Lesson Title: Life As We Know It

Grade Level: 9-12

Time Allotment: 3 45-minute class periods

Overview

Where did life on Earth come from, and how did it become what it is today? Students will explore the answer to that question in this lesson on evolution. The lesson begins with an overview of the history of evolutionary theory, and then takes students on a tour of three billion years of life on the planet using an online interactive timeline. Students will learn, using video segments from the PBS series *The Human Spark*, how modern humans evolved from our earliest primate ancestors. As a culminating activity, students will examine some of the factors that continue to contribute to the evolution of new species and life on Earth.

Media Resources

***The Human Spark*,** selected segments

Links in the Evolutionary Chain

An exploration of some of the different characteristics that distinguish different branches of the hominid "family tree," such as brain and face size, ability to make tools, and location.

Human Nature

A look at the ways in which monkeys and apes are similar to humans, not just biologically but mentally and socially

Websites:

Evolution: Change: Deep Time

(http://www.pbs.org/wgbh/evolution/change/deeptime/index.html)

This interactive timeline from the PBS series NOVA's extensive *Evolution* website shows geological and biological milestones on Earth starting 4.5 billion years ago.

Objectives

Students will be able to:

- Explain the history of evolutionary theory, and the theory of natural selection as developed by Charles Darwin;
- Identify milestones in the evolution of life on Earth over the past 3.8 billion years;
- Compare and contrast characteristics of modern humans with early human and primate ancestors, and analyze how this may have affected our evolutionary path;

- Define the terms *genetic drift*, *speciation*, *biodiversity*, and *extinction*, and discuss how these factors contribute to the evolution of species.

Standards

National Science Education Standards

Life Science

Content Standard C

BIOLOGICAL EVOLUTION

[See Unifying Concepts and Processes]

- Species evolve over time. Evolution is the consequence of the interactions of (1) the potential for a species to increase its numbers, (2) the genetic variability of offspring due to mutation and recombination of genes, (3) a finite supply of the resources required for life, and (4) the ensuring selection by the environment of those offspring better able to survive and leave offspring.
- The great diversity of organisms is the result of more than 3.5 billion years of evolution that has filled every available niche with life forms.
- Natural selection and its evolutionary consequences provide a scientific explanation for the fossil record of ancient life forms, as well as for the striking molecular similarities observed among the diverse species of living organisms.
- The millions of different species of plants, animals, and microorganisms that live on earth today are related by descent from common ancestors.
- Biological classifications are based on how organisms are related. Organisms are classified into a hierarchy of groups and subgroups based on similarities which reflect their evolutionary relationships. Species is the most fundamental unit of classification.

Before the Lesson/Prep for Teachers

Prior to teaching this lesson, you will need to:

Preview all of the video segments and websites used in the lesson.

Download the video clips used in the lesson to your classroom computer(s) or prepare to watch them using your classroom's Internet connection.

Bookmark all websites that you plan to use in the lesson on each computer in your classroom. Using a social bookmarking tool such as delicious.com or diigo (www.diigo.com) (or an online bookmarking utility such as portaportal) will allow you to organize all the links in a central location.

Prepare all classroom materials. Print out and make copies of the "Deep Time Milestones" student organizer for each student in your class.

a. Prepare for the Gallery Walk activity by writing the following questions at the top of flip chart pages or large pieces of paper (one question per page): Genetic Drift: When a new population is established by a very small number of individuals from a larger population there tends to be a lack of genetic variation. This is called the Founder Effect. What are some of the disadvantages to this lack of variation?
b. Speciation: It is speculated that the *Homo heidelbergensis* population split – some moving to Europe and evolving into Neanderthals, others remaining in Africa to become *Homo sapiens*. What type of speciation is this, and what effect did it have on the human population?
c. Biodiversity: During the Cretaceous period, biodiversity levels were high. Mammals, dinosaurs, birds, marine creatures, and plant life flourished all over the planet. Then, a massive meteor impact 65 million years ago wiped out 60 – 80% of all species on the planet. Why did some survive and not others?
d. Extinction: The most recent large scale extinction event, the Holocene, includes many plants and animals but most notably large mammals and rainforest species. Many believe that humans are largely responsible for these extinctions. Do you feel that humans have contributed to extinctions over the past 10,000 years? Why or why not?
e. Natural selection: Survival isn't always based on physical fitness, but on the way our brains work. Things like social skills, language, and technological capability may have been what allowed us to dominate over our ancestors. What skills do we have that our earlier or primate ancestors didn't, and why might they have been passed down to younger generations?

