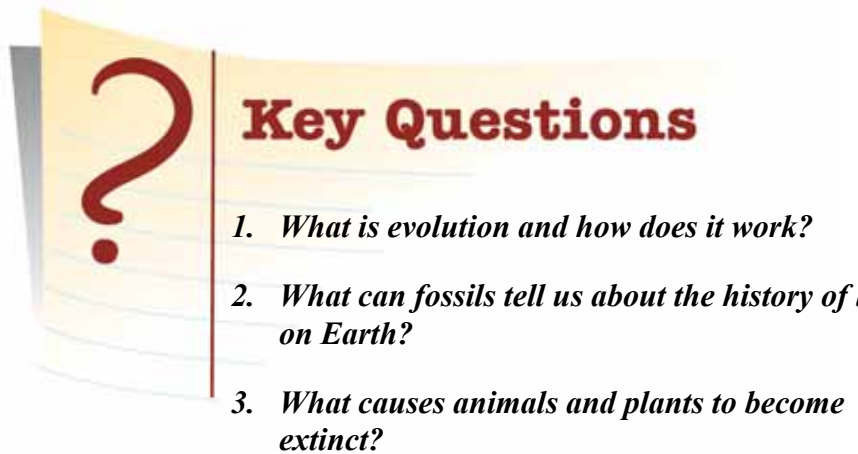
Chapter 11

Evolution

Why are polar bears white instead of brown or black? White fur helps polar bears blend into the Arctic ice and snow so they can hunt more successfully. White fur has a survival advantage for polar bears. As millions of years passed, and generations upon generations of polar bears survived and reproduced, natural selection occurred in the bear population to favor white fur. Evolutionary concepts like adaptation and natural selection are featured in this chapter.



11.1 Evidence for Evolution

Imagine going back in time 50 million years. You see a horse about the size of a cat. Would you believe you are looking at an ancestor of the modern horse (Figure 11.1)? *Eohippus* was only 20 cm tall at the shoulders and had five toes. A modern horse is about 150 cm tall at the shoulders and has only one toe. A scientific theory states that newer species have descended from older species through a process called *evolution*. What is evolution and what is the evidence that supports it as a theory?

Figure 11.1: *Eohippus is an ancestor of the modern horse.*

What is evolution?

Adaptation and evolution

An **adaptation** is an inherited trait that helps an organism survive. Adaptations include body structures that help an organism feed, move around, and protect itself. **Evolution** is the process of how organisms acquire adaptations over time.

A moth and a bird

Through evolution, the structures of organisms become adapted for their functions. Look at the organisms below. The one on the left is a sphynx moth (an insect). The one on the right is a hummingbird. Both species have evolved similar adaptations for feeding on flower nectar. Can you identify how they are similarly adapted for feeding? How are they different?

VOCABULARY

adaptation - an inherited trait that helps an organism survive.

evolution - the process of how organisms acquire adaptations over time.

Evolution is a branching process

All life forms had a common beginning

There is great diversity in living species. *Diversity* means variety. Scientists estimate that there are between 5 and 50 million living species. Among those species are single-celled bacteria that lack cell nuclei, single-celled eukaryotes that have cell nuclei, and multicellular fungi, plants, and animals. Where did all of these different species come from? Scientists hypothesize that **all life forms evolved from a common ancestor and new species branch off from earlier species.** An **ancestor** is an organism from which others have descended.

Cell evidence

You have learned that all living things are made of cells. There are striking similarities among all cells. For example, all cells have a similar cell membrane. Many cells have the same type of cellular respiration. Also, all cells have DNA as their hereditary material. Similarities among all cells support the hypothesis that all life evolved from a common ancestor.

Bacteria were the first living things

In Chapter 7, you learned that bacteria were the first organisms on Earth. Evidence for this comes from fossils of single-celled prokaryotes found in rocks that are more than 3 billion years old. Scientists hypothesize that all species evolved from a single prokaryotic cell such as a bacteria. Eukaryotic cells evolved from bacteria. Multicellular organisms followed. From there, more and more species branched off through the process of evolution.

Branching diagrams

A **cladogram** displays evolutionary relationships among living species and their ancestors. A cladogram resembles a branching tree. Each branch represents a different evolutionary path. The point where two branches come together represents a common ancestor that shares evolved characteristics with the species that branch off from it. Figure 11.2 shows a simple cladogram.

VOCABULARY

ancestor - an organism from which others have descended.

cladogram - a tree-like diagram that displays evolutionary relationships among living species and their ancestors.

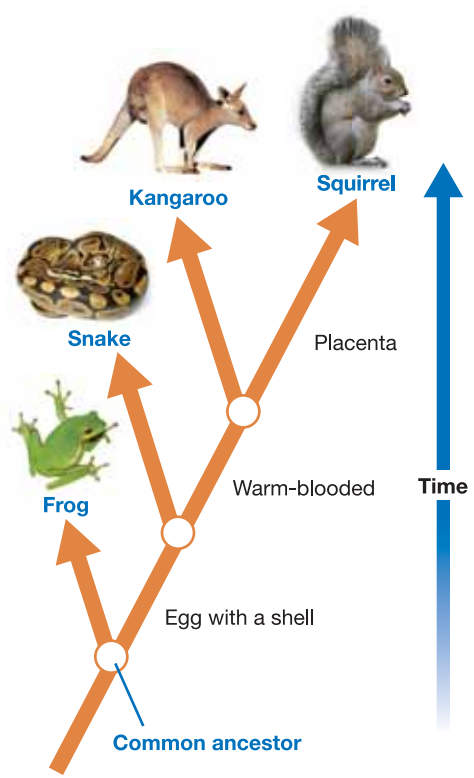
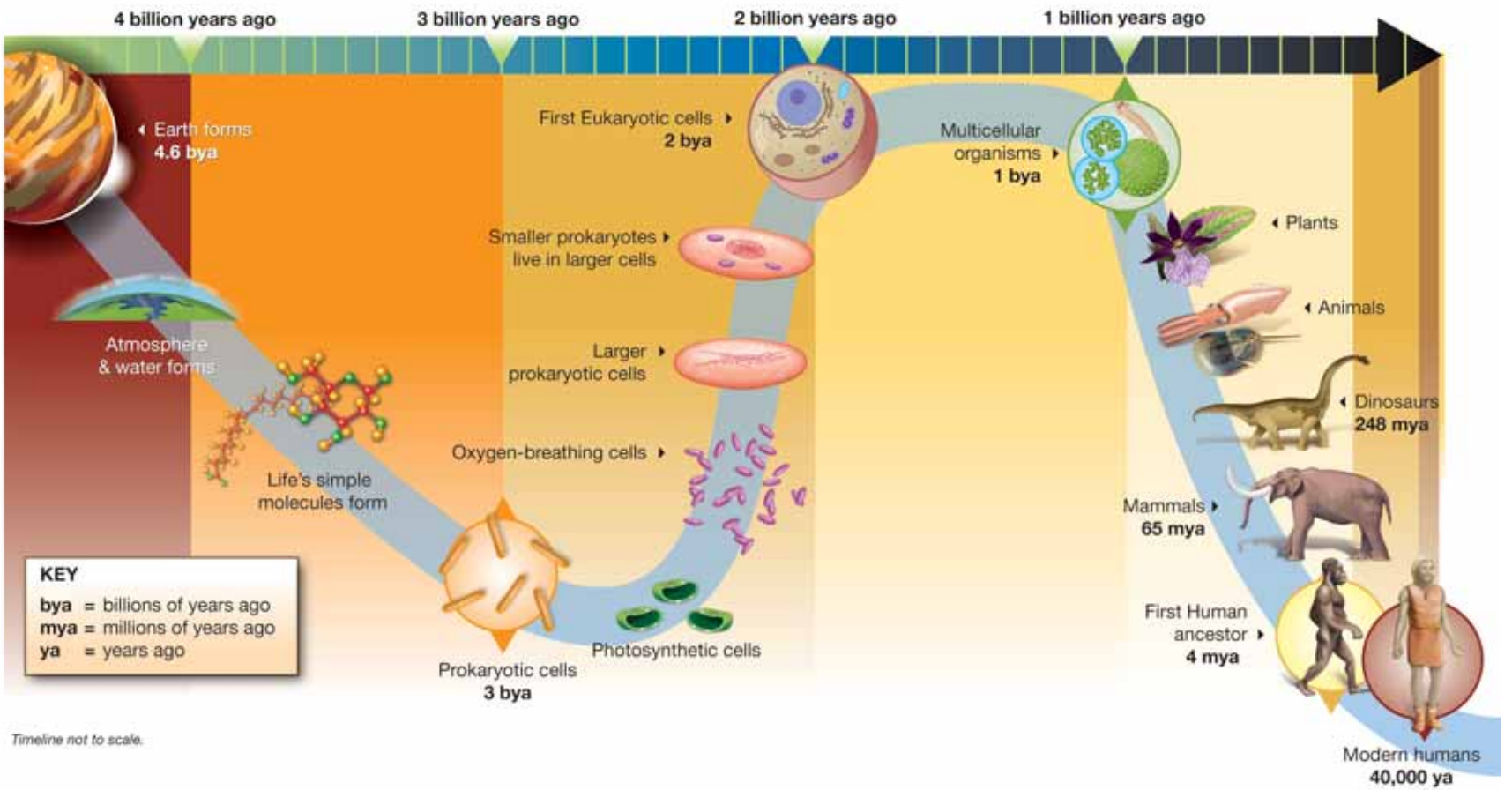


