At-Home Learning Packet
The Crossroads School
7th Grade Science

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Directions:
This packet provides you the opportunity to practice and show proficiency on standards (LS3-1, LS3-2, & LS4-1 through LS4-6). Completed work from this packet will be turned in upon return to school and graded.

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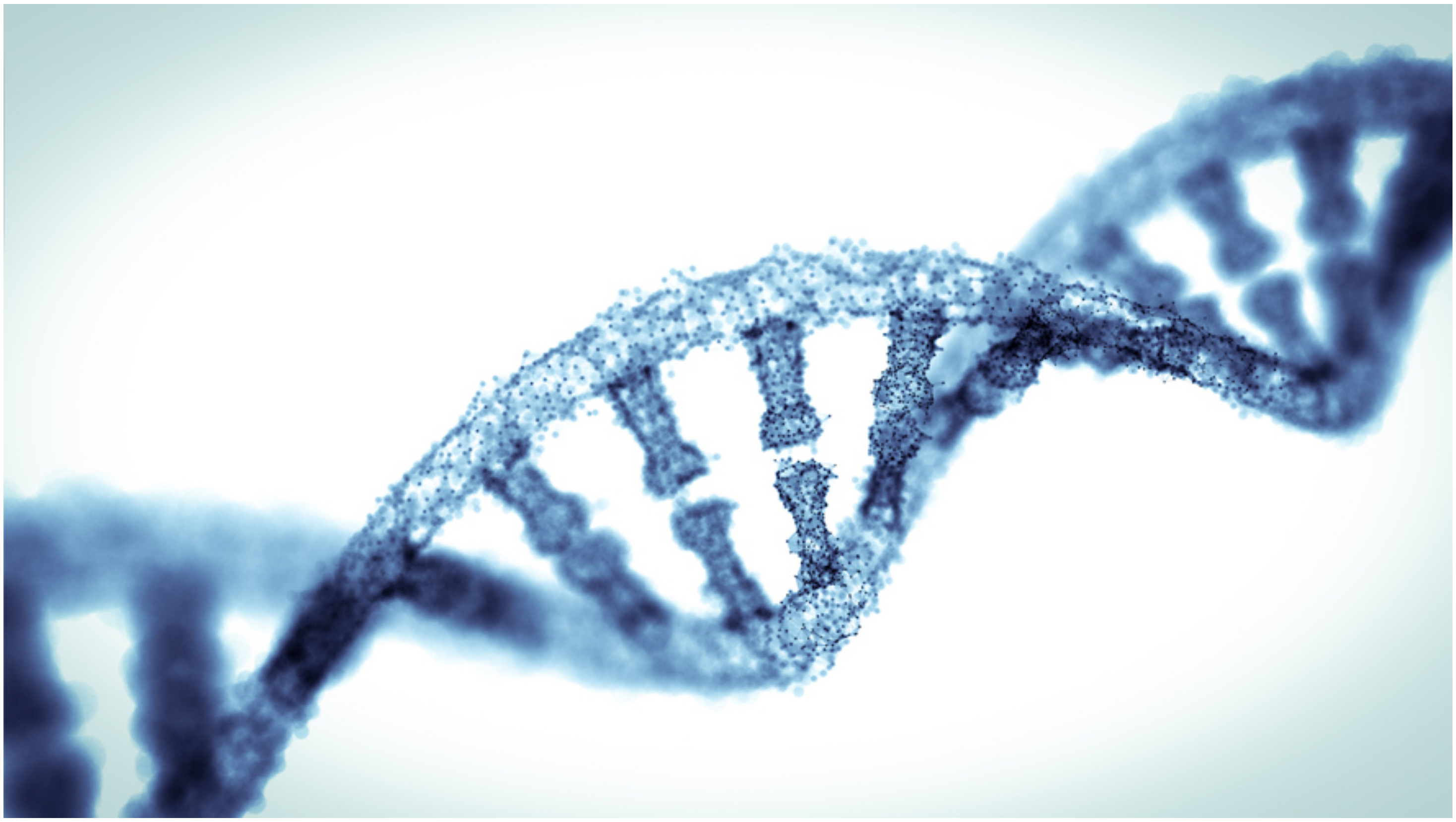
Explainer: What is a gene?

By The Conversation, adapted by Newsela staff on 03.29.17
Word Count **1,027**
Level **1050L**



TOP: DNA is found in the form of a double helix. Our DNA makes up our genes which play an important role in determining physical traits like the color of our eyes or hair. Photo from Getty Images. MIDDLE: An illustration of Gregor Mendel's famous pea flower experiment. This chart shows two red pea plants crossing to have red and white pea flower offspring. Photo from Wikimedia Commons. BOTTOM: The human genome is comprised of millions of DNA pairs such as these illustrated. The Human Genome Project works to identify all of them. Photo from Wikimedia Commons

When people use the word "gene," it's important to know what they intend it to mean. The meaning may depend on whether one is talking about carrying a gene, transferring a gene or discussing how many genes we have.

One reason the definition is so confusing is that the term was coined in 1909, before we really knew what a gene was. And the effects of genes – inherited characteristics – were observed before we understood genes.

As our knowledge has advanced, the definition of the word gene has evolved. And with all the information from the latest scientific discoveries, the definition needs updating again.

Mendel Theorized About Inherited Characteristics

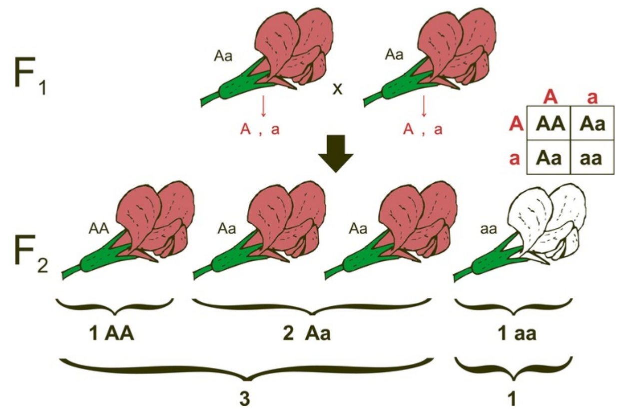
The Austrian monk Gregor Mendel first experimented with genetics in the 1850s and showed that characteristics were inherited.

We have always known that pea seeds grow into pea plants, not into kangaroos. What's more, plants with red flowers usually have offspring that have red flowers, as children resemble their parents.

Mendel showed that crossing a red flower pea with a white flower pea would not produce pea flowers that were pink. Instead, it produced flowers that were either white or red.

We miss this point sometimes because we all have features from our two parents, and many features seem to blend. But Mendel showed that distinct characteristics could be inherited unbroken and we can think of these as each being encoded by a gene.

Genes Not Formally Identified



But Mendel never used the word "gene." The word was first used in 1909 by Danish botanist Wilhelm Johannsen to refer to "determiners" by which many characteristics are "specified."

Later it was found that, whatever material carried these characteristics, it was linear, like string. In 1915, the American geneticist Thomas Morgan found some genes tended to be co-inherited. For example, flies might inherit short wings and red eyes together from one parent, more often than short wings and short legs.

He decided this might mean certain genes were close together, like beads on a string.

In the 1940s, the American physician Oswald Avery showed that an enzyme that chews up DNA could destroy genes.

We finally knew that the genetic material was DNA.

In 1953, James Watson and Francis Crick, using information from Rosalind Franklin, showed DNA was found in the form of a double helix. It was made of two matching strands that formed a spiral chain.

From Genes To RNA To Protein

But what exactly was a gene? Crick explained how DNA could be "transcribed" into ribonucleic acid (RNA), and how RNA could be "translated" into protein. Think of a protein as a tool that does something, such as the hemoglobin that carries oxygen in your blood.

This gave us our first solid definition. A gene is a stretch of DNA that encodes a piece of RNA that encodes a chain of protein.

The details are complicated, but let's imagine how you might make a metal ax, or many axes. Picture a piece of DNA bundled in the shape of an ax-head. RNA settles in and forms the outline of the ax-head, like a mold or cast. You pour in liquid iron, wait for it to harden and out comes an ax-head. Another mold is used to make the handle. The ax-head and the handle bounce around in the cell, find each other and join together, producing an ax.

It is important to note that there are no actual casts or liquid iron but instead strings of Lego-like blocks of different shapes. A section of the DNA blocks is read into RNA blocks.

The RNA blocks are read into protein-building blocks that fold up to make things - in this instance, an ax.

The ax doesn't actually resemble the DNA or the RNA in shape. Rather, the order of blocks is decided by the sequence in the DNA, through a special code called the genetic code.

