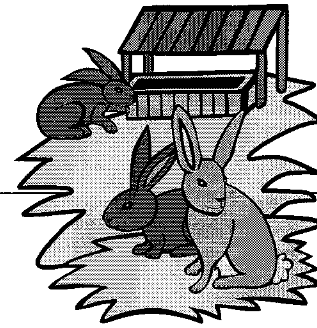
Evidence of Change

Section 14.1
Review of Natural Selection



Pre-View 14.1

- **Natural selection** – a process of nature that favors organisms that are best adapted to their environment
- **Species** – a group of similar organisms that can interbreed and produce fertile offspring
- **Population** – organisms of the same species that live in the same place at the same time and compete for resources such as food and water
- **Mutations** – mistakes in the genetic code
- **Adaptation** – any physical characteristic or behavior that helps an organism to better survive

As you've already seen, the process of **natural selection** describes how organisms that are best adapted to their environment survive and reproduce. It causes populations to change as certain organisms reproduce and pass on their genes to future generations.

Elements of Natural Selection

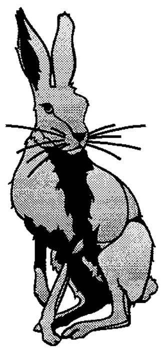
1. All species have genetic variation.
2. Since organisms generally produce more offspring than can be supported by the environment, individuals within a species frequently compete with each other for survival.
3. The environment itself presents many challenges to an organism's survival.
4. The organisms that can cope best with the environmental challenges usually produce more offspring than organisms that can't cope as well (sometimes called ***survival of the fittest***).
5. The traits of the organisms best suited to a certain habitat tend to become more frequent in a population over time.

When talking about natural selection, we often use the terms *species* and *population*. Be sure you understand what these terms mean.

A **species** is a group of very similar organisms that can interbreed and produce fertile offspring. (You may remember from classification that a species is the smallest taxon.) A thoroughbred and a quarter horse are both in the same species. They can interbreed and produce fertile offspring. A horse and a donkey can interbreed and produce offspring called mules, but they are not the same species since most mules are infertile.

A **population** is made of organisms of the same species that live in the same place at the same time. They may compete with each other for food, shelter, water, and other resources.

Whenever organisms interact, there is a struggle for survival as individuals compete for food, water, shelter, etc. If some individuals are better able to survive because they have a certain trait or characteristic, then they will survive to pass that trait to their offspring. The environment plays a large role in which traits are favored over others. Look at an example.



Example 1: Let's suppose that a wild rabbit population that lives in a densely wooded area has genes that can produce white offspring, brown offspring, or black offspring. How could environmental factors and natural selection affect which trait for fur color occurs most often?

In its environment, a densely wooded area, the brown offspring may be better camouflaged from predators than the black or white offspring. In this case, the brown offspring are more likely to survive, so this is an example of survival of the fittest. Because more brown rabbits survive and reproduce, they will pass on the brown fur color more often to their offspring. The genes for white and black fur will be seen in offspring less and less often, and these genes may eventually disappear.

It is important to remember that the process of natural selection does not cause individuals to *produce* new traits. Natural selection simply favors the traits already present that make an organism better able to survive. Through natural selection, populations of species can change over time.

Because natural selection acts on populations rather than individual organisms, we know that natural selection does not act directly on genes. Instead, it can cause changes in the frequencies of alleles. (Remember that an allele is a different form of a gene. For example, right-handedness and left-handedness are different alleles of the same gene.) Think of the rabbits in the example above. Natural selection caused a change in allele frequencies. In example 1 above, the allele for brown fur color occurs more often than the alleles for black or white fur color.

Natural selection actually affects the distribution of genes in a species in the three ways described below.

- **Stabilizing Selection:** When natural selection favors average individuals in a population, it is called **stabilizing selection**. For example, being average in size is an advantage to many insects. If an insect is larger than average, it is more visible to animals that would capture it for prey. If the insect is too small, it may not be able to capture and eat its prey.
- **Directional Selection:** The second type of natural selection is **directional selection**. It favors organisms with an extreme form of a trait. An example would be found in the Galapagos finches. During a period of drought, food became scarce, and the finches with larger beaks were better suited for survival and reproduction. As a result, the average size of the beaks increased.
- **Disruptive Selection:** The last type of natural selection is **disruptive selection**, which favors organisms with extremes in both directions and eliminates the traits in the middle. If only very large seeds and very small seeds were available to a species of bird, then the birds with large beaks and those with small beaks would be at an advantage. Birds with average-sized beaks would decrease.

