

Unit 4: Evolution and Classification

Module 10: Evolution

NC Essential Standard:

- 3.4 Explain the theory of natural selection as a mechanism for how species change over time.



Doesn't evolution mean that men came from monkeys?

NO, NO, NO!!! Evolution, simply defined, means CHANGE over time.

We can look at evolution in 2 ways:

- MACROEVOLUTION – how do new species originate
- MICROEVOLUTION – how do species change over time

Scientific consensus is that microevolution is a fact – species change over time. Scientists believe that these small changes can lead to bigger changes and the eventual development of new species – macroevolution.

I. How could life have begun on a lifeless Earth?

A. Abiogenesis / Spontaneous Generation

Abiogenesis =

Gases then =

Gases now =

1. **Abiogenesis** is the idea that life came from _____ material. This idea is sometimes called **spontaneous generation**.
2. The environment of the early Earth may have provided a unique set of conditions that allowed _____ to occur. Researchers now believe that the early atmosphere may have been similar to the vapors given off by modern volcanoes: _____ (note the absence of free atmospheric oxygen).

What was found in the "primordial soup"?

- a. Oparin developed a theory to explain the development of life on earth. His theory hypothesized that due to the chemicals in the atmosphere, the lack of free oxygen, and intense energy from lightening and volcanoes, _____
_____. At this time in earth's history the earth was covered by water. Therefore, this essential first step in the development of life must have occurred in the oceans. This supports the idea that life originated as a "**primordial soup**" in the _____.
- b. Miller and Urey designed an experiment to test Oparin's "primordial soup" hypothesis. They were able to successfully mimic the proposed conditions of early earth in the laboratory. Up to 4% of the carbon was converted to _____ (the building blocks of proteins). This experiment has been replicated numerous times.

B. Biogenesis

- 1. Once life was established in very simple cells, biogenesis began. **Biogenesis** is the _____
_____. For a long time people believed that non-living material could produce living things (spontaneous generation). For example, it was a common belief that fish arose from the mud in the bottom of a river.
 - a. Francesco Redi set out to _____ the theory of spontaneous generation/abiogenesis. He developed a _____ to test his hypothesis that life must come from life (biogenesis).

Abiogenesis	Biogenesis

Redi's Experiment:

	Control Group	Experimental Group
Independent Variable		
Constant	Rotting meat	Rotting meat
Observations	Flies entered jars, landing on the meat	Flies were unable to enter the jar
Results	Maggots developed on meat	No maggots developed on meat
Conclusions		

- b. After the development of the microscope and thus the discovery of microorganisms, Redi's work was called into question. Did the microscopic organisms come from a _____ in the air or did biogenesis hold true at all levels?
- c. Louis Pasteur designed an experiment to disprove spontaneous generation for _____.

Pasteur's Experiment:

Experimental Group	
Control Group	
Conclusion	

vilenski.org/.../historyoflife/pasteur.html

C. The evolution of cells

**Evolution of prokaryotic cells
(heterotroph hypothesis)**

- 1.
- 2.
- 3.


**The effect of
photosynthetic cells:**

- 1.
- 2.

1. Based on the conditions proven by Miller and Urey, scientists developed the **heterotroph hypothesis** to explain the evolution of _____.
 - a. The first cells would have been prokaryotic (no nucleus), _____ (does not require oxygen), and _____ (must take in nutrients). Prokaryotic, heterotrophic cells are the simplest cells and therefore most likely to evolve first. The lack of free atmospheric oxygen would have required an anaerobic cell.
 - b. Over time _____ prokaryotic cells evolved, allowing for the release of free _____. This profoundly changed earth's environment and led to the development of an ozone layer.
 - c. The production of oxygen led to conditions that favored the evolution of _____, prokaryotic cells.
2. Based on the idea of biogenesis and current research in

1. What is abiogenesis?

2. What were the conditions of the early atmosphere?

3. What  s are credited with developing and supporting the theory of th _____ on early Earth?

4. What is biogenesis?

5. What two scientists disproved spontaneous generation using controlled experiments?

6. What does the heterotroph hypothesis explain?

7. What does the endosymbiont hypothesis explain?



II. How did all of life on Earth come from a few cells?

A. Theory of Evolution

1. _____ is credited with developing the theory of evolution, but there were many people that contributed ideas upon which he built his own. Darwin also developed his ideas based on his travels as the ship naturalist on the H.M.S. Beagle. Of particular interest to Darwin were the animals of the Galapagos Islands.
2. In 1859, Darwin and Alfred Wallace jointly proposed that _____ by a process of **natural selection**. The theory can be described as a process:



Steps of Natural Selection

- 1.
- 2.
- 3.
- 4.