Figure 11.2: *An example of a cladogram.*

An evolutionary timeline

Scientists believe that Earth is about 4.6 billion years old. The first life appeared over 3 billion years ago in the form tiny, single-celled prokaryotes. About 2 billion years ago, those cells evolved into larger cells with a nucleus. Smaller prokaryotic cells took up residence inside the larger cells and eventually evolved into organelles like mitochondria. Multicellular organisms appeared about a billion years ago. Larger animals and plants have been evolving for the past 500 million years. The diagram below shows a theoretical timeline of how the diversity of life evolved.



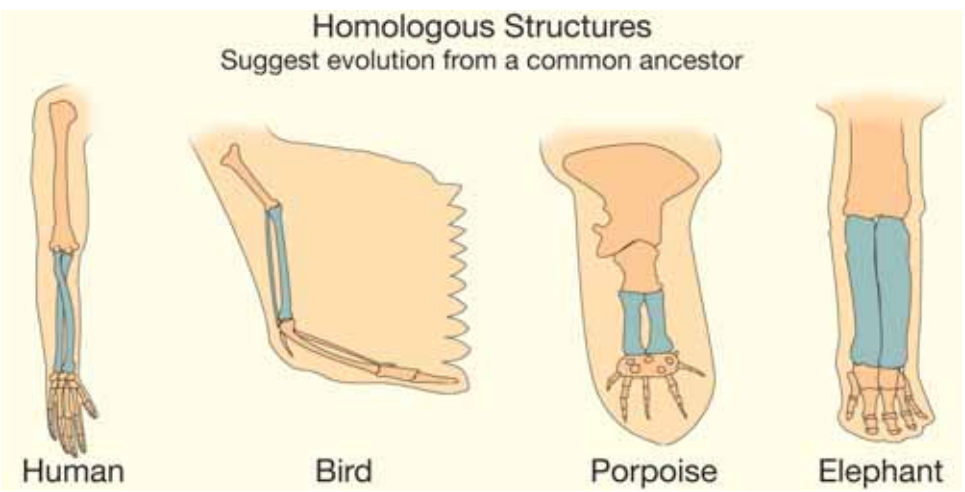
Lines of evidence

Three major lines of evidence

Evolution is a scientific theory that explains how life changes through time. A theory is based on scientific evidence gathered from data and observations. **Many lines of evidence provide the basis for the theory of evolution. These include comparative anatomy, DNA analysis, and the fossil record.**

Comparative anatomy

Comparative anatomy is the study of anatomical similarities and differences among species. For example, what does your arm have in common with the wing of a bird, the flipper of a porpoise, and the forelimb of an elephant? The diagram below shows that each has a similar bone structure. **Homologous structures** have a common origin, but do not necessarily perform the same function. The structures in the limbs below indicate that the organisms are related by a common ancestor.



Analogous structures

Analogous structures serve the same function but come from different origins. Though structurally similar, they do not arise from a common ancestor. An example of analogous structures is the wing of an insect and the wing of a bird (Figure 11.3).

VOCABULARY

homologous structures - body structures that have a common origin but do not necessarily perform the same function.

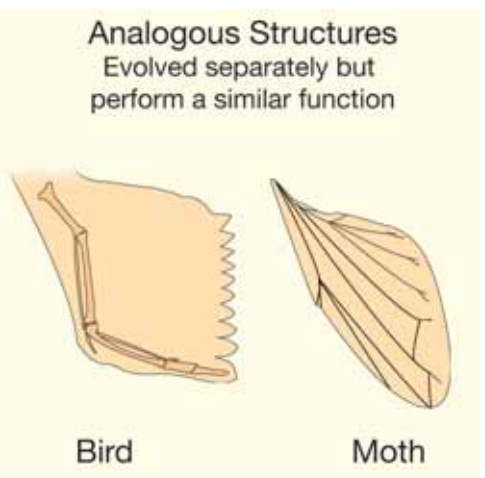


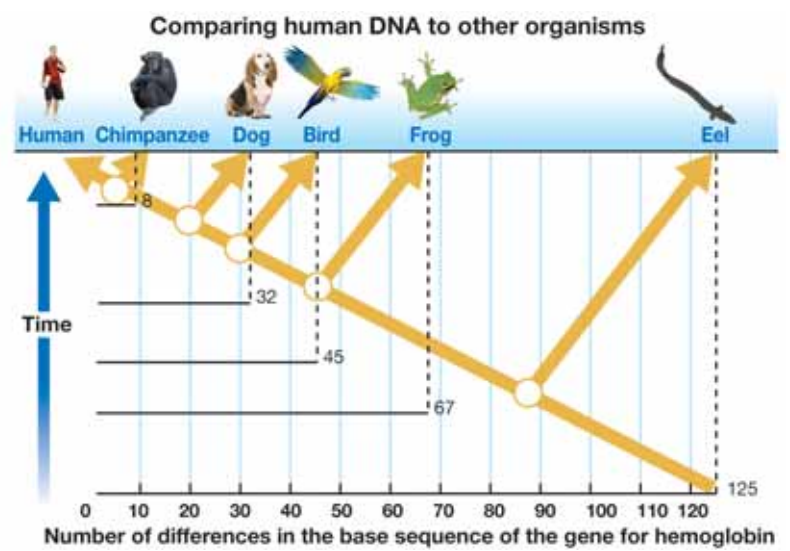
Figure 11.3: *An insect wing and the wing of a bird are both similar in function but do not come from a common ancestor.*

Comparing embryos

Another way to compare the anatomy of different species is to compare their embryos. Comparative anatomists have discovered similarities in embryos of vertebrates (Figure 11.4). **Vertebrates** are animals with a backbone. You are a vertebrate. So are other mammals, birds, reptiles, and fish. Adult vertebrates also share many similarities in their skeletons and muscles. This is evidence that all vertebrates descended from a common ancestor.

DNA evidence

All species of organisms have DNA as their hereditary material. Scientists compare the DNA base sequences of different species to determine evolutionary relationships. **Species that share more similarities in their DNA base sequences are more closely related than those that share fewer similarities.** Scientists hypothesize that if two species have similarities in their base sequences, they share a common ancestor. The diagram compares the DNA base sequences in the gene that codes for hemoglobin in vertebrates. The greater the number of differences in base sequences, the farther the evolutionary distance from humans.



VOCABULARY

vertebrates - animals with a backbone.

