performance Indicators**	**Performance Indicators**	**Performance Indicators**
H.B.2A.1 H.B.2A.2	H.B.2B.1 H.B.2B.2 H.B.2B.3	H.B.2C.1 H.B.2C.2 H.B.2C.3	H.B.2D.1 H.B.2D.2 H.B.2D.3 H.B.2D.4	H.B.3A.1 H.B.3A.2 H.B.3A.3 H.B.3A.4 H.B.3A.5	H.B.4A.1 H.B.4A.2	H.B.4B.1 H.B.4B.2	H.B.4C.1 H.B.4C.2 H.B.4C.3	H.B.4D.1
***Science and Engineering Practices**	***Science and Engineering Practices**	***Science and Engineering Practices**	***Science and Engineering Practices**	***Science and Engineering Practices**	***Science and Engineering Practices**	***Science and Engineering Practices**	***Science and Engineering Practices**	***Science and Engineering Practices**
H.B.1A.6 H.B.1A.3	H.B.1A.2 H.B.1A.6 H.B.1A.8	H.B.1A.1 H.B.1A.2 H.B.1A.4	H.B.1A.2 H.B.1A.6 H.B.1A.7	H.B.1A.2 H.B.1A.3 H.B.1A.7	H.B.1A.2	H.B.1A.2 H.B.1A.8	H.B.1A.2 H.B.1A.4 H.B.1A.6	H.B.4A.2
***Cross cutting Concepts**				***Cross cutting Concepts**	***Cross cutting Concepts**			
2, 4, 5, 6, 7				2, 4, 5	2, 3, 4, 6			

**Teachers have the discretion to enhance the selected SEP’s and CCC’s.*

Biology 1 Overview of Units

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Unit Title
Biology: Evolution
Standard http://ed.sc.gov/scdoe/assets/file/agency/ccr/Standards-Learning/documents/South_Carolina_Academic_Standards_and_Performance_Indicators_for_Science_2014.pdf
H.B.5. The student will demonstrate an understanding of biological evolution and the diversity of life.

Conceptual Understanding

H.B.5 is derived from 2005 B-5 which had no conceptual understanding.

New Academic Vocabulary

Some students may need extra support with the following academic vocabulary in order to understand what they are being asked to understand and do. Teaching these terms in an instructional context is recommended rather than teaching the words in isolation. A great time to deliver explicit instruction for the terms would be during the modeling process. Ultimately, the student should be able to use the academic vocabulary in conversation with peers and teachers. These terms are pulled from the essential knowledge portion of the Support Doc 2.0 (http://ed.sc.gov/instruction/standards-learning/science/support-documents-and-resources/) and further inquiry into the terms can be found there.

Natural selection	Genetic variability	Gene flow	Genetic drift	Artificial selection	Population
Paleontology	Biochemistry	Fossil	Fossil Record	Phylogeny	Phylogenetic Tree
Species	Homologous structure	Analogous structure	Vestigial structure	Geographic isolation	Reproductive isolation
Macroevolution	Microevolution	Species	Sexual Selection	Evolution	Comparative anatomy
Hardy-Weinberg equilibrium	Convergent evolution	Divergent evolution	Coevolution	Adaptive radiation	Gradualism
Speciation		Adaptation	Genetic equilibrium	Allele frequency	Punctuated equilibrium

Performance Indicators

B-5.1 Summarize the process of natural selection. The objective of this indicator is for students to summarize the process of natural selection. Therefore, the primary focus of assessment should be to construct explanations using major points about the principles of natural selection. This could include, but is not limited to, students using evidence to describe the fate of a particular species given a scenario of environmental change, to compare microevolution and macroevolution, and to explain how changes in the environment may result in the appearance or disappearance of particular traits.

B-5.2 Explain how genetic processes result in the continuity of life-forms over time. The objective of this indicator is to explain how genetic processes result in the continuity of life-forms over time; therefore, the primary focus of assessment should be for students to obtain, evaluate and communicate information regarding how sexual and asexual reproduction allow for the continuity of life-forms through the passing on of genetic material. This could include, but is not limited to, students answering questions about the similarities between organisms that live today with those that lived in the past, contrasting the results of sexual and asexual reproduction, and making claims using evidence about how sexual and asexual reproduction ensure that genetic material is passed to offspring allowing for the continuity of life-forms.