Example 1: In humans, infants with a low birth weight or with a high birth weight are less likely to survive. Which type of natural selection is seen in the birth weight of humans?

Birth weight in humans is an example of stabilizing selection. Babies with birth weights in the middle range are more likely to survive.

Mutations and Adaptations

Remember, natural selection by itself cannot cause large-scale evolutionary changes. Natural selection only chooses the traits that are already there. Evolutionary scientists believe that random **mutations**, changes in the genetic code, are responsible for creating the variety of life. Although natural selection doesn't produce the new traits, it may explain how mutations of beneficial traits are passed on to offspring.

Example 2: Let's suppose that the wild rabbits living in a heavily wooded area have genes for various shades of brown fur color. If a mutation occurs to produce offspring that are albino (white fur with pink eyes), would the mutation be harmful or beneficial?

Albino animals rarely live long in a wild environment because they are easily seen by predators. In most cases, an albino animal born in the wild is at a disadvantage and will not survive to pass that mutation on to future offspring.

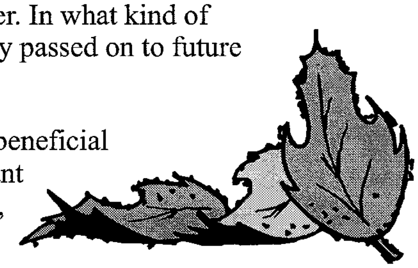
On the other hand, what if over time the climate in an area changes so that snow covers the ground most of the year. In that case, the white fur color might be beneficial. If the white-colored rabbits thrive because of a change in the environment, this gene mutation would likely be passed to additional generations of rabbits.

If you observe the plants and animals in your surroundings, you will likely notice that they all have specific characteristics that help them survive in their environment. These characteristics are called adaptations. An **adaptation** can be any trait, physical or behavioral, that helps the organism to survive. Cats have claws that help them to catch prey. They have pointed teeth that help them to tear apart their food. These are examples of adaptations, and you will see many examples of adaptations throughout the rest of this book.

How did a cat acquire its claws and teeth? Again, evolutionary scientists believe that all new structures have been acquired over time through small, random genetic mutations. Once these random mutations result in a useful characteristic, natural selection can then act on that characteristic so that it is passed on to future generations.

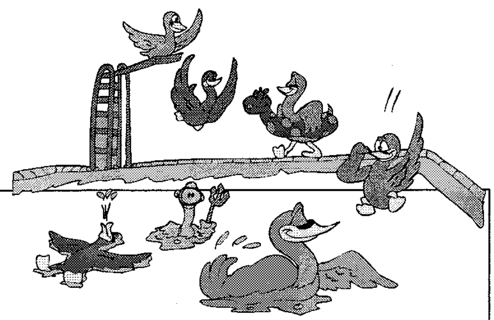
Example 3: A mutation occurs in a plant that causes its leaves to taste bitter. In what kind of environment would this mutation be beneficial and more likely passed on to future generations?

If the plant is eaten by insects or other animals, then this mutation could be beneficial to the plant. The bitter taste would then be a beneficial adaptation. If this plant is not a food source for other organisms, the mutation may serve no purpose, and the mutation may *not* be passed on to future generations.



Evidence of Change

Section 14.2
Diversity in Gene Pools



Pre-View 14.2

- **Diversity** – having a variety of traits
- **Genes** – sections of DNA that determine traits
- **Gene pool** – the total number of different genes available to a species
- **Genetic drift** – a process that changes the gene pool just because of chance
- **Founder effect** – the result of a new colony formed by a small population with a limited gene pool

Importance of Diversity

Most species have a variety of traits that might be passed on from generation to generation. This variety of traits is called **diversity**, and diversity makes organisms of the same species different from one another. Remember that traits are passed from generation to generation through **genes**, which are sections of DNA. The total number of genes that account for different traits in a species is called its **gene pool**. Think about humans. We are very diverse. We have different hair color, skin color, and eye color; we have different heights and weights; we have different sizes and shapes of noses, eyes, and ears; and we even have different personalities, intelligence, and talents. The different genes that account for all of these different traits make up the human gene pool.