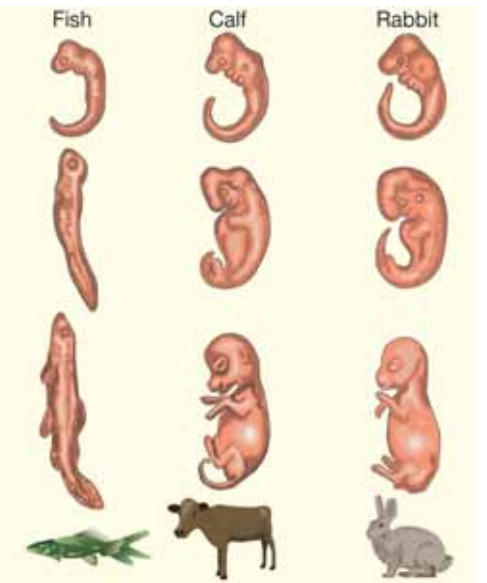


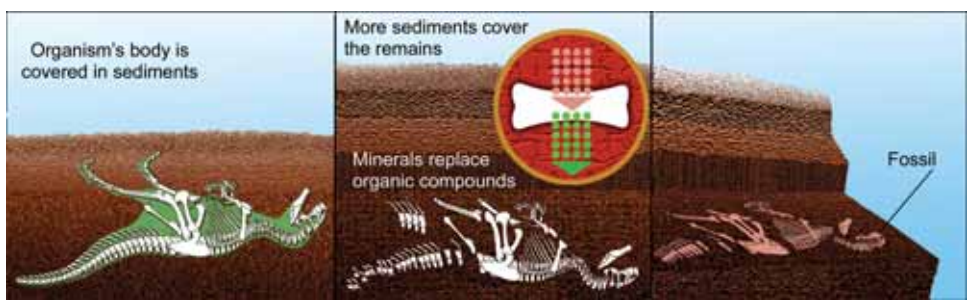
Figure 11.4: *Comparing the embryos of different vertebrates.*

Fossils

What are fossils? Much of the evidence for evolution comes from studying fossils. A **fossil** is a remnant or trace of an organism from the past, such as a skeleton or leaf imprint, embedded and preserved in Earth's crust. Earth's crust is its outermost layer made mostly of rock.

Sedimentary rock Most fossils are dug up from sedimentary rock layers. *Sedimentary rock* is rock that has formed from *sediments*, like sand, mud, or small pieces of rock. Over long periods of time, sediments are squeezed together as they are buried under more and more layers that pile up. Eventually, those sediments are compressed into sedimentary rock. The layers that are farther down in Earth's crust are older than the upper layers. Figure 11.5 shows layers of sedimentary rock that have been exposed along a river. Each layer contains fossils. Which fossils are oldest?

How fossils are formed Many fossils are formed from the hard parts of an organism's body like bones and teeth. Fossil formation begins when an organism's body is quickly covered in sediments from an event like a mudslide or a sand storm. Over time, more and more sediments cover the remains. The body parts that do not rot are buried under layers of sediments. After a long time, the chemicals in the body parts are replaced with rock-like minerals. This process results in a heavy, rock-like copy of the original object—a fossil.



VOCABULARY

fossil - a remnant or trace of an organism from the past, such as a skeleton or leaf imprint, embedded and preserved in Earth's crust.

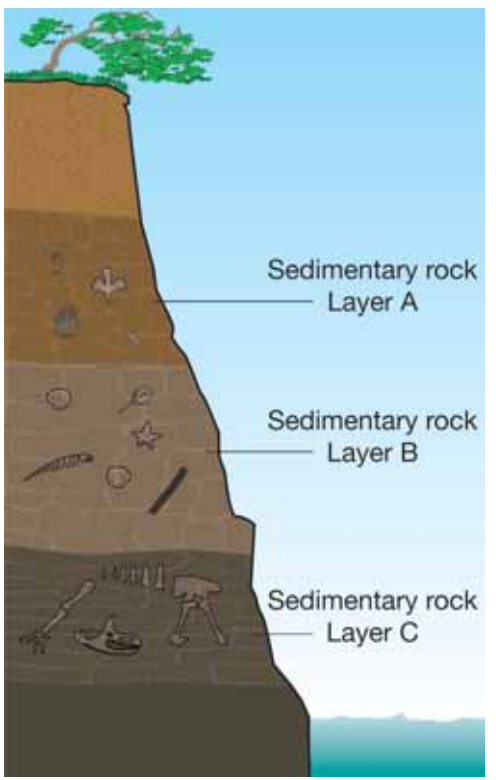


Figure 11.5: *Which fossils are oldest? Which are youngest?*

The fossil record

What is the fossil record?

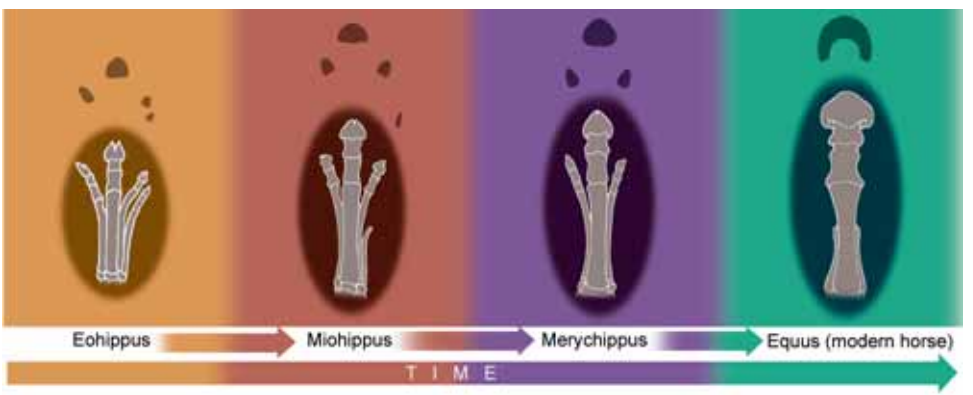
Fossils provide a historical sequence of life on Earth known as the **fossil record**. Fossils found in the upper (newer) sedimentary layers more closely resemble present-day organisms than fossils found in deeper (older) layers. Through that information, scientists have been able to piece together parts of the fossil record. Scientists use the fossil record to trace the order in which evolutionary changes occurred.

Gaps in the fossil record

Although scientists have collected thousands of fossils, there are many gaps in the fossil record. That is because most ancient species did not fossilize. They simply decayed and were lost from the fossil record. Scientists estimate that only a small percentage of past organisms have been (or will be) found as fossils.

Using the fossil record

A good example of how scientists use the fossil record to trace evolution is the horse. Scientists have found many fossils of horse ancestors. Figure 11.6 shows how some of the horse's ancestors may have looked. Below are the limb bones of horse ancestors and the modern horse. The evolution of a species takes millions of years and does not occur in a straight line. There are many branches that lead to different species with different adaptations.



VOCABULARY

fossil record - a historical sequence of life on Earth based on the sequence of fossils.

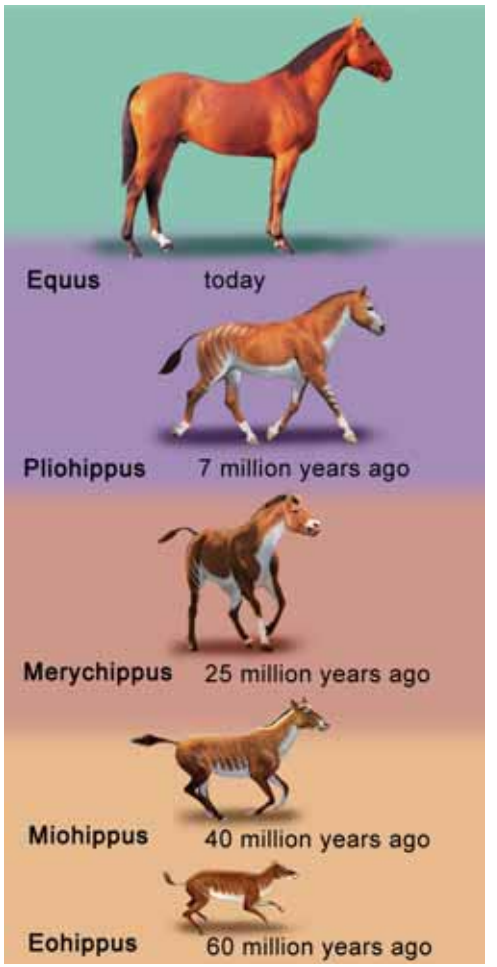
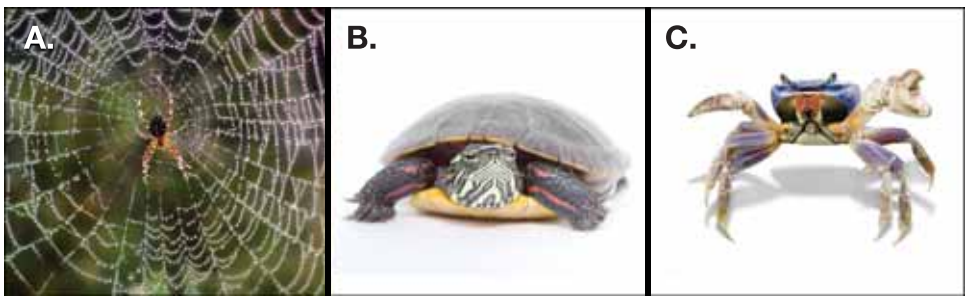


