Biology, Quarter 4, Unit 4.1

Natural Selection: Genetics of Families and Populations

Overview

Number of instructional days: 12 (1 day = 53 minutes)

Content to be learned

- Explain how information is passed from parents to offspring by encoded molecules.
- Explain how the sorting and recombination of genes in sexual reproduction results in a great variety of possible gene combinations in the offspring of any two parents.

Processes to be used

- Use tools and technology.
- Interpret models, diagrams, charts, and narratives.
- Make inferences.
- Support claims with evidence.
- Predict outcomes.
- Use data and observations to make connections.

Essential questions

- How does genetics explain the frequency of characteristics observed in families and populations?
- What is the relationship between genetic variation resulting from sexual reproduction and natural selection?

Written Curriculum

Grade Span Expectations

LS3 - Groups of organisms show evidence of change over time (structures, behaviors, and biochemistry).

LS3 (9-11) INQ POC-7

Given a scenario, provide evidence that demonstrates how sexual reproduction results in a great variety of possible gene combinations and contributes to natural selection (e.g., Darwin's finches, isolation of a species, Tay Sach's disease).

LS3 (9-11) -7 Students demonstrate an understanding of Natural Selection/ evolution by…

7a investigating how information is passed from parents to offspring by encoded molecules (e.g. evidence from electrophoresis, DNA fingerprinting).

7b investigating how the sorting and recombination of genes in sexual reproduction results in a great variety of possible gene combinations in the offspring of any two parents. (e.g. manipulate models to represent and predict genotypes and phenotypes, Punnett Squares, probability activities).

Clarifying the Standards

Prior Learning

In grades K–4, students learned to identify similarities that are inherited from a biological parent. Students also learned that organisms have identifiable external features and that these features can vary.

In grades 5–6, students learned that genetic variations/traits of organisms are passed on through reproduction and random genetic changes. Students learned to observe, record, and compare differences in inherited traits.

In grades 7–8, students learned how to explain how traits affect an organism's ability to survive over time. Students explained how natural selection leads to evolution. They learned that reproduction is a fundamental process by which the new individual receives genetic information from parent(s). Students can trace a genetic characteristic through a given pedigree and can identify that the genetic material is located in the cell nucleus.

Current Learning

In this unit of study, students learn patterns of inheritance (punnett squares, pedigrees, autosomal dominance and recessiveness, sex-linkage, polygenes). In addition, they study the relationship between genetic change in populations and evolution. Examples include directional, stabilizing, and disruptive selection of specific phenotypes in a population.

Students are able to construct and interpret the results of punnett squares and determine the pattern of inheritance of a particular trait through analysis of pedigrees.

Students learn the connection between genes present in parents and offspring, and the frequency of specific phenotypes observed in families and populations. Analyses of patterns of inheritance found in

genetic diseases help students understand how natural selection can act on specific traits and may change the frequency of those traits in a population over time.

Teachers may introduce the Hardy-Weinberg Theorem, which provides a mathematical model for measuring changes in allele frequencies in populations.

Future Learning

Students who choose to take an advanced biology class will extend their understanding of changes in allele frequency to the concept of evolution.

Additional Research Findings

According to *Making Sense of Secondary Science*, half of the adult respondents studied knew that genes were responsible for similarities between parents and offspring, but one-third could not explain it.

Fifty-percent of 15-year-old students understood that inheritance and reproduction occurred together and 44 percent understood that offspring gets a mixture of features from both parents. Fourteen percent of 15-year-olds understood that sexual reproduction is a source of natural variation. Many students believed that females favor their mother's traits while sons favor their father's traits—and that male traits are stronger. Students rarely showed evidence of applying the concept of chance and probability to inheritance and evolution. Students were often confused about the difference between an individual's adaptations during its lifetime and inherited changes in a population over time. Most gave the Lamarckian interpretation that individuals can adapt to change in the environment if they need to, and that these adaptations are inherited (pp. 51–53).

Biology, Quarter 4, Unit 4.2

Evidence of Evolution

Overview

Number of instructional days: 14 (1 day = 53 minutes)

Content to be learned

- Recognize patterns in molecular and fossil evidence to provide a scientific explanation for natural selection and its evolutionary consequences.
- Analyze how organisms are organized into a hierarchy of groups and subgroups based on evolutionary relationships.
- Distinguish between microevolution and macroevolution.
- Explain how macroevolution accounts for speciation and extinction.
- Illustrate that when an environment changes, the survival advantage/disadvantage of some characteristics may change.
- Cite evidence of how natural selection and its evolutionary consequences provide a scientific explanation for the diversity and unity of past and present life forms on earth.