Genes Encode Certain Characteristics In Plants And Animals

Now we have a definition for a gene. Genes are stretches of DNA that might create a tool or a characteristic, such as a red color in the pea flower.

A gene is a section of DNA – of a chromosome – that does something for a plant or animal. There are thousands of genes on each human chromosome.

At first, each gene was thought to produce one protein tool. However, we can use the example of the ax to explain how one gene can produce more than one protein tool.

The ax handle gene might be "spliced" - a process where bits are cut out of the RNA before it is translated into protein. In this way we might produce a short handle to make a hatchet instead of a full-sized ax.

The amount of splicing in humans is extensive, and typically several gene products are made from each gene.

A suggested updated definition of a gene is a union of strings encoding a set of working products.

We can now explain what it means for a plant to carry the gene for red flowers. It may mean that the plant has a stretch of DNA that encodes a protein tool to make a red color.

Are There Specific Genes?

But is there a gene for white flowers? There may just be a mistake in the red flower gene causing the protein tool not to work, leaving the flowers with no color.

What does carrying the gene for breast cancer mean? It doesn't mean a special gene has evolved with the job of causing breast cancer.

It means a gene has changed and no longer works, so the chance of a cancer growing is increased. The gene predisposes the carrier to cancer, it doesn't cause it.

We still don't know how many genes we have for certain.

There are probably about 20,000 genes encoding proteins and perhaps as many encoding working RNAs. We don't know the exact number because it is hard to be sure which pieces of DNA are read into working products.

As our knowledge of humans and other species increases, we are sure to discover new genes we didn't know were there.

Write a paragraph that summarizes the reading below. Include details from the text.

How are genes, proteins and characteristics related? Write your answer below.

Quiz

1 Why did Thomas Morgan believe genes were like beads on a string?

(A) He noticed some traits tended to be inherited together more than others.

(B) He understood the shape of DNA to be like a string of beads.

(C) He believed that genes could be arranged in any order, like beads on a string.

(D) He thought genes were stuck together, so traits were inherited together.

2 Read the sentence from the section "Genes Encode Certain Characteristics In Plants And Animals."

In this way we might produce a short handle to make a hatchet instead of a full-sized ax.

Which option is the best definition of the word "hatchet" as used in the sentence?

(A) a knife

(B) a big ax

(C) a small ax

(D) a hammer

3 What are transcribing and translation?

(A) They both describe how DNA codes for RNA.

(B) They both describe how RNA codes for certain proteins.

(C) Transcribing is how DNA codes for RNA and translation is how RNA codes for protein.

(D) Translation is how DNA codes for RNA and transcribing is how RNA codes for protein.

4 Read the sentence from the section "Genes Encode Certain Characteristics In Plants And Animals."

The amount of splicing in humans is extensive, and typically several gene products are made from each gene.

Which two words would BEST replace "extensive" and "typically" in the excerpt above?

(A) wide; abnormally

(B) large; generally

(C) stretching; average

(D) narrow; usually

5 Who discovered that DNA was in the shape of a double helix?

1. *Rosalind Franklin*
2. *James Watson*
3. *Francis Crick*

(A) 1 only

(B) 1 and 2

(C) 2 and 3

(D) 1, 2, and 3

6 Look at the graphic in the section "Mendel Theorized About Inherited Characteristics."

How does the chart relate to the main idea of the article?

(A) It shows the differences between what 'A' genes do and what 'a' genes do.

(B) It shows how flower peas are usually red, but can sometimes be white.

(C) It shows how two flower peas can reproduce to create four flower peas.

(D) It shows how combinations of genes can be expressed in reproduction.

7 You notice some pea plants growing in a garden. Which of the following differences is most likely to be caused by genetic differences?

(A) Some leaves look dry and are turning brown and others are still green.

(B) Some flowers are one color and some are another.

(C) Some of the plants are growing in the shade and some are growing in the sun.

(D) Some of the flowers have bees flying nearby.

8 Which conclusion is supported in BOTH the graphic and the article?

(A) The genes from parents can have unexpected results in their offspring.

(B) The genes from parents are usually consistent in their offspring.

(C) The genes from parents do not blend in their offspring.

(D) The genes from parents always blend in their offspring.

How gene mutation works

By Regina Bailey and Heather Scoville, ThoughtCo.com on 11.06.19
Word Count **1,002**
Level **MAX**

Image 1. DNA mutations happen when there are changes in the nucleotide sequence that makes up the strand of DNA. Image by: BlackJack3D/Getty Images

Genes are segments of DNA located on chromosomes. A gene mutation is defined as an alteration in the sequence of nucleotides in DNA. This change can affect a single nucleotide pair or larger gene segments of a chromosome. DNA consists of a polymer of nucleotides joined together. During protein synthesis, DNA is transcribed into RNA and then translated to produce proteins. Altering nucleotide sequences most often results in nonfunctioning proteins. Mutations cause changes in the genetic code that lead to genetic variation and the potential to develop the disease. Gene mutations can be generally categorized into two types: point mutations and base-pair insertions or deletions.

Point Mutations

Point mutations are the most common type of gene mutation. Also called a base-pair substitution, this type of mutation changes a single nucleotide base pair. Point mutations can be categorized into three types:

Silent Mutation: Although a change in the DNA sequence occurs, this type of mutation does not change the protein that is to be produced. This is because multiple genetic codons can encode for the same amino acid. Amino acids are coded for by three-nucleotide sets called codons. For example, the amino acid arginine is coded for by several DNA codons including CGT, CGC, CGA, and CGG (A = adenine, T = thymine, G = guanine, and C = cytosine). If the DNA sequence CGC is changed to CGA, the amino acid arginine will still be produced.

Missense Mutation: This type of mutation alters the nucleotide sequence so that different amino acid is produced. This change alters the resulting protein. The change may not have much effect on the protein, may be beneficial to protein function, or may be dangerous. Using our previous example, if the codon for arginine CGC is changed to GGC, the amino acid glycine will be produced instead of arginine.

Nonsense Mutation: This type of mutation alters the nucleotide sequence so that a stop codon is coded for in place of amino acid. A stop codon signals the end of the translation process and stops protein production. If this process is ended too soon, the amino acid sequence is cut short and the resulting protein is most always nonfunctional.

Base-Pair Insertions And Deletions

Mutations can also occur in which nucleotide base pairs are inserted into or deleted from the original gene sequence. This type of gene mutation is dangerous because it alters the template from which amino acids are read. Insertions and deletions can cause frame-shift mutations when base pairs that are not a multiple of three are added to or deleted from the sequence. Since the nucleotide sequences are read in groupings of three, this will cause a shift in the reading frame. For example, if the original, transcribed DNA sequence is CGA CCA ACG GCG ..., and two base pairs (GA) are inserted between the second and third groupings, the reading frame will be shifted.

Original Sequence: CGA-CCA-ACG-GCG...

Amino Acids Produced: Arginine/Proline/Threonine/Alanine...

Inserted Base Pairs (GA): CGA-CCA-GAA-CGG-CG...

Amino Acids Produced: Arginine/Proline/Glutamic Acid/Arginine...

The insertion shifts the reading frame by two and changes the amino acids that are produced after the insertion. The insertion can code for a stop codon too soon or too late in the translation process. The resulting proteins will be either too short or too long. These proteins are for the most part defunct.

DNA Mutation Analogy

Much like reading text, the DNA sequence is "read" by messenger RNA to produce a "story" or an amino acid chain that will be used to make a protein. Since each codon is three letters long, let's see what happens when a "mutation" occurs in a sentence that uses only three letter words.

THE RED CAT ATE THE RAT.

If there was a point mutation, the sentence would change to:

THC RED CAT ATE THE RAT.

The "e" in the word "the" mutated into the letter "c". While the first word in the sentence is no longer the same, the rest of the words still make sense and are what they are supposed to be.

If an insertion were to mutate the above sentence, then it might read:

THE CRE DCA TAT ETH ERA T.

The insertion of the letter "c" after the word "the" completely changes the rest of the sentence. Not only is the second word no longer readable, neither are any words after it. The entire sentence has changed into nonsense.

A deletion would do something similar to the sentence:

THE EDC ATA TET HER AT.

In the example above, the "r" that should have come after the word "the" has been deleted. Again, it changes the entire sentence. Even though in this example, some of the subsequent words are readable, the meaning of the sentence has completely changed. This shows that even if codons are changed into something that isn't nonsense, it still completely changes the protein into something that is no longer functional.

Causes Of Gene Mutation

Gene mutations are most commonly caused as a result of two types of occurrences. Environmental factors such as chemicals, radiation, and ultraviolet light from the sun can cause mutations. These mutagens alter DNA by changing nucleotide bases and can even change the shape of DNA. These changes result in errors in DNA replication and transcription.