A body-builder's large muscles would NOT be an adaptation because....

- a. **Variation** of traits within the population leads to different _____. Some variations are better suited to the current conditions of the environment.
 - b. **Overproduction** in populations leads to _____ for limited resources (food, for example).
 - c. **Natural selection** favors the _____ phenotype at the time. This does not necessarily mean that those struggling die, but will be in a poorer condition.
 - d. The **survival** (or better success) **of the best adapted** individuals leads to _____. The variations will be passed on to the offspring. Over time, if the environment does not change, those favorable variations will be seen more frequently in the population because nature has "selected" that trait.
3. Central to the theory of natural selection is the idea of adaptations. An **adaptation** is any _____ that suits an organism to its natural function in the environment (its niche). There are three basic types of adaptations:
- a. Examples of _____ adaptations are defensive structures, camouflage, and mimicry. Typically, _____ occurs when a harmless species (mountain king snake) resembles a harmful species (coral snake) using coloration.
 - b. Examples of _____ adaptations are herding, schooling, and growling
 - c. Examples of _____ adaptations are enzymes, oxygen-binding of hemoglobin, and sight.

Check Yourself!

1. Who is credited with developing the theory of natural selection?
2. List the four steps in the process of natural selection.
3. What is an adaptation?



B. Mechanisms of Evolution

1. Individuals don't evolve; _____. The population is the smallest unit of evolution because acquired traits in an individual cannot be passed on (inherited by offspring). However, different traits already present in a population can be "_____", changing the population.
2. Evolution occurs when the **gene pool** (all of the genes of a population) changes. A change in genotype may lead to a change in phenotype. _____.
 - a. **Mutations** are _____ and may lead to a new phenotype. Mutations provide the _____ for evolution – diversity. For example, a mutation causing white fur in Arctic foxes may lead to better camouflage in winter.
 - b. The environment also plays a key role in evolution. _____ are nature's "**selection forces**" that act upon the phenotype ranges caused by genes. There are three basic patterns by which natural selection occurs:



<p>Mutations → _____ in _____ → change in _____</p>

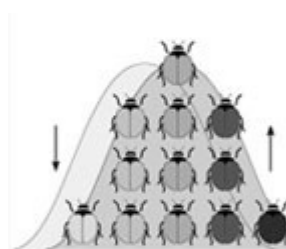
Three types of Natural Selection:

- 1.
- 2.
- 3.

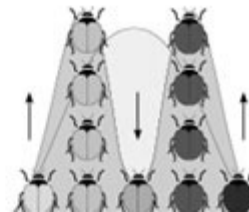
- i. **Stabilizing selection** favors the “_____” phenotype in a population.



- ii. **Directional selection** favors _____ of the “typical” distribution.



- iii. **Disruptive Selection** favors _____ of the “typical” distribution.



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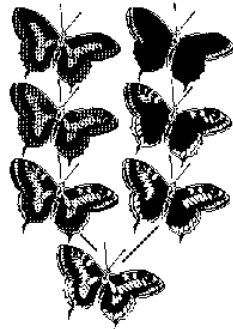
3. **Speciation** is the _____. A species is defined as a group of organisms that can _____. Speciation occurs when a population is separated, usually due to a _____, and natural selection changes the population so much the two groups could no longer interbreed. Therefore, **geographic isolation** leads to **reproductive isolation**.

Geographic isolation is related to speciation because...

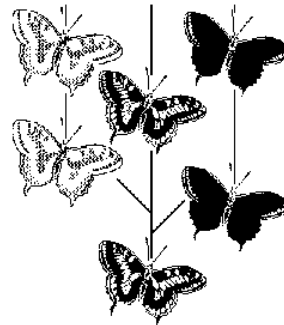
C. Timeframes of evolution differ based on the environment and the population. The fossil record provides evidence for two rates of speciation:

Venn Diagram: (Gradualism vs. Puntuated Equilibrium)

1. **Gradualism** describes speciation that occurs over a _____ due to the accumulation of small changes.
2. **Punctuated equilibrium** describes speciation that occurs in _____ that may be separated by 1000's of years of stability. The primary stimulus is environmental change.



gradualism



punctuated equilibrium

abyss.uoregon.edu/.../lectures/lec09.html

Check Yourself!

