4 Unit Overview:

Evolution and Classification

Name: _____

Teacher: _____

4.1 Evolution

4.1.1 Mechanism for Evolution: Study

4.1.2 Mechanism for Evolution: Lesson QUIZ Scoring: 20 points

4.1.3 Evidence for Evolution: Study

4.1.4 Evidence for Evolution: Lesson QUIZ Scoring: 20 points

Instructions: Read each question and answer choice carefully. Choose the ONE best answer. **Use CAPITAL letters to record your answers on this page.**

Lesson Quiz 4.1.2

1. _____
2. _____
3. _____
4. _____
5. _____
6. _____
7. _____
8. _____
9. _____
10. _____

Score: _____ out of 20

Lesson Quiz 4.1.4

1. _____
2. _____
3. _____
4. _____
5. _____
6. _____
7. _____
8. _____
9. _____
10. _____

Score: _____ out of 20

Submit only this page for grading.

Use Capital Letters for each answer.

Instructions:

Students please *annotate, by highlighting or underlining*, words or sentences in the Study sections to show that you have read and studied the study sections prior to taking the quizzes.

4.1.1 Evolution

A dinosaur skull.

Life on Earth has gone through many changes. From strange sea creatures to enormous dinosaurs, different species have evolved and then gone extinct.

Scientists study evolution in order to understand the history of life on Earth. They use fossils and other types of evidence to discover how life evolved into the many different species we see today.

This lesson will explore the world of fossils and other types of evidence that supports the theory of evolution. It will also describe different types of natural selection and other forces that drive evolution.

Objectives:

- Describe how natural selection causes organisms on Earth to change over time.
- Describe how factors like genetic drift and sexual selection can affect how populations evolve.
- Explain the differences between a hypothesis, a theory, and a law.
- List the different types of evidence that are used to support the theory of evolution.
- Describe how the age of fossils can be found using radioactive decay and other dating methods.

Mechanism for Evolution

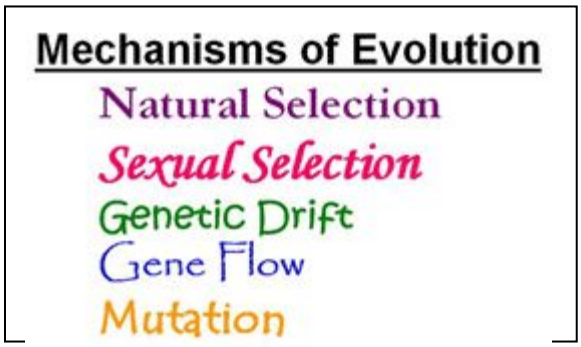
Different traits could have different kinds of advantages

A male peacock has a very elaborate tail-feather display.
Animals have to survive in the wild, fend off attacks, gather food, and make offspring. So why would a species of bird have feathers like this? For protection? For food gathering? What's your best guess of why male peacocks have these feathers?

How Evolution Works

There are different mechanisms of evolution.

Darwin's theory of evolution states that populations of organisms change over time, and that the main way, or mechanism, by which they change is natural selection.



But there are other mechanisms by which evolution occurs. You can see them listed to the right.
The peacock's tail is a part of sexual selection.
That's only one mechanism. There are others. You'll learn about the major mechanisms of evolution in this study.

Polygenic Traits

Many traits are polygenic traits.

Humans can vary greatly in size.
To understand the mechanisms of evolution, it's important to recall that many traits in organisms have a range of values. For example, humans have a wide range of heights.
Many traits, like human height or the color of a peacock's tail, are controlled by multiple genes. Any trait that is controlled by multiple genes is called a polygenic trait.
Polygenic traits make it possible to have a wide range of diversity in a species. This wide range allows a specific type of natural selection that you'll learn about next.

Sexual Selection

Sexual selection is a form of natural selection.

Ducks are just one kind of bird in which the female seems to prefer males with bright feathers.
Animals are naturally attracted to the traits in a mate that they want to pass to their offspring. So why would the peacock's tail feathers be attractive to a peahen?
Scientists aren't exactly sure, but here is one possibility: Female peahens want their male offspring to have the brightest displays possible, so that other females will find their male offspring

attractive. In order to have male offspring with the brightest possible feathers, females mate with males with bright displays.
The process of sexual selection is how animals attract mates. In complex animals, individuals often actively choose mates. This means that the ability to attract mates determines the individual's reproductive success. This ability to attract mates is based on the traits that an individual possesses.
Sexual selection is a form of natural selection, because sexual selection leads to certain traits in a population being selected over other traits. Sexual selection causes allele frequencies in the population to change over time.

Females and Males

Females and males have different selective pressures.

This seal mother must have enough resources to feed herself, as well as produce enough milk to feed her baby.
Females and males have different roles in any given population. For example, in most animal species, females produce eggs and carry, deliver, and raise offspring. Thus a female's fitness depends more on her ability to get the resources needed to carry and raise young than on her ability to find a mate.
A male, on the other hand, does not have the pressure to do all of those things. His role in reproduction is to provide the sperm to fertilize the female egg. Sperm are much easier to produce than eggs, and males can produce a limitless amount of sperm.
For males, fitness is measured by the number of his offspring that live to reproduce themselves.

