

NGSS Tools Work: HSLS-4 Biological Evolution: Unity and Diversity for A Study of Changes in Populations

HSLS42:

Construct an explanation based on evidence that the process of evolution primarily results from four factors: (1) the potential for a species to increase in number, (2) the heritable genetic variation of individuals in a species due to mutation and sexual reproduction, (3) competition for limited resources, and (4) the proliferation of those organisms that are better able to survive and reproduce in the environment.

Clarification Statement: Emphasis is on using evidence to explain the influence each of the four factors has on number of organisms, behaviors, morphology, or physiology in terms of ability to compete for limited resources and subsequent survival of individuals and adaptation of species. Examples of evidence could include mathematical models such as simple distribution graphs and proportional reasoning.

Assessment Boundary: Assessment does not include other mechanisms of evolution, such as genetic drift, gene flow through migration, and coevolution.

HS.LS4.B: Natural Selection

- Natural selection occurs only if there is both (1) variation in the genetic information between organisms in a population and (2) variation in the expression of that genetic information—that is, trait variation—that leads to differences in performance among individuals. (HSLS42), (HSLS43)
- The traits that positively affect survival are more likely to be reproduced, and thus are more common in the population. (HSLS43)

HS.LS4.C: Adaptation

- *Evolution Changes in the proportion of individuals with particular traits in a population* is a consequence of the interaction of four factors: (1) the potential for a species to increase in number, (2) the genetic variation of individuals in a species due to mutation and sexual reproduction, (3) competition for an environment's limited supply of the resources that individuals need in order to survive and reproduce, and (4) the ensuing proliferation of those organisms that are better able to survive and reproduce in that environment.(HSLS42)
- Natural selection leads to adaptation, that is, to a population dominated by organisms that are anatomically, behaviorally, and physiologically well suited to survive and reproduce in a specific environment. That is, the differential survival and reproduction of organisms in a population that have an advantageous heritable trait leads to an increase in the proportion of individuals in future generations that have the trait and to a decrease in the proportion of individuals that do not. (HSLS43), (HSLS44)
- Adaptation also means that the distribution of traits in a population can change when conditions change. (HSLS43)

Analyzing and Interpreting Data

Analyzing data in 9–12 builds on K–8 experiences and progresses to introducing more detailed statistical analysis, the comparison of data sets for consistency, and the use of models to generate and analyze data.

- Analyze data using tools, technologies, and/or models (e.g., computational, mathematical) in order to make valid and reliable scientific claims or determine an optimal design solution. (HSESS22)

Developing and Using Models

Modeling in 9–12 builds on K–8 experiences and progresses to using, synthesizing, and developing models to predict and show relationships among variables between systems and their components in the natural and designed world(s).

- Develop a model based on evidence to illustrate the relationships between systems or between components of a system. (HSESS26)
- Use a model to provide mechanistic accounts of phenomena. (HSESS24)

Constructing Explanations and Designing Solutions

Constructing explanations and designing solutions in 9–12 builds on K–8 experiences and progresses to explanations and designs that are supported by multiple and independent student generated sources of evidence consistent with scientific ideas, principles, and theories.

- Construct an explanation based on valid and reliable evidence obtained from a variety of sources (including students' own investigations, models, theories, simulations, peer review) and the assumption that theories and laws that describe the natural world operate today as they did in the past and will continue to do so in the future. (HSLS42), (HSLS44)

Engaging in Argument from Evidence

Engaging in argument from evidence in 9–12 builds on K–8 experiences and progresses to using appropriate and sufficient evidence and scientific reasoning to defend and critique claims and explanations about the natural and designed world(s). Arguments may also come from current scientific or historical episodes in science.

- Evaluate the evidence behind currently accepted explanations or solutions to determine the merits of arguments. (HSLS45)
- Make and defend a claim based on evidence about the natural world that reflects scientific knowledge, and student generated evidence. (HSLS32)
- Construct an oral and written argument or counterarguments based on data and evidence. (HSESS27)

Cause and Effect

- Empirical evidence is required to differentiate between cause and correlation and make claims about specific causes and effects. (HSLS42), (HSLS44), (HSLS45), (HSLS46)

Stability and Change

- Much of science deals with constructing explanations of how things change and how they remain stable. (HSESS16), (HSESS27)

A Study of Changes in Populations Unit

Grade 9-10 General Biology

Length of unit: Approximately 3 weeks

Six lesson unit

Unit Overarching Goal

Populations of organisms change over generational time (evolve) as a consequence of natural selection and adaptation due to the interaction of four factors: (1) the potential for a population (species) to increase in number, (2) variations in traits inherited from organisms' parents, (3) competition for an environment's limited supply of the resources that individuals need in order to survive and reproduce, and (4) the ensuing proliferation of those organisms that are better able to survive and reproduce in that environment.