1. Why can't individuals evolve?
2. What provides the raw material for evolution?
3. What are the three types of natural selection?
4. What is speciation?
5. What condition leads to reproductive isolation?
6. Name the two time frames for speciation.



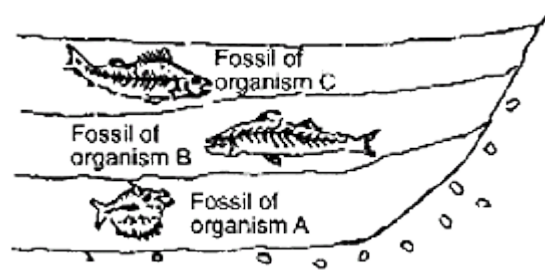
D. Evidence for Evolution

1. Fossil evidence provides an _____ of early life.

Fossils can include any evidence of life, such as imprints and remains of organisms. This evidence must be interpreted to form an overall picture of how species have changed over time (evolved). By examining the fossil record, scientists have concluded that evolution happens in a _____ pattern and life emerged from sea to land. Fossils must be dated to help establish a time frame for the existence of a species. There are two methods of determining the age of fossils.

- a. In **relative dating** the exact age of the fossil cannot be determined, only the order of appearance as _____ found in nearby rocks. Fossils occur in layers of sedimentary rock. The fossils near the top will be _____ than fossils in lower layers of rock.

Explanation of the fossil diagram:



www.ekcsk12.org/science/regbio/evolutionqz1.html

- b. **Radioactive dating** gives a more _____ using the natural decay of radioactive isotopes in organisms.



2. **Biochemical similarities** include comparisons of DNA and the resulting _____ for certain shared proteins. This is considered one of the _____ and objective types of evidence used to determine evolutionary relationships. In general, the _____ found between two species, the _____ the evolutionary relationship.

Explanation of the amino acid sequence diagram:

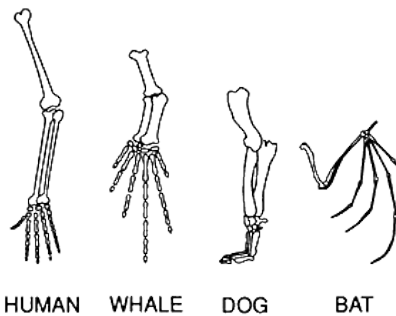
Species	Sequence of Amino Acids in the Same Part of the Hemoglobin Molecules
Human	Lys-Glu-His-Iso
Horse	Arg-Lys-His-Lys
Gorilla	Lys-Glu-His-Lys
Chimpanzee	Lys-Glu-His-Iso
Zebra	Arg-Lys-His-Arg

www.ekcsk12.org/science/regbio/evolutionqz1.html

3. Shared **anatomical structures** supports some type of evolutionary relationship.

a. Structures with a _____ are called **homologous** structures. A similar bone arrangement, even if the functions are different, supports evolution from a _____.

Explanation of the bone diagram:



www.ekcsk12.org/science/regbio/evolutionqz1.html

Example of vestigial structure:

- b. Structures that perform the same function (ex. flying) but are very different anatomically (ex. bird wing vs. butterfly wing) are called **analogous** structures. This supports evolution in _____ though not from a recent common ancestor.
- c. **Vestigial** structures (ex. appendix or tail bone in human) are _____ in that organism, but may represent a link to a previous ancestor.

Check Yourself!

1. Name the two methods by which fossils may be dated.
2. How do biochemical similarities support the theory of evolution?
3. What does similar bone structure (even if the function is different) suggest about two species?



- III. Does evolution still happen today?
- A. As long as variation, overproduction, competition, natural selection and mutations occur, evolution will occur. Because evolution leading to speciation happens over such a long period of time, _____.
- B. Natural selection, one of the main mechanisms of evolution, is observable in some populations. For example, the evolution of **resistance** to _____:
1. Farmers use _____ to eliminate insects. In a population of insects, some individuals will possess _____ to certain chemicals. When the chemicals are applied, the individuals with genetic immunity will _____, passing this resistance to the next

generation of offspring. Over time, more individuals are born with this immunity, rendering the pesticide useless.