The factors that affect the ability of males and females to reproduce are called selective pressures. Females have different selective pressures than males do. These differences in the sexes play out in several different methods of sexual selection.

Female Choice

Female choice results in male traits that indicate the fitness of the male.
In some species, the female selects her mate. Since females will spend time and energy producing eggs and caring for young, it makes sense for them to choose mates carefully.
When individuals differ in their ability to attract mates, males must compete more than females do. Males are generally willing to mate with any female, so males must compete with each other for mates.

Male Competition

When males compete to mate with females, a large size is an advantage.
In some species, females choose mates that have attractive characteristics. These characteristics, or traits, tell the female that the male has adaptations that increase the likelihood that his offspring will survive.
In other species, the females don't choose; in these species, the males compete against each other for the right to mate with all of the females in a certain territory.
In these species, the males fight for the right to fertilize and thereby pass on their genes to the next generation. Success in the competition is usually based on size, with only the largest and strongest male mating. The result can be that only one male in the group fathers children. This type of sexual selection is most common in species in which males and females are very different in size.
Look at some of the traits the males shown in the following exercise display. Which ones indicate female choice, and which ones indicate male competition?

Male Competition

Which selective force is most likely at work in this species?

- ◯ Female choice
- ◯ Male competition

Patterns of Selection

Selective pressures lead to patterns of natural selection.

Over several generations, a shift in the traits of the population can be seen. There are three ways that a shift can happen:

- stabilizing selection, which *stabilizes* the traits by selecting for characteristics that are in the middle of a range
- directional selection, which selects for characteristics in just one *direction* of the range of traits
- disruptive selection, which *disrupts* the range of traits by selecting against characteristics in the middle of the range, instead selecting for traits that are on the high and low ends of the range

All three types of selection tend to decrease the genetic variation of the population over time.

The Role of Chance

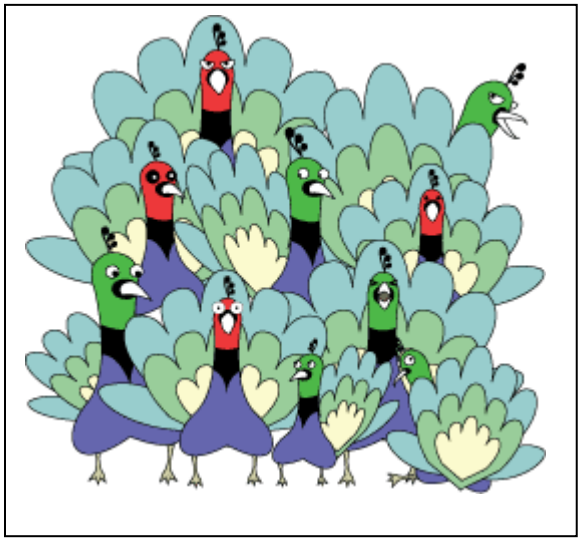
Chance plays a role in evolution.

Selective pressures, like sexual selection and other forms of natural selection, select for certain traits in a population and against others. These forces cause allele frequencies in the population to change over time.

There are other forces that act on populations that are not selective. These forces are affected by chance and do not increase the survival rate or the reproductive success of the organisms involved.

In a population of 10 peacocks, 60 percent of the birds have green heads, whereas 40 percent have red heads.

Neither green nor red has a selective advantage, so in each generation, these frequencies stay about the same.



Genetic Drift

Genetic drift is the random change of allele frequency from generation to generation.
Some changes in allele frequency are based on chance. When allele frequencies change from generation to generation due to random processes, it is called genetic drift.
If there were a population with a 50/50 distribution of alleles, and this population randomly had a 75/25 distribution in one generation, this could change the population frequencies. This is not natural selection, because neither of the alleles provided an advantage.
Genetic drift can also be seen in situations like the bottleneck effect and the founder effect.

Gene Flow

Gene flow is the exchange of genes between populations or species.
The movement of genes from one gene pool to another is called gene flow. With gene flow there is movement of genetic information. When an individual moves from one population to another, its genes go with it.
Genes move from one population to another in two ways. The individuals can move, taking their genes with them. Or their gametes can move. In plants, for example, gametes in the form of pollen can be blown by the wind or carried by animals or insects like bees.
Gene flow equalizes allele frequency between two populations and does not give either population any kind of advantage.

Mutation

Mutations increase variety in a population.
Natural selection and sexual selection tend to decrease genetic variation. Variation is also decreased by gene flow and genetic drift.
Without variation, a species cannot survive environmental changes and may face extinction. The process of mutation constantly introduces new alleles into a population.
Most mutations are negative, not positive, but natural selection would favor a population that included some mutation in DNA, because mutation increases genetic variety in a population.
Do you remember seeing the animals with these mutations? These mutations have all added variety to a population, and the individuals with mutations may or may not have an advantage.