Post the flip chart pages around the room prior to the Culminating Activity. If you are not familiar with conducting a "Gallery Walk" in your classroom, review the procedure at the "How to Use Gallery Walk?" Web page.

Introductory Activity

1. Ask students what they know about the history of the theory of evolution. (*Most likely answers will be about Charles Darwin; accept all answers.*) Explain that while Charles Darwin is best known for his work on the theory of evolution by natural selection,

scholars and scientists had been devoting thought to the subject for hundreds if not thousands of years. For much of history, many scientists were bound by religious teachings, and so when they did develop theories about origins of life on earth they were in the context of the Bible or other spiritual doctrines, which constrained the way they were able to perceive the natural world. As scientific knowledge increased, and modern understandings of things like the age of the earth and structure of cells, scientists were able to develop more complex theories.

2. One of the first scientists to contribute to our modern understanding of life systems was Carolus Linnaeus. Alive in the 18th century, Linnaeus named species using the classification system we use today – the "binomial" system, consisting of a genus and species name (like *Homo sapiens*). He also developed the nested hierarchy of Kingdom, Phylum, Class, Order, Family, Genus, and Species for classifying organisms. Linnaeus's groupings were based on shared physical characteristics, but Darwin would later use these classifications for organisms sharing genetic characteristics and evolutionary lines as well.
3. One of the next major theories was put forward at the turn of the 19th century by a scientist named Jean-Baptiste Lamarck. Lamarck believed not only that organisms acquired the characteristics of their ancestors, but that any characteristic an organism acquired during its lifetime it would pass down to its offspring (Mom gets a tattoo on her arm, baby is born with a tattoo on its arm). He also theorized that organisms developed characteristics that were particularly useful to them and lost ones that weren't (for example, giraffes have long necks from consistently stretching to reach fruit in tall trees). Some of his ideas were eventually incorporated into Darwin's theory. One of the scientists whose work challenged key elements of Lamarck's theory was Gregor Mendel, a monk whose experiments breeding pea plants in the 19th century led to important early discoveries about heredity, genetics, and inheritance. He discovered that dominant and recessive genes account for which traits are passed down from generation to generation.
4. The most famous name in evolution theory, Charles Darwin, became a household name with the publication of his book *On the Origin of Species by Means of Natural Selection* in 1859. He presented this theory (along with fellow scientist Alfred Russell Wallace, who arrived at an almost-identical theory independently) to the Linnaean Society of London, positing that all species descended over time from a common ancestor, and that organisms with traits favoring survival and reproduction are more likely to have offspring and pass those traits on to future generations. Darwin avoided discussing human evolution in detail in *On the Origin of Species*, giving it only a fleeting mention. While many scientists and individuals embraced these new theories, not everyone was ready to

accept the idea that all life on earth, including human beings, may have evolved from a single cell billions of years ago.