2. _____ are drugs that fight bacterial infections. Within any population there is genetic variation. In the case of antibiotic resistance, some bacteria are genetically more _____ to the antibiotic than other bacteria. If the amount of antibiotic delivered is too low or the full course not completed, only those least resistant will die. The surviving, _____. With future applications of antibiotics the population is selected to become more and more resistant. The overuse of antibiotics has led to many resistant strains of bacteria.

Definition of antibiotic resistance:

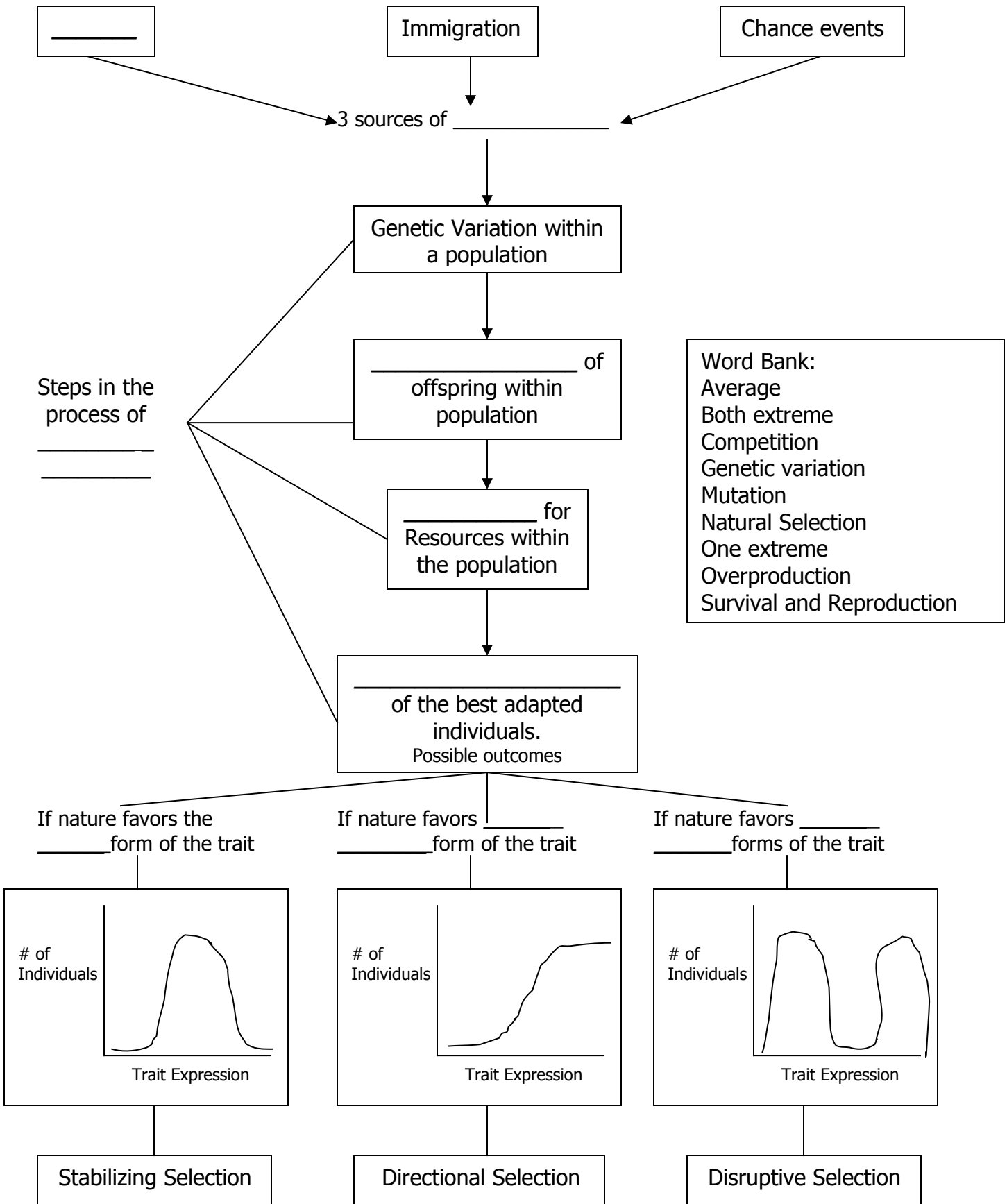
CAUSE of resistance:

EFFECT of resistance:

Check Yourself!