Other mutations are caused by errors made during mitosis and meiosis. Common errors that occur during cell division can result in point mutations and frameshift mutations. Mutations during cell division can lead to replication errors which can result in the deletion of genes, translocation of portions of chromosomes, missing chromosomes, and extra copies of chromosomes.

Genetic Disorders

According to the National Human Genome Institute, almost all diseases have some sort of genetic factor. These disorders can be caused by a mutation in a single gene, multiple gene mutations, combined gene mutation, and environmental factors, or by chromosome mutation or damage. Gene mutations have been identified as the cause of several disorders including sickle cell anemia, cystic fibrosis, Tay-Sachs disease, Huntington disease, hemophilia, and some cancers.

Quiz

1 Which of the following MOST influences a major shift in how the entire nucleotide sequence is read?

(A) base-pair substitutions and point mutations

(B) silent mutations and nonfunctioning proteins

(C) missense mutations and nonsense mutations

(D) base-pair insertions and deletions

2 According to the article, why do point mutations and frameshift mutations occur?

(A) They occur as a result of factors such as chemicals, radiation and ultraviolet light.

(B) They occur as a result of errors that happen during mitosis and meiosis.

(C) They occur as a result of mutagens that change nucleotide bases and even the shape of DNA.

(D) They occur as the result of genetic disorders such as sickle cell anemia and cystic fibrosis.

3 What is the main reason the author includes the section "DNA Mutation Analogy"?

(A) to highlight the three types of point mutations and what makes them similar and different

(B) to explain what environmental factors cause genetic mutations to occur and the results of those mutations

(C) to provide a simple way of helping the reader better understand the different types of genetic mutations

(D) to introduce the idea that frameshift mutations are much more dangerous than point mutations

4 Read the introduction [paragraph 1].

How does the introduction introduce the main idea?

(A) by explaining what types of diseases are caused by genetic mutations

(B) by listing and defining the three different types of point mutation

(C) by comparing and contrasting the two most common types of genetic mutations

(D) by defining genetic mutation and explaining its effects

How do genes change characteristics? Explain using evidence from the text AND an example newsela

Plant and animal reproduction

By National Geographic Society, adapted by Newsela staff on 02.20.20
Word Count **689**
Level **1180L**

Image 1. A lion-tailed macaque and its offspring. Photo by: National Geographic

All organisms reproduce, which is the biological process where an organism produces and/or gives birth to another organism. Both plants and animals reproduce, though they have evolved the processes so that they overlap and diverge from each other in several ways.

Types Of Reproduction

There are two types of reproduction: asexual reproduction and sexual reproduction. Asexual reproduction involves a single parent that produces a genetically identical offspring. Sexual reproduction involves two parents of the opposite sex. A male plant or animal contributes genetic material in the form of sperm or pollen to a female plant or animal's egg. The offspring then has genetic material from both parents. Different plants and animals can reproduce either asexually or sexually; however, asexual reproduction is more common among plants than animals.

Asexual and sexual reproduction each have benefits and drawbacks. Organisms that reproduce asexually have the advantage of producing several genetically identical offspring quickly and with little energy. On the other hand, the lack of genetic diversity among asexual offspring means they have a lower chance of adapting to an unstable environment. By contrast, organisms that reproduce sexually have the advantage of producing a genetically diverse offspring, which is able to adapt to its environment. But sexual reproduction comes at a cost, requiring more time and energy to produce an offspring than asexual reproduction.

Asexual Reproduction

There are a variety of ways plants can reproduce asexually, or without a partner. For example, some nonflowering plants, such as moss and algae, reproduce by spore formation. Spores grow on a plant, then break off and grow into separate organisms.

Other plants, such as strawberries, are able to reproduce asexually through vegetative propagation. This process involves using a part of a plant, such as a root or stem, to produce a new plant, and can happen either naturally or artificially. Other artificial methods, such as grafting, involve combining two plants into one by attaching the top part of a plant, called a scion, to the lower part of a plant, called a rootstock.

Sexual Reproduction And Fertilization

Many plants and most animals require partners to reproduce. Plants and animals share their genetic material in a process called fertilization. In plants, fertilization happens when the male shares pollen, which contains its genetic material, with a female plant's egg.

In flowering plants, an egg is fertilized by cross-pollination. This process often requires an insect, such as a bee, that transfers grains of pollen from the male part of a flower, which is called the anther, to the female part of a flower, which is called the stigma. Once the pollen lands on the stigma, it passes through a long, tube-like structure called a style to reach the plant's ovaries. This part of the reproductive organ is where fertilization takes place. Some plants, called hermaphrodites, have male and female parts on the same plant, and are able to self-pollinate.

Animals, by contrast, do not depend on third parties like insects for fertilization. As mobile creatures, animals can directly transfer sperm to an egg by physically interacting with each other. They often perform various mating rituals in order to attract a potential partner.

Embryonic Development

Once a plant or animal egg is fertilized, it starts developing into a multicellular organism. During this early stage, the fertilized egg is called an embryo. Despite differences in the fertilization process, the development of plant and animal embryos is similar. A plant embryo is contained within a seed, which provides the nutrients it needs to grow, while an animal embryo develops within an egg, outside the organism, or within a uterus, inside the female parent organism.

Birth And Germination

Plants and animals also differ with respect to how they give birth. Animals exit the female's uterus as a newborn or hatch from an egg that has already left the female's body. A plant, by contrast, begins its life by sprouting from a seed. The plant releases the seed, which begins to grow once it is in the soil and the conditions are right. After the seed has sprouted into a plant, it can collect additional nutrients through its roots.

Quiz

1 How does the author develop the central idea of the article?

(A) by exploring the similarities between plant and animal development

(B) by contrasting the primary types of reproduction that are used by plants and animals

(C) by explaining the benefits of sexual and asexual reproduction in plants and animals

(D) by describing how plant and animal reproduction relies on eggs

2 Which of these statements would be MOST important to include in an objective summary of the article?

(A) Plants and animals can reproduce either asexually or sexually, though asexual reproduction is more common among plants.

(B) Some nonflowering plants, such as moss and algae, reproduce by spore formation without a partner.

(C) Mobile creatures often perform various mating rituals in order to attract a potential partner for sexual reproduction.

(D) A plant releases a seed that then sprouts into another plant that can collect additional nutrients through its roots.

3 Read the following paragraph from the section "Embryonic Development."

> *Once a plant or animal egg is fertilized, it starts developing into a multicellular organism. During this early stage, the fertilized egg is called an embryo. Despite differences in the fertilization process, the development of plant and animal embryos is similar. A plant embryo is contained within a seed, which provides the nutrients it needs to grow, while an animal embryo develops within an egg, outside the organism, or within a uterus, inside the female parent organism.*

What is the main reason why the author includes this paragraph in the article?

(A) to provide a scientific definition of an embryo for the reader

(B) to emphasize that plant seeds have many similarities to eggs in animals

(C) to explain that genetic material is passed to offspring in plants and animals

(D) to show how one stage in the life cycle of plants and animals is similar

4 Read the section "Types Of Reproduction."

What is the MOST likely reason for including information about the benefits and drawbacks of sexual and asexual reproduction?

(A) to argue that asexual reproduction is superior to sexual reproduction

(B) to explain why there is greater genetic diversity in plants

(C) to show that neither form of reproduction is necessarily better

(D) to reveal which organisms are more likely to reproduce in certain ways

What is the genetic outcome difference between sexual and asexual reproduction? Explain below.

Asexual reproduction with a twist: Whiptail lizards' genetic advantage

By Patricia Edmonds, National Geographic, adapted by Newsela staff on 08.02.19

Word Count **298**

Level **1060L**

Image 1. The western whiptail lizard (Aspidoscelis tigris) reproduces asexually. In asexual reproduction, the offspring have the same genes as the mother. Photo: Kenneth M. Highfill/Science Source

Sexual reproduction is the way most life-forms procreate, or produce offspring. Each parent provides half an offspring's chromosomes. Over generations, this procreating shuffles the DNA cards, giving sexual reproducers genetic diversity. It is believed that this range of variation in genes can help organisms adapt more successfully to changing environments.

By contrast, asexual reproduction happens in some 70 vertebrate species – species with backbones – and in many less complex organisms, too. Asexual species use "all the chromosomes they have" to solitarily produce offspring that are genetic clones, says molecular biologist Peter Baumann. The organisms are genetically identical. Because of that, they're more vulnerable: A disease or an environmental shift that kills one could kill all.