B-5.3 Explain how diversity within a species increases the chances of its survival. The objective of this indicator is to explain how diversity within a species increases the chances of its survival; therefore, the primary focus of assessment should be to obtain evaluate, and communicate scientific information to (1) answer questions; (2) explain or describe phenomena; (3) develop models; (4) evaluate hypotheses, explanations, claims, or designs; or (5) identify and/or fill gaps in knowledge regarding how variability in species affects reproductive success and adaptation to its environment. This could include, but is not limited to, students using information to make and support claims that summarize the ways that diversity affects a species chances of survival, exemplify favorable traits that ensure reproductive success or species survival, infer the fate of a particular species in the face of a specific environmental change based on the degree of diversity of its members, or compare the chances of two species to survive in the face of a specific environmental change based on the degree of diversity among the members of each group.

B-5.4 Explain how genetic variability and environmental factors lead to biological evolution. The objective of this indicator is to explain how genetic variability and environmental factors lead to biological evolution; therefore, the primary focus of assessment should obtain, evaluate, and communicate information regarding how the factors influencing genetic variability, speciation, and processes of evolution due to environmental changes can lead to the evolution of a species over time. This could include, but is not limited to, students developing a model based on information obtained from informational texts to compare gradual and mass extinction. Students may also summarize the factors influencing genetic variability in a population, summarize the Hardy-Weinberg principle, explain the process of speciation, and summarize the patterns of macroevolution.

B-5.5 Exemplify scientific evidence in the fields of anatomy, embryology, biochemistry, and paleontology that underlies the theory of biological evolution. The objective of this indicator is to exemplify scientific evidence in the fields of anatomy, embryology, biochemistry, and paleontology that underlies the theory of biological evolution. Therefore, the primary focus of assessment should be for students to construct explanations using (1) primary or secondary scientific evidence and models; (2) conclusions from scientific investigations; (3) predictions based on observations and measurements; or (4) data communicated in graphs, tables, or diagrams to give or use examples of how the fields of anatomy, embryology, biochemistry, and paleontology that underlies the theory of biological evolution provide evidence that support the change in species over time. This could include, but is not limited to, students inferring relationships among organisms based on primary and secondary evidence from each field of science listed. Students may also be asked to identify fields of science that provide evidence for biological evolution; illustrate evidence for biological evolution using pictures, diagrams, or words; or summarize the ways that each field of science listed provides evidence for evolutionary relationships.

B-5.6 Summarize ways that scientists use data from a variety of sources to investigate and critically analyze aspects of evolutionary theory. The objective of this indicator is to summarize ways that scientists use data from a variety of sources to investigate and critically analyze aspects of evolutionary theory. Therefore, the primary focus of assessment should be to construct and analyze scientific arguments to support claims, explanations, or designs using evidence and valid reasoning from observations, data, or informational texts regarding how scientists in the fields of anatomy, embryology, paleontology, and biochemistry have used data to develop a picture of the process of evolutionary theory. This could include, but is not limited to, students using evidence to support claims about how analogous and homologous structures provide for evolutionary relationships, how the fossil record has challenged scientists in paleontology, and how biochemists use DNA evidence to show evolutionary relationships.

B-5.7 Use a phylogenetic tree to identify the evolutionary relationships among different group of organisms. The objective of this indicator is to use a phylogenetic tree to identify the evolutionary relationships among different groups of organisms. Therefore, the primary focus of assessment should be to use the phylogenetic tree to understand or represent the evolutionary relationships among species. This could include, but is not limited to, students using the phylogenetic tree to classify organisms according to evolutionary relationships, infer the evolutionary relationships among groups represented, and explain why organisms would be placed at various positions on a phylogenetic tree based on given scientific data. In addition to using models (the phylogenetic tree), students should also be asked to ask questions; analyze and interpret data; construct explanations; and obtain, evaluate and communicate information from evidence.

