Name_____ Date_____

TEKS 3.B.7.A Biology

BIOLOGICAL EVOLUTION AND CLASSIFICATION

The student will demonstrate an understanding of the theory of biological evolution and the hierarchical classification of organisms.

(B.7) **Science concepts.** The student knows evolutionary theory is a scientific explanation for the unity and diversity of life. The student is expected to (A) analyze and evaluate how evidence of common ancestry among groups is provided by the fossil record, biogeography, and homologies, including anatomical, molecular, and developmental;

STANDARD REVIEW

Evidence that supports the theory of evolution by natural selection comes from a variety of science fields. For example, earth science has contributed evidence in support of evolution through studies of fossils and biogeography. Biology provides evidence of evolution through analyses of anatomical and developmental similarities and differences among organisms. Chemistry also provides evidence in support of evolution through analysis of biological molecules.

Fossils, the preserved remains or traces of past organisms, offer the most direct evidence that evolution occurs. Fossils have enabled scientists to learn about the sizes and physical structures of Earth's past organisms while also providing clues about the behaviors and diets of some organisms. The locations in which fossils are discovered also provide scientists with data about when in Earth's history a particular organism lived, where it lived, and what the conditions in its environment may have been like. By organizing similar fossils by age, scientists have been able to assemble a partial fossil record of Earth's organisms. Although incomplete, this record enables scientists to observe an orderly change in species over time.

Biogeography, the study of the distribution of Earth's organisms, relies on studies of both fossils and living organisms. Studies in this area help to explain how geographic barriers that separate a population may enable natural selection to favor traits that allow some members of the separated population to successfully live and reproduce in a new environment.

Similarities in the physical structures and developing embryos of organisms also provide scientists with evidence of evolution. For example, the similarities of structures in different vertebrates provide evidence that all vertebrates share a common ancestor. Scientists also use similarities in the sequence of stages and characteristics of developing embryos as evidence of a shared evolutionary history in organisms.

Analysis of biological molecules also provides scientists with evidence of shared ancestry among organisms. For example scientists analyze and evaluate protein and DNA sequences of organisms to determine evolutionary relationships because differences in amino acid sequences and nucleotide sequences in DNA are greater between species that are more distantly related than between species that are more closely related.

Name_____ Date_____

TEKS 3.B.7.B Biology

BIOLOGICAL EVOLUTION AND CLASSIFICATION

The student will demonstrate an understanding of the theory of biological evolution and the hierarchical classification of organisms.

(B.7) **Science concepts.** The student knows evolutionary theory is a scientific explanation for the unity and diversity of life. The student is expected to (B) analyze and evaluate scientific explanations concerning any data of sudden appearance, stasis, and sequential nature of groups in the fossil record;

STANDARD REVIEW

Paleontologists have long noticed a repeating pattern in the history of life, reflected in the fossil record. Bursts of evolutionary activity are followed by long periods of stability. This pattern is described by the theory of **punctuated equilibrium,** which states that episodes of speciation occur suddenly in geologic time and are followed by long periods of little evolutionary change. Niles Eldredge and Stephen Jay Gould originally proposed this theory in 1972. It was written as a revision of Darwin's idea that new species arise through gradual transformations of ancestral species. It is important to note that the theory of punctuated equilibrium offers a revised explanation for the rate of speciation, but still involves Darwinian natural selection.

The diversification of one ancestral species into many descendent species is called **adaptive radiation.** These descendent species are usually adapted to a wide range of environments. One example of adaptive radiation is the evolution of mammals following the mass extinction at the end of the Cretaceous period 65 million years ago.

Although mammals had evolved for about 150 million years before the end of the Cretaceous period, they barely resembled the mammals we know today. The earliest mammals were tiny, usually insect eaters, and mostly nocturnal. These characteristics allowed them to coexist with the dinosaurs. The extinction of the dinosaurs left environments full of opportunities for other types of animals. In the first 10 million years following the dinosaurs' extinction, more than 4000 mammal species had evolved, including whales, bats, rodents, and primates.

Name_____ Date_____

TEKS 3.B.7.C Biology

BIOLOGICAL EVOLUTION AND CLASSIFICATION

The student will demonstrate an understanding of the theory of biological evolution and the hierarchical classification of organisms.