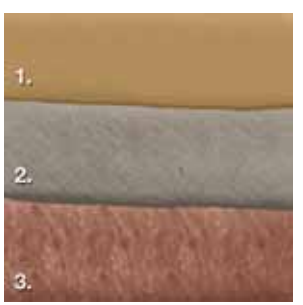
Figure 11.6: *Ancestors of the modern horse.*

11.1 Section Review

1. What are adaptations? Give an example of an adaptation.
2. For each organism, name one adaptation and its function.



3. Use the words *evolution* and *ancestor* in a sentence.
4. Name one reason scientists believe that all life evolved from a single common ancestor.
5. Match the organism with its place on the cladogram (Figure 11.7). Explain the reasoning behind your placement.
6. How do similarities in the bones of humans, dolphins, horses, and birds provide evidence for evolution?
7. How is DNA evidence used to show evolutionary relationships?
8. The diagram (right) shows different fossil layers. Match each layer with the ages of the fossils that would be found there.
   a. 150 million years ago
   b. 140 million years ago
   c. 120 million years ago



9. Explain why there are gaps in the fossil record.

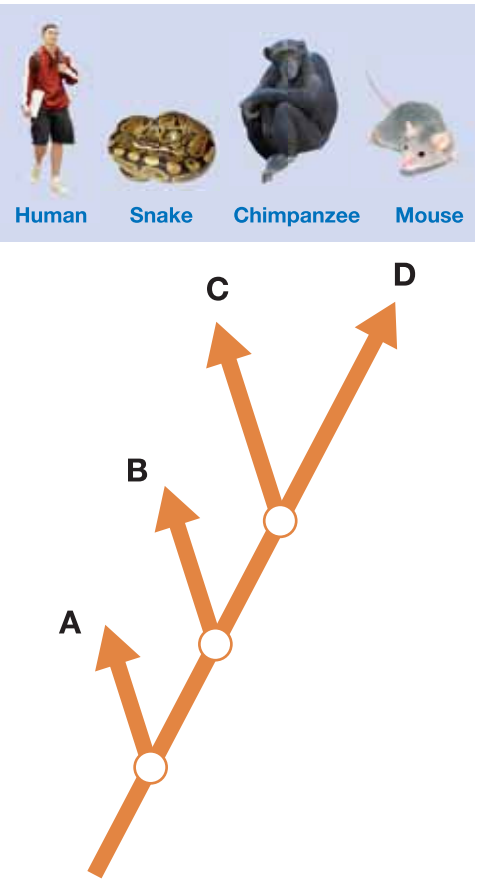


Figure 11.7: *Use the diagram above to answer question 5.*

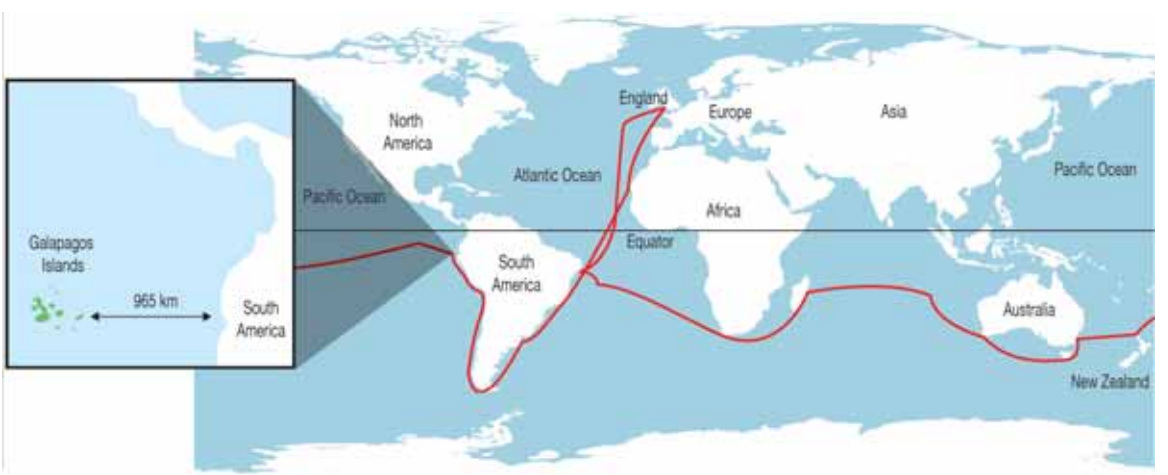
11.2 How Evolution Works

In 1831, the research ship *H.M.S. Beagle* left England for a five-year cruise around the world. On the ship was a young man named Charles Darwin (1809–1882). During the trip, Darwin collected thousands of plant and animal species. He was amazed at the diversity of life he encountered. Darwin wrote down his observations and collected evidence about evolution. That evidence led him to propose a theory about how evolution works called *natural selection*.

The finches of the Galapagos

The voyage of the *Beagle*

One of the places where the *Beagle* stopped was the Galapagos Islands, located 965 km west of South America. There, Darwin observed that the finches were different than those found on the mainland. He also noted differences in finches from island to island. One difference he found was in the shape of their beaks. The shape of finch beaks appeared to differ with the type of food eaten (Figure 11.8). Darwin concluded that finch beaks were adapted for the type of food they ate. He began to think about why and how the finches became different from each other.



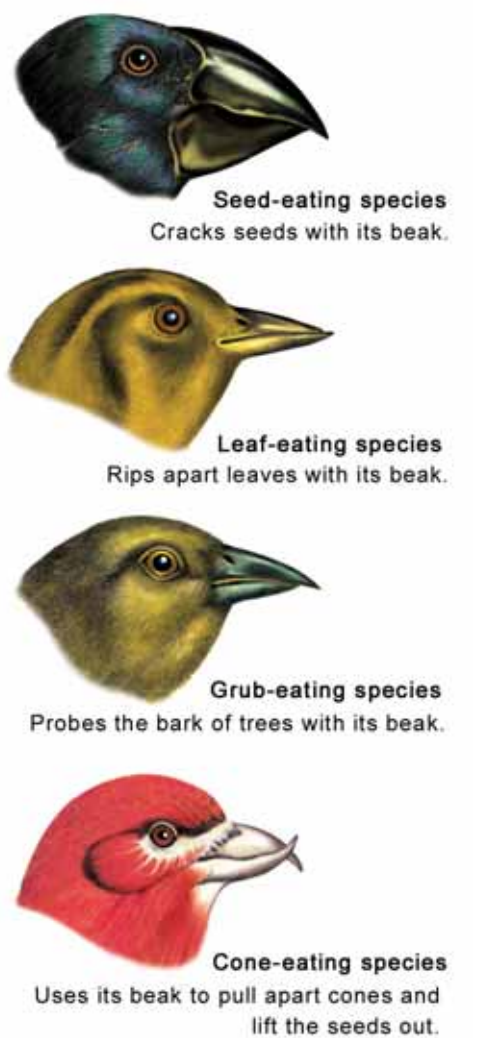


Figure 11.8: *The beaks of finches are adapted to obtain food in different ways.*

Darwin's hypothesis about finches

Darwin hypothesized that an ancestral species of finch from the mainland somehow ended up on the Galapagos Islands. The finches of that species scattered to different environments. There, they had to adapt to different conditions. Over many generations, they evolved adaptations that allowed them to get enough food to survive and reproduce. Each group of finches became isolated from the other groups. Eventually, each group became a different species (Figure 11.9). When Darwin returned to England from his voyage, he began to develop a theory about how the adaptations evolved.