***Science and Engineering Practices** **Support for the guidance, overviews of grade level progressions, and explicit details of each SEP can found in the Science and Engineering Support Doc (http://ed.sc.gov/scdoe/assets/File/instruction/standards/Science/Support%20Documents/Complete_2014SEPsGuide_SupportDoc2_0.pdf). It is important that teachers realize that the nine science and engineering practices are not intended to be used in isolation. Even if a performance indicator for a given standard only lists one of the practices as a performance expectation, scientists and engineers do not use these practices in isolation, but rather as part of an overall sequence of practice. When educators design the learning for their students, it is important they see how a given performance expectation fits into the broader context of the other science and engineering practices. This will allow teachers to provide comprehensive, authentic learning experiences through which students will develop and demonstrate a deep understanding of scientific concepts.**
H.B.1A.2 **(B-5.7)** Develop, use, and refine models to (1) understand or represent phenomena, processes, and relationships; (2) test devices or solutions; or (3) communicate ideas to others. H.B.1A.6 **(B-5.1, B-5.5)** Construct explanations of phenomena using (1) primary or secondary scientific evidence and models; (2) conclusions from scientific investigations; (3) predictions based on observations and measurements; or (4) data communicated in graphs, tables, or diagrams. H.B.1A.7 **(B-5.6)** Construct and analyze scientific arguments to support claims, explanations, or designs using evidence and valid reasoning from observations, data, or informational texts. H.B.1A.8 **(B-5.2, B-5.3, B-5.4)** Obtain and evaluate scientific information to (1) answer questions; (2) explain or describe phenomena; (3) develop models; (4) evaluate hypotheses, explanations, claims, or designs; or (5) identify and/or fill gaps in knowledge. Communicate using the conventions and expectations of scientific writing or oral presentations by (1) evaluating grade-appropriate, primary or secondary, scientific literature or (2) reporting the results of student experimental investigations.
***Cross Cutting Concepts** **(http://www.nap.edu/read/13165/chapter/8)** **The link above provides support from the Framework for K-12 Science Education: Practices, Crosscutting Concepts, and Core Ideas (2012). The text in blue and *italicized/underlined* below provides a brief explanation of how the specific content ties to the CCC's.**
1. Patterns: The National Research Council (2012) states that "observed patterns of forms and events guide organization and classification, and they prompt questions about relationships and the factors that influence them" (p. 84). *There are patterns of macroevolution. They are adaptive radiation, coevolution, and extinction.* 2. Cause and effect: Mechanism and explanation: The National Research Council (2012) states that "events have causes, sometimes simple, sometimes multifaceted. A major activity of science is investigating and explaining causal relationships and the mechanisms by which they are mediated. Such mechanisms can then be tested across given contexts and used to predict and explain events in new contexts" (p. 84). *As the environment of a population changes, the entire process of natural selection can yield populations with new phenotypes adapted to new conditions.* 3. Scale, proportion, and quantity: The National Research Council (2012) states that "in considering phenomena, it is critical to recognize what is

relevant at different measures of size, time, and energy and to recognize how changes in scale, proportion, or quantity affect a system's structure or performance" (p. 84). *Most species produce more offspring than the environment can support; therefore, some individuals will not be able to reach their full potential for reproduction.*

7. Stability and change: The National Research Council (2012) states that "For natural and built systems alike, conditions of stability and determinants of rates of change or evolution of a system are critical elements of study" (p. 84). *The fossil record provides evidence of life forms and environments along a timeline and supports evolutionary relationships by showing the similarities between current species and ancient species.*

**Teachers have the discretion to enhance the selected SEP's and CCC's.*

Prior Knowledge

- 6.L.4A.1 Living organisms reproduce
- 7.L.4A.1 Genes, chromosomes, and inheritance
- 7.L.3A.1 Asexual and Sexual Reproduction in Extended Knowledge
- 8.E.6A Earth's History
- 8.E.6B Natural Selection

Subsequent Knowledge

- H.E.3B.4 Human Activities and Species Endangerment
- H.E.4A Impacts of Organisms on the Conditions of Earth, Changes in Complexity and Diversity of Life, and The Fossil Record

Possible Instructional Strategies/Lessons

Strategies and lessons that will enable students to master the standard and/or indicator.

- B-5.1
  - Evolution Lab: This interactive virtual lab provides a good introduction to the concept of natural selection as students simulate the evolution of a hypothetical species. The simulation allows students to control the strength of the selective pressure and the frequency of mutations in the species. Students see very clearly that over time mutations that create the longer-armed individuals become more common in the population because they are more fit for the environment. This resource is available from http://biologyinmotion.com/evol/ .

  - Peppered Moth Simulation: Students will use their prior knowledge about the Industrial Revolution to brainstorm the environment impacts that mass production, factory pollution, etc. had during that time of economic development. They can then use the simulation to investigate the phenotypic changes experienced in a population of peppered moths in "light" and "dark" tree bark conditions. Afterwards, students can discuss their findings and how environmental conditions drive phenotypic and thus genotypic ratios in populations. This activity could potentially be used as a cross-curricular lesson with a history course. This resource can be found at http://peppermoths.weebly.com/.