Processes to be used

- Use tools and technology.
- Interpret models, diagrams, charts, and narratives.
- Make inferences.
- Use supporting evidence to make claims.
- Predict outcomes.
- Use data and observations to make connections.

Essential questions

- What evidence indicates that evolution occurred?
- How does Darwin's Theory of Evolution by Natural Selection and its supporting evidence help explain the unity and diversity of life?
- What is the link between genetics and evolution?
- What is the role that genetic change plays in the process of evolution?

Written Curriculum

Grade Span Expectations

LS3 - Groups of organisms show evidence of change over time (structures, behaviors, and biochemistry).

LS3 (9-11) INQ FAF+POC -8

Given information about living or extinct organisms, cite evidence to explain the frequency of inherited characteristics of organisms in a population, OR explain the evolution of varied structures (with defined functions) that affected the organisms' survival in a specific environment (e.g., giraffe, wind pollination of flowers).

LS3 (9-11) -8 Students demonstrate an understanding of Natural Selection/ evolution by…

8a illustrating that when an environment changes, the survival advantage /disadvantage of some characteristics may change.

8b distinguish between microevolution (on small scale within a single population –e.g., change in gene frequency within a population) and macroevolution (on a scale that transcends boundaries of a single species – e.g., diversity of all beetle species within the order of insects) and explain how macroevolution accounts for speciation and extinction.

8c recognizing patterns in molecular and fossil evidence, to provide a scientific explanation for Natural Selection and its evolutionary consequences (e.g. survival, adaptation).

8d using data or models (charts, diagrams, table, narratives etc.) to analyze how organisms are organized into a hierarchy of groups and subgroups based on evolutionary relationships. (e.g. creating a taxonomic key to organize a given set of examples).

LS3 (9-11) INQ POC-7

Given a scenario, provide evidence that demonstrates how sexual reproduction results in a great variety of possible gene combinations and contributes to natural selection (e.g., Darwin's finches, isolation of a species, Tay Sach's disease).

LS3 (9-11) -7 Students demonstrate an understanding of Natural Selection/ evolution by…

7c citing evidence of how natural selection and its evolutionary consequences provide a scientific explanation for the diversity and unity of past and present life forms on Earth. (e.g. Galapagos Islands, Hawaiian Islands, Australia, geographic isolation, adaptive radiation).

Clarifying the Standards

Prior Learning

In grades K–4, students explored how plants and animals might respond to certain changes in their environment.

In grades 5–6, students learned how to use fossil evidence to explain the history of life on earth. Students explained how the traits of a population or species affect its ability to survive over time.

In grades 7–8, students learned that evolutionary histories are classified according to closely related traits. The also learned that genetic variations are passed on through reproduction and random genetic changes. They studied how natural selection leads to evolution. Students compared and contrasted embryonic development in various life forms and compared the patterns of human development after birth to life stages of other species. Students demonstrated an understanding of natural selection/evolution by explaining how natural selection leads to evolution.

Current Learning

Students learn the various types of evidence that support evolution theory, including relative (superposition of index fossils) and absolute dating (radioisotopes) of fossil evidence, anatomical comparisons of embryos and adult forms, nucleotide sequence homologies in common genes, amino acid sequence comparisons of common proteins, selective breeding (artificial selection), pesticide-resistant insect populations, and antibiotic-resistant strains of bacteria. Students differentiate between divergent and convergent evolution and between homologous and analogous structures.

Students compare and contrast Darwinian and Lamarckian theories on the mechanism of evolution and describe why the Darwinian theory best fits our understanding of genetics and best explains the unity and diversity of life on earth.

Students learn the higher taxonomic groupings of organisms, comparing the traditional five kingdoms, six kingdoms, and three domains of classification. Students expand their prior knowledge of natural selection and the major components of Darwin's theory, which include variation in a trait in a population, overproduction of offspring, one or more environmental factors that differentiate between more fit and less fit individuals, competition for limited resources, and increased reproductive success in the more fit individuals resulting in characteristic changes in a population over time (microevolution). Students describe the role of geographic isolation and isolation of gene pools in divergent evolution/adaptive radiation/speciation (macroevolution). Students explore the further isolating effects of geographic isolation including seasonal isolation, mechanical isolation, and behavioral isolation.

Students understand that, when an environment changes, the survival advantage/disadvantage of some characteristics may change. Students recognize variation in a population as necessary to avoid extinction in a changing environment. They analyze data and draw conclusions, cite claims, and defend claims using evidence. Students calculate the age of fossils based on radioisotope data. They predict how a population might evolve in response to selection pressures caused by changes in the environment. Students are required to integrate their understanding of genetics and ecology to provide an explanation for the evolution of biodiversity on earth.