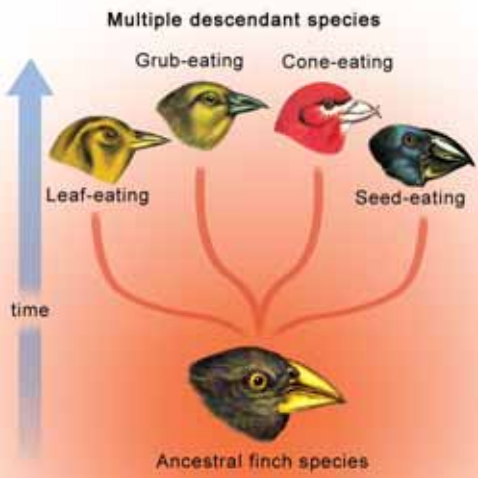


Figure 11.9: *New finch species evolved from a common ancestor.*

Earth formed slowly

From geologists, Darwin learned that Earth was formed very slowly over a long period of time. Its surface also changed slowly over time through natural processes like sedimentation and erosion. Darwin reasoned that populations of organisms changed slowly as their environment slowly changed. If the environment changes rapidly from an event like a flood, an earthquake, or a volcanic eruption, a species could become *extinct* (all members die off completely).

Fossil evidence

Darwin used fossils as evidence that different species evolve over a long period of time. He found fossils of species that lived a few million years ago that resembled living species. For example, the *glyptodon*, an extinct mammal, resembled the armadillo, an organism Darwin knew as a living species (Figure 11.10).

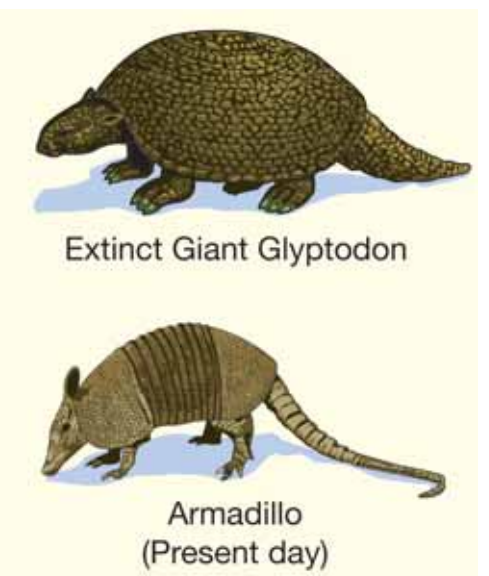


Figure 11.10: *The ancient glyptodon resembles the modern armadillo.*

Artificial and natural selection

In Darwin's time, animal and plant breeders used selective breeding to produce organisms with the traits they desired. Darwin called selective breeding *artificial selection* because the breeders selected the desired traits to produce changes in a species over a few generations. In wild animals and plants, Darwin believed that traits were selected by the environment. He called this process *natural selection*. He believed that natural selection took longer than artificial selection because it happened by chance.

Darwin's theory of evolution and natural selection

Darwin publishes his results

In 1859, Darwin published the results of his study in a book called *On the Origin of Species by Means of Natural Selection*. Based on his research and evidence, Darwin concluded that:

1. **Organisms change over time.**
2. **All organisms are descended from common ancestors by a process of branching.**
3. **Evolution is gradual, taking place over a long time.**
4. **The mechanism of evolution is natural selection.**

What is natural selection?

Natural selection is the process by which organisms with favorable adaptations survive and reproduce at a higher rate than organisms with less-favorable adaptations. Darwin based his ideas about natural selection, in part, on the work of British professor Thomas Malthus (1766–1834).

Populations grow faster than their food supply

In 1798, Malthus published his *Essay on Population*. In that essay, he argued that humans have a tendency to grow faster than their food supply (Figure 11.11). This causes food shortages and a "struggle for existence." Darwin's observations in the Galapagos Islands led him to apply Malthus' ideas to animals and plants.

Darwin's conclusions

Darwin proposed that environmental variables affect the size of a population. Variables include predators, food supply, disease, and climate. He reasoned that if a species produces too many offspring and only a certain number survive, the survivors must be better adapted to their environment than those that die. Darwin concluded that offspring of the survivors would inherit the favorable adaptations. Organisms with unfavorable adaptations die before they can pass them on to offspring.

VOCABULARY

natural selection - the process by which organisms with favorable adaptations survive and reproduce at a higher rate than organisms with less-favorable adaptations.

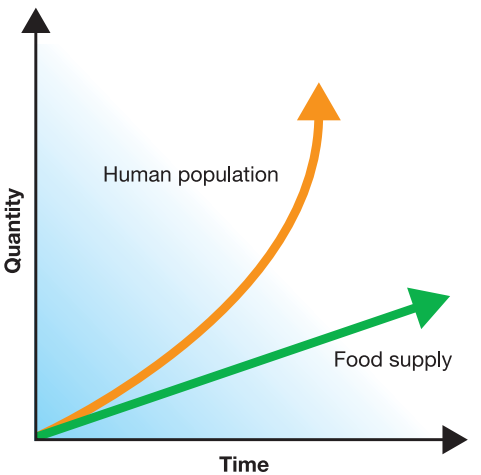


Figure 11.11: *Populations tend to grow faster than their food supply.*

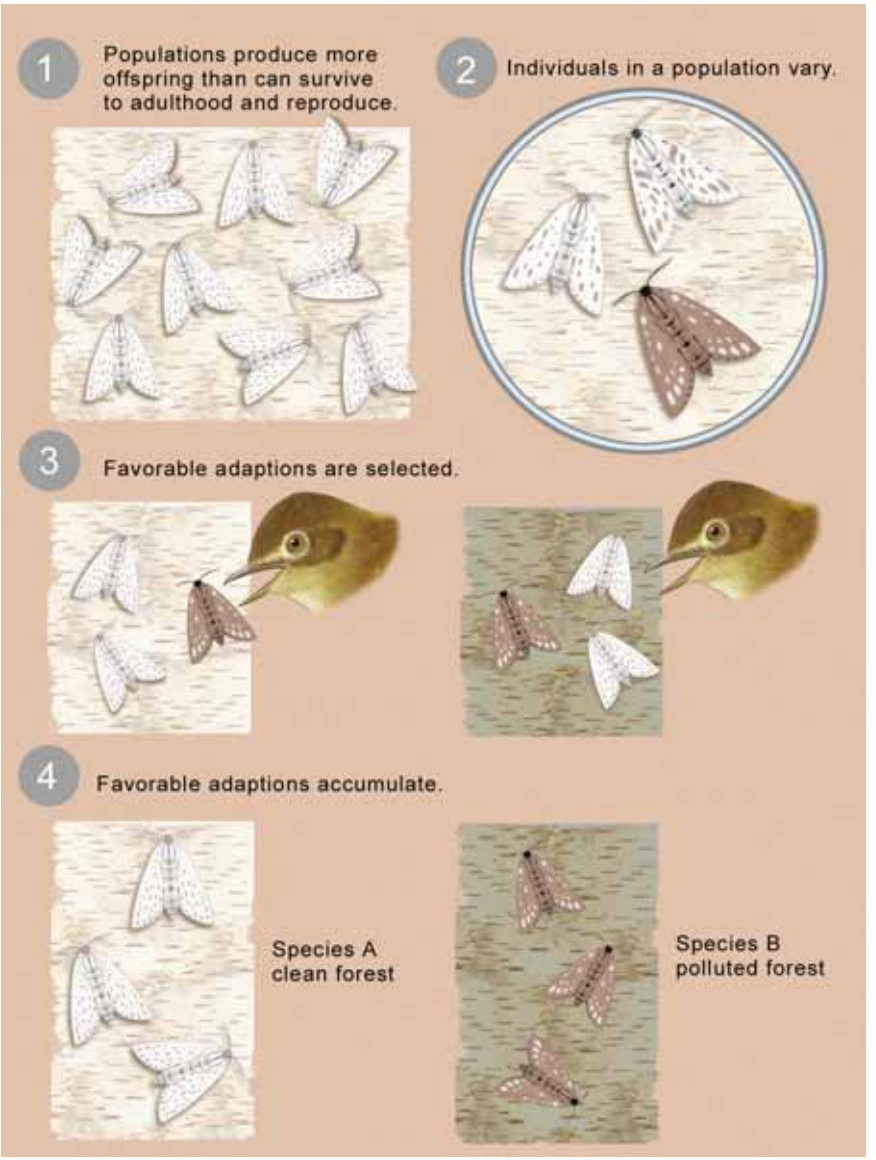
MY JOURNAL

When wolves hunt deer, they are usually able to catch only the weak or sick deer. The stronger and faster deer can escape. Explain how the wolf population may influence the adaptations of the deer population over time.