A Full Chromosome Count

But there's a twist in the case of the genus Aspidoscelis, the asexually reproducing whiptail lizard. Baumann and his colleagues have been studying this species at the Stowers Institute for Medical

Research in Kansas City, Missouri. The lizards are all female and parthenogenetic, meaning their eggs develop into embryos without fertilization. But Baumann's team discovered something curious about the whiptail. Before the eggs form, the females' cells gain twice the usual number of chromosomes. This means that the eggs get a full chromosome count. It also means they get genetic variety and breadth (known as heterozygosity) rivaling that of those from sexually reproducing lizards.

Baumann believes he knows why this occurs. At some time in the past, lizards of the genus Aspidoscelis had "a hybridization event," he explains. Females of one species broke form and mated with males of another species. This gave whiptails robust heterozygosity, which has been preserved by the identical replication — essentially, cloning — that occurs in asexual reproduction. It's a genetic-diversity advantage that today's Aspidoscelis females still enjoy and replicate.

URL: https://www.nationalgeographic.com/magazine/2016/11/basic-instincts-whiptail-lizard-asexual-reproduction/

How are Whip Tail Lizards that reproduce asexually similar and different than sexually reproducing lizards? Include information about their genetics in your explanation below.

Quiz

1 Read the selection from the section "A Full Chromosome Count."

> *The lizards are all female and parthenogenetic, meaning their eggs develop into embryos without fertilization. But Baumann's team discovered something curious about the whiptail. Before the eggs form, the females' cells gain twice the usual number of chromosomes. This means that the eggs get a full chromosome count. It also means they get genetic variety and breadth (known as heterozygosity) rivaling that of those from sexually reproducing lizards*

What conclusion is BEST supported by the paragraph above?

(A) The whiptail does a common type of asexual reproduction where the offspring get genetic variety.

(B) The whiptail is unique because it has heterozygosity despite the fact that it reproduces asexually.

(C) The whiptail is more vulnerable than other asexually reproducing vertebrates because of its heterozygosity.

(D) The whiptail has far more genetic variation than sexually reproducing lizards because it is parthenogenetic.

2 The sentence below from the introduction [paragraphs 1-2] helps prove the claim that sexual reproduction is more common than asexual reproduction.

> *Sexual reproduction is the way most life-forms procreate, or produce offspring.*

Which sentence from the section provides further support for the claim?

(A) It is believed that this range of variation in genes can help organisms adapt more successfully to changing environments.

(B) By contrast, asexual reproduction happens in some 70 vertebrate species – species with backbones – and in many less complex organisms, too.

(C) Asexual species use "all the chromosomes they have" to solitarily produce offspring that are genetic clones, says molecular biologist Peter Baumann.

(D) Because of that, they're more vulnerable: A disease or an environmental shift that kills one could kill all.

3 Read the sentence from the introduction [paragraphs 1-2].

> *Each parent provides half an offspring's chromosomes. Over generations, this procreating shuffles the DNA cards, giving sexual reproducers genetic diversity.*

Why did the author use the word "shuffles"?

(A) to convey a sense of how important genetic diversity is

(B) to convey a sense of how ordinary genetic diversity is

(C) to illustrate that DNA gets rearranged during sexual reproduction

(D) to illustrate that DNA gets cut in two parts during sexual reproduction

4 Read the paragraph from the section "A Full Chromosome Count."

> *This gave whiptails robust heterozygosity, which has been preserved by the identical replication — essentially, cloning — that occurs in asexual reproduction. It's a genetic-diversity advantage that today's Aspidoscelis females still enjoy and replicate.*

Which word from the paragraph helps you understand that heterozygosity in whiptails is beneficial to them?

(A) robust

(B) preserved

(C) cloning

(D) advantage

Take notes on the margins of the pages as you read about Natural Selection and Evolution

Khan Academy

Darwin, evolution, & natural selection

AP Bio: EVO-1 (EU), EVO-1.C (LO), EVO-1.C.1 (EK), EVO-1.C.2 (EK), EVO-1.D (LO), EVO-1.D.1 (EK), EVO-1.D.2 (EK), EVO-1.E (LO), EVO-1.E.1 (EK), EVO-1.E.2 (EK), EVO-1.E.3 (EK)

Charles Darwin's voyage on the HMS Beagle and his ideas about evolution and natural selection.

Key points:

- Charles Darwin was a British naturalist who proposed the theory of biological evolution by natural selection.
- Darwin defined **evolution** as "descent with modification," the idea that species change over time, give rise to new species, and share a common ancestor.
- The mechanism that Darwin proposed for evolution is **natural selection**. Because resources are limited in nature, organisms with heritable traits that favor survival and reproduction will tend to leave more offspring

than their peers, causing the traits to increase in frequency over generations.

- Natural selection causes populations to become **adapted**, or increasingly well-suited, to their environments over time. Natural selection depends on the environment and requires existing heritable variation in a group.

What is evolution?

The basic idea of biological evolution is that populations and species of organisms change over time. Today, when we think of evolution, we are likely to link this idea with one specific person: the British naturalist Charles Darwin.

In the 1850s, Darwin wrote an influential and controversial book called *On the Origin of Species*. In it, he proposed that species evolve (or, as he put it, undergo "descent with modification"), and that all living things can trace their descent to a common ancestor. *[What exactly is a species?]*

Darwin also suggested a mechanism for evolution: natural selection, in which heritable traits that help organisms survive and reproduce become more common in a population over time.
[What does "heritable" mean?]

In this article, we'll take a closer look at Darwin's ideas. We'll trace how they emerged from his worldwide travels on the ship *HMS Beagle*, and we'll also walk through an example of how evolution by natural selection can work.

[Early ideas about evolution]
[Influences on Darwin]

Darwin and the voyage of the *Beagle*

Darwin's seminal book, *On the Origin of Species*, set forth his ideas about evolution and natural selection. These ideas were largely based on direct observations from Darwin's travels around the globe. From 1831 to 1836, he was part of a survey expedition carried out by the ship *HMS Beagle*, which included stops in South America, Australia, and the southern tip of Africa. At each of the expedition's stops, Darwin had the opportunity to study and catalog the local plants and animals.

Over the course of his travels, Darwin began to see intriguing patterns in the distribution and features of organisms. We can see some of the most important patterns Darwin noticed in distribution of organisms by looking at his observations of the Galápagos Islands off the coast of Ecuador.

Darwin found that nearby islands in the Galápagos had similar but nonidentical species of finches living on them. Moreover, he noted that each finch species was well-suited for its environment and role. For instance, species that ate large seeds tended to have large, tough beaks, while those that ate insects had thin, sharp beaks. Finally, he observed that the finches (and other animals) found on the Galápagos Islands were similar to species on the nearby mainland of Ecuador, but different from those found elsewhere in the world[2].

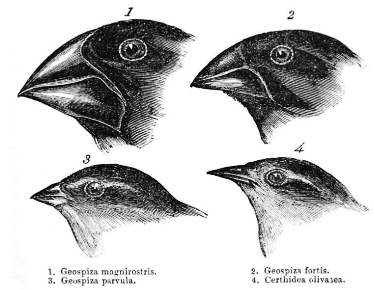


Image credit: "Darwin's finches," by John Gould (public domain).

Darwin didn't figure all of this out on his trip. In fact, he didn't even realize all the finches were related but distinct species until he showed his specimens to a skilled ornithologist (bird biologist) years later[3]! Gradually, however, he came up with an idea that could explain the pattern of related but different finches.

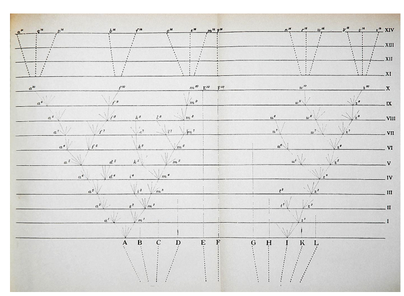
According to Darwin's idea, this pattern would make sense if the Galápagos Islands had long ago been populated by birds from the neighboring mainland. On each island, the finches might have gradually adapted to local conditions (over many generations and long periods of time). This process could have led to the formation of one or more distinct species on each island.

If this idea was correct, though, *why* was it correct? What mechanism could explain how each finch population had acquired **adaptations**, or features that made it well-suited to its immediate environment? During his voyage, and in the years after, Darwin developed and refined a set of ideas that could explain the patterns he had observed during his voyage. In his book, *On the Origin of Species*, Darwin outlined his two key ideas: evolution and natural selection.

[Didn't Alfred Russel Wallace also come up with these ideas?]

Evolution

Darwin proposed that species can change over time, that new species come from pre-existing species, and that all species share a common ancestor. In this model, each species has its own unique set of heritable (genetic) differences from the common ancestor,



Modern-day species appear at the top of the chart, while the ancestors from which they arose are shown lower in the chart. Image credit: "Darwin's tree of life," by Charles Darwin. Photograph by A. Kouprianov, public domain.

which have accumulated
gradually over very long time periods. Repeated branching events, in which new species split off from a common ancestor, produce a multi-level "tree" that links all living organisms.