Future Learning

This will be the final exposure to this content unless students choose to enroll in an advanced biology course.

Additional Research Findings

See the National Science Digital Library's science literary map (Strand map: The Living Environment / Natural Selection 9-12; <http://strandmaps.nsdl.org/?id=SMS-MAP-1437>) for the following research:

Even after some years of biology instruction, high school and college students have difficulty understanding the notion of natural selection. Students' inability to integrate two distinct evolutionary processes—the occurrence of new traits in a population and their effect on long-term survival—appear to be a major hindrance to understanding natural selection. Many students believe that environmental

conditions are responsible for changes in traits, that organisms develop new traits because they need them to survive, or that traits develop due to overuse or underuse of certain bodily organs or abilities. By contrast, students have little understanding that chance alone produces new heritable characteristics by forming new combinations of existing genes or by mutations of genes. Some students believe that a mutation modifies an individual's own form during its life rather than only its germ cells and offspring (see almost any science fiction movie). Students also misunderstand that changes to a population result from the survival and preferential reproduction of a few individuals, rather than from the gradual change of all individuals in the population. Explanations about "insects or germs becoming more resistant" rather than "more insects or germs becoming resistant" may reinforce these misunderstandings. Specially designed instruction can improve students' understanding of natural selection.

Middle school and high school students may have difficulty with the various uses of the word *adaptation*. In everyday usage, individuals adapt deliberately. But in the theory of natural selection, populations inadvertently change or adapt over generations. Students of all ages often believe that adaptations result from some overall purpose or design, or they describe adaptation as a conscious process to fulfill some need or want. Elementary and middle school students also tend to confuse noninherited adaptations acquired during an individual's lifetime with adaptive features inherited by a population.

See the National Science Digital Library's science literary map (Strand map: The Living Environment / Biological Evolution 9-12; <http://strandmaps.nsdl.org/?id=SMS-MAP-1430>) for the following research:

Some research suggests that students' understanding of evolution is related to their understanding of the nature of science and their general reasoning abilities. Findings indicate that poor reasoners tend to retain nonscientific beliefs such as "evolutionary change occurs as a result of need" because they fail to examine alternative hypotheses and their predicted consequences, and they fail to comprehend conflicting evidence. Thus, they are left with no alternative but to believe their initial intuitions or the misstatements they hear.

Students of all ages find it difficult to distinguish between a theory and the evidence for it, or between description of evidence and interpretation of evidence.

According to *Benchmarks for Science Literacy*, people usually do not reject evolution for scientific reasons, but because they dislike its implications, such as the relation of human beings to other animals, or because they prefer a biblical account of creation. Students do not have a clear understanding of the difference between acclimation and adaptation (p. 255).

Biology, Quarter 4, Unit 4.3

Review Options: Teacher Choice

Overview

Number of instructional days: TBD (following unit 4.2 until end of the year)

Content to be learned

Mandatory

- Successfully complete the end-of-year comprehensive course assessment (CCA).

Review Options

- Analyze and evaluate contemporary issues in biology.
- Write a short scientific paper (2–3 pages) using valid sources and modeling proper scientific citation.
- Develop concept maps of unifying themes in biology that show connections between the units of study over all four quarters.
- Do research and write a short paper on a scientist, including his/her research and contributions to a biological topic of study.
- Conduct enrichment activities related to previous units of study (i.e., mitosis – cancer, classification – animal taxonomy, etc.).
- Explore plant structure, reproduction, and uses in medicine/genetic engineering.
- Do case studies and guided learning

Processes to be used

- Collect data.
- Communicate understanding and ideas.
- Design, conduct, and critique investigations.
- Represent, analyze, and interpret data.
- Make observations and predictions.
- Question and hypothesize.
- Use evidence to draw conclusions.
- Use tools and techniques.

Essential questions

- What identifiable structures and characteristics allow for survival (organisms, populations, and species)?
- How does matter cycle and energy flow through an ecosystem?
- How do groups of organisms show evidence of change over time (structures, behaviors, and biochemistry)?
- In what ways are humans similar to other species?
- In what ways are humans unique among earth's life forms?

Written Curriculum

Current Learning

During this unit, all students will complete the performance portion of the end-of-year comprehensive course assessment (CCA). After completing work on the CCA, teachers will select from the list of review options to help students prepare for the objective portion of the end-of-year course assessment.