The process of natural selection

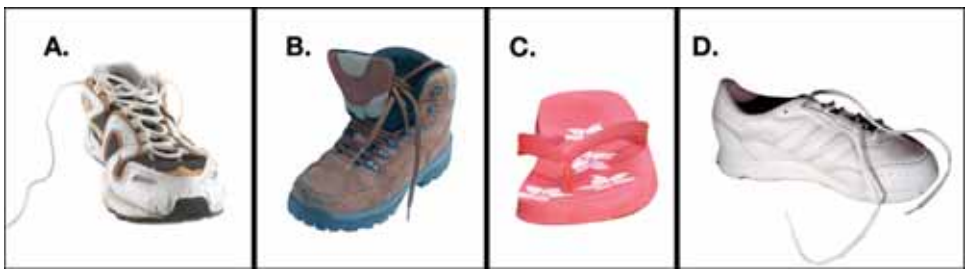
Darwin proposed that natural selection is the process for evolution. Today, it is still the most thorough explanation of how evolution occurs. The process of natural selection may be summarized in the steps below.

1. **Populations over-reproduce.** All organisms produce more offspring than can survive to adulthood and reproduce. This means that many of those offspring will die without reproducing. Survivors that are able to reproduce pass their traits on to their offspring.
2. **Individuals in a population vary.** There is random variation in traits among individuals in a population of a species. the variations each individual possesses happen by chance. Those variations are inherited.
3. **Favorable adaptations are selected.** The changing environment causes a selection of favorable traits (adaptations). Adaptations that fit well with the environment are passed on to offspring in greater numbers than adaptations that do not fit well.
4. **Favorable adaptations accumulate.** Favorable adaptations accumulate over many generations. This may lead to new species.



11.2 Section Review

1. On his journey, Darwin observed how different animal and plant species had adapted to function in their environments. Explain how each of the following items is best suited to its unique function.



2. Why did Darwin use selective breeding as evidence for evolution?
3. How did the work of geologists support Darwin's theories about evolution?
4. What is natural selection?
5. How did the work of Malthus help Darwin reach his conclusion about natural selection?
6. List three environmental variables that affect the size of a population.
7. A population of beetles eats only red flowers. Most of the beetles are red but a few of them are yellow. The red beetles are hidden from hungry, beetle-eating birds. The beetles eat up all of the red flowers and now there are only yellow flowers left. What would you expect to happen to the traits of the beetle population over time? What process would cause this to happen?

CHALLENGE

A challenge to Darwin's theory

Darwin's theory of evolution states that changes occur gradually and over many years.He used the fossil record to support his ideas. In the 1970s, American biologist Stephen Jay Gould (1941–2002) presented a challenge to Darwin's theory called *punctuated equilibrium*. He argued that a species can remain unchanged for millions of years. If a dramatic environmental event occurs, a species can undergo rapid changes in a short period of time. He also found evidence in the fossil record to support his idea.

1. What does Gould mean by a dramatic environmental event? List some of your ideas.
2. Do you agree or disagree with Gould's ideas? Explain your position and justify it with your knowledge about evolution.
3. Could Darwin's model for evolution and Gould's model both be correct? Explain your reasoning.

11.3 Natural Selection

Natural selection explains how a population changes in response to its environment. Those changes are called *adaptations*. Adaptations are inherited, therefore they must be carried on genes. Since Darwin developed his theory before Gregor Mendel's experiments, he knew nothing about genes. In this section, you will learn about the connection between natural selection and heredity.

Mutations

What causes genetic variation?

Since Darwin's time, there has been a growing body of knowledge about heredity. That knowledge explains many of Darwin's observations and supports the theory of evolution. For example, Darwin observed that individuals in a population show variation in their traits. Today, scientists know that variations in the population of a species are caused by random mutations in genes.

Random mutations in genes produce variations of traits in a population.

Mutations lead to alleles

Recall that alleles are different forms of a gene. A gene mutation leads to different alleles of that gene which in turn, leads to variations of a trait. Mutated alleles may cause favorable and unfavorable adaptations.

Favorable alleles are selected

Imagine a population of brown squirrels that has a single gene that determines fur color. A mutated allele causes white fur instead of brown fur. The squirrels with brown fur can hide from predators better than squirrels with white fur (Figure 11.12). Most of the squirrels that survive to reproduce are brown. Since brown fur is a favorable adaptation, the allele for brown fur is selected over the allele for white fur. What would happen to the frequency of the brown fur allele if the climate changed and the ground became covered in snow for most of each year?

STUDY SKILLS

Reviewing past topics will help you understand the concepts in this chapter. Below are topics and the page number in the text where you will find them. For each topic, go back and reread the page. Then, write down how that topic relates to what you are currently learning.

Species (definition) - page 40
Populations - page 56
Bacteria and evolution - page 137
Alleles - page 174
Mutations - page 198

Figure 11.12: *Squirrels with brown fur are better adapted than squirrels with white fur.*

The importance of genetic variation

Helpful mutations

You have learned that some mutations are harmful because they cause genetic disorders. Mutations may also be helpful because they contribute to genetic variation. **Genetic variation** refers to the variety of alleles in a population. Genetic variation is necessary for natural selection and ensures that a population has a better chance of survival should the environment change.

Changing environment

Because our fictional squirrel population carries an allele for white fur, it may have a better chance of surviving a change to a colder climate. The allele for white fur may be selected over the brown if the ground is covered in snow for most of each year. Over many generations, the frequency of the white fur allele may increase in the population while brown decreases.

Natural selection in action

Scientists have observed natural selection in species that produce new generations quickly. An example is pesticide resistance in the potato beetle. Farmers routinely spray pesticides to prevent this pest from destroying their crops. Each time they spray, a few of the beetles survive. The survivors carry a mutated allele that resists the pesticide. The survivors pass the resistant allele to their offspring. Because generations multiply quickly, it does not take long for a population of pesticide-resistant beetles to evolve (Figure 11.13).

VOCABULARY

genetic variation - the variety of alleles in a population.