Learning Activity 1

1. Tell students that since almost the beginning of Earth's history, life has been growing, evolving, and changing in new and different ways. Where did the first life come from? Many scientists believe that the first life on earth developed through a process known as abiogenesis, meaning biological life developing from inorganic matter – most likely from amino acids that organized themselves into proteins, over 3.5 billion years ago.
2. As we can see, a lot has changed on the planet in the nearly 4 billion years since the first single-celled organism emerged. Several factors and natural forces have affected the variety of flora and fauna we see around us today. Tell students that they are going to learn about the evolution of life on earth using an online activity. Direct students to the Deep Time interactive. Depending on how many computers are available, students can do the activity individually, in pairs, or in small groups.
3. Distribute the "Deep Time Student Organizer" to each student in the class. Ask students to click through the interactive, read the accompanying text, and fill in the appropriate information for each section of the organizer. Give students approximately 20 – 30 minutes to complete the activity. When students have completed the activity and organizers, review answers with the class. Ask students if they saw any trends as they moved through the timeline. Were there any correlations between the evolution of plant life and the evolution of animal life? Were there any correlations between the levels of diversity between species and the extinction events? Engage in discussion with students about the amount of time that passes during the milestones on the timeline – how can 10 million years feel like the blink of an eye?
4. Remind students that although we tend to focus on the "human" part of evolution, life on Earth was around for a very long time before humans arrived. Based on where they ended the timeline in the interactive (mammals, dinosaurs, birds, flowering plants), how do they think life made the jump to humans? (*Accept all answers*). Tell students that in the next activity they are going to learn more about the next stage of evolution of life – how we got here.

Learning Activity 2

1. Remind students that when Charles Darwin published his famous work *On the Origin of Species* he barely touched upon the idea of human evolution. It wasn't until his 1871 book

The Descent of Man that he directly argues human beings, like all other organisms, were descended from a common ancestor. While this theory remains controversial to some, it is widely accepted by most scientists that modern humans descent from primates that first appeared (having evolved from other mammals) approximately 60 million years ago.

2. Modern humans belong to the biological family Hominidae, commonly known as the Great Apes. This includes orangutans, gorillas, bonobos, and chimpanzees, and we last shared a common ancestor with these other hominoids approximately 14 million years ago. Scientists think that by looking at these "relatives" today, it can tell us things about how we evolved the way we did. Tell students that you are going to show them a video clip with different scientists explaining different hominoids' behavior. Ask students, as they watch the clip, to observe which behavioral characteristics are similar to modern human behavior patterns. Play clip "Human Nature." Follow up with students by reviewing the focus question. Which characteristics were similar? Which were different? (*Similar traits include monkeys' and chimps' tendencies to think about where people are looking, their awareness of the minds of others, social scheming and political behavior. The differences in behavior are that humans can apply the awareness of others' minds more broadly than monkeys and chimps, they are capable of more complicated thought processes, they are more capable of manipulation, and have greater social skills.*) Ask students, how might these traits have aided humans in the evolutionary process?
3. The earliest humans are thought to have branched off from our closest hominoid relative, chimpanzees, between five and seven million years ago. Following that divergence, several species of human ancestors – now extinct – populated Africa and parts of Asia and Europe. Like other life on Earth, these species survived and perished based on their skills, characteristics, changing environmental conditions, and competition from other species. Tell students you are going to show them another video clip, this one about our human ancestors. Ask students, as they watch the clip, to note the evolution of early humans' toolmaking skills. Play clip "Links in the Evolutionary Chain." When clip is finished, review focus question with students. How and when did early humans first develop the skills to make stone tools? How was this skill beneficial to them? How did this skill evolve over time – if at all? (*As early humans evolved their brains grew larger, and approximately 1.6 million years ago they first started to make stone hand axes. The design of these stone tools did not change for approximately one million years – no "natural selection" process applied to the tool, as it was adequate for their needs.*) Ask students, what might have ultimately encouraged humans to change or adapt their toolmaking skills and abilities?

4. Presently, modern humans – *Homo sapiens* – are the only species of humans existing on earth. Give students this writing prompt, and 10 – 15 minutes of free writing time: Do you think we have evolved to be the dominant species on the planet? Why or why not? When time is up, ask students to share their responses and discuss with the class.