(B.7) **Science concepts.** The student knows evolutionary theory is a scientific explanation for the unity and diversity of life. The student is expected to (C) analyze and evaluate how natural selection produces change in populations, not individuals;

STANDARD REVIEW

Natural selection is the process by which organisms that are better adapted to their environment survive and reproduce more successfully than less well adapted organisms. For natural selection to occur, a population must have genetic variation. The genetic variation of a population is a measure of how much individuals in a population differ genetically. Genetic variation is important for the survival of a species. Populations with a low genetic variation are less likely than populations with a high genetic variation to adapt to changes in their environment.

Individuals in a population often have different traits, but the individuals themselves don't evolve. Which traits are favorable depends on environmental factors. Environmental factors are the conditions in an environment that affect the organisms that live there. Different environments have different environmental factors. For example, organisms that live in a desert need to be able to survive in an area that receives little water. Individuals with traits beneficial to survival in a desert environment have a greater chance of living long enough to reproduce and pass these traits to their offspring. Natural selection produces changes at the population level, not at the individual level. Over time, these traits will become more frequent in the population.

Name_____ Date_____

TEKS 3.B.7.D **Biology**

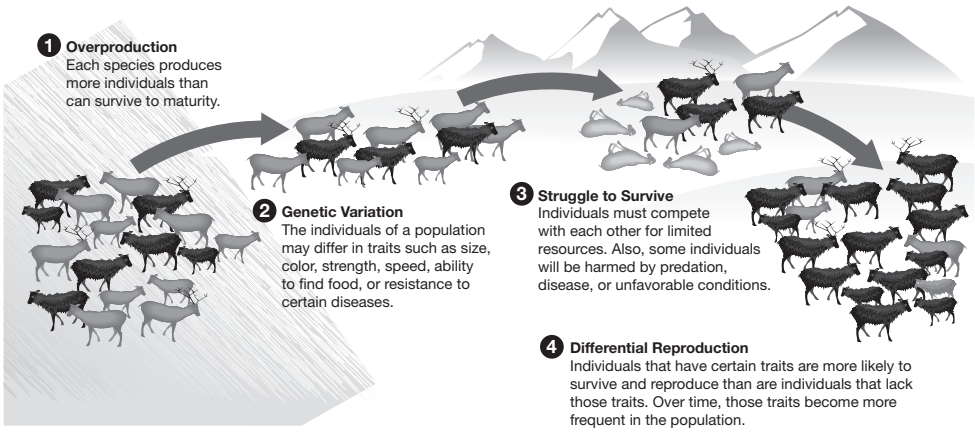
BIOLOGICAL EVOLUTION AND CLASSIFICATION

The student will demonstrate an understanding of the theory of biological evolution and the hierarchical classification of organisms.

(B.7) **Science concepts.** The student knows evolutionary theory is a scientific explanation for the unity and diversity of life. The student is expected to (D) analyze and evaluate how the elements of natural selection, including inherited variation, the potential of a population to produce more offspring than can survive, and a finite supply of environmental resources, result in differential reproductive success;

STANDARD REVIEW

Evolution is a change in the characteristics of a population from one generation to the next. Darwin proposed that evolution happened due to natural selection. Natural selection is the process by which individuals that have favorable variations and are better adapted to their environment survive and reproduce more successfully than less well adapted individuals. Over many generations, natural selection can result in the evolution of new species, which is called speciation. The diagram below shows how natural selection changes populations.



Name_____ Date_____

TEKS 3.B.7.E Biology

BIOLOGICAL EVOLUTION AND CLASSIFICATION

The student will demonstrate an understanding of the theory of biological evolution and the hierarchical classification of organisms.

(B.7) **Science concepts.** The student knows evolutionary theory is a scientific explanation for the unity and diversity of life. The student is expected to (E) analyze and evaluate the relationship of natural selection to adaptation and to the development of diversity in and among species;

STANDARD REVIEW

The heart of Darwin's theory of evolution is that natural selection is the mechanism that drives the development of adaptations and evolution. The process of natural selection is driven by four important points that are true for all real populations:

1. All populations have genetic variation. That is, in any population there is an array of individuals that differ slightly from each other in genetic makeup. While this may be obvious in humans, it is also true in species whose members may appear identical, such as a species of bacteria.
2. The environment presents challenges to successful reproduction. Naturally, an organism that does not survive to reproduce or whose offspring die before the offspring can reproduce does not pass on its genes to future generations.
3. Individuals tend to produce more offspring than the environment can support. Thus, individuals of a population often compete with one another to survive.
4. Individuals that are better able to cope with the challenges presented by their environment tend to leave more offspring than those individuals less suited to the environment.