- The Problem With Antibacterial Products Investigation: Students will analyze claims that antibacterial products kills 99.99% of bacteria, and then make predictions about the evolutionary fate of the surviving .01% of those microbes. Students model natural selection with using marshmallows and hard candy, and then use their observations to develop concepts about bacterial resistance. This resource can be found at https://www.nsta.org/middleschool/connections/201312WelbornWorksheetAnswers.pdf.

- Take As Directed: Antibiotic Resistance Simulation: Students will mimic the effectiveness of antibiotics in the treatment of resistant bacteria with bingo chip and dice. Further discussion includes the impact of inconsistency of use and overabundance in which they are prescribed for illnesses. Analysis of "surviving bacteria" in this activity will allow students to interpret how antibiotic usage drives bacterial evolution. This activity can be found at http://www.flinnsci.com/media/1167812/bf11236.pdf.

- Color Variation Over Time in Rock Pocket Mouse Populations: Print the handouts in color and give to students in groups. Ask students to put the pictures in order from earliest to latest. Show the HHMI short film *The Making of the Fittest: Natural Selection and Adaptation* (see resources). Have the students revise the order of the pictures based on the information in the video and answer the questions on the accompanying worksheet. There are many other lessons on evolution associated with this film. This lesson is available from http://www.hhmi.org/biointeractive/color-variation-over-time-rock-pocket-mouse-populations.

- B-5.2
  - See What Did T-Rex Taste Like? activity in B-5.7.

- B-5.3
  - See Peppered Moth Simulation activity in B-5.1.
  - See The Problem with Antibacterial Products Investigation activity in B-5.1

- See Color Variation Over Time in Rock Pocket Mouse Populations activity in B-5.1.

- B-5.4
    - Population Genetics Fishbowl: In this interactive activity, students model a population of fish in Hardy-Weinberg Equilibrium. Students can then adjust any of the five Hardy-Weinberg conditions to explore how it will affect the color of the fish population and the allele frequencies. Teachers will have to explain what adjusting each slider means, but the activity is otherwise self-directed. This activity can be found at http://virtualbiologylab.org/PopGenFishbowl.htm.

    - Random Effects: In this interactive activity, students can explore how the founder effect and bottleneck effect impact genetic variation of a simulated species. Students will need to conduct the simulation several times in order to better illustrate the random nature of these effects. This activity is available from http://virtualbiologylab.org/RandomEffects.htm.
- B-5.5
    - Natural Selection and Evolution of Rock Pocket Mouse Populations: This activity uses the HHMI short film *The Making of the Fittest* (see Resources) as a basis for students to analyze molecular genetic data to investigate the cause and evolutionary relationship between genetics and evolution. This activity can be retrieved from http://gpschools.schoolwires.net/cms/lib05/MI01000971/Centricity/Domain/2027/Hardy-Weinberg%20Goldfish%20Lab.pdf.
- B-5.6
    - Cytochrome C Comparison Lab: This laboratory activity has students analyze the amino acid sequence for the Cytochrome C protein from numerous different eukaryotic species. Students compare the amino acid sequences and then use this data to create phylogenetic trees. See B-5.6 in Resources for Easy Comparison Data Charts. This activity is available from http://www.indiana.edu/~ensiweb/lessons/molb.ws.pdf.

    - See Natural Selection and Evolution of Rock Pocket Mouse Populations in B-5.5.

- B-5.7
    - What Did T-Rex Taste Like?: This online activity guides students through the interrelationships of all life on Earth and how scientists use evidence to build cladograms and phylogenetic trees that can be used to infer information about extinct and extant species. This activity is entirely self-directed. There is a teacher guide and student data sheet available for printing. This lesson can be

retrieved from http://www.ucmp.berkeley.edu/education/explorations/tours/Trex/.

- See Cytochrome C Comparison Lab in B-5.6.

Resources

- B-5.1
  - The Making of the Fittest-Natural Selection and Adaptation: This short film from the Howard Hughes Medical Institute explores the natural selection and evolution of fur color in different populations of rock pocket mice. This resource is available from http://www.hhmi.org/biointeractive/making-fittest-natural-selection-and-adaptation.

  - Chickens look way different today, and here's the reason why: This article discusses how humans have affected the evolution of chickens since 1957. This article can begin a discussion about natural and artificial selection. It is important to consider artificial selection as well as natural selection to demonstrate that dramatic changes in organisms can be achieved in a short amount of time. This could also be illustrated through an analysis of dog breeds or the evolution of fruits and vegetables such as those derived from the wild mustard plant. This article is available from http://www.huffingtonpost.com/2014/10/21/chickens-bred-bigger_n_5983142.html.