Culminating Activity

1. Tell students that there is more to the process of evolution than just natural selection. There are several trends and phenomena that contribute to the evolution of life on Earth, some of which they have already encountered in the earlier lesson activities. Explain that in addition to natural selection, you'll be discussion genetic drift, speciation, biodiversity, and extinction.
2. Review definitions of the terms listed below. You can project these on a screen for the class, or print them for each student.
    a. Genetic Drift: the change in frequency of a particular gene variant (trait) in a population due to completely random sampling. Genetic drift can cause two separate populations that began with the same genetic structure to completely diverge. The effect of genetic drift is larger in small populations and smaller in large populations.
    b. Speciation: the process by which new species arise. There are four types of natural speciation: allopatric (population splits into two geographically isolated groups), peripatric (peripheral groups are prevented from interacting with the main population), paripatric (partial separation of two diverging populations), sympatric (species diverge while inhabiting the same place). Natural or man-made barriers creating isolated population groups lead to reproductive isolation.
    c. Biodiversity/Genetic diversity: the degree of variation of life forms within an ecosystem or on a whole planet. Genetic diversity is crucial to a species survival and ability to adapt. Slight gene variations are necessary to produce changes in organisms that will enable them to adapt. This is crucial to a species' ability to evolve. Similarly, an ecosystem or planet with a great level of biodiversity has the potential for a greater number of species to survive through environmental changes.
    d. Extinction: the end of an organism, group of organisms, or species. A species becomes extinct when it is no longer able to reproduce or survive due to changing conditions or competition with superior organisms. A typical species becomes extinct within ten million years of its first appearance, and it is estimated that 99.9% of all species that have ever existed are now extinct.

e. Natural selection: the process by which genes and traits that aid survival and reproduction are passed down through generations. Popularly known as "survival of the fittest," where "fitness" is the potential for survival. Individuals with greater fitness are more likely to contribute offspring to the next generation.

3. Post the following questions on chart paper around the room:
   a. Genetic Drift: When a new population is established by a very small number of individuals from a larger population there tends to be a lack of genetic variation. This is called the Founder Effect. What are some of the disadvantages to this lack of variation?
   b. Speciation: It is speculated that the *Homo heidelbergensis* population split – some moving to Europe and evolving into Neanderthals, others remaining in Africa to become *Homo sapiens*. What type of speciation is this, and what effect did it have on the human population?
   c. Biodiversity: During the Cretaceous period, biodiversity levels were high. Mammals, dinosaurs, birds, marine creatures, and plant life flourished all over the planet. Then, a massive meteor impact 65 million years ago wiped out 60 – 80% of all species on the planet. Why did some survive and not others?
   d. Extinction: The most recent large scale extinction event, the Holocene, includes many plants and animals but most notably large mammals and rainforest species. Many believe that humans are largely responsible for these extinctions. Do you feel that humans have contributed to extinctions over the past 10,000 years? Why or why not?
   e. Natural selection: Survival isn't always based on physical fitness, but on the way our brains work. Things like social skills, language, and technological capability may have been what allowed us to dominate over our ancestors. What skills do we have that our earlier or primate ancestors didn't, and why might they have been passed down to younger generations?

   Divide class into groups for the Gallery Walk activity (about 4 -5 students to a group, more if the class is larger). Assign one group to each of the five questions. Give the class 5 – 7 minutes to work in their groups and discuss their answers. One member of the group should write the answer on the flip chart page. Rotate the groups every 5 – 7 minutes until each group has had a change to discuss and write answers for each question. The activity should take approximately 25 – 35 minutes.
4. When the students have completed the activity, review the questions with the class and ask each group to report out on at least one answer. Encourage discussion among the students.

Name:_____ Date:_____

Deep Time Milestones

Use the timeline bar at the top to navigate through the different eons and eras of earth's history. Click on the names of the eras, and the circles, triangle, and squares on the timeline to learn more information.

Each of the biological events or life forms on this sheet appears in the "Transformation" section of the timeline. For each one, note the approximate timeframe it first appeared on earth, basic information about it, any effects from surrounding geological and/or extinction events, and any relevant information about the period, era, or eon.

I. PRECAMBRIAN EON

First Evidence of Life: _____

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Bacteria Diversify: _____

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First Eukaryotes: _____

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True Algae: _____

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II. PALEOZOIC ERA

The Cambrian Explosion:

Land plants:

Arthropods on land:

Reptiles:

III. MESOZOIC ERA

Mammals:

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Dinosaurs: _____

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Birds: _____

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Flowering plants: _____

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Click on the square for the "End Cretaceous" extinction event, and read the text. The Earth has now changed in significant ways. What changes are to come in the next and most recent stage of Earth's history, the Cenozoic era?