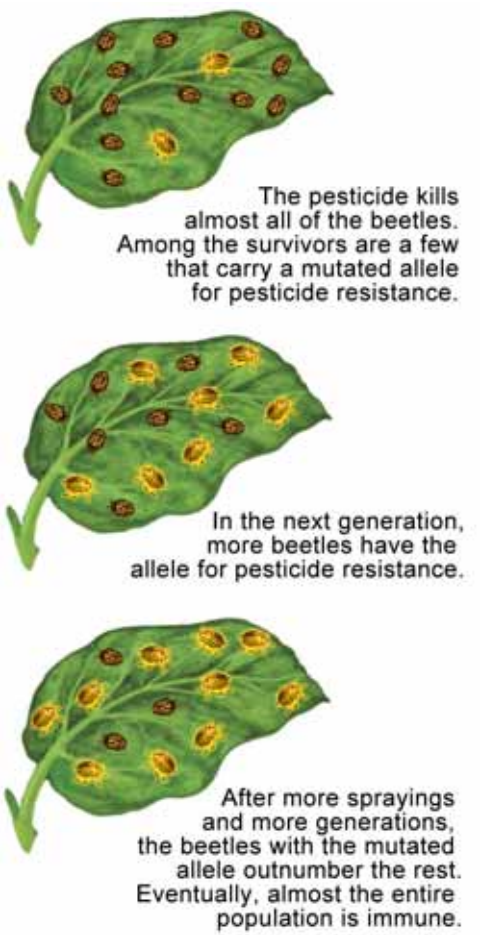


Figure 11.13: *How a population of potato beetles changes over time.*

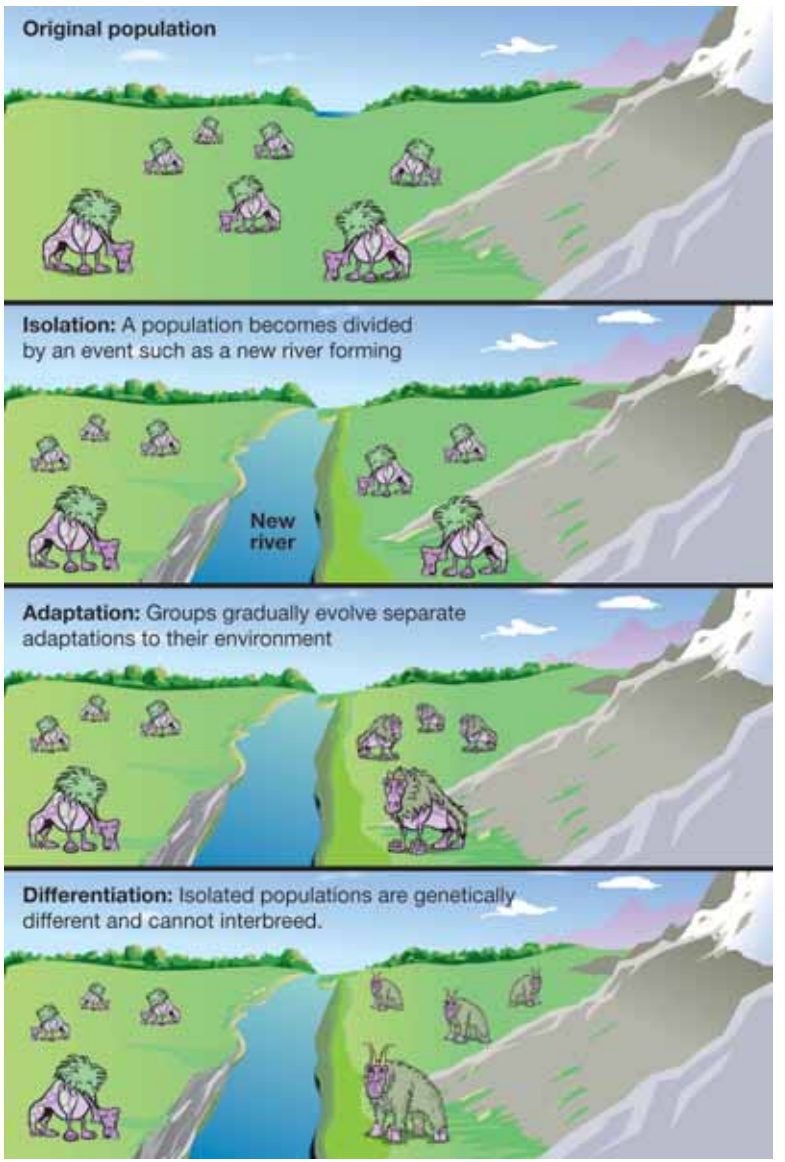
How a new species evolves

How does a new species evolve? Scientists theorize that natural selection leads to the formation of new species. Recall that a *species* is an isolated population of similar organisms that interbreed and produce fertile offspring. One way for a new species to evolve happens in three steps: *isolation*, *adaptation*, and *differentiation*.

Isolation *Isolation* happens when a population becomes divided by an event. Possible events include floods, volcanic eruptions, mountain formation, earthquakes, and storms. The original population becomes divided into smaller populations. Each population is physically and reproductively isolated from the others.

Adaptation *Adaptation* happens through natural selection. The event that causes isolation may also change the environment. As the environment changes, the population that lives there undergoes natural selection. Over time, each separated population may become adapted to their environment. If the environments are different, each population will have different adaptations.

Differentiation *Differentiation* happens when the isolated populations become so different that they can no longer interbreed, even if they could unite again. Over many generations, the isolated populations become genetically different from each other. Each population may have different allele frequencies. Random mutations in each population may create new alleles and thus new traits. As a result, one or more new species are formed.



Extinction of a species

What is extinction?

Extinction occurs when the environment changes and the adaptations of a species are no longer sufficient for its survival. Changes may include increased competition with other species, newly introduced predators, loss of habitat, and catastrophes. Based on the fossil record, scientists think most of the species that once lived on Earth are now extinct.

An example of extinction

The dodo bird is an example of how human impact may contribute to extinction. The dodo was first sighted around 1600 on Mauritius, an island in the Indian Ocean (Figure 11.14). It was a flightless bird with a stubby body and tiny wings (Figure 11.15). Scientists believe that the dodo evolved from a bird capable of flight. When an ancestor of the dodo landed on Mauritius, it found a habitat with plenty of food and no predators. It had no reason to fly and eventually evolved into a flightless bird.

The cause of the dodo's extinction

The dodo was extinct less than eighty years after its discovery. Some of the birds were eaten by the Dutch sailors who discovered them. Also, domestic pigs and cats destroyed their nests which were built on the ground. But the main cause of their extinction was the human destruction of their habitat.

The importance of genetic variation

One reason the dodo may have become extinct is the lack of genetic variation. As a species' population gets smaller, its genetic variation may decrease. Natural selection requires genetic variation. Therefore, a small population may be more susceptible to extinction than a large population if their environment changes. If genetic variation is not present, the population may not have enough favorable adaptations to survive changes in the environment. Scientists study extinctions like the dodo's in hope of preventing future extinctions.

Figure 11.14: *Mauritius is located off the coast of Madagascar.*

Figure 11.15: *The dodo was a flightless bird.*

11.3 Section Review

1. Why are mutations beneficial to the process of evolution?
2. Many species of animals carry an allele for albinism (lack of pigmentation). Albinos are usually pale or white in color. Explain why the allele for albinism is present at a lower frequency than the allele for having pigments. What conditions would be necessary for the albino allele to be more frequent?
3. Why is genetic variation necessary for natural selection to occur?
4. Construct a concept map that shows how a population of bacteria can develop resistance to antibiotics.
5. Describe how a new species evolves.
6. What is meant by the term *extinction*? List three causes of extinction.
7. Cheetahs are the largest of the small cats. The cheetah population once covered all of Africa and Asia. Now cheetahs are an endangered species. Loss of habitat, commercial farming, and development are major causes of its decline. Today, there are fewer than 12,000 cheetahs left on the planet. Explain, using your knowledge of natural selection, why it may be difficult to stop the decline of the cheetah population.

VOCABULARY

From previous page:

extinction - occurs when the environment changes and the adaptations of a species are no longer sufficient for its survival.

CHALLENGE

A cactus is a plant that lives in very hot and dry habitats. The spines of a cactus are modified leaves. The stem of a cactus is thickened and stores water. Explain how cactus leaves and stems may have changed over time through the process of natural selection.

ECOLOGY CONNECTION

Chameleons of the Sea

All animals try to blend into their surroundings - even us humans - but some are nearly perfect at it. Or should that read "nearly invisible?" What animal do you think is the best at blending in? If you guessed the chameleon, you're close. That reptile can change the color of its skin to match its surroundings. Yet no animal compares to the octopus and its relative the squid when it comes to disguises.

Most animals blend into their surroundings in order to protect themselves. But predators also want to blend in - so that they can surprise their prey. Many animals, like the octopus and squid, need to remain unseen because they are both predator and prey.

The octopus and squid can change color almost instantly, far faster than a chameleon. Indeed, they have been called "the chameleons of the sea." Their ability to change their body color, shape, and texture is quite a complicated process. They can create an amazing variety of appearances. The way they blend into their surroundings is one of nature's most dramatic examples of how organisms can adapt to their environments.

Intelligent invertebrates

The octopus and squid are *cephalopods*. In ancient times, cephalopods were one of the dominant life forms in the planet's oceans. They are the most biologically advanced of the mollusks (which include snails, clams, and oysters), and are considered to be highly intelligent invertebrate animals.

Cephalopods have large brains and complex nervous systems. They are very sensitive to their environments and are able to adapt quickly to change. Their eyes are sophisticated and similar to the human eye, with a cornea, lens, and retina.

Remember that their ability to blend into their surroundings is an adaptation that also makes cephalopods excellent predators. On the other hand, they lack the protection of a hard shell, which makes them attractive as prey.