Species that have a large gene pool have a greater diversity because they have more combinations of genes available to them. Diversity in a species allows a species to adapt to different environments and to overcome disasters like drought, famine, and diseases. The larger the gene pool, the more a species is able to adapt and survive. The plagues of the Middle Ages killed many people across Europe and Asia. Why were some killed when others survived? People who had a higher immunity to the disease survived. Without diversity, all people exposed to the plague would have died.

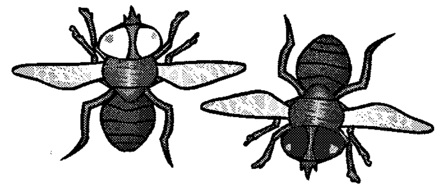
A small gene pool limits a species' diversity. The gene pool of a species can increase due to mutations, or it can decrease when traits die out. As a species becomes more specialized to a specific environment, it loses its ability to adapt to changes. Species can lose traits through natural selection, genetic drift, the threat of extinction, and selective breeding. Let's look at examples of each.

Effect of Natural Selection on the Gene Pool

Natural selection is an important biological concept. Remember that environmental factors often favor some genetic characteristics over others. Through natural selection, specific traits may be favored over others to the point that undesirable traits can no longer be found in the gene pool. Consider the following example.

Example 1: A wild rabbit population has a gene pool that can produce white offspring, brown offspring, or black offspring. If the population lives in a densely wooded area, the brown offspring may be better camouflaged from predators than the black or white offspring. How could this environment affect the gene pool of the rabbits?

If the brown rabbits are better camouflaged against predators, more brown rabbits will survive by natural selection. White and black rabbits will be eaten by predators. Since parents with brown fur are the only ones that survive long enough to reproduce, they will pass the brown fur gene to their offspring. Fewer and fewer white and black rabbits will be born. The genes for white and black fur color may disappear altogether.



Effect of Genetic Drift on the Gene Pool

The process of natural selection gets a lot of attention, but there is another process that also affects the gene pool. This process is called genetic drift. Instead of the environment selecting a trait, sometimes mere chance can cause one trait to occur more frequently and other to occur less frequently. **Genetic drift** is the change in a gene pool generated by chance. To clarify, look at an example.

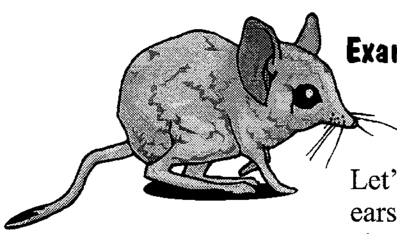
Example 2: A species of insect can have white eyes or brown eyes. Both eye colors are equally beneficial and equally found in a population. Just because of chance, more insects are born with brown eyes than with white eyes during one season. Because more of the population has brown eyes, the next generation is more likely to have brown eyes as well. Over time, the population drifts towards having more brown eyes than white eyes, and the gene for white eyes may eventually be lost.

Genetic drift is more likely to occur in small populations than in large ones. In a small population, any random event can have large consequences on future generations.

The Effect of the Threat of Extinction on the Gene Pool

When a species is threatened with extinction, very few organisms are available for mating. Only the genes of the few living organisms are in the gene pool. If the species recovers, only the genes in that limited gene pool will get passed on to the offspring, so the diversity of the species is diminished.

Even if a population size is reduced for just one generation, the gene pool can be greatly affected. Look at the example below.

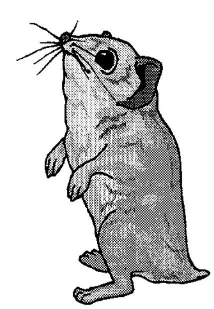


Example 3: A mouse species lives on a small island. A hurricane kills 80% of all life on the island including the mouse population. How might this decrease in the population affect the gene pool?

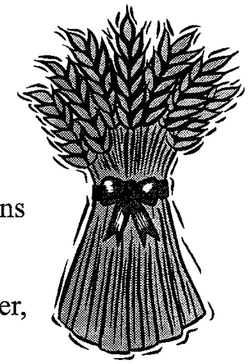
Let's say that in the original mouse population, 10% of the mice were born with larger ears. If none of the mice that survived have the gene for larger ears, this trait may be lost altogether. By chance, some of the genes that were present in the 80% that died will be lost. Only the genes present in the 20% that survived will remain in the gene pool.