Mutation and Gene Flow

The impact of mutation on allele frequency depends on gene flow.
In most populations, gene flow stops the spread of a mutation through a population. A single organism with a mutation will not have a large impact on the population as a whole. But in small populations or populations with low gene flow, mutations can quickly increase in frequency.
If the mutation does not have a negative affect on fitness and survival, the mutation can continue to spread through a population after only a few generations. In this way, mutation creates genetic diversity and becomes a driving force of evolution.

Artificial Selection

Using selective breeding, humans can cause alleles in populations to change.

Natural selection occurs in response to environmental pressures and results in changes in species over long periods of time. A human strategy for speeding up the appearance of desired traits is called artificial selection. In artificial selection (or selective breeding), humans select certain animals or plants to breed because of specific traits they possess. The goal is to increase the frequency of these traits in the population, while decreasing the appearance of undesired traits.

Artificial selection has been applied to many different plant and animal species. In fact, most of today's domestic animals, like pets and livestock, are the direct result of artificial selection.

Human Impact on Evolution

Humans have an impact on the evolution of species.

There are many mechanisms that can cause allele frequencies to change over time. Understanding these mechanisms helps us better understand how we affect other species on Earth.

For example, overapplication of pesticides has led to some plant species evolving resistance to pesticides. These plants now grow in a way that cannot be controlled, destroying valuable forests.

Overuse of antibiotics has caused some harmful bacteria to evolve resistance to antibiotics, making these bacteria even more difficult to treat.

Mass Extinction

Mass extinction decreases biodiversity.

A mass extinction is an event in which 60 percent of the organisms present on Earth become extinct. Scientist believe that there have been five mass extinctions since life first formed on Earth. After each mass extinction, the biodiversity of the planet greatly decreased.

Many species, like this panther, are nearly extinct.

Human activity has threatened many species on the planet, and many species are near extinction. A decrease in biodiversity means a decrease in adaptations available to select for if the environment changes. Because of the threat of extinctions, humans must consider the long-term effects of their activities.

STUDY GUIDE

Main idea 1: Natural selection drives the evolution of populations.

Mechanisms of Evolution

Natural Selection
Sexual Selection
Genetic Drift
Gene Flow
Mutation

Mechanisms for Evolution

Sexual Selection (pg. 4)

Define:
The process that animals use to attract mates and reproduce

How are sexual traits adaptations?
The ability to attract mates determines reproductive success and is based on the traits that the individual animal possesses.

Patterns of Natural Selection (pg. 8)

Describe the effect of each type of selection:
Stabilizing selection:
When phenotypes on either extreme of a bell curve are selected against, populations tend to have a tight range of traits, and the bell curve narrows.

Directional selection:
When traits on one side of a bell curve are favored, the phenotypes in a population tend to move in that direction.

How are sexual traits adaptations?
The ability to attract mates determines reproductive success and is based on the traits that the individual animal possesses.

What drives sexual selection?
The selective pressures on males and females in a population are different and have different results.

Directional selection:
When traits on one side of a bell curve are favored, the phenotypes in a population tend to move in that direction.

Disruptive selection:
When traits on either side of a bell curve are selected for, the graph tends to have two peaks; speciation may occur.

Females versus Males (pgs. 4-5)

Describe the factors that determine female fitness:
A female's fitness is limited by her ability to get the resources needed to produce more eggs or raise more offspring.

Describe the factors that determine male fitness:
For males, fitness is measured by the number of offspring he has that live to reproduce themselves.

Reproductive Strategies (pgs. 5-7)

Female choice — describe the effect on male traits:
When females choose their mates, males that have characteristics that will attract female attention are more likely to pass on their genes. These traits tell the female that the male has adaptations that enhance the survival of his offspring.

Male competition — describe the effect on male traits:
When males compete to mate with females, a large body size is an advantage.

Main idea 2: Evolution is also caused by several nonselective types of pressures.

Nonselective Pressures

Genetic Drift (pg. 11)

Describe:
Genetic drift results from random processes.

Describe population bottlenecks:
When a large population undergoes a rapid decline and subsequent expansion

Describe founder effects:
When a small number of organisms in a population move to a new location, the resulting allele frequencies may be determined largely by random genetic drift.

Gene Flow (pg. 13)

Describe:
Gene flow is caused by immigration and emigration. The movement of genes from one gene pool to another is called gene flow. With gene flow there is movement of genetic information. When an individual migrates from one population to another, its genes go with it.

Mutation (pgs. 14-15)

Describe the effect of mutation on genetic diversity:
Genetic drift results from random processes.

Why does mutation occur?
Natural selection would favor a population that included some mutation in DNA, because mutation increases genetic variety in a population.

Would evolution happen without mutation? Explain your answer.
No, without diversity between individuals, there would be no differences for natural selection to act on.