Deep Time Milestones (Answer Key)

Use the timeline bar at the top to navigate through the different eons and eras of earth's history. Click on the names of the eras, and the circles, triangle, and squares on the timeline to learn more information.

Each of the biological events or life forms on this sheet appears in the "Transformation" section of the timeline. For each one, note the approximate timeframe it first appeared on earth, basic information about it, any effects from surrounding geological and/or extinction events, and any relevant information about the period, era, or eon.

NOTE: This answer key should be used as a guideline or departure point for discussion only rather than a grading key. Student answers will likely vary from the answers shown here; it is acceptable for students to write more, less, or slightly different answers than the ones shown here. It is recommended that educators review the website before conducting the activity with students to determine acceptable answers.

I. PRECAMBRIAN EON

First Evidence of Life: ___3,850 million years ago in what is now SW Greenland. Carbon isotope ratios, signifying life, found in volcanic and sedimentary rock. At the end of the Hadean era, which was uninhabitable.___

Bacteria Diversify: _____3,800 mya. Bacteria reproduce through fission, show staggering diversity, lateral transfer of genetic information. Beginning of Archaean era, very little or no oxygen in atmosphere. Bacterial formations known as stromatolites form, first continents form.___

First Eukaryotes: ____2,500 mya. First eukaryotes evolve from free living bacteria inside host bacteria, carry out cellular respiration. More oxygen being produced in oceans at the end of Archaean/beginning or Proterozoic eras._____

True Algae: _____1,200 mya. Multicellular algae fossils found. Biodiversity greatly increasing from eukaryote ancestors. Rodinia supercontinent forms. In Proterozoic era oxygen collects in oceans and atmosphere. Soft-bodied animals evolve and then are scarce. Extinction event at the end of era.___

II. PALEOZOIC ERA

The Cambrian Explosion: __530 mya. Basic body plans of major animal phyla – including all existing today – are established. Land is still devoid of life during Cambrian period. Animals with hard-shelled bodies, chordates, and marine reefs emerge around this time. 2 extinction events at the end of the Cambrian wipe out 40-50% of marine genera.__

Land plants: ____480 mya. Green algae likely washed ashore, evolve shallow root systems, occupy freshwater areas. In Ordovician period species exhibit greater diversity than Cambrian. Plants adapt to open air living. Catastrophic extinction wipes out 70% of marine species at end of era.__

Arthropods on land: __420 mya. First animals to adapt to land, ultralight body and spindly, strong legs. This is when great mountain ranges are starting to form on earth. On the cusp of the Silurian and Devonian periods, the climate is warm and stable.__

Reptiles: ____350 mya, early reptiles are similar to amphibians but share similarities with later reptiles as well, first amniotes, complete the evolution of life from water to land. The Carboniferous period is hot and humid in the north, cold in the couth. Large plants and animals flourish. Coal is formed from carbon-rich organic matter.__

III. MESOZOIC ERA

Mammals: __220 mya, mammal-like reptiles evolve into true mammals and possess several traits exhibited by reptilian ancestors, earliest are rodent-like, nocturnal, and solitary. Triassic period follows a near-complete extinction of life at the end of the Permian period, critical for land vertebrates.__

Dinosaurs: ___220 mya, emerge following extinction eliminating mammal-like reptiles. Reign spans 150 million years. In Jurassic era dinosaurs range in size, in Cretaceous they dominate the landscape, disappearing with mass extinction approximately 65 mya.__

Birds: _____
__150 mya, evolved directly from small feathered dinosaurs but without a breastbone or a beak at first.
_____
_____
_____

Flowering plants: ____130 mya, angiosperms use color and scent to attract pollinating insects. They become the dominating plant life on land. Evolution of angiosperms and pollinating insects is connected – bees, ants, and butterflies also thrive.__

Click on the square for the "End Cretaceous" extinction event, and read the text. The Earth has now changed in significant ways. What changes are to come in the next and most recent stage of Earth's history, the Cenozoic era?