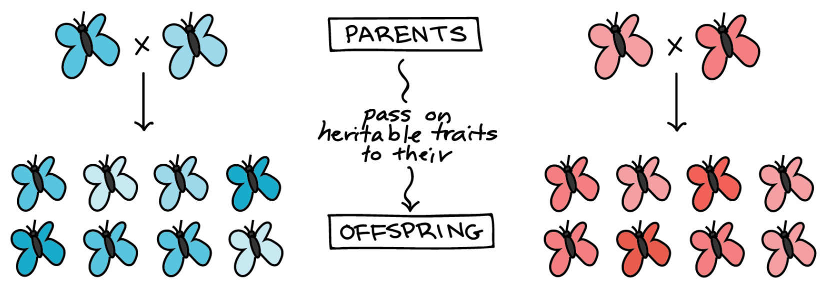
Darwin referred to this process, in which groups of organisms change in their heritable traits over generations, as “descent with modification." Today, we call it **evolution**. Darwin's sketch above illustrates his idea, showing how one species can branch into two over time, and how this process can repeat multiple times in the "family tree" of a group of related species.

Natural selection

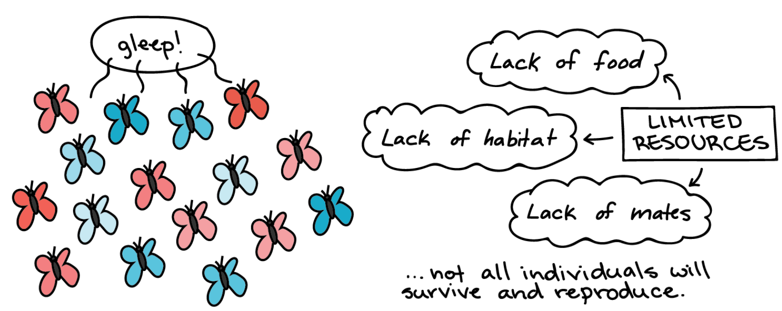
Importantly, Darwin didn't just propose that organisms evolved. If that had been the beginning and end of his theory, he wouldn't be in as many textbooks as he is today! Instead, Darwin also proposed a mechanism for evolution: **natural selection**. This mechanism was elegant and logical, and it explained how populations could evolve (undergo descent with modification) in such a way that they became better suited to their environments over time.

Darwin's concept of natural selection was based on several key observations:

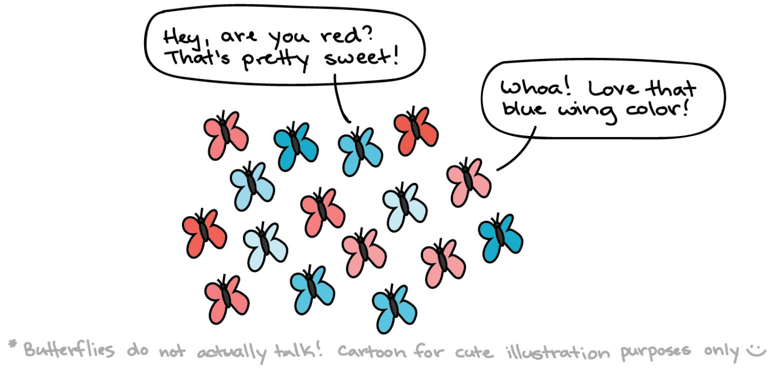
- **Traits are often heritable.** In living organisms, many characteristics are inherited, or passed from parent to offspring. (Darwin knew this was the case, even though he did not know that traits were inherited via genes.)



- **More offspring are produced than can survive.** Organisms are capable of producing more offspring than their environments can support. Thus, there is competition for limited resources in each generation.



- **Offspring vary in their heritable traits.** The offspring in any generation will be slightly different from one another in their traits (color, size, shape, etc.), and many of these features will be heritable.



Based on these simple observations, Darwin concluded the following:

- In a population, some individuals will have inherited traits that help them survive and reproduce (given the conditions of the environment, such as the predators and food sources present). The individuals with the helpful traits will leave more offspring in the next generation than their peers, since the traits make them more effective at surviving and reproducing.

- Because the helpful traits are heritable, and because organisms with these traits leave more offspring, the traits will tend to become more common (present in a larger fraction of the population) in the next generation.

- Over generations, the population will become **adapted** to its environment (as individuals with traits helpful in that environment have consistently greater reproductive success than their peers).

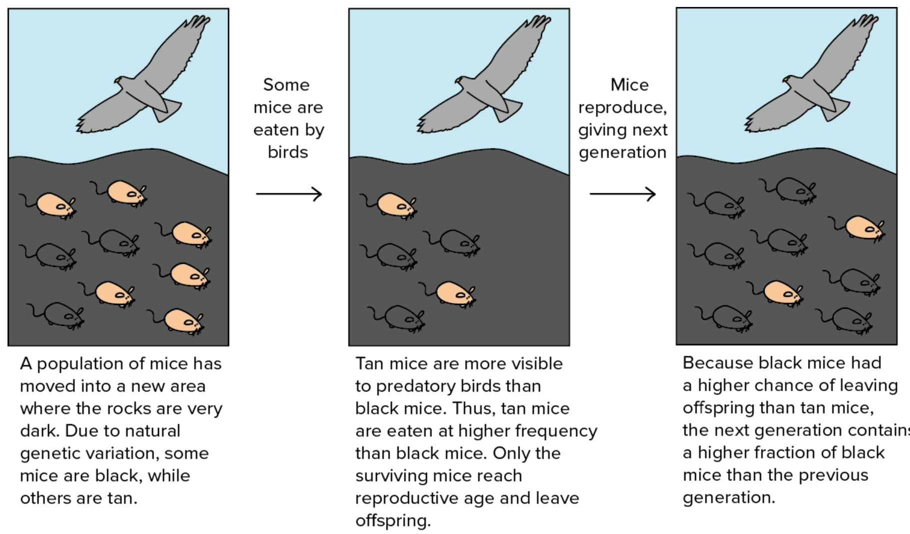
Darwin's model of evolution by natural selection allowed him to explain the patterns he had seen during his travels. For instance, if the Galápagos finch species shared a common ancestor, it made sense that they should broadly resemble one another (and mainland finches, who likely shared that common ancestor). If groups of finches had been isolated on separate islands for many generations, however, each group would have been exposed to a different environment in which different heritable traits might have been favored, such as different sizes and shapes of beaks for using different food sources. These factors could have led to the formation of distinct species on each island.

[Wait, how would that work?]

Example: How natural selection can work

To make natural selection more concrete, let's consider a simplified, hypothetical example. In this example, a group of mice with heritable variation in fur color (black vs. tan) has just moved into a new area where the rocks are black. This environment features hawks, which like to eat mice and can see the tan ones more easily than the black ones against the black rock.

Because the hawks can see and catch the tan mice more easily, a relatively large fraction of the tan mice are eaten, while a much smaller fraction of the black mice are eaten. If we look at the ratio of black mice to tan mice in the surviving ("not-eaten") group, it will be higher than in the starting population.



Schematic based on similar schematic in Reece et al. [4]. Hawk outline traced from "Black and white line art drawing of Swainson hawk bird in flight," by Kerris Paul (public domain).

Fur color is a heritable trait (one that can be passed from parent to child). So, the increased fraction of black mice in the surviving group means an increased fraction of black baby mice in the next generation. After several generations of selection, the population might be made up almost entirely of black mice. This change in the heritable features of the population is an example of evolution.

[What genes and alleles are we assuming here?]

Key points about natural selection

When I was first learning about natural selection, I had some questions (and misconceptions!) about how it worked. Here are explanations about some potentially confusing points, which may help you get a better sense of how, when, and why natural selection takes place.

Natural selection depends on the environment

Natural selection doesn't favor traits that are somehow inherently superior. Instead, it favors traits that are beneficial (that is, help an organism survive and reproduce more effectively than its peers) in a specific environment. Traits that are helpful in one environment might actually be harmful in another. *[Example]*

Natural selection acts on existing heritable variation

Natural selection needs some starting material, and that starting material is heritable variation. For natural selection to act on a feature, there must already be variation (differences among individuals) for that feature. Also, the differences have to be heritable, determined by the organisms' genes. *[Example]*

Heritable variation comes from random mutations

The original source of the new gene variants that produce new heritable traits, such as fur colors, is random mutation (changes in DNA sequence). Random mutations that are passed on to offspring typically occur in the germline, or sperm and egg cell lineage, of organisms. Sexual reproduction "mixes and matches" gene variants to make more variation. *[Do organisms mutate on purpose?]*

Natural selection and the evolution of species

Let's take a step back and consider how natural selection fits in with Darwin's broader vision of evolution, one in which all living things share a common ancestor and are descended from that ancestor in a huge, branching tree. What is happening at each of those branch points?