  - Selective Breeding of Corn, Peaches, and other Crops Article: This article gives examples of artificial selection of crops as humans have cultivated them to have longer shelf life, resist pests and drought, and appeal aesthetically to the shopper. This resource can be found at http://www.vox.com/2014/10/15/6982053/selective-breeding-farming-evolution-corn-watermelon-peaches.

  - Natural Selection and the Bacterial Resistance: This Amoeba Sisters video details the process of natural selection and how it leads to evolution while relating it to a real-world problem of antibiotic resistance. This resource is available from https://www.youtube.com/watch?v=7VM9YxmULuo&list=PLwL0Myd7Dk1F0iQPGrjehze3eDpco1eVz&index=26.

  - Natural Selection and the Evolution of Darwin's Finches: This activity accompanies a video; and as each segment is played, students modify their predictions concerning the physical changes the finch population experiences as weather patterns fluctuate. Using evidence provided from the video segments and by comparing data, students are asked to construct explanations of how environmental change requires intraspecific competition and how some individuals are better suited to survive. This resource can be found at http://www.hhmi.org/biointeractive/natural-selection-and-evolution-darwins-finches.

- Selection for Tuskless Elephants: This short film discusses how human activities, such as poaching, have influenced the frequency of tuskless African elephants in Gorongosa National Park. Students can then make predictions concerning the phenotype of future populations and discuss the impact of environmental pressures on species survival. This resource can be found at http://www.hhmi.org/biointeractive/selection-tuskless-elephants.

- B-5.2
  - The Red Queen- Sexual vs. Asexual Reproduction in Minnows: This short video segment is from *Evolution: Why Sex* series, and it discusses the evolutionary implications of asexual vs. sexual reproduction. This resource can be found at http://wtvi.pbslearningmedia.org/resource/tdc02.sci.life.evo.redqueen/the-red-queen/.

  - Sexual and Asexual Reproduction: This video presentation covers the differences between evolutionary consequences of sexual and asexual reproduction. This resource is available from https://www.youtube.com/watch?v=cGBQRyzeZBY.

- B-5.3
  - See The Making of the Fittest: Natural Selection and Adaptation in B-5.1.

- B-5.4
  - Hardy-Weinberg Assumptions: This video explains the five assumptions necessary for a population to maintain Hardy-Weinberg equilibrium and therefore not evolve. This video can be retrieved from https://www.youtube.com/watch?v=zNb_i9ih97c.

  - Goldfish Crackers Hardy-Weinberg Activity: This hands-on activity allows students to use "populations" of Goldfish crackers to simulate the occurrence of allele frequencies with and without environmental pressures. This resource can be found at http://www.carolina.com/teacher-resources/Interactive/teaching-hardy-weinberg-in-the-classroom/tr10630.tr.

  - Macroevolution Patterns: This video presentation describes several patterns of macroevolution including speciation, adaptive radiation and divergent evolution, convergent evolution, and extinction. This video might be better used as a teacher resource than a student resource, as a teacher could provide a more interactive lesson with the material. This resource is available from https://www.youtube.com/watch?v=MfuFiE4hYFM.

- B-5.5
    - Evidence for Evolution: This video explains the four major categories of evidence for evolution: paleontology, embryology, anatomy, and biochemistry. This resource is available from https://www.youtube.com/watch?v=O21VOcLIb3M.
    - See The Making of the Fittest: Natural Selection and Adaptation in B-5.1.
    - See Macroevolution Patterns in B-5.4.
- B-5.6
    - Easy Comparison Data Charts: These data charts are formatted for easy comparison of Cytochrome C amino acid sequences. This resource goes with the Cytochrome C Comparison Lab in *Instructional Strategies* for B-5.6. This resource is available from http://www.indiana.edu/~ensiweb/lessons/molb.dat.pdf.
    - See The Making of the Fittest: Natural Selection and Adaptation in B-5.1.
    - See Macroevolution Patterns in B-5.4.
    - See Evidence for Evolution in B-5.5.
- B-5.7
    - Phylogenetic Trees: This video explains how scientists use evidence to construct phylogenetic trees. It also explains how to obtain information about species relatedness from these tree diagrams. This resource is available from https://www.youtube.com/watch?v=OYRYQ6YFsow.
    - Making Cladograms Activity: This activity allows student to interpret anatomical data to determine the phylogenetic relationships of different organisms. This resource provides a thorough breakdown of how interpretations of derived characteristics can be used to determine evolutionary relationships. An extension of this activity would be to allow students to development phylogenetic trees/cladograms for organisms not listed on this resource. This resource can be found at http://www.indiana.edu/~ensiweb/lessons/mclad.ws.pdf.