Unit Central Question

What is the process that leads to changes in populations of organisms over time?

Lesson	Main Learning Goal	Focus Question	Science Content Storyline
1	Populations of organisms change over time (evolve) and there have been competing explanations of what causes populations to change.	What are possible explanations for how a population of organisms gains or loses characteristics?	Scientists offer different explanations of what causes populations of organisms to change overtime. Scientist 2 would explain the change in the freshwater stickleback population as the result of natural selection and Scientist 1 would explain the change based on inheritance of acquired traits.
2	Living populations change over time as organisms with heritable traits that are well suited to the environment are better able to survive and reproduce. This leads to an increase in the proportion of individuals in future generations that have the traits and to a decrease in the proportion of individuals that do not.	What would happen to a population if there were a change in the environment where the population lived?	Thinking consistent with Scientist 1 would indicate that changes to populations, like the stickleback population in Loberg Lake, would have occurred quickly when a parent "wanted" to change or needed to change and changed as an individual. Thinking consistent with Scientist 2 would predict that changes to stickleback population in Loberg Lake occur more slowly, and do not occur in an individual, but as a proportion of the overall population. In general, Darwin's ideas of natural selection seem better able to explain the changes that occurred to the stickleback population in Loberg Lake.
3	Darwin's idea of natural selection consists of four factors supported by evidence. The four factors are: 1. the potential for a species to increase in number, 2. organisms have variations in traits inherited from their parents, 3. competition for an environment's limited supply of the resources that individuals need in order to survive and reproduce, and 4. the ensuing proliferation of those organisms that are better able to survive and reproduce in that environment.	What evidence supports Darwin's (scientist 2's) idea of how populations change over time?	Evidence generated from studying the Loberg Lake stickleback population support Darwin's ideas of natural selection. Stickleback fish have many offspring, and not all offspring survive and/or reproduce (Factor 1). Variations exist within the stickleback body armor trait and this trait can be passed down from parents to offspring (Factor 2). Also, as time went on, a larger proportion of the stickleback population had the low body armor trait variation that helped them escape dragonfly predation. (Factor 4).

Lesson	Main Learning Goal	Focus Question	Science Content Storyline
4	The interaction of four factors of natural selection influences the changes that occur in populations of organisms.	Which of the four factors of natural selection is necessary to explain the changes we see in populations in nature over time?	The changes that occurred to the freshwater stickleback population in Loberg Lake can be explained using the four factors of natural selection. The loss of stickles and body armor that occurred in the stickleback population was a result of dragonfly larvae predation. Fish with low body armor were better able to escape predation and, thus, have a better chance of surviving and reproducing.
5	A change in a population is a consequence of the interaction of four factors: (1) the potential for a species to increase in number, (2) variations in traits inherited from organisms' parents, (3) competition for an environment's limited supply of the resources that individuals need in order to survive and reproduce, and (4) the ensuing proliferation of those organisms that are better able to survive and reproduce in that environment.	What causes populations of organisms to change over time? How can an explanation of what happened to the population help people predict what might happen in the future?	Knowledge of Darwin's four factors of natural selection coupled with data that were gathered and observed in previous lessons can be used to thoughtfully explain how the Loberg Lake fish population changed over time. Certain data can provide evidence for a claim concerning the fish population, and the four factors of natural selection can be used to strengthen the overall argument by supporting a line of reasoning that links the evidence to the claim.
6	The factors of natural selection that explain the changes in one population are generalizable and can be used to explain changes in other populations.	What causes populations of organisms to change over time?	The medium ground finch population on the Galápagos Island of Daphne Major changed due to natural selection. The drought that occurred on the island in 1977 drastically decreased the amount of available food for the medium ground finch population. Finches with larger beaks were better able to compete for food by their ability to expose and eat seeds that were encased in hard, thorny seed pods. Finches with smaller beaks were not as successful in accessing seeds encased in these hard seed pods. Consequently, medium ground finches with larger beaks were much more likely to survive, reproduce, and pass on the larger beak trait to their offspring.