

The Environment and Change Over Time

Biological Evidence of Evolution

..... Before You Read

What do you think? Read the two statements below and decide whether you agree or disagree with them. Place an A in the Before column if you agree with the statement or a D if you disagree. After you've read this lesson, reread the statements to see if you have changed your mind.		
Before	Statement	After
	5. Living species contain no evidence that they are related to each other.	
	6. Plants and animals share similar genes.	

..... Read to Learn

Evidence for Evolution

The pictures of horse fossils in Lesson 1 seem to show that horses evolved in a straight line. That is, one species replaced another in a series of orderly steps. Evolution does not occur this way. Different horse species were sometimes alive at the same time. They are related to one another because each descended from a common ancestor.

Living species that are closely related share a close common ancestor. How closely they are related depends on how closely in time they diverged, or split, from that ancestor. Evidence of common ancestors can be found in the fossil record and in living organisms.

Comparative Anatomy

It is easy to see that some species evolved from a common ancestor. For example, robins, finches, and hawks have similar body parts. They all have feathers, wings, and beaks. The same is true for tigers, leopards, and house cats. But how are hawks related to cats?

Studying the structural and functional similarities and differences in species that do not look alike can show the relationships. *The study of similarities and differences among structures of living species is called **comparative anatomy**.*

Key Concepts

- What evidence from living species supports the theory that species descended from other species over time?
- How are Earth's organisms related?

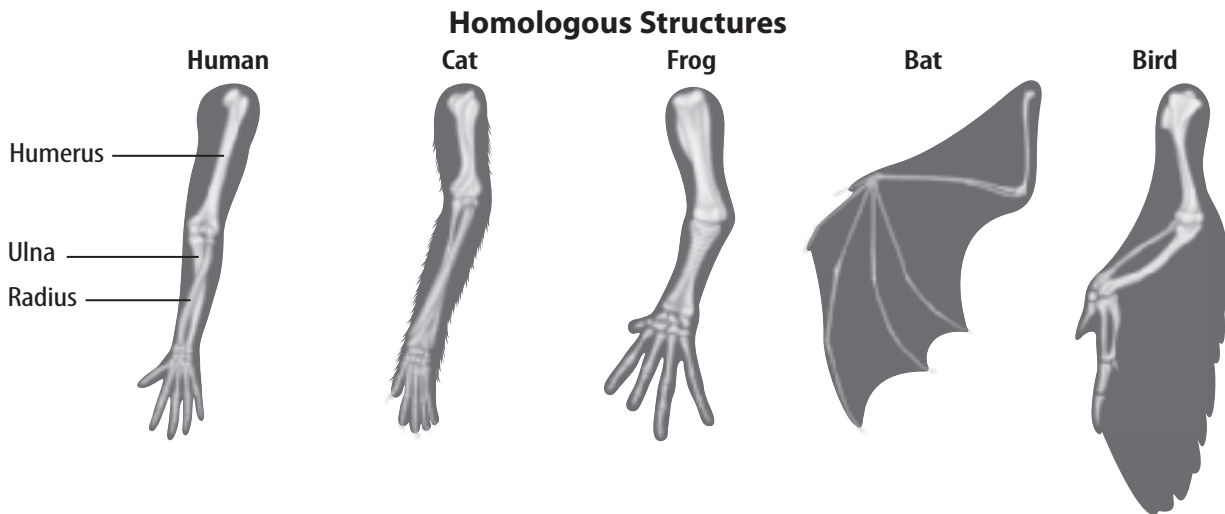
Mark the Text

Identify Main Ideas

Highlight the main idea of each paragraph. Highlight two details that support each main idea with a different color. Use your highlighted copy to review what you studied in this lesson.

Make a table with five rows and three columns. Label the rows and columns of the table as shown below. Give your table a title.

	Explanation	Example
Comparative Anatomy		
Vestigial Structures		
Developmental Biology		
Molecular Biology		



Visual Check

1. Infer What is the function of the bones in bats that are homologous to finger bones in humans?

Key Concept Check

2. Explain How do homologous structures provide evidence for evolution?

Homologous Structures Humans, cats, frogs, bats, and birds look different and move in different ways. Humans use their arms for balance and their hands to grasp objects. Cats use their forelimbs to walk, run, and jump. Frogs use their forelimbs to jump. The forelimbs of bats and birds are wings and are used for flying. However, the forelimb bones of all these species show similar patterns, as shown in the figure above. The forelimbs of the species in the figure are different sizes, but their placement and structure suggest common ancestry.

Homologous (huh MAH luh gus) **structures** are body parts of organisms that are similar in structure and position but different in function. Homologous structures, such as the forelimbs of humans, cats, frogs, bats, and birds, suggest that these species are related. The more alike two structures are, the more likely it is that the species have evolved from a recent common ancestor.