The threat of extinction or any drastic decrease in population size often accelerates genetic drift. The remaining organisms have a more limited gene pool. This new gene pool may favor a different trait than was seen in the original population. When a small population repopulates, it results in what is called the **founder effect**.

Example 4: Let's consider again the mouse population in example 3. Let's say that the 20% of mice that survived belonged mostly to one closely related family that happened to live on higher ground and was protected by surrounding rocks. In this family of mice, many have a genetic defect that causes them to be born with stumpy tails instead of long ones. How will the new mouse population be affected?



In the original mouse population, most mice had long tails. In the new mouse population, stumpy tails will probably be more common because of the founder effect. The gene pool now contains a larger percentage of this genetic defect, so this trait will become more common in the new population than it was in the original one.



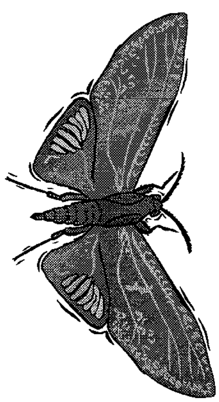
Effect of Selective Breeding on the Gene Pool

Nature uses natural selection and genetic drift for determining genes that are passed on, but humans can use artificial selection through selective breeding. For example, wheat is a crop that has been harvested for many thousands of years. Wheat used to grow wild in many different types of climates. It had a large gene pool, which led to diversity in wheat plants. In modern times, however, farmers began selectively breeding wheat so that the wheat has only the traits that make it more profitable and more easily harvested. Through selective breeding, farmers have bred out certain "undesirable" wild traits, and the gene pool for wheat decreased. Today, wheat is almost genetically uniform with little variation. If the earth's climate changes, what will happen to the wheat? Will it be able to survive? Since wheat lacks diversity, it may not be able to grow in a different climate. This lack of variation also makes wheat susceptible to evolving diseases and pests.

The Effect of Mutations on the Gene Pool

When organisms cannot adapt to an environment, they die. You've seen that through natural selection, genetic drift, and selective breeding, organisms can lose genetic variation. This loss of genetic variation can cause them to be less able to adapt to a changing environment, but they may thrive in a stable, unchanging environment.

Mutations, on the other hand, can add genetic variation. In a stable environment, mutations may have little or no benefit, or they are likely to be harmful. However, in a changing environment, a mutation may allow an organism to adapt. Consider another example.



Example 5: In a population of moths, dark wing color is best adapted to its environment because the moths are well camouflaged against the tree trunks where they usually rest. If a mutation occurs so that a moth is born with light-colored wings, how might it be beneficial?

As long as the environment stays the same, the dark-colored wings will be selected over the light-colored wings. For example, the light-colored moths may be more easily seen by predators and therefore quickly eaten as prey. On the other hand, what if trees in the area change over time so that the bark of the trees is lighter in color? In that case, the moths with light-colored wings may be better camouflaged against predators, so the light color might now be beneficial. If the light-colored moths thrive because of a change in the environment, this gene mutation would likely be passed to additional generations of moths.

Antibiotic and Pesticide Resistance

People have a habit of using chemicals to kill undesirable organisms. We use antibiotics to kill disease-causing bacteria, we use pesticides to kill insects that eat crops, and we use herbicides to kill unwanted weeds. Unfortunately, we may make the problem worse. Consider how mutations and natural selection enable organisms to survive.

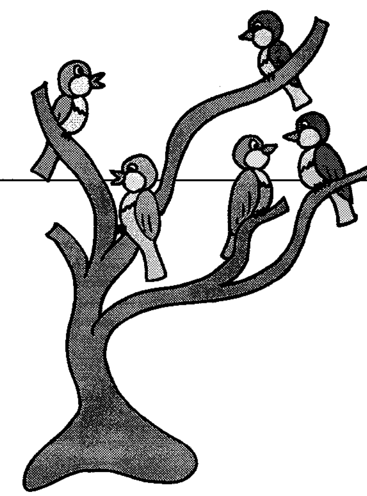
Organisms with a high rate of mutations have a better chance of survival in a changing environment. Bacteria, for example, seem to mutate easily. As a result, bacteria can acquire antibiotic resistance in only a few generations. Insects and plants also have the ability to mutate. Insects and plants have mutated in order to acquire a resistance to man-made pesticides and herbicides. For example, some mosquitos have acquired a resistance to the pesticide DDT. Once an organism acquires a mutation that allows it to survive against a harmful substance, natural selection can quickly take over and allow that organism to pass on the beneficial mutation to its offspring.