In the example of Darwin's finches, we saw that groups in a single population may become isolated from one another by geographical barriers, such as ocean surrounding islands, or by other mechanisms. Once isolated, the groups can no longer interbreed and are exposed to different environments. In each environment, natural selection is likely to favor different traits (and other evolutionary forces, such as random drift, may also operate separately on the groups). Over many generations, differences in heritable traits can accumulate between the groups, to the extent that they are considered separate species.

Based on various lines of evidence, scientists think that this type of process has repeated many, many times during the history of life on Earth. Evolution by natural selection and other mechanisms underlies the incredible diversity of present-day life forms, and the action of natural selection can explain the fit between present-day organisms and their environments.

The types of natural selection

By Encyclopædia Britannica, adapted by Newsela staff on 11.20.19
Word Count **2,351**
Level **MAX**

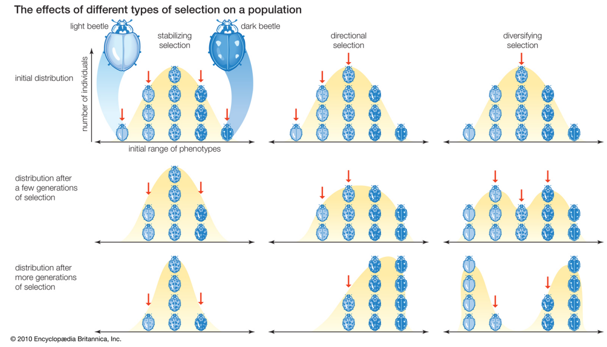
Image 1. A female and male baboon. Male baboons are more than twice as large as females, and the behavior of the females contrasts with that of the aggressive males. This is thanks to sexual selection, which can come about when certain traits, like increased size and aggressiveness in males, help them to secure mates. Photo by: Steve Clancy Photography/Getty Images

This article from Encyclopaedia Britannica has intentionally not been leveled by Newsela staff, and has not been edited for accuracy or quality.

Natural selection can be studied by analyzing its effects on changing gene frequencies, but it can also be explored by examining its effects on the observable characteristics — or phenotypes — of individuals in a population. Below we will discuss the various types of natural selection.

Stabilizing Selection

Distribution scales of phenotypic traits such as height, weight, number of progeny, or longevity typically show greater numbers of individuals with intermediate values and fewer and fewer toward the extremes—this is the so-called normal distribution. When individuals with intermediate phenotypes are favored and extreme phenotypes are selected against, the selection is said to be stabilizing. The range and distribution of phenotypes then remains approximately the same from one generation to another. Stabilizing selection is very common. The individuals that survive and reproduce more successfully are those that have intermediate phenotypic values. Mortality among newborn infants, for example, is highest when they are either very small or very large; infants of intermediate size have a greater chance of surviving.



Stabilizing selection is often noticeable after artificial selection. Breeders choose chickens that produce larger eggs, cows that yield more milk, and corn with higher protein content. But the selection must be continued or reinstated from time to time, even after the desired goals have been achieved. If it is stopped altogether, natural selection gradually takes effect and turns the traits back toward their original intermediate value.

As a result of stabilizing selection, populations often maintain a steady genetic constitution with respect to many traits. This attribute of populations is called genetic homeostasis.

Directional Selection

The distribution of phenotypes in a population sometimes changes systematically in a particular direction. The physical and biological aspects of the environment are continuously changing, and over long periods of time the changes may be substantial. The climate and even the configuration of the land or waters vary incessantly. Changes also take place in the biotic conditions—that is, in the other organisms present, whether predators, prey, parasites, or competitors. Genetic changes occur as a consequence, because the genotypic fitnesses may shift so that different sets of alleles are favored. The opportunity for directional selection also arises when organisms colonize new environments where the conditions are different from those of their original habitat. In addition, the appearance of a new favorable allele or a new genetic combination may prompt directional changes as the new genetic constitution replaces the preexisting one.

The process of directional selection takes place in spurts. The replacement of one genetic constitution with another changes the genotypic fitnesses at other loci, which then change in their allelic frequencies, thereby stimulating additional changes, and so on in a cascade of consequences.

Directional selection is possible only if there is genetic variation with respect to the phenotypic traits under selection. Natural populations contain large stores of genetic variation, and these are continuously replenished by additional new variants that arise by mutation. The nearly universal success of artificial selection and the rapid response of natural populations to new environmental challenges are evidence that existing variation provides the necessary materials for directional selection.

In modern times human actions have been an important stimulus to this type of selection. Human activity transforms the environments of many organisms, which rapidly respond to the new environmental challenges through directional selection. Well-known instances are the many cases of insect resistance to pesticides, which are synthetic substances not present in the natural environment. When a new insecticide is first applied to control a pest, the results are encouraging because a small amount of the insecticide is sufficient to bring the pest organism under control. As time passes, however, the amount required to achieve a certain level of control must be increased again and again until finally it becomes ineffective or economically impractical. This occurs because organisms become resistant to the pesticide through directional selection. The resistance of the housefly, Musca domestica, to DDT was first reported in 1947. Resistance to one or more pesticides has since been recorded in several hundred species of insects and mites.

Another example is the phenomenon of industrial melanism, which is exemplified by the gradual darkening of the wings of many species of moths and butterflies living in woodlands darkened by industrial pollution. The best-investigated case is the peppered moth, Biston betularia, of England. Until the middle of the 19th century, these moths were uniformly peppered light gray. Darkly pigmented variants were detected first in 1848 in Manchester and shortly afterward in other industrial regions where the vegetation was blackened by soot and other pollutants. By the middle of the 20th century, the dark varieties had almost completely replaced the lightly pigmented forms in many polluted areas, while in unpolluted regions light moths continued to be the most common. The shift from light to dark moths was an example of directional selection brought about by bird predators. On lichen-covered tree trunks, the light-gray moths are well camouflaged, whereas the dark ones are conspicuously visible and therefore fall victim to the birds. The opposite is the case on trees darkened by pollution.

Over geologic time, directional selection leads to major changes in morphology and ways of life. Evolutionary changes that persist in a more or less continuous fashion over long periods of time are known as evolutionary trends. Directional evolutionary changes increased the cranial capacity of the human lineage from the small brain of Australopithecus—human ancestors of three million years ago—which was less than 500 cc in volume, to a brain nearly three times as large in modern humans. The evolution of the horse from more than 50 million years ago to modern times is another well-studied example of directional selection.

Diversifying Selection

Two or more divergent phenotypes in an environment may be favored simultaneously by diversifying selection. No natural environment is homogeneous; rather, the environment of any plant or animal population is a mosaic consisting of more or less dissimilar subenvironments. There is heterogeneity with respect to climate, food resources, and living space. Also, the heterogeneity may be temporal, with change occurring over time, as well as spatial. Species cope with environmental heterogeneity in diverse ways. One strategy is genetic monomorphism, the selection of a generalist genotype that is well adapted to all the subenvironments encountered by the species. Another strategy is genetic polymorphism, the selection of a diversified gene pool that yields different genotypes, each adapted to a specific subenvironment.

There is no single plan that prevails in nature. Sometimes the most efficient strategy is genetic monomorphism to confront temporal heterogeneity but polymorphism to confront spatial heterogeneity. If the environment changes in time or if it is unstable relative to the life span of the organisms, each individual will have to face diverse environments appearing one after the other. A series of genotypes, each well adapted to one or another of the conditions that prevail at various times, will not succeed very well, because each organism will fare well at one period of its life but not at others. A better strategy is to have a population with one or a few genotypes that survive well in all the successive environments.

If the environment changes from place to place, the situation is likely to be different. Although a single genotype, well adapted to the various environmental patches, is a possible strategy, a variety of genotypes, with some individuals optimally adapted to each subenvironment, might fare still better. The ability of the population to exploit the environmental patchiness is thereby increased. Diversifying selection refers to the situation in which natural selection favors different genotypes in different subenvironments.

