

This text is taken from the Framework starting on page 6-15. It states the overall topic and then divides this topic into four subtopics. For each subtopic content is divided up into portions that are believed to be best taught in different grade bands. These bands entail what information needs to be taught by the end of that grade level. In a hurry? Read the conclusion.

IDEA LS4: BIOLOGICAL EVOLUTION: UNITY AND DIVERSITY

How can there be so many similarities among organisms yet so many different kinds of plants, animals, and microorganisms? How does biodiversity affect humans?

Biological evolution explains both the unity and the diversity of species and provides a unifying principle for the history and diversity of life on Earth [8]. Biological evolution is supported by extensive scientific evidence ranging from the fossil record to genetic relationships among species. Researchers continue to use new and different techniques, including DNA and protein sequence analyses, to test and further their understanding of evolutionary relationships. Evolution, which is continuous and ongoing, occurs when natural selection acts on the genetic variation in a population and changes the distribution of traits in that population gradually over multiple generations or more rapidly after sudden changes in conditions, which can lead to the extinction of species. Through natural selection, traits that provide an individual with an advantage to best meet the challenges in their environment and reproduce are the ones most likely to be passed on to the next generation. Over multiple generations, this process can lead to the emergence of new species. Evolution thus explains both the similarities of genetic material across all species and the multitude of species existing in diverse conditions on Earth—its biodiversity—which humans depend on for natural resources and other benefits to sustain themselves.

LS4.A: Evidence of Common Ancestry and Diversity

What evidence shows that different species are related?

Biological evolution, the process by which all living things have evolved over many generations from shared ancestors, explains both the unity and the diversity of species. The unity is illustrated by similarities found across

all species; it can be explained from the inheritance of similar characteristics from similar ancestors. The diversity of species is also consistent with common ancestry; it is explained by the branching and diversification of lineages as populations adapted, primarily through natural selection, to local circumstances. Evidence for common ancestry can be found in the fossil record, from comparative anatomy, from comparative embryology, and from the similarities of cellular processes and structures and of DNA across all species. The understanding of evolutionary relationships has recently been greatly accelerated by molecular biology, especially as applied to developmental biology, with researchers investigating the genetic basis of some of the changes seen in the fossil record, as well as those that can be inferred to link living species (e.g., the armadillo) to their ancestors (e.g., glyptodonts, a kind of extinct gigantic armadillo).

Grade Band Endpoints for LS4.A

By the end of grade 2. Some kinds of plants and animals that once lived on Earth (e.g., dinosaurs) are no longer found anywhere, although others now living (e.g., lizards) resemble them in some ways.

By the end of grade 5. Fossils provide evidence about the types of organisms (both visible and microscopic) that lived long ago and also about the nature of their environments. Fossils can be compared with one another and to living organisms according to their similarities and differences.

By the end of grade 8. Fossils are mineral replacements, preserved remains, or traces of organisms that lived in the past. Thousands of layers of sedimentary rock not only provide evidence of the history of Earth itself but also of changes in organisms whose fossil remains have been found in those layers. The collection of fossils and their placement in chronological order (e.g., through the location of the sedimentary layers in which they are found or through radioactive dating) is known as the fossil record. It documents the existence, diversity, extinction, and change of many life forms throughout the history of life on Earth. Because of the conditions necessary for their preservation, not all types of organisms that existed in the past have left fossils that can be retrieved. Anatomical similarities and differences between various organisms living today and between them and organisms in the fossil record enable the reconstruction of evolutionary history and the inference of lines of evolutionary descent. Comparison of the embryological

development of different species also reveals similarities that show relationships not evident in the fully formed anatomy.

By the end of grade 12. Genetic information, like the fossil record, also provides evidence of evolution. DNA sequences vary among species, but there are many overlaps and common features; the ongoing branching that produces multiple lines of descent can be inferred from the DNA composition of organisms. Such information is also derivable from the similarities and differences in amino acid sequences and from anatomical and embryological evidence.

LS4.B: Natural Selection

How does genetic variation among organisms affect survival and reproduction?

Genetic variation in a species results in individuals with a range of traits. In any particular environment individuals with particular traits may be more likely than others to survive and produce offspring. This process is called natural selection and may lead to the predominance of certain inherited traits in a population and the suppression of others. Natural selection occurs only if there is variation in the genetic information within a population that is expressed in traits that lead to differences in survival and reproductive ability among individuals under specific environmental conditions. If the trait differences do not affect reproductive success, then natural selection will not favor one trait over others.

Grade Band Endpoints for LS4.B

By the end of grade 2. Intentionally left blank.

By the end of grade 5. Sometimes the differences in characteristics between individuals of the same species provide advantages in surviving, finding mates, and reproducing.

By the end of grade 8. Genetic variations among individuals in a population give some individuals an advantage in surviving and reproducing in their environment. This is known as natural selection. It leads to the predominance of certain traits in a population and the suppression of others. In *artificial* selection, humans have the capacity to influence certain

characteristics of organisms by selective breeding. One can choose desired parental traits determined by genes, which are then passed on to offspring.

By the end of grade 12. 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. The traits which positively affect survival are more likely to be reproduced and thus are more common in the population.