Example 6: A bacteria culture is started from a single bacterium. After treating the culture with an antibiotic, only 2% of the culture survives. If the culture is left to repopulate, how will it likely respond to future antibiotic treatment?

The 2% of bacteria that survive are resistant to the antibiotic. It is likely that they have acquired a mutated gene that allows them to survive against the antibiotic. If the bacteria culture repopulates, the resulting population will be less affected by the antibiotic and more resistant to it. These bacteria cells will be more difficult to kill.

Evidence of Change

Section 14.3
Speciation



Pre-View 14.3

- **Speciation** – the formation of a new species
- **Geographic isolation** – a separation of a population due to a physical barrier
- **Temporal isolation** – a type of isolation that occurs when a species develops different reproductive cycles
- **Behavioral isolation** – a type of isolation between populations due to differences in courtship or other mating behaviors

You've already seen that natural selection, genetic drift, the threat of extinction, selective breeding, and mutations can change the gene pool of a population over time. Natural selection will always favor specific traits that allow an organism to better survive. As the gene pool shifts, speciation can occur. **Speciation** is the beginning of a new species and occurs when members of populations no longer interbreed. Speciation can be caused by different types of isolation. Let's look at the three main types.

Geographic Isolation

Geographic isolation occurs when an event creates a physical barrier that divides a population into two or more separate groups. Such an event could be a force of nature like a volcanic eruption or the separation of a land mass into several isolated islands. If the populations cannot interbreed, the new, smaller populations may adapt in different ways through natural selection. In time, each new population could become so different that they would become different species.

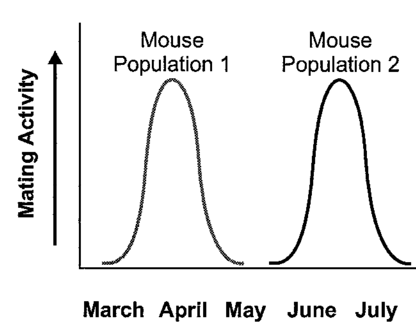
Geographic isolation may be the cause of the speciation seen in the Galapagos finches. Remember, the finches on the Galapagos Islands were different from finches found on the mainland. Darwin and others believe that finches from the mainland may have originally populated the islands, but over time, these finches were geographically isolated from the finches on the mainland. These finches eventually became new species.

Temporal Isolation

Sometimes populations will not interbreed because of **temporal isolation**, which occurs when a species develops different reproductive cycles (like a spring cycle or a fall cycle). Members of the spring cycle will not interbreed with members of the fall cycle. Eventually the two groups may become so different that they can no longer interbreed, and they would be considered two distinct species.

The graph on the right shows the hypothetical breeding times for two different populations of mice. The mice live in the same geographic location, but they do not interbreed. Scientists determine that the two populations of mice can interbreed when they are held in captivity at the local zoo. These populations are an example of temporal isolation. Over time, these two populations may become two species that are no longer able to interbreed, even in captivity.

Breeding Times in Mice Populations



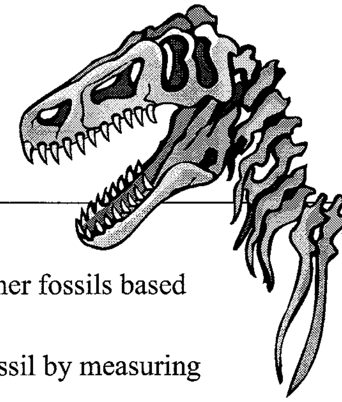
Behavioral Isolation

Many animals have elaborate courtship rituals and behaviors. Each species of bird will sing a distinct song to attract a mate. Other animals also have specific mating calls. Some animals perform dances. These rituals and behaviors help an individual to identify a suitable mate of the same species. If the song isn't correct or the dance steps aren't in the right order, mating is unlikely to occur.

