

Unit 4: Evolution and Classification

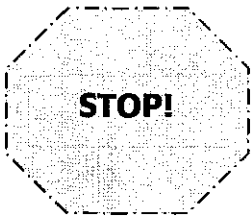
Module 10: Evolution

NC Essential Standard:

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

True or False ...What do you think?

1. The environmental conditions of earth have changed since life began and are continuing to change today.
2. Evolution happens when individuals "get used to" a new situation.
3. Individuals can develop new traits because they need them for survival.
4. Except for differences between males and females and young and old, all members of a population look and act the same.
5. Evolution occurs when favorable, inherited traits lead to successful reproduction in some individuals.
6. Species that have no obvious, physical similarities have no similarities at all.
7. Humans share a common ancestor with other species.
8. Humans evolved from other primates such as apes.



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

A. Abiogenesis / Spontaneous Generation

1. **Abiogenesis** is the idea that life came from non-living 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 abiogenesis to occur. Researchers now believe that the early atmosphere may have been similar to the vapors given off by modern volcanoes: carbon monoxide, carbon dioxide, hydrogen sulfide, and nitrogen (note the absence of free atmospheric oxygen).

Abiogenesis =

Gases then =

Gases now =

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, simple organic molecules could form from inorganic compounds. 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 oceans.
- 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 amino acids (the building blocks of proteins). This experiment has been replicated numerous times.

B. Biogenesis

Abiogenesis	Biogenesis

1. Once life was established in very simple cells, biogenesis began. **Biogenesis** is the continuation of life from other living cells. 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 disprove the theory of spontaneous generation/abiogenesis. He developed a controlled experiment to test his hypothesis that life must come from life (biogenesis).

Redi's Experiment:

	Control Group	Experimental Group
Independent Variable	Open jars	Covered jars
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	The maggots came from the flies, NOT the meat.	

- 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 vital force in the air or did biogenesis hold true at all levels?
- c. Louis Pasteur designed an experiment to disprove spontaneous generation for microorganisms.

Pasteur's Experiment:

Experimental Group	
Control Group	
Conclusion	Microorganisms came from other microorganisms carried on dust in the air, NOT the air itself.

[vilenski.org/.../ historyoflife/pasteur.html](http://vilenski.org/.../historyoflife/pasteur.html)

C. The evolution of cells

The effect of photosynthetic cells:

- 1.
- 2.
- 3.

1. Based on the conditions proven by Miller and Urey, scientists developed the **heterotroph hypothesis** to explain the evolution of prokaryotic cells.
 - a. The first cells would have been prokaryotic (no nucleus), anaerobic (does not require oxygen), and heterotrophic (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 photosynthetic prokaryotic cells evolved, allowing for the release of free oxygen. 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 aerobic, prokaryotic cells.
2. Based on the idea of biogenesis and current research in symbiosis, Lynn Margulis developed the **endosymbiont hypothesis** to explain the development of eukaryotic cells.
 - a. A variety of prokaryotic cells existed, some autotrophs and some heterotrophs.
 - b. A larger heterotrophic cell consumed the smaller cells, using some of them for food. However, the energy harnessing power of these smaller cells could also be used by the larger cells.
 - c. A symbiotic relationship was formed and the smaller cells evolved into what we now know as mitochondria and chloroplasts. A nuclear envelope formed around the DNA.

Watch It!



Check Yourself!

1. What is abiogenesis?
2. What were the conditions of the early atmosphere?
3. What three scientists are credited with developing and supporting the theory of these conditions 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. 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 new species could develop 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 phenotypes. Some variations are better suited to the current conditions of the environment.
 - b. **Overproduction** in populations leads to competition for limited resources (food, for example).
 - c. **Natural selection** favors the best suited 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 higher reproductive success. 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 heritable trait that suits an organism to its natural function in the environment (its niche). There are three basic types of adaptations:
- a. Examples of structural adaptations are defensive structures, camouflage, and mimicry. Typically, mimicry occurs when a harmless species (mountain king snake) resembles a harmful species (coral snake) using coloration.
 - b. Examples of behavioral adaptations are herding, schooling, and growling
 - c. Examples of physiological 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; populations do. 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 "selected", 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. Evolution acts on the phenotype.
 - a. **Mutations** are random changes in DNA and may lead to a new phenotype. Mutations provide the raw material 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. Environmental changes are nature's "**selection forces**" that act upon the phenotype ranges caused by genes. There are three basic patterns by which natural selection occurs:

**Mutations →**

_____ in

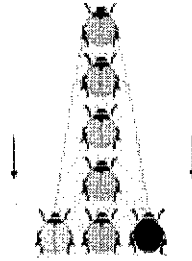
_____ →

change in

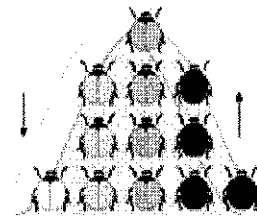
Three types of Natural Selection:

- 1.
- 2.
- 3.