So what adaptations have the octopus and squid made to ensure their survival? The ability to blend into their surroundings is their primary defense. Their soft bodies allow them to squeeze into small burrows between rocks, and they also have chemical weapons they use as a defensive smokescreen. They can shoot a cloud of ink into the water, giving them time to escape a predator.

In a blink of its eye

So just how do cephalopods blend into the ocean background so well? Their advantage is a special skin cell called a chromatophore. There are hundreds of chromatophores in each square centimeter of a cephalopod's skin.

Each of those chromatophores has three bags that contain different colors of liquid pigment. The bags are squeezed or

expanded to change the color displayed by each cell. And each of those cells is controlled separately. The cephalopod's complex brain coordinates all this.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North Carolina State University

Imagine how many subtle differences in color can be created in this way. The octopus or squid is capable of producing millions of patterns to match any background. And, amazingly, the cephalopod does all this instantaneously.

Survival strategies

Cephalopods still must use a variety of other strategies to adapt to their environments. For example, an octopus or squid can change its texture using muscles in the skin. They also use different body postures to sculpt themselves into their surroundings. So they may curl into a ball and change their skin texture and look like a rock - to predator or prey.

Cephalopods change their appearance in courtship, in acts of aggression, and to warn of danger. Squid will display a high-contrast zebra pattern when courting in order to discourage other males from mating with a certain female.

These chameleons of the sea have survived over eons because they adapted to their surroundings. Like every animal, their survival depends on escaping predators, finding food, and reproducing. Think of it: The cephalopod's complex ability to sometimes render itself nearly invisible has meant the species has not disappeared from the ocean.

Questions:

1. How do cephalopods differ from other mollusks?
2. What is "background resemblance"?
3. Why is it important for cephalopods to blend in?
4. What are chromatophores?

CHAPTER ACTIVITY

The Hunter and the Hunted

In this chapter, you learned about the process of natural selection. In this activity you will simulate how natural selection works in a population of mice. Imagine a population of mice that have variations in their fur color. They are hunted by a species of hawk that has pincher-like claws. You will work in groups of four. You and your classmates will play the role of the hawks. The materials and what they represent in the simulation are shown below.

Material	What it represents
Paper squares (30 black, 30 white, 30 white with black spots)	Population of mice
Sheet of newspaper	The environment for the mice
Forceps	Hawk's claw
Petri dish	Hawk's nest

You will also need a stopwatch or a watch with a second hand, pencils, and graph paper.

What you will do

1. Open your sheet of newspaper and place it on a flat surface such as a lab table. This will serve as the environment for your mice.
2. Place the petri dish on the other side of the table. This will be the nest.
3. Select one person from your group to act as a hawk. This person should stand by the nest.
4. The hawk should have a pair of forceps. These represent one of its claws. The hawk can only pick up the mice with the forceps.
5. Spread the mice on their environment evenly.
6. Have another student play the role of the timer.
7. The hawk now swoops over and has 1 minute to pick up as many mice as possible. The hawk may only pick up one mouse at a time. Then, the hawk must place it in the nest before flying back to pick up another. The goal is to pick up as many mice as possible in the time period.
8. When the time is up record the number of mice left in the environment in the data table below.
9. Repeat this procedure for each person in the lab group.
10. After all data is collected, construct a bar graph. Be sure to label the graph and its axes.

	Number of black mice left	Number of white mice left	Number of spotted mice left
Hawk 1			
Hawk 2			
Hawk 3			
Hawk 4			

Questions:

a. What variations are present in your mouse population?
b. Why is variation important to the survival of a population?
c. Make a bar graph of your data.
d. What happened to the mouse population after each trial?
e. Suppose the surviving population goes on to reproduce. What do you think the next generation will look like?
f. How might the mouse population change over many generations?
g. In this simulation, which variation is a favorable adaptation? Which variations are least favorable?
h. If the environment suddenly changed to white, which variation would be the most favorable?

Chapter 11 Assessment

Vocabulary

Select the correct term to complete the sentences.

evolution	vertebrates	fossil
ancestor	genetic variation	fossil record
adaptations	homologous structures	natural selection
	cladogram	

Section 11.1

1. Inherited from parent to offspring, _____ increase an organism's chance of survival in their environment.
2. Biologists use a _____ to illustrate evolutionary relationships between organisms and their ancestors.
3. _____ share common evolutionary origins, but can be functionally unalike.
4. Mammals, bony fish, and birds are just a few examples of _____, animals with backbones.
5. Typically found in sedimentary rock, remains of organisms called _____ offer clues into evolutionary history.
6. The location in which fossils appear in the sedimentary layers is used to piece together an evolutionary sequence of life on Earth called the _____.

Section 11.2

7. _____ is a process by which organisms with favorable traits survive and reproduce more successfully than those

Section 11.3

8. Greater _____ signifies a larger variety of alleles and therefore greater survivability of a species over time.

Concepts

Section 11.1

1. As environmental conditions change over time, which population will have a better chance of survival?
   a. A population with a high level of variation.
   b. A population with several very fit and genetically similar organisms.
   c. Organisms that mutate very rarely.
   d. A population that feeds exclusively on one type of food.
2. How would a mutation in a skin cell differ from a mutation within a sperm or egg cell in relation to the theory of evolution?
3. In trying to understand the evolutionary relationships between two species which of the following would NOT be helpful?
   a. DNA analysis shows nearly identical strings of DNA sequence within each genome.
   b. Both species live in the similar environments and feed the same food.
   c. Embryos of each species show distinct similarities.
   d. Comparative analysis of dental impressions shows similarities in number and structure of each tooth.
4. Which statement best describes adaptation:
   a. A lily suddenly mutates its tissues to store more water in a drought.
   b. Fish swim away from a sudden source of pollution.
   c. A beetle hatches in time of food shortage with a mutation that contains enzymes to digest a greater variety of food.
   d. Environmental factors are a cause of natural selection in which there are only favorable traits.

Section 11.2

5. After studying the beaks of finches, Darwin developed a theory of how adaptations evolved. Are there other ideas that led him to this theory? Explain.
6. The size of a white-footed mouse population is influenced by
   a. the availability of acorns, a main source of food.
   b. an increase in the owl population, a primary predator.
   c. an extremely dry summer leading to a severe drought.
   d. All of the above
7. Variation:
   a. is not random and occurs due an environmental change.
   b. describes only changes in the behavior of a species.
   c. is acquired throughout an organism's lifetime.
   d. happens by chance and is passed to offspring.

Section 11.3

8. Mutations:
   a. occur randomly and produce variation in a population.
   b. occur due to changes in the environment.
   c. change only the physical appearance of an organism and not its genotype.
   d. were explained by Darwin's analysis of Mendel's pea experiments.
9. Do changes in the environment CAUSE mutations or are they already present in gene pool of a population? Explain.
10. Give an example of how a random mutation in an organism could give it an environmental edge over other members of its species.
11. A pregnant jungle tree frog is released into a remote and isolated mountain community. Of the 2000+ eggs she lays only she a few hundred last a sudden freeze. How might this situation develop further to create a new species?
12. Which is not a cause of extinction:
   a. Sudden environmental changes occur
   b. Poor adaptations to the changing environment
   c. Too much variation in the gene pool
   d. Introduction of a foreign species increases competition

Math and Writing Skills

In earlier periods of history, people believed fossils were organisms that spontaneously sprouted from the ground but were unable to properly develop and come to the surface. How is this different from modern understanding of fossil formation? How is the fossil record used to understand Earth's evolutionary history?

Chapter Project

Endangered species

Extinct species are living things that have disappeared from Earth. The United States government has a protection program that places animals and plants on a special list if they are in danger of extinction. If a plant or animal makes the "endangered" or "threatened" list, funding is available for protecting it. The U.S. Fish and Wildlife Service maintains a list of endangered species. Find a list of animals that are listed as "endangered" in the United States. Choose a mammal, bird, reptile, amphibian, or fish from the list and create a large poster to teach others about this endangered species. On the poster, be sure to include the common and scientific name of the animal, interesting facts, a map with current locations marked, and list important things being done to protect this species. Your goal is to educate others about this endangered species.