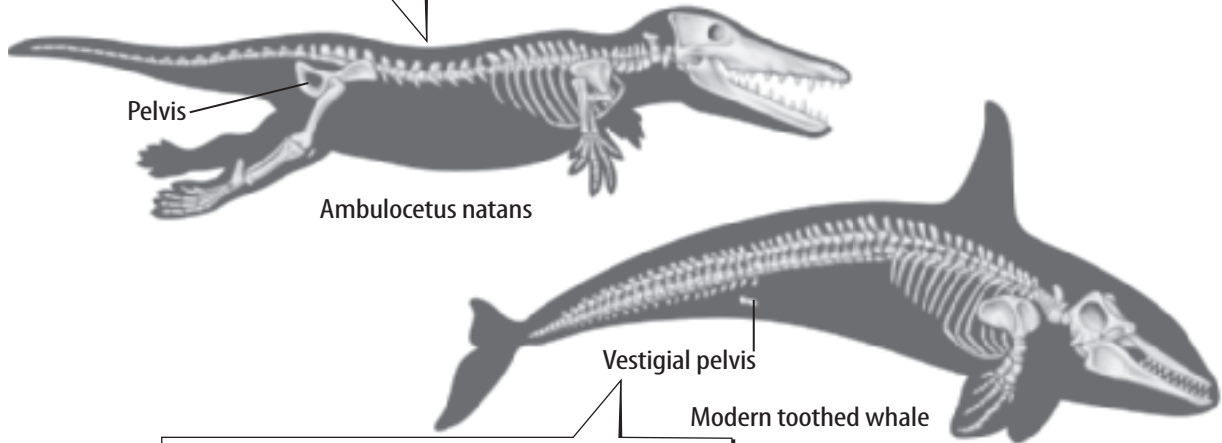
Analogous Structures Can you think of a body part in two species that does the same job but differs in structure? How about the wings of birds and flies? The wings in both species are used for flight. But bird wings are covered with feathers. Fly wings are covered with tiny hairs. Though used for the same function—flight—the wings of birds and insects are too different in structure to suggest close common ancestry.

Bird wings and fly wings are analogous (uh NAH luh gus) structures. **Analogous structures** are body parts that perform a similar function but differ in structure. The differences in wing structure show that birds and flies are not closely related.

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Vestigial Structures


Between 50–40 million years ago, this mammal breathed air and walked clumsily on land. It spent a lot of time in water, but swimming was difficult because of its rear legs. Individuals born with variations that made their rear legs smaller lived longer and reproduced more. This mammal is an ancestor of modern whales.



After 10–15 million more years of evolution, the ancestors of modern whales could not walk on land. They were adapted to an aquatic environment. Modern whales have two small vestigial pelvic bones that no longer support legs.

Vestigial Structures

Ostriches have wings. Yet they cannot fly. An ostrich's wings are an example of vestigial structures. **Vestigial** (veh STIH jee ul) **structures** are body parts that have lost their original function through evolution. The best explanation for vestigial structures is that the species with a vestigial structure is related to an ancestral species that used the structure for a specific purpose.

The whale shown in the figure above has tiny pelvic bones inside its body. Pelvic bones are hip bones, which in many species attach the leg bones to the body. Modern whales do not have legs. The pelvic bones in whales suggest that whales came from ancestors that used legs for walking on land. The fossil evidence supports this conclusion. Many fossils of whale ancestors show a slow loss of legs over millions of years. They also show, at the same time, that whale ancestors became better adapted to their watery environments. 

Developmental Biology

Studying the internal structures of living organisms is not the only way that scientists learn about common ancestors. Studying how embryos develop can also show how species are related. *The science of the development of embryos from fertilization to birth is called **embryology** (em bree AH luh jee).*

Visual Check

3. Infer Why does a vestigial pelvis show that the ancestors of the modern whale once had legs?

Key Concept Check

4. Explain How are vestigial structures evidence of descent from ancestral species?

Pharyngeal Pouches Embryos of different species often look like each other at different stages of their growth. For example, all vertebrate embryos have pharyngeal (fuh rihn JEE ul) pouches at one stage. These pouches become different body parts in each vertebrate. Yet, in all vertebrates, each part is in the face or neck.

In reptiles, birds, and humans, part of the pharyngeal pouch develops into a gland in the neck. This gland regulates, or balances, the body's calcium levels.

In fish, the same part becomes the gills. One function of gills is to regulate calcium. The similar function and location of gills and glands suggest a close evolutionary relationship between fish and other vertebrates.

Molecular Biology

Studies of fossils, comparative anatomy, and embryology provide support for Darwin's theory of evolution by natural selection. Molecular biology is the study of gene structure and function.

Discoveries in molecular biology have confirmed and extended much of the data already collected about the theory of evolution. Darwin did not know about genes, but scientists today know that mutations in genes are the source of variations upon which natural selection acts. Genes provide powerful support for evolution.

Comparing Sequences All living organisms have genes. All genes are made of DNA, and all genes work in similar ways. This supports the idea that all living organisms are related.