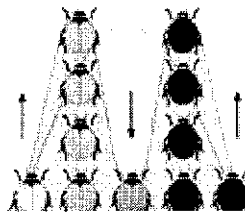
- i. **Stabilizing selection** favors the "average" phenotype in a population.



- ii. **Directional selection** favors ONE of the extreme ends of the "typical" distribution.



- iii. **Disruptive Selection** favors BOTH of the extreme ends of the "typical" distribution.



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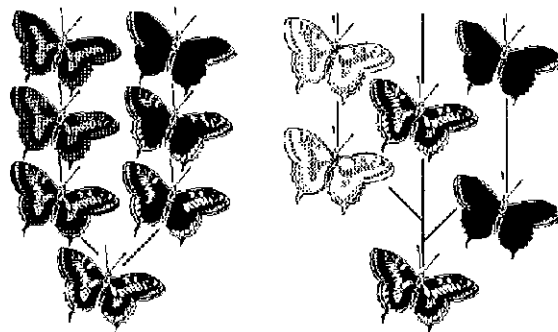
Geographic isolation is related to speciation because...

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

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. Punctuated Equilibrium)

1. **Gradualism** describes speciation that occurs over a long period of time due to the accumulation of small changes.
2. **Punctuated equilibrium** describes speciation that occurs in rapid bursts 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.



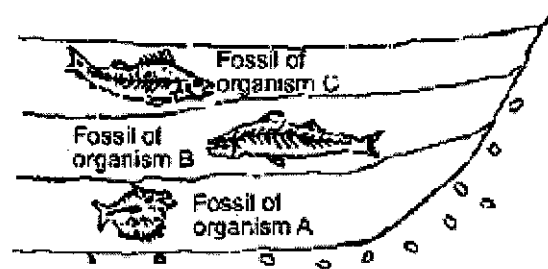
D. Evidence for Evolution

1. Fossil evidence provides an incomplete record 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 simple to complex 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 compared to other fossils found in nearby rocks. Fossils occur in layers of sedimentary rock. The fossils near the top will be more recent 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 exact age using the natural decay of radioactive isotopes in organisms.



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

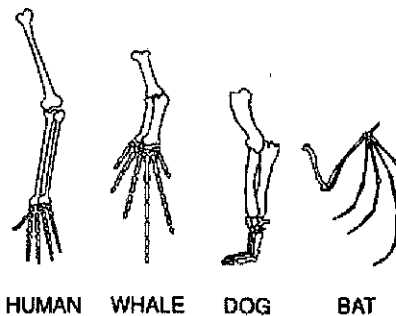
Explanation of the amino acid sequence diagram:

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

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 similar habitats though not from a recent common ancestor.
- c. **Vestigial** structures (ex. appendix or tail bone in human) are not functional 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, speciation is not readily observable within a lab.
- B. Natural selection, one of the main mechanisms of evolution, is observable in some populations. For example, the evolution of **resistance** to chemicals:
 - 1. Farmers use pesticides to eliminate insects. In a population of insects, some individuals will possess genetic immunity to certain chemicals. When the chemicals are applied, the individuals with genetic immunity will survive and reproduce, passing this resistance to the next

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

2. Antibiotics are drugs that fight bacterial infections. Within any population there is genetic variation. In the case of antibiotic resistance, some bacteria are genetically more resistant 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, resistant bacteria will reproduce. 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:

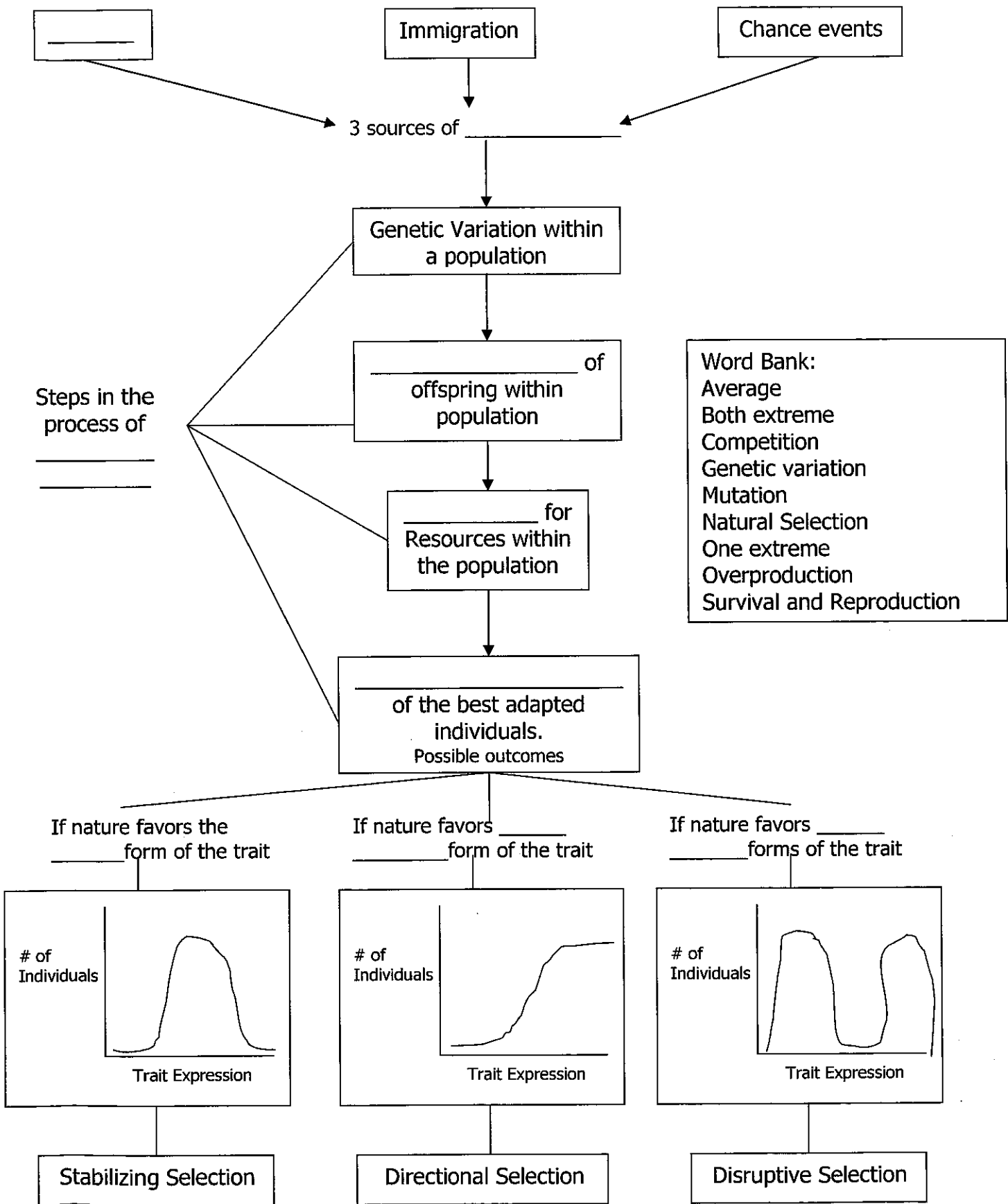
CAUSE of resistance:

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. Sequence the evolution of cells according to the heterotroph hypothesis:
 - i) Prokaryotic, heterotrophic, anaerobic
 - ii) _____ (release of free oxygen)
 - iii) _____
 - iv) Eukaryotic

2. Explain the evolution of eukaryotic cells according to the endosymbiont hypothesis:

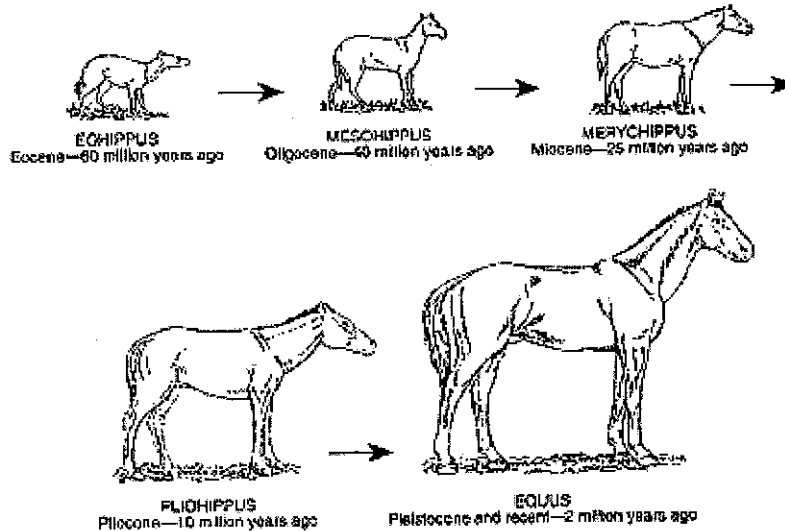
3. Use Darwin's four points of natural selection to explain the evolution of a long neck in giraffes. The first step has been done for you:

a. Variation	<i>In a population of giraffes, there is variation in neck length. Some will have short necks, some medium, and some long.</i>
b. Overproduction/ Competition	
c. Natural Selection	
d. Survival of the best adapted	

4. List 4 specific adaptations in plants or animals. For example, you might say that porcupines have quills for protection.

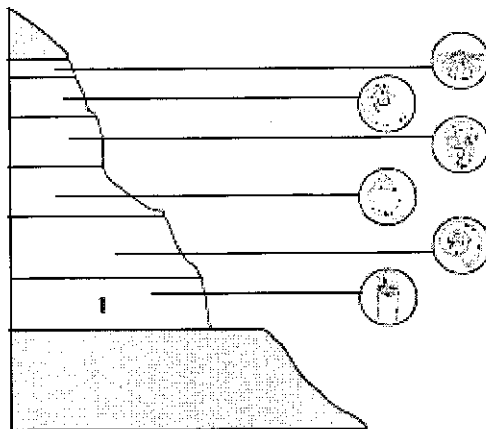
- a.
- b.
- c.
- d.

5. The fossil record gives us evidence for evolution by showing us how living organisms have changed over time. Observe the diagram of the evolution of the horse:



According to the fossil record, how have horses changed in 60 million years?

6. On the diagram, number the fossil layers in the order that they were formed:



Number the fossils in the correct order:



Suppose that you found a fossil of the same species as fossil #1 in a rock layer in another location. What could you conclude about the age of that rock layer? _____

7. 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

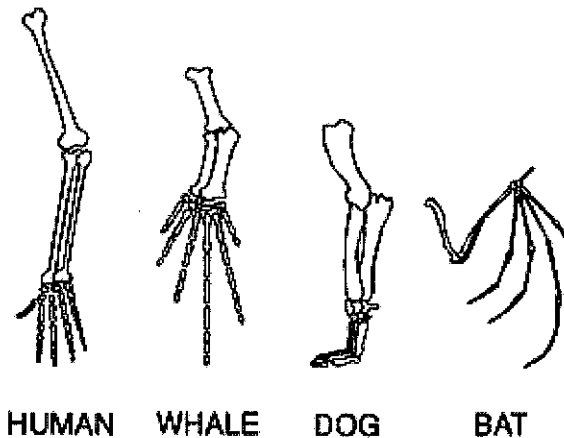
	102	103	104	105	106	107	108	109	110	111	112	113	114	115	116
Human	ASN	PHE	ARG	LEU	LEU	GLY	ASN	VAL	LEU	VAL	CYS	VAL	LEU	ALA	HIS
Chimpanzee	ASN	PHE	ARG	LEU	LEU	GLY	ASN	VAL	LEU	VAL	CYS	VAL	LEU	ALA	HIS
Gorilla	ASN	PHE	LYS	LEU	LEU	GLY	ASN	VAL	LEU	VAL	CYS	VAL	LEU	ALA	HIS
Rhesus monkey	ASN	PHE	LYS	LEU	LEU	GLY	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 closest relationship to humans? _____
- Which species is least related to humans? _____

8. Structural similarities also provide evidence for evolution.



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

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

9. For each of the following scenarios, identify the type of natural selection that is occurring in that environment.

Example	Type of Selection
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.	

10. 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 Abert squirrel. Both species have big, tufted ears. However, the Kaibab has a flashy white tail and the Abert 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 Abert squirrels?

- b. What is the term for the development of a new species? _____
- c. What mechanism led to the development of these two new species of squirrels? _____

11. Identify each of the following examples as gradualism or punctuated equilibrium:

Example	Time frame
Elephants are believed to have evolved from the prehistoric woolly mammoth. Fossil evidence shows little change from the mammoth fossils until the appearance of the Asian and African elephants.	
Fossils of horses and their ancestors show evidence of small changes over a long period of time. They have gotten taller, toes changed to hooves, and teeth became larger and flatter.	

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www.orbro.com/miclimb/fulldoc.html
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