Behavioral isolation occurs when two populations do not interbreed because of differences in courtship behaviors. For example, two similar species of birds may overlap in their territories and may be capable of producing fertile offspring, but because they sing slightly different mating songs, they will not interbreed in the wild.

Evidence of Change

Section 14.4
Evidences of Evolution



Pre-View 14.4

- **Relative dating** – a technique that ages a fossil as older or younger than other fossils based on its location in sedimentary rock layers
- **Radiometric dating** – a technique for approximating the actual age of a fossil by measuring the amounts of radioactive isotopes present
- **Punctuated equilibrium** – the idea that evolution is not always gradual but that changes in a species may occur rapidly for short periods of time
- **Homologous structures** – structures in different species that have similar internal structure even though they may function differently
- **Analogous structures** – structures that have similar functions but are structurally different
- **Vestigial organs** – structures that have no useful purpose
- **Biogeography** – the study of how plants and animals are distributed around the world

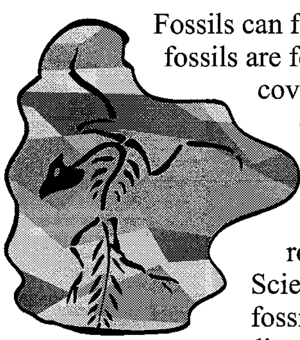
How many different species of organisms do you think inhabit the earth? If you're thinking that you don't know, then you're on the right track. In less than 250 years, scientists have identified and named almost 1.5 million different species, and over 750,000 of those are insects. And we're still counting.

Most scientists estimate that there are between 20 billion and 100 billion species existing today, and they believe about 99% of all species that ever lived are now extinct. How do we know anything about what existed on our planet in the past? What evidence shows that species have changed over time?

The theory of evolution requires millions, or even billions, of years for organisms to make noticeable changes. Scientists have not yet made much progress in artificially producing large-scale evolutionary changes in a laboratory setting. Indeed, it may not be possible to do so. Instead, scientists rely on things like the fossil record, comparative anatomy, and biogeography, to show evidence of evolution. Let's look at each of these.

Fossil Record

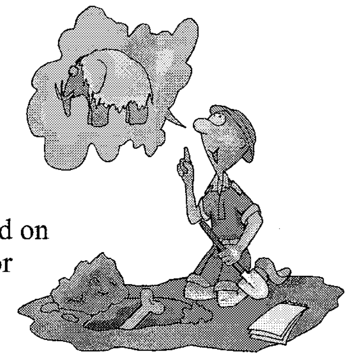
Much of what we know about life on the earth long ago comes from indirect knowledge based on the fossil record.



Fossils can form in various ways, but they provide us with valuable information about the past. Most fossils are found in sedimentary rock. In order for fossils to form, organisms have to be completely covered in mud or clay shortly after death. Once covered, the clay or mud particles get compressed more and more, layer by layer, until sedimentary rock forms. Minerals replace the wood, shells, and bone, and the organisms petrify or fossilize.

Relative Dating: As a general rule, the lower the layer of sedimentary rock, the older the rock. Fossils found in lower layers, therefore, are older than fossils found in upper layers. Scientists use this principle to date fossils as they relate to other fossils. **Relative dating** of fossils tells which fossils are older than other fossils based on where they are found in sedimentary rock layers.

Section 14.4, continued
Evidences of Evolution



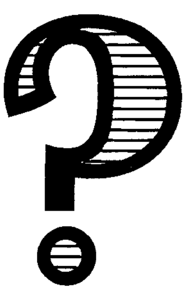
Radiometric Dating: Scientists can also determine the approximate age of a fossil by using **radiometric dating**. Radiometric dating techniques measure the amount of radioactive isotopes found in the fossil. The approximate age can then be calculated based on the half-lives of the radioactive isotopes. (A half-life is the amount of time that it takes for half of a radioactive material to decay into a different material.)

By using processes like radiometric dating and relative dating, scientists are able to determine the time period in which an organism lived. Although the fossil record is not complete, they can then compare modern species with species believed to exist millions of years ago. This comparison helps to determine what changes have occurred and why some species no longer exist. They can also see when new species split off from older ones along an evolutionary time line.