1. What is a pesticide?
2. Why do some insects become resistant to pesticides?
3. What is an antibiotic?
4. What has led to the many resistant strains of bacteria?

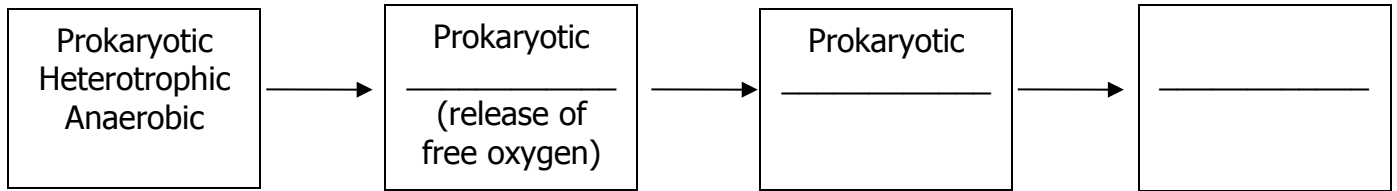




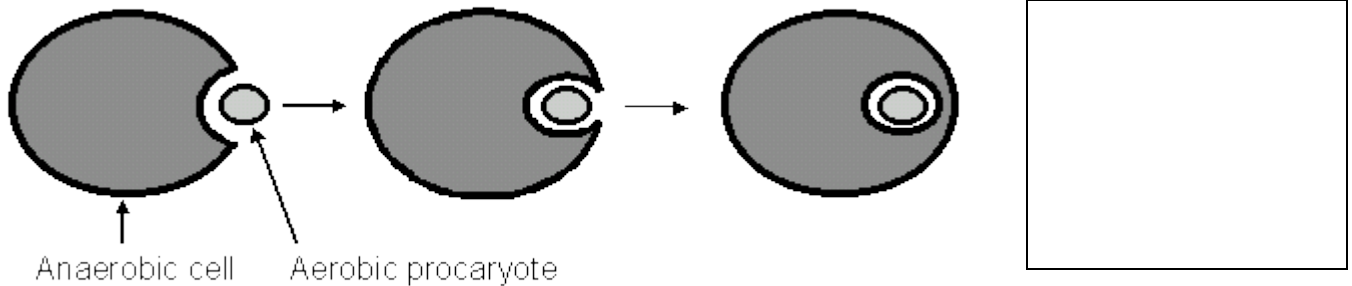
**Unit 4 / Module 10
Problem-Solving Set**

1. An explanation for the evolution of the first cells is called the Heterotroph Hypothesis. Literally translated, heterotroph means *other feeder*. What does this tell us about how the earliest cells obtained food?

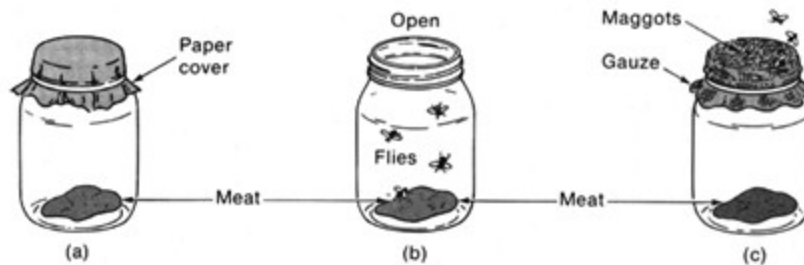
2. Sequence the evolution of cells according to the heterotroph hypothesis:



3. The endosymbiont hypothesis is a theory that explains how eukaryotic cells may have evolved from prokaryotic cells. Based on the diagram below, what might the smaller aerobic prokaryote have eventually become?



4. While the earliest cells may have arisen through spontaneous generation, this theory has been disproven for life as it continues. Explain how the experiment shown below helped to disprove spontaneous generation.