The efficiency of diversifying natural selection is quite apparent in circumstances in which populations living a short distance apart have become genetically differentiated. In one example, populations of bent grass can be found growing on heaps of mining refuse heavily contaminated with metals such as lead and copper. The soil has become so contaminated that it is toxic to most plants, but the dense stands of bent grass growing over these refuse heaps have been shown to possess genes that make them resistant to high concentrations of lead and copper. But only a short distance from the contaminated soil can be found bent grass plants that are not resistant to these metals. Bent grasses reproduce primarily by cross-pollination, so that the resistant grass receives wind-borne pollen from the neighboring nonresistant plants. Yet they maintain their genetic differentiation because nonresistant seedlings are unable to grow in the contaminated soil and, in nearby uncontaminated soil, the nonresistant seedlings outgrow the resistant ones. The evolution of these resistant strains has taken place in the fewer than 400 years since the mines were first opened.

Protective morphologies and protective coloration exist in many animals as a defense against predators or as a cover against prey. Sometimes an organism mimics the appearance of a different one for protection. Diversifying selection often occurs in association with mimicry. A species of swallowtail butterfly, Papilio dardanus, is endemic in tropical and Southern Africa. Males have yellow and black wings, with characteristic tails in the second pair of wings. But females in many localities are conspicuously different from males; their wings lack tails and have color patterns that vary from place to place. The explanation for these differences stems from the fact that P. dardanus can be eaten safely by birds. Many other butterfly species are noxious to birds, and so they are carefully avoided as food. In localities where P. dardanus coexists with noxious butterfly species, the P. dardanus females have evolved an appearance that mimics the noxious species. Birds confuse the mimics with their models and do not prey on them. In different localities the females mimic different species; in some areas two or even three different female forms exist, each mimicking different noxious species. Diversifying selection has resulted in different phenotypes of P. dardanus as a protection from bird predators.

Sexual Selection

Mutual attraction between the sexes is an important factor in reproduction. The males and females of many animal species are similar in size and shape except for the sexual organs and secondary sexual characteristics, such as the breasts of female mammals. There are, however, species in which the sexes exhibit striking dimorphism. Particularly in birds and mammals, the males are often larger and stronger, more brightly colored or endowed with conspicuous adornments. But bright colors make animals more visible to predators — the long plumage of male peacocks and birds of paradise and the enormous antlers of aged male deer are cumbersome loads in the best of cases. Darwin knew that natural selection could not be expected to favor the evolution of disadvantageous traits, and he was able to offer a solution to this problem. He proposed that such traits arise by "sexual selection," which "depends not on a struggle for existence in relation to other organic beings or to external conditions but on a struggle between the individuals of one sex, generally the males, for the possession of the other sex."

The concept of sexual selection as a special form of natural selection is easily explained. Other things being equal, organisms more proficient in securing mates have higher fitness. There are two general circumstances leading to sexual selection. One is the preference shown by one sex (often the females) for individuals of the other sex that exhibit certain traits. The other is increased strength (usually among the males) that yields greater success in securing mates.

The presence of a particular trait among the members of one sex can make them somehow more attractive to the opposite sex. This type of "sex appeal" has been experimentally demonstrated in all sorts of animals, from vinegar flies to pigeons, mice, dogs and rhesus monkeys. When, for example, Drosophila flies, some with yellow bodies as a result of spontaneous mutation and others with the normal yellowish gray pigmentation, are placed together, normal males are preferred over yellow males by females with either body color.

Sexual selection can also come about because a trait — the antlers of a stag, for example — increases prowess in competition with members of the same sex. Stags, rams and bulls use antlers or horns in contests of strength; a winning male usually secures more female mates. Therefore, sexual selection may lead to increased size and aggressiveness in males. Male baboons are more than twice as large as females, and the behavior of the docile females contrasts with that of the aggressive males. A similar dimorphism occurs in the northern sea lion, Eumetopias jubata, where males weigh about 2,200 pounds, about three times as much as females. The males fight fiercely in their competition for females; large, battle-scarred males occupy their own rocky islets, each holding a harem of as many as 20 females. Among many mammals that live in packs, troops or herds — such as wolves, horses and buffaloes — there usually is a hierarchy of dominance based on age and strength, with males that rank high in the hierarchy doing most of the mating.

Quiz

1 The following evidence was gathered to support the idea that natural selection illustrates a direct relationship between species' environments and their physical traits.

> 1. *Well-known instances are the many cases of insect resistance to pesticides, which are synthetic substances not present in the natural environment. When a new insecticide is first applied to control a pest, the results are encouraging because a small amount of the insecticide is sufficient to bring the pest organism under control. As time passes, however, the amount required to achieve a certain level of control must be increased again and again until finally it becomes ineffective or economically impractical. This occurs because organisms become resistant to the pesticide through directional selection.*
> 2. *In localities where P. dardanus coexists with noxious butterfly species, the P. dardanus females have evolved an appearance that mimics the noxious species. Birds confuse the mimics with their models and do not prey on them. In different localities the females mimic different species; in some areas two or even three different female forms exist, each mimicking different noxious species. Diversifying selection has resulted in different phenotypes of P. dardanus as a protection from bird predators.*
> 3. *Darwin knew that natural selection could not be expected to favor the evolution of disadvantageous traits, and he was able to offer a solution to this problem. He proposed that such traits arise by "sexual selection," which "depends not on a struggle for existence in relation to other organic beings or to external conditions but on a struggle between the individuals of one sex, generally the males, for the possession of the other sex."*

Is this evidence adequate support for the idea? Why or why not?

(A) Yes; absolutely; this evidence illustrates that species adapt in relation to various changes in the environment, which include artificial, natural and social factors.

(B) Yes; mostly; this evidence indicates that species adapt in relation to very specific changes in the environment, which cannot explain changes in size, color or shape.

(C) No; not technically; this evidence suggests that the correlation between adaptions and environments is anecdotal, and confined to males and females of few species.

(D) No; definitely not; this evidence demonstrates that the opposite is true, and species evolve despite the changes or challenges of their environments.

2 Read the following paragraph from the section "Stabilizing Selection."

> *Stabilizing selection is often noticeable after artificial selection. Breeders choose chickens that produce larger eggs, cows that yield more milk, and corn with higher protein content. But the selection must be continued or reinstated from time to time, even after the desired goals have been achieved. If it is stopped altogether, natural selection gradually takes effect and turns the traits back toward their original intermediate value.*

What conclusion can BEST be drawn from this paragraph?

(A) Breeders and farmers spend most of their money every year on reinstating artificial selection.

(B) Animals are incapable of surviving natural environments if bred through artificial selection.

(C) Natural selection is powerful enough to reverse the course of human-made artificial selection.

(D) Species grow stronger each time they are altered through the process of artificial selection.

3 What limitations does Image 2 have that the article DOES NOT have?

(A) It uses arrows to indicate the phenotypes against which selection acts, but does not illustrate how distribution changes over generations or include artificial selection.

(B) It uses graphs to illustrate the flow of three types of natural selection, but does not indicate the variables capable of causing the distribution nor does it include sexual selection.

(C) It uses symbols to indicate types of selection, but fails to demonstrate the possible outcomes that occur in a population with each different type.

(D) It uses outlines to illustrate how the rise and fall of populations affects natural selection, but does not detail the involvement of species extinction.

4 How do the images and the article address the types of natural selection?

(A) Both the images and the article provide evidence that stabilizing selection is more common among animal species than plant species.

(B) Both the images and the article indicate the differences in size and color among males and females that result from directional selection.

(C) The images suggest that natural selection favors the males of various species, while the article explains that the physical size and colors of females are actually what ensure the species' survival.

(D) The images emphasize the various physical characteristics that can result from natural selection, and the article explains how variations in these and other species evolved to serve a purpose.

Summarize the main types of evolution in the space below. You can write sentences or use bullet points.

How artificial selection works with animals

By ThoughtCo.com, adapted by Newsela staff on 11.05.19
Word Count **561**
Level **610L**

An adult male labradoodle stands in a meadow. The labradoodle dog breed is a product of artificial selection in breeding. Photo by: Jurgen & Christine Sohns/Imagebroker/Shutterstock

People sometimes mate two animals within a species. A species is a group of organisms that are very closely related. They are able to have babies with one another. When people mate two animals in a species, they are using artificial selection.

During the artificial selection process, a person will pick two animals. The animals have desirable traits. The person allows the animals to mate. This means they have babies. The goal of mating the animals is to produce babies with the same desirable traits.

Artificial selection is different from natural selection. Natural selection means that animals with traits that help them survive will live on. If an animal lives long enough, its children can also have traits that help them survive. Natural selection is random. But artificial selection is not random. It is controlled by humans.

People use artificial selection to breed pets. They also use it to breed zoo animals. They use artificial selection to get the ideal animal. They want the animal to have a certain look or behavior.

Darwin And Artificial Selection

Artificial selection is an old practice. Charles Darwin is the father of evolution. He used artificial selection. He did so to support his work. He was working on the idea of natural selection and the Theory of Evolution.