Human Effect on Evolution (pgs. 18-19)

Describe three effects humans are having on the evolution of other species:
Answers may vary but could include these types of ideas:
Humans are close to causing a mass extinction.
The introduction of chemicals into human food production affects plants and animals.
Weed species quickly evolve herbicide resistance.

QUIZ 4.1.2

1. Which best describes genetic drift?

A.	Changes to polygenic traits
B.	Random changes in allele frequency
C.	Changes caused by male competition
D.	A type of artificial selection

2. Which of the following would cause gene flow?

A.	Artificial selection
B.	Individuals moving into a population
C.	Mutation
D.	Genetic drift

3. What is it called when a high percentage of the species on Earth dies off?

A.	Mass extinction
B.	Selective pressure
C.	Founder situation
D.	Disruptive selection

4. When is genetic drift a major factor in evolution?

A.	When there is sexual selection
B.	When there is high selective pressure
C.	When there is low gene flow
D.	When there is female choice

5. Which feature would you expect to find in a population in which sexual selection depends on female choice?

A.	Bright-colored males
B.	Bright-colored females
C.	Large males
D.	Large females

6. Under which condition would a mutation have the *most* impact on allele frequency?

A.	There is gene flow.
B.	There is no gene flow.
C.	The population is large.

D.	Individuals are moving in and out of the population.

7. A flood kills most of the population of ants that live near a river. After the flood, the ant population increases, but its allele frequency is different. What type of situation is this?

A.	Bottleneck
B.	Founder
C.	Genetic drift
D.	Mass extinction

8. Which tends to increase genetic variation in a population?

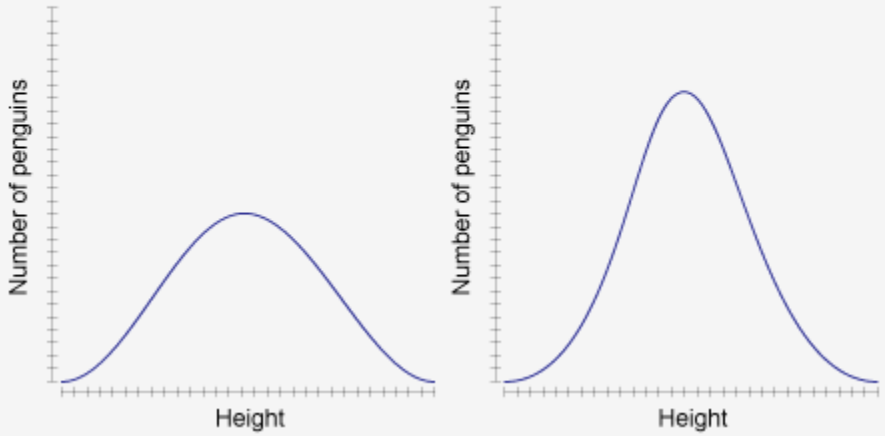
A.	Bottlenecks
B.	Disruptive selection
C.	Selective pressures
D.	Mutation

9. What do stabilizing selection and disruptive selection have in common?

A.	They both cause mutations.
B.	They both cause bottlenecks.
C.	They both are caused by gene flow.
D.	They both decrease genetic variation.

10.

The curve on the left shows the height of a population of penguins. The curve on the right shows the population five years later. What has happened to this population?



A.	Directional selection
B.	Polygenic selection
C.	Stabilizing selection
D.	Disruptive selection

4.1.3 Evidence for Evolution

The theory of evolution is supported by evidence.

Science is a method of explaining the natural world. Experimentation and the collection of data are essential parts of the scientific process.

In science, a theory has a different meaning than in everyday life. In everyday life, people use the word *theory* to mean a "guess." In science, only the most important and well-supported ideas are called *theories.* Theories must be supported by scientific evidence.

The theory of evolution is a scientific theory that explains the process by which organisms change over time. This study will focus on the scientific evidence that supports the theory of evolution.

Fossils

Fossils are the remains or impressions of dead organisms.

Evidence for evolution can be found by looking at the past.

For millions of years, all sorts of living things have had an impact on Earth. Even species that have become extinct have left their mark.

A preserved part or impression left by a once-living organism is called a fossil.

Fossils can be bones, teeth, or other body parts. They can also be marks left by an organism, such as footprints or a hole where the roots of a plant once grew.

Fossil Evidence

Fossils support the theory of evolution.

Fossils are evidence of evolution. They provide information about organisms that once lived on Earth. They provide evidence that the organism existed, as well as valuable information about what the organism was like and what kind of life it lived. Fossils also provide information about how the Earth has changed and give a relative time line of the earth's formation.

Here's an example from the fossil record showing how modern horses slowly developed from small five-toed animals. The early horse species died out and was replaced by its "fitter" descendants. However, we can trace the horse's evolutionary path by looking at the trail of fossils it left behind.

Fossil Formation

Fossils can form in sedimentary rock.

A fossil of a leaf from a fern tree.

When you think of the word *fossil,* what's the first image that comes to mind? Dinosaur skeletons in a museum? A fern imprint? A mosquito trapped in sap?