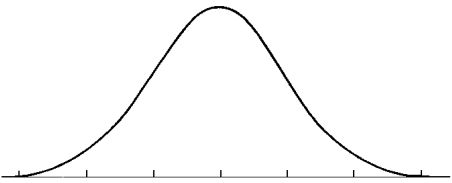
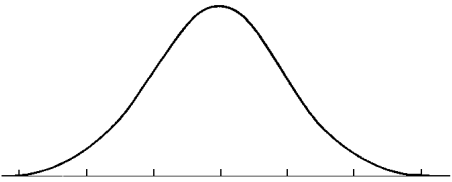
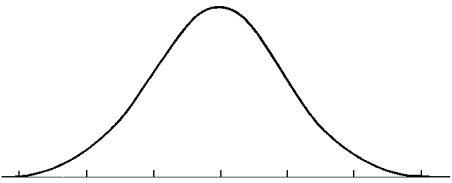
5. Life changes over time through natural selection. Sequence the steps in the evolution of a long neck in giraffes according to the theory of natural selection.

Step #	Explanation
	In a population of giraffes, there is variation in neck length. Some will have short necks, some medium, and some long.
	Over time, more long-necked giraffes will survive, reproduce, and pass their genes to the next generation.
	The giraffes with the longer necks will be able to reach food in the trees when food on the ground becomes scarce.
	Because there are more giraffes born than there are available resources, the giraffes will have to compete for food.

6. Natural selection results in adaptations. List 3 specific adaptations in plants or animals. For example, you might say that porcupines have quills for protection from predators.

- a.
- b.
- c.

7. For each of the following scenarios, identify the type of natural selection that is occurring in that environment AND draw a graph of the selection.

Example	Type of Selection	Graph
In woodpeckers, the birds with the longest bills get the most insects. Those with medium bills can't get quite enough to thrive, and those with the shortest bills have little chance of survival.		
In some species of spiders, medium size is best. The smallest are unable to successfully compete for resources and the largest are easily spotted by predators.		
Limpets are shelled invertebrates that attach themselves to rocks. In the areas that they are found, the rocks are generally quite light in color or quite dark. Therefore, the light and dark colored limpets camouflage well on these rocks, while those medium in color are easily spotted by predators.		

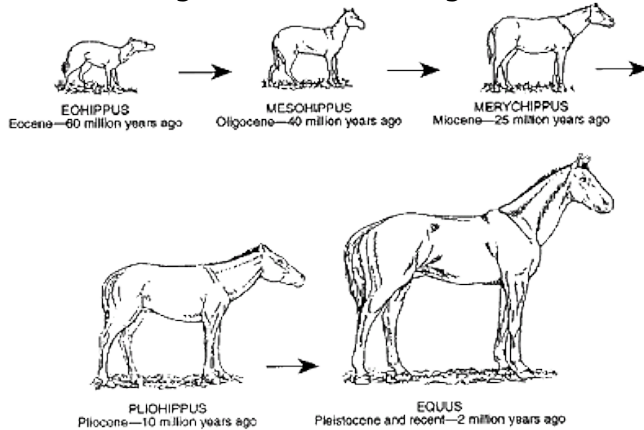
8. Natural Selection can result in the evolution of new species. Read the paragraph and answer the questions that follow:

Along the North rim of the Grand Canyon lives the black Kaibab squirrel. Across the canyon on the opposite rim lives the Albert squirrel. Both species have big, tufted ears. However, the Kaibab has a flashy white tail and the Albert has a grey tail and body and a white belly. Scientists believe that these two different species of squirrels were once one population that was divided as the Grand Canyon developed. Through natural selection, the squirrels on either side of the canyon developed different characteristics. These two species of squirrel are separated by an environment that is totally different than on either rim of the canyon. The temperature on the rims is cool, but in the canyon it is much warmer and drier. Therefore, the squirrels do not cross the canyon and the populations remain separated.

- a. What isolates the populations of the Kaibab and Albert squirrels?