LS4.C: Adaptation

How does the environment influence populations of organisms over multiple generations?

When an environment changes, there can be subsequent shifts in its supply of resources or in the physical and biological challenges it imposes. Some individuals in a population may have morphological, physiological, or behavioral traits that provide a reproductive advantage in the face of the shifts in the environment. Natural selection provides a mechanism for species to adapt to changes in their environment. The resulting selective pressures influence the survival and reproduction of organisms over many generations and can change the distribution of traits in the population. This process is called adaptation. Adaptation can lead to organisms that are better suited for their environment because individuals with the traits adaptive to the environmental change pass those traits on to their offspring, whereas individuals with traits that are less adaptive produce fewer or no offspring. Over time, adaptation can lead to the formation of new species. In some cases, however, traits that are adaptive to the changed environment do not exist in the population and the species becomes extinct. Adaptive changes due to natural selection, as well as the net result of speciation minus extinction, have strongly contributed to the planet's biodiversity. Adaptation by natural selection is ongoing. For example it is seen in the emergence of antibiotic-resistant bacteria. Such species as bacteria, in which multiple generations occur over shorter time spans, evolve more rapidly than those for which each generation takes multiple years.

Grade Band Endpoints for LS4.C

By the end of grade 2. Living things can survive only where their needs are met. If some places are too hot or too cold or have too little water or food, plants and animals may not be able to live there.

By the end of grade 5. Changes in an organism's habitat are sometimes beneficial to it and sometimes harmful. For any particular environment, some kinds of organisms survive well, some survive less well, and some cannot survive at all.

By the end of grade 8. Adaptation by natural selection acting over generations is one important process by which species change over time in response to changes in environmental conditions. Traits that support successful survival and reproduction in the new environment become more common; those that do not become less common. Thus, the distribution of traits in a population changes. In separated populations with different conditions, the changes can be large enough that the populations, provided they remain separated (a process called reproductive isolation), evolve to become separate species.

By the end of grade 12. Natural selection is the result 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. 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. Adaptation also means that the distribution of traits in a population can change when conditions change. Changes in the physical environment, whether naturally occurring or human-induced, have thus contributed to the expansion of some species, the emergence of new distinct species as populations diverge under different conditions, and the decline—and sometimes the extinction—of some species. Species become extinct because they can no longer survive and reproduce in their altered environment. If members cannot adjust to change that is too fast or too drastic, the opportunity for the species' evolution is lost.

LS4.D: Biodiversity and Humans

What is biodiversity, how do humans affect it, and how does it affect humans?

Human beings are part of and depend on the natural world. Biodiversity—the multiplicity of genes, species, and ecosystems—provides humans with renewable resources, such as foods, medicines, and clean water. Humans also benefit from “ecosystem services,” such as climate stabilization, decomposition of wastes, and pollination that are provided by healthy (i.e., diverse and resilient) ecosystems. The resources of biological communities can be used within sustainable limits, but in many cases humans affect these ecosystems in ways—including habitat destruction, pollution of air and water, overexploitation of resources, introduction of invasive species, and climate change—that prevent the sustainable use of resources and lead to ecosystem degradation, species extinction, and the loss of valuable ecosystem services.

Grade Band Endpoints for LS4.D

By the end of grade 2. There are many different kinds of living things in any area, and they exist in different places on land and in water.

By the end of grade 5. Scientists have identified and classified many plants and animals. Populations of organisms live in a variety of habitats, and change in those habitats affects the organisms living there. Humans, like all other organisms, obtain living and nonliving resources from their environments.

By the end of grade 8. Biodiversity is the wide range of existing life forms that have adapted to the variety of conditions on Earth, from terrestrial to marine ecosystems. Biodiversity includes genetic variation within a species, in addition to species variation in different habitats and ecosystem types (e.g., forests, grasslands, wetlands). Changes in biodiversity can influence humans’ resources, such as food, energy, and medicines, as well as ecosystem services that humans rely on—for example, water purification and recycling.

By the end of grade 12. Biodiversity results from the formation of new species (speciation) minus the loss of species (extinction). Biological extinction, being irreversible, is a critical factor in reducing the planet's natural capital. Humans depend on the living world for the resources and other benefits provided by biodiversity. But human activity is also having adverse impacts on biodiversity through overpopulation, overexploitation, habitat destruction, pollution, introduction of invasive species, and climate change. These problems have the potential to cause a major wave of biological extinctions—as many species or populations of a given species, unable to survive in changed environments, die out—and the effects may be harmful to humans and other living things. Thus sustaining biodiversity so that ecosystem functioning and productivity are maintained is essential to supporting and enhancing life on Earth. And sustaining biodiversity so that landscapes of recreational or inspirational value are preserved is essential to supporting and enhancing human life.

Conclusion

By not challenging this material you agree to the following: There is no need for God. The Bible is not true. Evolution explains everything in science. Science has given the real answers to mankind. Evolution has been proven true. All living things came by evolution. Humans came from a common ancestor with the apes. Recent discoveries in science show this is a fact. Rock layers show long periods of time. DNA provides clear evidence of Evolution. Natural selection and mutations caused evolution. Climate change has been caused by humans. Science will eventually find solutions to all problems. Do you want your children and grandchildren taught these things?