Each of these is a different kind of fossil, formed in a different way.

Fossils can be the actual, preserved remains of an organism, or they can be an imprint of the organism.

Not every organism that dies leaves behind fossil evidence. Many organisms are eaten or decompose before they can be preserved.

The kind of rock that we find fossils in is sedimentary rock, which forms from sedimentation at the bottom of oceans, lakes, and rivers.

Over time, layer upon layer settles, and then the layers are either pressed together by the weight of the layers or cemented together by minerals dissolved in the water.

Types of Fossils

Fossils can form in different ways.

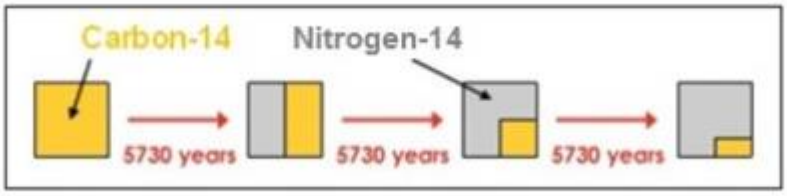
The fossils found in sedimentary rock are one type of fossil, but there are many others.

Radioactive Dating

The age of fossils can be determined using radioactive dating.

Atoms of normal carbon, called carbon-12, are found in all living and dead organisms. A specific type of carbon atom found in smaller amounts in all living and dead organisms, including fossil bones, is called carbon-14. Carbon-14 is an isotope, meaning it is a form of carbon whose atoms have two more neutrons than normal carbon atoms. Carbon-14 is radioactive. Over time, one neutron in carbon-14 atoms becomes a proton through radioactive decay and the carbon-14 atoms turn into nitrogen-14 atoms.

Because carbon-14 atoms turn into nitrogen-14 atoms at a fixed rate, it's possible for scientists to determine how old a fossil is by how much carbon-14 is left in a bone. This process of determining how old a fossil is by measuring the amount of carbon-14 is called radioactive dating.



This shows how carbon-14 turns into nitrogen-14 over many years.

Carbon isn't the only type of atom used for radioactive dating. Uranium, potassium, chlorine, and other atoms are all used.

Index Fossils

The age of fossils can be estimated using relative dating.

Certain fossils are very common in rocks of a particular age, but have not been found in rocks of any other time period. Each of these types of fossil is called an index fossil because it provides an index, or organizational timeline, for when organisms lived.

A trilobite fossil.

Using index fossils, scientists can determine the relative age of a fossil. This is called relative dating, and it's a way of estimating the age of a rock or fossil by comparing it to something else.

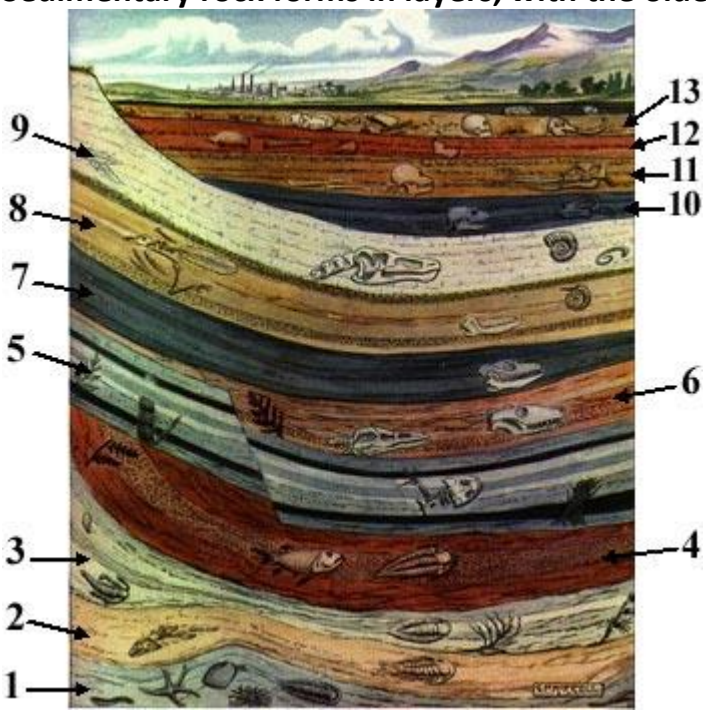
For example, trilobite fossils are a common index fossil. Trilobites existed over 300 million years ago and became extinct before dinosaurs lived.

If geologists find a rock layer that contains trilobites, they can estimate that the rock surrounding the fossils formed no more recently than 300 million years ago.

If, in the process of science, new information about an index fossil were found, then the comparisons based on that index fossil would need to be adjusted.

Fossils in Layers

Sedimentary rock forms in layers, with the oldest layer at the bottom.



Layers of sedimentary rock.
Fossils are found in sedimentary rock, which forms in layers.
In the image shown, you can see at least 13 distinct layers, each containing fossils.
Notice that the layers don't all continue in a straight line directly across the picture.
That's because the Earth's surface is constantly moving and bending. This makes the layers bend and break.
The key idea here is that the layers that are oldest are toward the bottom, and the youngest are at the top.