Separate populations of a single species often live in several different kinds of environments. In each environment, natural selection acts on the population. Natural selection results in the evolution of offspring that are better adapted to that environment. If their environments differ enough, separate populations of the same species can become very dissimilar. Over time, populations of the same species that differ genetically because of adaptations to different living conditions become what biologists call subspecies. The members of newly formed subspecies have taken the first step toward speciation. Eventually, the subspecies may become so different that they can no longer interbreed successfully. Biologists then consider them separate species.

Name_____ Date_____

TEKS 3.B.7.F Biology

BIOLOGICAL EVOLUTION AND CLASSIFICATION

The student will demonstrate an understanding of the theory of biological evolution and the hierarchical classification of organisms.

(B.7) **Science concepts.** The student knows evolutionary theory is a scientific explanation for the unity and diversity of life. The student is expected to (F) analyze and evaluate the effects of other evolutionary mechanisms, including genetic drift, gene flow, mutation, and recombination;

STANDARD REVIEW

Natural selection is a mechanism by which on average, those individuals that have inherited beneficial adaptations survive and produce more offspring than other individuals. Natural selection can lead to microevolution, the observable change in the allele frequencies of a population over time. In addition to natural selection, other mechanisms of microevolution include genetic variation through mutation and recombination, genetic drift, and gene flow.

Genetic variation is stored in a population's gene pool. A gene pool is the combined alleles of all the individuals in a population. Two major sources of genetic variation are mutation and recombination in sexual reproduction. A mutation is a random change in the DNA of a gene. Some mutations affect a single gene, while others affect entire chromosomes. Mutations can occur during DNA replication, meiosis, or as a result of environmental factors. Mutations that occur in reproductive cells can be passed on to offspring, increasing genetic variation in the gene pool.

Recombination in sexual reproduction is a process in which new allele combinations form in offspring. During meiosis, each gamete that is produced contains a different combination of alleles. For example, in humans, there are 23 pairs of chromosomes, with each chromosome containing dozens to thousands of different genes. Also during meiosis, some chromosomes randomly swap pieces of DNA, further increasing the number of possible allele combinations.

In small populations, the frequency of an allele can be impacted by a chance event. For example, a fire or landslide can reduce a large population to a few survivors. When an allele is found in only a few individuals in a population, the loss of even one individual can have major effects on the allele's frequency. Genetic drift is change in allele frequencies due to chance. Genetic drift results in a loss of genetic variation in a population's gene pool.

Gene flow is the movement of alleles from one population to another. Gene flow occurs because new individuals (immigrants) add alleles to a population's gene pool and departing individuals (emigrants) take alleles away. This movement of alleles increases the genetic variation within a population.

Name_____ Date_____

TEKS 3.B.7.G Biology

BIOLOGICAL EVOLUTION AND CLASSIFICATION

The student will demonstrate an understanding of the theory of biological evolution and the hierarchical classification of organisms.

(B.7) **Science concepts.** The student knows evolutionary theory is a scientific explanation for the unity and diversity of life. The student is expected to (G) analyze and evaluate scientific explanations concerning the complexity of the cell.

STANDARD REVIEW

The evolution of single-celled organisms from organic molecules was an important event in the history of life that changed Earth's environment. Based on the fossil record, scientists hypothesize that eukaryotic cells evolved about 1.5 billion years ago. Eukaryotic cells differ from prokaryotic cells in that eukaryotic cells have membrane-bound organelles, including a nucleus, and prokaryotic cells do not. There are several theories that describe how eukaryotic cells evolved from prokaryotic cells.