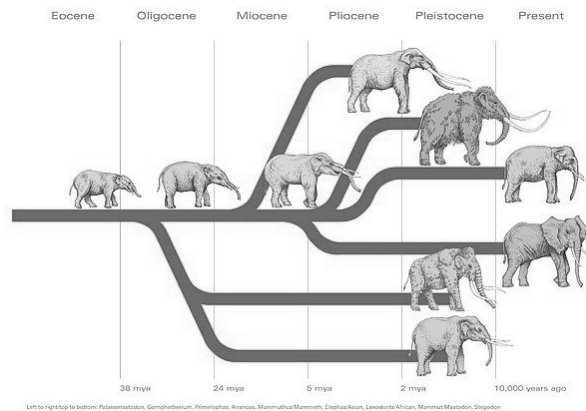
- b. Over time, geographic isolation can lead to _____ isolation.
- c. What is the term for the development of a new species? _____

9. The fossil record gives us evidence for evolution by showing us how living organisms have changed over time.



The fossil record of horses shows natural selection by *gradualism*. Explain what this means.

The fossil record of elephants shows natural selection by *punctuated equilibrium*. Explain what this means.



10. Biochemical similarities also provide evidence for evolution. The chart below shows similarities in amino acid sequences in hemoglobin for several species.

	87	88	89	90	91	92	93	94	95	96	97	98	99	100	101
Human	THR	LEU	SER	GLU	LEU	HIS	CYS	ASP	LYS	LEU	HIS	VAL	ASP	PRO	GLU
Chimpanzee	THR	LEU	SER	GLU	LEU	HIS	CYS	ASP	LYS	LEU	HIS	VAL	ASP	PRO	GLU
Gorilla	THR	LEU	SER	GLU	LEU	HIS	CYS	ASP	LYS	LEU	HIS	VAL	ASP	PRO	GLU
Rhesus monkey	GLN	LEU	SER	GLU	LEU	HIS	CYS	ASP	LYS	LEU	HIS	VAL	ASP	PRO	GLU
Horse	ALA	LEU	SER	GLU	LEU	HIS	CYS	ASP	LYS	LEU	HIS	VAL	ASP	PRO	GLU
Kangaroo	LYS	LEU	SER	GLU	LEU	HIS	CYS	ASP	LYS	LEU	HIS	VAL	ASP	PRO	GLU

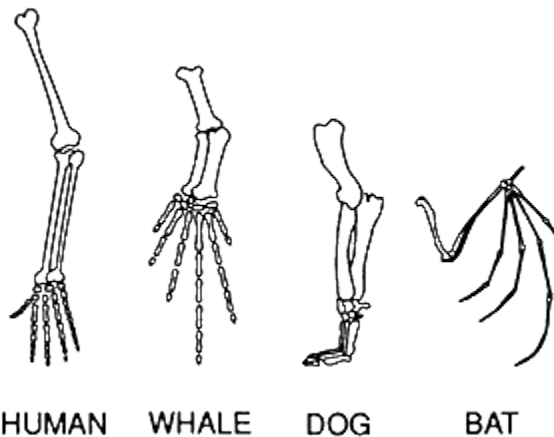
	102	103	104	105	106	107	108	109	110	111	112	113	114	115	116
Human	ASN	PHE	ARG	LEU	LEU	GLY	ASN	VAL	LEU	VAL	CYS	VAL	LEU	ALA	HIS
Chimpanzee	ASN	PHE	ARG	LEU	LEU	GLY	ASN	VAL	LEU	VAL	CYS	VAL	LEU	ALA	HIS
Gorilla	ASN	PHE	LYS	LEU	LEU	GLY	ASN	VAL	LEU	VAL	CYS	VAL	LEU	ALA	HIS
Rhesus monkey	ASN	PHE	LYS	LEU	LEU	GLY	ASN	VAL	LEU	VAL	CYS	VAL	LEU	ALA	HIS
Horse	ASN	PHE	ARG	LEU	LEU	GLY	ASN	VAL	LEU	ALA	LEU	VAL	VAL	ALA	ARG
Kangaroo	ASN	PHE	LYS	LEU	LEU	GLY	ASN	ILE	ILE	VAL	ILE	CYS	LEU	ALA	GLU

Human hemoglobin is being used as the standard for comparison.

Species comparison	# similarities	# differences
Human/Chimpanzee		
Human/ Gorilla		
Human/ Rhesus monkey		
Human / Horse		
Human/ Kangaroo		

- According to the information in the chart, which species have the closet relationship to humans? _____
- Which species is least related to humans? _____

11. Structural similarities also provide evidence for evolution.



HUMAN WHALE DOG BAT

a. Describe how the bones shown in the diagram are structurally similar to one another.

b. What does the diagram tell us about the relationship of human to the other species pictured?