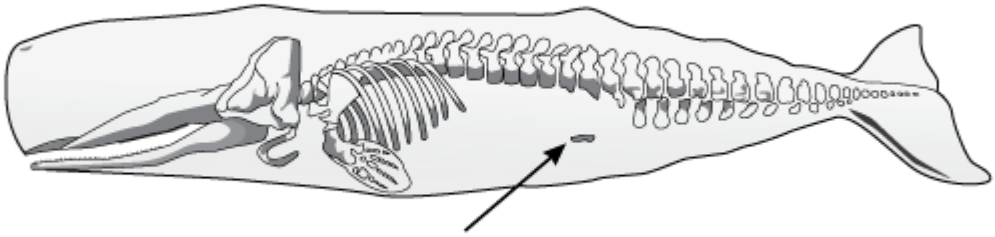
Homologous Structures

Many organisms have homologous structures.
There is much evidence and information to be gathered from the fossil record. But the theory of evolution is not supported by fossil evidence alone. Evidence is also found in the bodies of living organisms.
Did you know that humans, lions, birds, and seals all have "arms," or forelimbs, made up of similar bones? This type of physically similar structure that performs different functions for different animals is known as a homologous structure.

Vestigial Structures

Vestigial structures are body parts that are no longer needed in an organism.
Why does a whale or a snake have a pelvic bone? A pelvis is where legs attach to the body, and whales do not have legs!

Whale Skeleton and Pelvic Bone

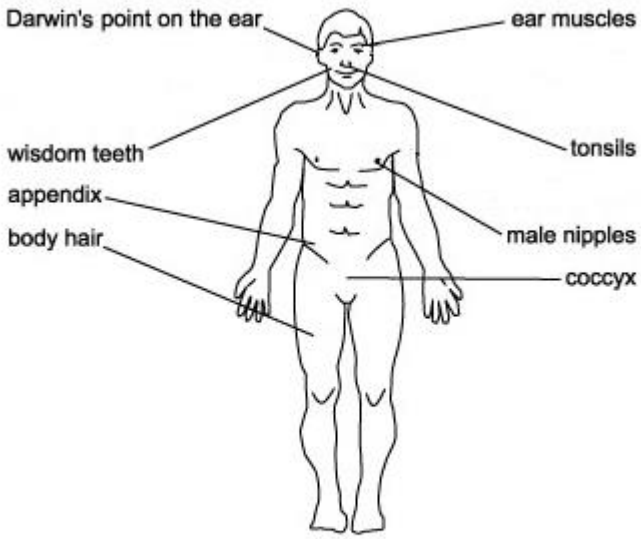


The pelvic bones in whales are only weakly developed and may one day no longer be present at all.

The pelvic bone of a whale or a snake is an example of a vestigial structure. A vestigial structure is a structure in an organism that has lost all or most of its original function. At one point, an ancestor probably used this structure, but the modern day species does not.
Why would an organism retain a structure it does not use? Having a pelvis bone would not decrease the whale's chance of survival, so it was not selected against in the process of natural selection, and it remains in the body of the whale.

Vestigial Human Structures

Humans have a variety of vestigial structures.
Humans have vestigial structures too. Humans have a tail bone, which is the ancestral remains of a tail. This tailbone is called a coccyx. See the image below for other vestigial structures.



These structures are generally thought to be vestigial structures. Some of these structures may still have some function, but their primary function has been lost.

Comparative Embryology

Organisms with similar embryonic development are often considered to have similar ancestry.

These drawings of a human fetus were done by the great Leonardo da Vinci around 1510.

The evolution of organisms can be seen in even the smallest members of the species: developing embryos.

People have been interested in the development of organisms for a long time.

To your right are some images drawn by Leonardo da Vinci centuries before technology would make it possible for doctors to observe fetuses during development.

Some scientists study how organisms develop, looking for clues about the ancestry of the organisms.

Organisms that are closely related tend to look similar as they develop.

DNA and Protein Similarities

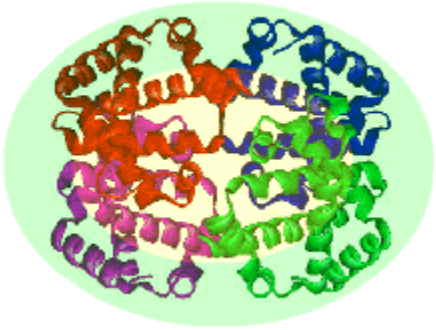
Similar DNA and protein sequences indicate two organisms are closely related.

All organisms have a DNA code, which is considered evidence that all organisms have a common ancestor.

If two organisms have similar sequences in one gene, or similar protein sequences produced by that gene, it suggests that two organisms are closely related. Why is this? It's similar to how you might have ears or eyes that look like those of a cousin because you share a set of grandparents.