The *endosymbiont theory* is the idea that mitochondria and chloroplasts were once simple prokaryotic cells that were engulfed by larger prokaryotic cells. Instead of being digested, the engulfed prokaryotic cells began to live inside the larger prokaryotic cells where they performed either cellular respiration (mitochondria) or photosynthesis (chloroplasts). Endosymbiosis is a relationship in which one organism lives within the body of another, and both organisms benefit. In this case, the larger prokaryotic cell received energy in the form of ATP or food in the form of sugars, while the smaller prokaryotic cell received nutrients and a stable environment. In the 1970s, the biologist Lynn Margulis brought attention to this theory by providing the following evidence in support of it.

- Mitochondria and chloroplasts have their own DNA and ribosomes.
- Like prokaryotes, DNA found in mitochondria and chloroplasts is in the form of a circle; and the gene structures of mitochondria and chloroplasts are similar to prokaryotes.
- Mitochondria and chloroplasts are able to copy themselves within cells.
- Mitochondria and chloroplasts are similar in size and structure to prokaryotic cells.

The *autogenous theory* states that the organelles in eukaryotic cells evolved from infoldings of the plasma membrane found in a prokaryotic ancestor. These infoldings produced pockets that eventually separated into distinct structures that contained nucleic acids and ribosomes. Over time, these separate structures became specialized, increasing the complexity of the cell. Those structures that performed photosynthesis became chloroplasts and those structures that performed cellular respiration became mitochondria. The botanist F.J.R. Taylor proposed this theory in 1976 based on the infolding of internal membranes present in chloroplasts and mitochondria today.

Name_____ Date_____

TEKS 3.B.7.G Biology

The *horizontal gene transfer theory* states that the horizontal transfer of genes (HTG) among early cells led to the development of more complex cell structures. This theory was proposed by biologist Carl Woese in 2002, who also is known for establishing the three major domains used today in classification. His research suggested that the genetic makeup of early cells was highly fluid, and that at least three cell types (eukaryotic), bacteria (prokaryotic), and archaea (prokaryotic) evolved parallel to each other at a point in time when natural selection began to act on distinctly separate gene pools. He further based his theory on the fact that HTG continues today among prokaryotes through the reproductive process of conjugation.

Name_____ Date_____

TEKS 3.B.8.A Biology

BIOLOGICAL EVOLUTION AND CLASSIFICATION

The student will demonstrate an understanding of the theory of biological evolution and the hierarchical classification of organisms.

(B.8) **Science concepts.** The student knows that taxonomy is a branching classification based on the shared characteristics of organisms and can change as new discoveries are made. The student is expected to (A) define taxonomy and recognize the importance of a standardized taxonomic system to the scientific community;

STANDARD REVIEW

More than 2,000 years ago, the Greek philosopher and naturalist Aristotle grouped plants and animals according to their structural similarities. Later Greeks and Romans grouped plants and animals into basic categories such as oaks, dogs, and horses. Eventually each unit of classification came to be called a *genus* (plural, *genera*), the Latin word for "group." Starting in the Middle Ages, genera were named in Latin. The science of naming and classifying organisms is called taxonomy.

Until the mid-1700s, biologists named a particular type of organism by adding descriptive phrases to the name of the genus. These phrases sometimes consisted of 12 or more Latin words. They were called polynomials (from *poly*, meaning "many," and *nomen*, meaning "name"). For example, the European honeybee once had a 12-part scientific name: *Apis pubescens, thorace subgriseo, abdomine fusco, pedibus posticis glabis, untrinque margine ciliatus.* As you can see, the polynomial became very large and awkward. Polynomials were often changed by biologists, so organisms were rarely known to everyone by the same name.

A simpler system for naming organisms was developed by the Swedish biologist Carolus Linnaeus. Linnaeus used a two-word Latin name for each species. Linnaeus's two-word system for naming organisms is called binomial nomenclature (from *bi*, meaning "two"). His two-part name for the European honeybee was *Apis mellifera*, the genus name followed by a single descriptive word. This unique two-part name for a species is now referred to as its scientific name.

Linnaeus worked out a broad system of classification for plants and animals in which an organism's form and structure are the basis for arranging specimens in a collection. The genera and species that he described were later organized into a ranked system of groups that increase in inclusiveness. The different groups into which organisms are classified have expanded since Linnaeus's time and now consist of eight levels: domain, kingdom, phylum, class, order, family, genus, and species.