Scientists can study how living organisms are related by comparing their genes. For example, nearly all organisms have a gene for cytochrome *c*, a protein required for cellular respiration. Some species, such as humans and rhesus monkeys, have nearly identical cytochrome *c*. The more closely related two species are, the more similar their genes and proteins are.

Divergence Scientists have found that some stretches of shared DNA mutate at regular, predictable rates. Scientists use this "molecular clock" to estimate when in the past living species split from common ancestors. This is how scientists have shown that whales and porpoises are more closely related to hippopotamuses than they are to other living things. Whales and hippopotamuses share an ancestor that lived 50–60 million years ago.

Key Concept Check

5. Analyze How do pharyngeal pouches provide evidence of relationships among species?

Reading Check

6. Describe What is molecular biology?

Key Concept Check

7. Explain How is molecular biology used to determine relationships among species?

The Study of Evolution Today

The theory of evolution by natural selection is the cornerstone of modern biology. Since Darwin published his theory, scientists have confirmed, refined, and extended his work. They have observed natural selection in hundreds of living species. Their studies of fossils, anatomy, embryology, and molecular biology have shown relationships among living and extinct species. ✓

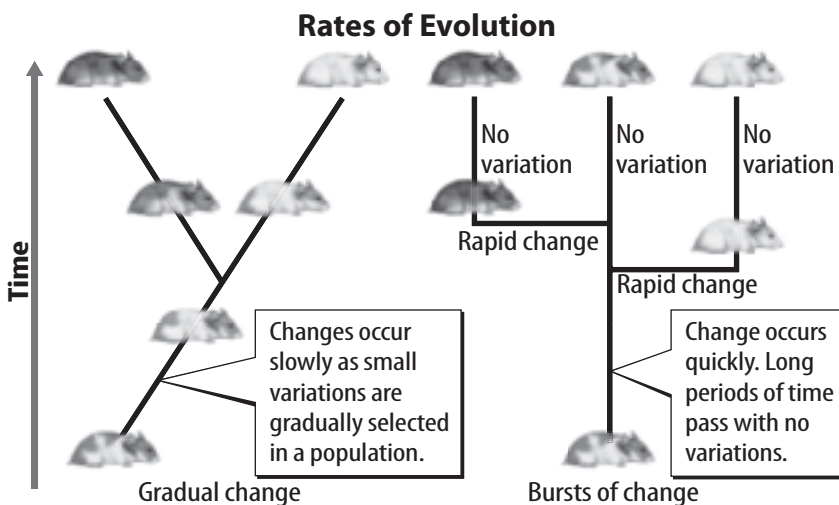
How New Species Form

New evidence supporting the theory of evolution by natural selection is discovered nearly every day. But scientists debate some of the details. The figure below shows how scientists have different ideas about the rate at which natural selection produces new species. Some say it works slowly and gradually. Others say it works quickly, in bursts. How different species first came about is difficult to study on human time scales. It is also difficult to study with the incomplete fossil record. Yet, new fossils that fill in the holes are discovered all the time. Further fossil discoveries will help scientists study more details about the origin of new species. ✓

Diversity

Evolution has produced Earth's wide diversity of living things using the same basic building blocks called genes. This is an active area of study in evolutionary biology. Scientists are finding that genes can be reorganized in simple ways and give rise to dramatic changes in organisms. Scientists now study evolution by looking at molecules. Yet, they still use the same basic ideas that Darwin came up with over 150 years ago.

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✓ Reading Check

8. Connect What is the connection between modern biology and the theory of evolution by natural selection?

✓ Reading Check

9. Describe a difference of opinion in regard to how scientists interpret the theory of evolution by natural selection.

✓ Visual Check

10. Analyze What does a flat (horizontal) line mean in the figure? (Circle the correct answer.)

- a. gradual change
- b. no variation
- c. rapid change

..... After You Read

Mini Glossary

analogous (uh NAH luh gus) structure: a body part that performs a similar function to the body part of another organism, though it differs in structure

comparative anatomy: the study of similarities and differences among structures of living species

embryology (em bree AH luh jee): the science of the development of embryos from fertilization to birth

homologous (huh MAH luh gus) structure: a body part that is similar in structure and position to the body part of another organism, though it has a different function

vestigial (veh STIH jee ul) structure: a body part that has lost its original function through evolution

- Review the terms and their definitions in the Mini Glossary. Use one of the terms to write your own sentence.

- Use what you have learned about analogous, homologous, and vestigial structures to complete the table. The last row has been completed for you.

Structures	Example Pair of Structures	Similar Structure or Function (circle one)
Analogous		similar structure or function
Homologous		similar structure or function
Vestigial	pelvic bone in modern whales pelvic bone in whale ancestors	similar <u>structure</u> or function

- How did highlighting the main idea in each paragraph help you study this lesson?

What do you think **NOW?**

Reread the statements at the beginning of the lesson. Fill in the After column with an A if you agree with the statement or a D if you disagree. Did you change your mind?



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