Scientists have also learned to extract DNA from fossils. They use the DNA to compare the amino acid and nucleotide sequences to those in living species. A lot of similarities indicate that the organisms are closely related. Scientists can also use this information to help determine if certain gene mutations could play a role in the formation of a new species.

Punctuated Equilibrium

Does the fossil record give strong evidence that slow, gradual change has occurred? You may be surprised to know that Charles Darwin didn't think so. Read the following passage taken from Chapter 6 of *On the Origin of Species*:



> *On the absence or rarity of transitional varieties.* As natural selection acts solely by the preservation of profitable modifications, each new form will tend in a fully-stocked country to take the place of, and finally to exterminate, its own less improved parent or other less-favoured forms with which it comes into competition. Thus extinction and natural selection will, as we have seen, go hand in hand. Hence, if we look at each species as descended from some other unknown form, both the parent and all the transitional varieties will generally have been exterminated by the very process of formation and perfection of the new form.
>
> But, as by this theory innumerable transitional forms must have existed, why do we not find them embedded in countless numbers in the crust of the earth?

In other words, Darwin believed that as an organism evolved, there must have been many intermediate forms. He was puzzled, however, that the fossil record doesn't show these many transitional forms. Darwin later answers his own question by reasoning that the fossil record is incomplete. He believed transitional forms would eventually be found.

Was Darwin correct? Have transitional fossils been found? Paleontologists continually find new fossils, and some extinct organisms have been discovered that scientists believe are transitional forms. For example, archaeopteryx is believed to be a transitional species that links reptiles to birds. However, there isn't a smooth, continuous fossil record that shows the transition of one species to another. This is not to suggest that gaps will not be filled in as new fossils are discovered. They may be, but it is still considered unusual that even today large gaps are still present.

The lack of transitional forms and the sudden appearance of some fully-formed species in the fossil record have caused some scientists to reconsider how species evolve. In the 1970s, two scientists Niles Eldredge and Stephen Jay Gould suggested that sometimes evolution moves very slowly, but at other times, it occurs quickly. This new idea is called **punctuated equilibrium**, and it suggests that long intervals in which little or no change occurs are suddenly interrupted by short bursts of quick, radical transitions. Many scientists now believe that a combination of gradual evolution and punctuated equilibrium have occurred over time.

Comparative Anatomy

Another way that scientists look for evidence of change in species is by looking at similarities in living organisms.

Homologous and Analogous structures: Homologous structures develop from the same tissues as embryos and have similar internal structures. They may look different on the outside, and they may have different functions. For example, if you looked at the forelimb of a bat, a human, a crocodile, and a bird, you would see that they all have the same skeletal structures — humerus, ulna, carpals, and radius — although they have different functions. See figure 14-1. These similarities suggest that they may have had a common ancestor long ago.

Homologous Structures

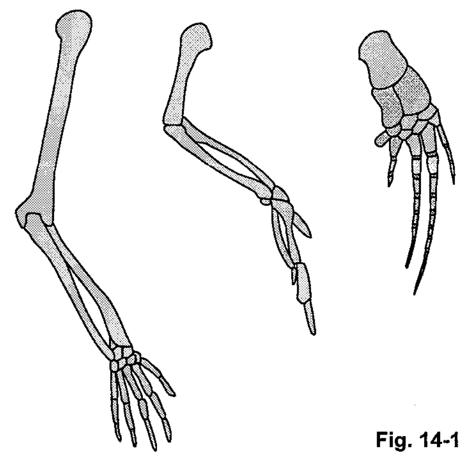


Fig. 14-1

Homologous structures should not be confused with **analogous structures**, structures that have similar functions but are not believed to have evolved from a common ancestor. A bird's wing and a butterfly's wing are analogous structures. Both have the same function, to enable flight, but these two types of wings are structurally very different.

Vestigial structures: Sometimes an animal has structures that seem to have no useful purpose now although they resemble structures that are useful in other species. These structures are called **vestigial structures**. The flightless wings of the ostrich, the sightless eyes of the cave salamander, and the pelvis bone found in some whales are considered examples of vestigial structures.