Name_____ Date_____

TEKS 3.B.8.B **Biology**

BIOLOGICAL EVOLUTION AND CLASSIFICATION

The student will demonstrate an understanding of the theory of biological evolution and the hierarchical classification of organisms.

(B.8) **Science concepts.** The student knows that taxonomy is a branching classification based on the shared characteristics of organisms and can change as new discoveries are made. The student is expected to (B) categorize organisms using a hierarchical classification system based on similarities and differences shared among groups;

STANDARD REVIEW

Modern classification of living things is based on a system developed by the Swedish biologist Carolus Linnaeus. It is organized into a ranked system of groups that increase in inclusiveness. Similar genera are grouped into a family. Similar families are combined into an order. Orders with common properties are united in a class. Classes with similar characteristics are assigned to a phylum. Similar phyla are collected into a kingdom. Similar kingdoms are grouped into domains. All living things are grouped into one of three domains. Two domains, Archaea and Bacteria, are each composed of a single kingdom of prokaryotes. The third domain, Eukarya, contains all four kingdoms of eukaryotes.

Linnaeus's classification system was based on his observation that organisms have different degrees of similarity. For instance, a tiger resembles a gorilla more closely than either resembles a fish. According to Darwin's views, organisms that are more similar to one another than they are to other organisms have descended from a more recent common ancestor. Therefore, classification based on similarities should reflect an organism's phylogeny, that is, its evolutionary history. Inferring evolutionary connections from similarities, however, can be misleading. Not all features—or characters—are inherited from a common ancestor. Consider the wings of a bird and the wings of an insect. Both enable flight, but the structures of the two kinds of wings differ.

Most biologists today analyze evolutionary relationships using cladistics. Cladistics is a method of analysis that reconstructs phylogenies by inferring relationships based on shared characters. Cladistics can be used to hypothesize the sequence in which different groups of organisms evolved. To do this, cladistics focuses on the nature of the characters in different groups of organisms.

Name_____ Date_____

TEKS 3.B.8.C Biology

BIOLOGICAL EVOLUTION AND CLASSIFICATION

The student will demonstrate an understanding of the theory of biological evolution and the hierarchical classification of organisms.

(B.8) **Science concepts.** The student knows that taxonomy is a branching classification based on the shared characteristics of organisms and can change as new discoveries are made. The student is expected to (C) compare characteristics of taxonomic groups, including archaea, bacteria, protists, fungi, plants, and animals.

STANDARD REVIEW

For many decades, scientists recognized two basic forms of life, prokaryotes and eukaryotes. Then, scientists showed that the group of prokaryotes that make up the kingdom Archaea are more closely related to eukaryotes than they are to the other kingdom of prokaryotes, Bacteria. Thus, now living things are classified into three domains.

The domain thought to be the oldest is Bacteria, which is composed of the organisms in the kingdom Bacteria. Archaea is the second prokaryotic domain and is also composed of a single kingdom, Archaea. A third domain, Eukarya, contains all four of the eukaryotic kingdoms: Animalia (animals), Fungi (fungi), Plantae (plants), and Protista (protists). The table below summarizes the major characteristics of the organisms in the six kingdoms and three domains.

Domain and Kingdom Characteristics

Domain	Kingdom	Characteristics				
		Cell type	Cell structure	Body type	Nutrition	Example
Bacteria	Bacteria	Prokaryotic	Cell wall, peptidoglycan	Unicellular	Autotrophic and heterotrophic	Enterobacteria Spirochetes
Archaea	Archaea	Prokaryotic	Cell wall, no peptidoglycan	Unicellular	Autotrophic and heterotrophic	Methanogens
Eukarya	Protista	Eukaryotic	Mixed	Unicellular and multicellular	Autotrophic and heterotrophic	Amoebas Euglenas Kelps
Eukarya	Fungi	Eukaryotic	Cell wall, chitin	Unicellular and multicellular	Heterotrophic	Yeasts Mushrooms
Eukarya	Plantae	Eukaryotic	Cell wall, cellulose	Multicellular	Autotrophic	Ferns Pine trees
Eukarya	Animalia	Eukaryotic	No cell wall	Multicellular	Heterotrophic	Birds Earthworms