Scientists often look at differences in protein sequences between different species in order to determine how

Hemoglobin



closely two species are related to each other.

For example, hemoglobin is the main oxygen-carrying protein in the blood of many different species.

In order to study how closely related two species are, scientists can compare the amino acid sequence of hemoglobin from two or more species.

Sequences that are very similar indicate that the two species likely had similar origins and ancestry.

Sequence Similarity

Examining protein sequences could give clues about the origins of the species.
Take a look at this table. It compares the sequences of amino acids in the hemoglobin of eight different species and humans. Then answer the questions below.

Comparison of Hemoglobin Sequences Among Species		
Species	**# Different Amino Acids (compared to humans)**	**Percentage Difference**
Humans	—	—
Gorilla (ape)	1	Less than 1%
Gibbon (ape)	2	1%
Rhesus monkey (primate)	8	6%
Dog (placental mammal)	15	11%
Mouse (placental mammal)	27	19%
Kangaroo (marsupial)	38	27%
Chicken	45	32%
Frog	67	49%

The Theory of Evolution

The theory of evolution is part of the basis for how scientists see the world.

You may be curious about where you came from, your role in the world, and the nature of the world around you. Different fields of study — philosophy, religion, psychology, history, or science — might contribute different things to how you understand your life and your place on Earth.
The theory of evolution is part of a point of reference for how most scientists think about the world.
The theory of evolution allows scientists to look at all living organisms as one system, connected through time. In doing so, scientists can look for patterns and relationships between organisms, and between organisms and their environment.

STUDY GUIDE

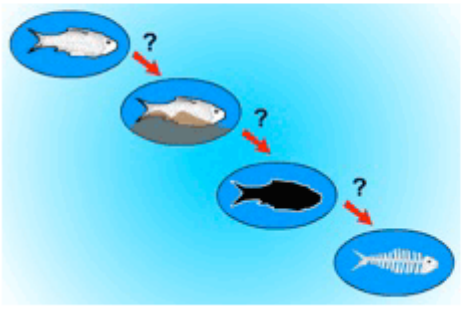
Main idea 1: Physical evidence for evolution includes information found in the fossil record.

Fossils (pgs. 2-8)

Describe *fossils*:
Fossils are remains or traces of a once-living organism. Fossils can be bones, teeth, or other body parts. Sometimes impressions of an animal, the holes where roots of a plant once grew, or even a footprint can be preserved through fossilization.

Describe *sedimentary rock*:
The kind of rock that we find fossils in is sedimentary rock, which forms when sediments are deposited at the bottom of oceans and lakes or on land. Over time, layer upon layer settles, and then the layers are cemented together.

How do fossils provide evidence for evolution?
They provide information about organisms that once lived on Earth. They provide evidence that the organism existed. Fossils also provide information about how the Earth has changed and give a relative timeline of the Earth's formation.



Fossil Formation (pg. 4)

Describe how fossils form in sedimentary rock:
The organism dies and is not eaten. Its body is covered with sediment. Over time, more sediment settles. The body is replaced by minerals, leaving an imprint or mold.

Other Types of Fossil Formation (pg. 5)

Amber
Describe:
Often, insects are found trapped in amber, which is a hardened form of tree sap.

Tar Pits
Describe:
The organisms were buried alive in the tar, and because oxygen couldn't reach their bodies, they didn't decompose the way normal dead tissue would.

Ice
Describe:
Sometimes the remains of dead organisms are perfectly preserved in ice.

Determining the Age of Fossils (pg. 6)

Fossil Formation

Describe:
The age of fossils can be determined using radioactive decay. Carbon forms radioactive isotopes. By measuring the amount of radioactive carbon in a sample, its age can be determined.

Usefulness:
If fossils are to be used to trace evolutionary development, it is important to know how old they are.

Relative Dating

Describe:
Relative dating is a way of estimating the age of a rock or fossil by comparing it to something else. It uses rock layers to determine whether one fossil is older than another.

Describe the fossil record:
The fossils deeper down are generally older, while the ones higher up came later and are younger. This time-sequenced order of fossils is called the *fossil record*.

Index Fossils

Describe:
The age of fossils can be determined using radioactive decay. Carbon forms radioactive isotopes. By measuring the amount of radioactive carbon in a sample, its age can be determined.

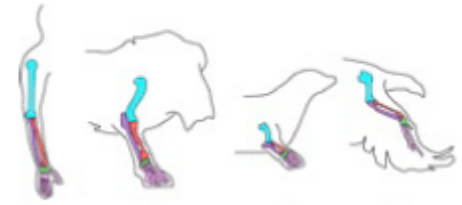
Usefulness:
If fossils are to be used to trace evolutionary development, it is important to know how old they are.

Main idea 2: Different species show have similar anatomy, suggesting that they have common ancestors.

Homologous Structures (pg. 10)

Describe:
Types of physically similar structures that perform different functions for different animals are known as homologous structures. Animals with different-looking limbs have similar bones in the same relative positions.