Embryology: Embryos of many vertebrates look very similar, especially in the earliest stages of development. These physical similarities suggest that the organisms have genetic similarities as well. By looking at the similarities in embryological development, scientists can determine if two very different species might have had a common ancestor.

Biogeography

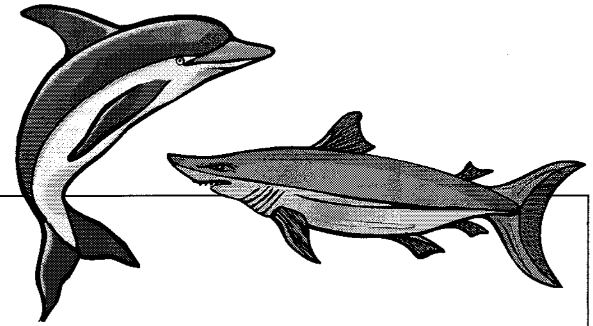
Plate tectonics theory explains that the surface or "crust" of the earth is divided into large plates that float on a semi-molten layer underneath the earth's surface. According to this theory, these plates continually move, and this movement explains earthquake and volcanic activity as well as continental drift. Continental drift is the movement of continents. Scientists believe that all land mass was once consolidated together in a single continent called *Pangaea*. Over time, the different continents have been formed as the plates of the earth drifted apart.

Biogeography is the study of how plants and animals are distributed around the world. This distribution depends on the migration ability of a particular species and how plants and animals have been separated from one another over time by continental drift.

Scientists use this distribution of organisms to figure out how and when species may have evolved. For example, some species are isolated to specific continents. Apes, including all fossils of apes, are found only in Africa and Asia. Marsupials, mammals with pouches, are found only in Australia. These species must have been separated from a common ancestor early in their history and then evolved differently. In other cases, species on a nearby island are similar but not exactly the same as those on the nearest mainland. Darwin made many of these observations about species on the Galapagos Islands. The explanation of how these different species may have evolved differently is explained by speciation, which you saw in Section 14.3.

Evidence of Change

Section 14.5
Patterns of Evolution



Pre-View 14.5

- **Divergent evolution** – the pattern of evolution that shows new species being formed from a common ancestor
- **Adaptive radiation** – a type of divergent evolution in which one species splits into many different related species
- **Convergent evolution** – the pattern of evolution that shows unrelated species evolving similar characteristics
- **Coevolution** – the pattern of evolution that shows two species evolving together

As natural selection works on different populations over time, scientists believe it can be observed as different patterns of evolution. Let's look at three types of patterns: divergent evolution, convergent evolution, and coevolution.

Divergent Evolution

Remember that speciation is the creation of a new species, and it is believed to occur when part of a population becomes isolated from the rest of the population. This process of forming new species results in **divergent evolution**. In divergent evolution, new species "diverge" or split from a common ancestor. For example, evolutionary biologists believe that apes and humans diverged from a common ancestor. Homologous structures as you saw in Section 14.4 are seen as evidence of divergent evolution.

Adaptive radiation is a specific kind of divergent evolution in which one ancestoral species splits into many related species. When Charles Darwin visited the Galapagos Islands, he noticed many different species of finches. These finches were not only different from one another, but they were also different from the finches found on the nearest mainland. Each species of finch was specifically adapted to its environment. Scientists believe that all the Galapagos finches had one common ancestor and that the many different species are a result of adaptive radiation. Through natural selection, these finches adapted to specific environments. Adaptive radiation is commonly seen in island populations of both plants and animals.

Convergent Evolution

Evolutionary scientists believe that through natural selection, organisms in similar environments acquire similar characteristics. Organisms that have similar characteristics but are not considered closely related show the pattern of **convergent evolution**. Sharks and porpoises, for example, have many similar characteristics, but sharks are classified as fish and porpoises are classified as mammals. They are not considered closely related even though they look alike. Analogous structures as you saw in Section 14.4 are seen as evidence of convergent evolution. The fins of sharks and the flippers of porpoises are analogous structures.

Coevolution

When two organisms are dependent on one another for survival, coevolution is suspected. Coevolution is a pattern of evolution in which two species must have evolved, or changed, together. Flowering plants and the specific insects that pollinate them are believed to be examples of coevolution. For example, the yucca plant has small flowers that are pollinated by yucca moths. Scientists believe that the plant and the moths must have evolved together.