- See Evidence for Evolution in B-5.6.

- See Macroevolution Patterns in B-5.4.

Sample Formative Assessment Tasks/Questions

Additional sample formative assessment tasks/questions for grade bands are located at the end of each of the SEP Support Doc.
(http://ed.sc.gov/scdoe/assets/File/instruction/standards/Science/Support%20Documents/Complete_2014SEPsGuide_SupportDoc2_0.pdf)

- B-5.1
  - See The Problem with Antibiotic Products Investigation instructional strategy. This activity can be extended by having students transfer this knowledge to antibiotic usage, and then develop plans to reduce the development of resistant bacteria within the school or surrounding community.

  - Modern Day Giraffe: Students can be given a picture of the short necked ancestor of the giraffe; and using their understanding of vocabulary such as adaptation, natural selection, population, species, variation, etc., be asked to construct a plausible explanation of how the modern giraffe's body type has been selected for over time. This activity can be altered to begin with any other ancestral species (e.g. the multi-toed ancestor of the horse or the hippo-like ancestor of the whale).
- B-5.2
  - Sexual vs. Asexual Reproduction Venn Diagram: Have students complete a Venn diagram comparing and contrasting sexual and asexual reproduction, focusing on the evolutionary implications of each reproductive strategy.

  - Arguing for Continuity of Life: Provide students with a set of evidence that includes the following: *all living things have DNA or RNA and make proteins, the process for making proteins is the same in all living things, proteins are made from the same twenty amino acids in all living things, and the genetic code is essentially universal for all living things*. Using this evidence, have students construct an argument supporting the claim that genetic processes result in the continuity of life forms over time.
- B-5.3
  - Evaluating Adaptations: Provide students with various examples of adaptations of organisms in a specific environment. Have the students evaluate these adaptations for fitness based on their ability to help the organism survive to reproduce, then have students create a new adaptation and predict how that adaptation will or will not become more common over time and explain their prediction.

- Evaluating Population Fitness: Provide students with representations of sample populations of a real or hypothetical species that have differing amounts of variation. Students should then be given an environmental change (e.g. ice-age, global warming, new predator, extinction of food source, etc.) and asked to predict which population would most likely be able to survive the change based on the amount of variation present.

- B-5.4
  - Making and Breaking the Hardy Weinberg Assumptions: For each of the five assumptions for Hardy-Weinberg equilibrium, students should come up with an example of a real-world situation where a population would and would NOT meet that assumption and explain if their example population would be evolving or not.

  - Speciating a Population: Provide students with a sample hypothetical population containing some variations. Have students draw a reproductive barrier (e.g. a river) across the middle of their population and then explain how the resulting populations on each side of the river could evolve into new species.

  - Evaluating the 6th Mass Extinction: Have students research the current rate of extinction on planet Earth, then develop an argument whether or not the current extinction rate is consistent with gradual extinction or a sixth mass extinction.

  - See Modern Day Giraffe in B-5.1.

- B-5.5
  - Evolutionary Dossiers: The teacher would prepare a dossier of several different species. Each dossier should include several types of evolutionary evidence (e.g. gene/amino acid sequences, embryo diagrams, fossils, and/or highlighted homologous structures). The students would then use the dossiers to provide examples of evidence for the evolution of at least two different species from a common ancestor.
  - Analysis of Rock Strata: Students can be given various diagrams of fossils in sedimentary rock strata, and asked to discuss the similarities and differences between the species found at each level. Additionally, students can be asked to interpret evolutionary relationships, geological time, etc.
- B-5.6
  - See Evolutionary Dossiers in B-5.5: Have students use the dossiers and evidence inside to construct a phylogenetic tree of three to five different species. They should then support WHY they chose to place the relationships as they did using the evidence provided.

- B-5.7
    - Phylogenetic Tree Analysis: Present students with phylogenetic trees of varying groups of species. The students should use the phylogenetic trees to describe the evolutionary relationships present between species. The teacher can limit this activity by assigning each student/group a different set of species to analyze.
    - See Evolution Dossiers in B-5.6.

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