How does this provide evidence for evolution?
The structures are variations of a common ancestor.



Vestigial Structures (pgs. 11-12)

Describe:
Vestigial structures are body parts that are no longer needed in an organism. They are structures in an organism that have lost all or most of their original function.

How does this provide evidence for evolution?
A vestigial structure is a genetic leftover. At one point, an ancestor used this structure, but the modern-day species do not.

Comparative Embryology (pg. 13)

Describe:
A fertilized egg goes through several developmental stages as an embryo. The beginning stages for different species are very similar.

DNA and Protein Sequence Similarity (pg. 14)

Describe:
DNA or protein sequences are more similar for organisms thought to be more closely related.

How does this provide evidence for evolution?
Similar DNA sequences for two organisms could indicate these two organisms are more closely related.

QUIZ 4.1.4

1. What is an index fossil?

A.	A fossil that is from an animal that did not evolve
B.	A fossil that is more than 60,000 years old
C.	A fossil found in rocks from one time period
D.	A fossil that is found all over the world

2. What is a homologous structure?

A.	A structure that only exists in the embryo
B.	A structure that is only in index fossils
C.	A structure with similar shape but a different use
D.	A structure that has no use in the organism

3. What is the term for a preserved footprint left behind by an animal?

A.	Isotope
B.	Fossil
C.	Embryo
D.	Code

4. Which would be a homologous structure to a human arm bone?

A.	A chimpanzee's skull bone
B.	A whale pelvis bone
C.	A lion's tooth
D.	A bird's wing bone

5. Why is evolution considered a theory?

A.	It cannot be proven.
B.	It was proposed by a scientist.
C.	It is backed up by scientific evidence.
D.	It is a guess about what happened.

6. How is radioactive dating important for providing evidence for evolution?

A.	It tells you which protein sequences are similar.
B.	It tells you which structures are homologous.
C.	It tells you what DNA an animal had.
D.	It tells you how old fossils are.

7. How is the fossil record evidence for evolution?

A.	It shows how new organisms develop instantly.
B.	It shows how organisms change over time.
C.	It shows similarities in protein sequences.

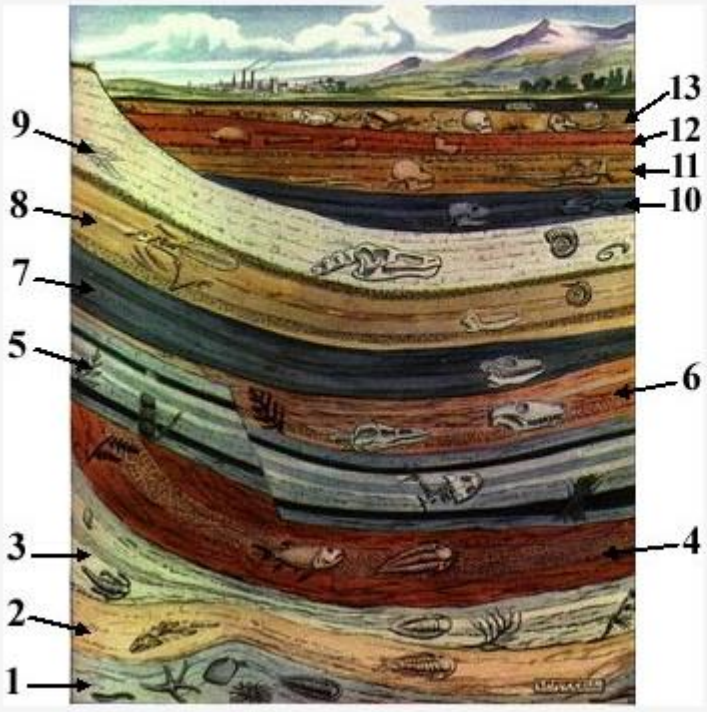
D.	It shows that embryos are similar.

8. Why are vestigial structures not removed by natural selection?

A.	They do not harm the organism.
B.	Vestigial structures are genetic traits.
C.	They are helpful to the organism.
D.	Only unimportant structures can be removed.

9.

Fossils of a species of beaver are found in layer 6. Which layer is most likely to have organisms that lived at the same time as the beaver species?



A.	Layer 3
B.	Layer 10
C.	Layer 1

D.	Layer 5

10.

Cytochrome c is a protein found in the electron transport chain of all eukaryotes. The table below shows the relative differences in cytochrome c among several species.

Comparison of Cytochrome Sequences Among Species

Species	# Different Amino Acids (compared to humans)	Percentage Difference
Human	–	–
Chimpanzee	0	0%
Sheep	10	10%
Rattlesnake	14	13%
Carp	18	17%
Garden snail	29	28%

What conclusion can you draw from this data?

A.	Humans and chimpanzees are the same species.
B.	Sheep and rattlesnake both evolved from carp.
C.	Chimpanzees evolved from sheep.
D.	Humans are more closely related to chimpanzees than carp.

Next Lesson:
Unit 4
4.2, 4.3, 4.4

-end-