Darwin traveled to South America. He visited the Galapagos Islands. There, he observed finches with differently shaped beaks. Darwin wanted to see if he could re-create this type of change on his own.

Darwin returned to England. He bred birds. He mated parents that had desired traits. Darwin was able to create babies, or offspring, that had those traits. The traits included color, beak shape and size.

Benefits Of Artificial Selection

People can make a lot of money with artificial selection. Racehorses are one example. People will pay a lot of money for racehorses with particular traits. People will use champion racehorses. They breed them in the hopes of getting future winners. Certain traits are passed down from parent to offspring. These traits include muscle structure, size and even bone structure.

Another example of artificial selection is dog breeding. Some dogs compete in dog shows. Certain traits are more desirable for dog shows. The judges look at coat coloring and patterns. They also look at their teeth and behavior. Behaviors can be trained. However, some behaviors are passed down from parent to offspring.

Not all dogs are entered in shows. Some breeds have become more popular in households. Newer breeds such as the labradoodle are in high demand. This is a mix between a Labrador retriever and a poodle. Another example is the puggle. It comes from breeding a pug and a beagle.

Artificial Selection In Research

Researchers also use artificial selection. Many laboratories use mice and rats. They use them to perform tests that aren't ready for humans. Sometimes the research involves breeding mice. The mice are bred to get a certain trait in the offspring. Then, the researchers study the offspring.

Humans can use artificial selection on any animal. It can be a domestic animal like a cat or dog. Or, it could be a wild animal in captivity. An example is a tiger in a zoo. Artificial selection can help endangered species survive. It can mean a new companion animal. Or it can mean a lovely new animal to look at.

Quiz

1 What is the goal of artifical selection?

(A) to create new traits in animals

(B) to increase good traits in animals

(C) to create new species of animal

(D) to increase the number of pets for people

2 Read the introduction [paragraphs 1-4].

Select the sentence from the section that explains WHY people use artificial selection.

(A) During the artificial selection process, a person will pick two animals.

(B) The goal of mating the animals is to produce babies with the same desirable traits.

(C) Natural selection means that animals with traits that help them survive will live on.

(D) But artificial selection is not random.

3 Which statement is true?

(A) Natural selection is random.

(B) Natural selection is over.

(C) Natural selection is rare.

(D) Natural selection is bad.

4 Read the paragraph below from the section "Benefits Of Artificial Selection."

> *People can make a lot of money with artificial selection. Racehorses are one example. People will pay a lot of money for racehorses with particular traits. People will use champion racehorses. They breed them in the hopes of getting future winners. Certain traits are passed down from parent to offspring. These traits include muscle structure, size and even bone structure.*

Which question is answered in this paragraph?

(A) Which breeds of racehorses are used the most in artificial selection?

(B) When did people start using artificial selection for racehorses?

(C) How much does it cost to breed horses through artificial selection?

(D) Why do people use artificial selection with racehorses?

5 How is artificial selection used with dogs?

(A) for looks only

(B) for behavior only

(C) for looks and behavior

(D) for neither looks nor behavior

6 According to the section "Darwin And Artificial Selection," WHY did Charles Darwin use artificial selection?

(A) because he wanted to help the finches from disappearing forever

(B) because he wanted to prove the Theory of Evolution wrong

(C) because he wanted to prove his ideas about natural selection

(D) because he wanted a reason to visit the Galapagos Islands

7 How could artificial selection be used in research?

(A) to train dogs

(B) to collect wild animals

(C) to keep animals in the zoo

(D) touse animals in laboratories

8 HOW does artificial selection affect endangered species?

(A) It does not have any effect on endangered species.

(B) It can turn more animals into endangered species.

(C) It can cause problems for endangered species.

(D) It can help endangered species to not die out.

Explain how humans “created” the dogs that we know today by using Artificial Selection.

Explainer: The theory of evolution

By The Conversation, adapted by Newsela staff on 09.03.19
Word Count **1,026**
Level **570L**

Image 1. Blue footed boobies rest on volcanic rocks in the town of Puerto Villamil on Isabela island on January 21, 2019 in Galapagos Islands, Ecuador. Charles Darwin's research in the Galapagos inspired his theory of evolution by natural selection. Photo by: Chris J Ratcliffe/Getty Images for Lumix

The theory of evolution states that life on our planet has changed over long periods of time. It continues to change. That change happens according to a process. That process is known as natural selection.

Charles Darwin lived in the 1800s. He was a naturalist. That is a scientist who studies natural history. He is given credit for the theory of evolution. This is not because he was the first person to suggest that evolution happens. Rather, it's because he described how evolution works. He did this in his book, "On the Origin of Species."

The name, "the theory of evolution," contains two parts. Some people argue about both, which isn't necessary. The first part is the word "theory." Its meaning is different in the world of science than in everyday speech.

The second part is the word "evolution." Some people argue against evolution. They say that there is not enough evidence to believe it. Supporters of this view rely on the different meanings of the word "theory." That confuses the issues.

What Is A Theory?

When most people use the word "theory," what they mean is guesswork. This is the process of guessing. Someone might have a theory about why a football team lost. They have ideas about why the team lost. But this theory is based on guesswork.

When scientists use the word "theory," however, they aren't referring to guesswork. They are referring to the laws of nature. A theory is developed over many years. It takes detailed hypothesis testing. A hypothesis is an explanation based on evidence. Scientific theories are backed up with mathematical formulas. They are supported by evidence. All of this together explains observations.

Gravity is a fact. It sums up a number of observations. But different theories explain gravity. Newton's law is one theory. Einstein's theory of relativity is another. Even though there are different theories, everyone agrees that gravity exists.

Biological evolution is also a fact. It is backed up by lots of evidence. The evidence comes from many different fields of science. Because of all this, biological evolution is a fact, just like gravity. So the theory of evolution is not about whether or not it is true. The theory is about how it happens.

Our understanding of gravity has changed over time. In the same way, our understanding of the process of evolution has changed over time. It continues to change.

Natural Selection

There are two major parts to the theory of evolution: natural selection and the nature of inheritance. Let's look at natural selection first.

How natural selection works was proposed in 1858. Two British naturalists had each proposed the theory. They did this separately. Their names were Charles Darwin and Alfred Russel Wallace.

To understand natural selection, let's look at artificial selection. This is when humans make the selection. Animal breeders can do this. A breeder will select an animal. This animal will improve the outcome for the next generation. This could happen with cattle, horses or sheep. For example, the breeder would choose the best horse. Then, it can reproduce and have better horses in the next generation.

Natural selection is similar. Humans do not control it. It is a natural process of sorting living things. They are sorted out according to how well-adapted they are to their environment.

In artificial selection, humans decide on traits. Those will be the characteristics for future generations. How does natural selection decide? What does natural selection favor? It favors traits that increase the chance of survival and reproduction. These traits become more common in a population or species over time.

In the past, natural selection has been called "the survival of the fittest." This phrase does not represent the true meaning. It says the same thing twice. According to this, "the survival of the fittest" sounds like it means "the survival of those who survive." This is wrong.

The truth is that individuals don't survive. What survives is the process for making another individual. In other words, reproduction survives. This process is carried down through generations in the form of genes. A gene is made up of tiny sections of DNA. DNA contains the instructions for how our bodies grow and work. It is passed on from parents to children.

Natural selection focuses on the different rates of reproduction. Genes that code for desirable traits get selected. What's desirable about these genes? They improve a population's chances to reproduce. This improves a species' chances. Over time, individuals with favorable traits are more successful at reproducing. How individuals interact with their environment is also important. It provides a way for sorting out which traits will be passed on to the next generation.

Nature Of Inheritance

The second major part of the theory of evolution is the nature of inheritance. This is based on the insights made in 1865, by Gregor Mendel. He is the founder of genetics. The nature of inheritance has changed since then. It is much more advanced. Now we have a greater understanding of genes. We also understand DNA.

When Darwin and Wallace first wrote about natural selection, they did not understand the nature of inheritance. Now we do. Our understanding is very complex. It includes exact processes. We understand how genes get passed on. We also understand now how genes are changed by mutations. We know how genes are shared among species.

We can predict the change in the frequency of genes over time. This means we can predict how common a gene is in a population. We can tell how this will change over time. We do this using math formulas.

The change of gene frequencies is very small. It is a tiny change. But it is not too small to call it evolution. These small changes at the level of genes lead over time to large changes in organisms.

The sorting of genes affects populations. Populations drift apart. They become species. Species split off to create whole groups of plants or animals. These plants and animals control the landscape for millions of years.

All of these processes form a continuation. This continuation is the history of life on Earth.

Quiz

1 One MAIN idea of the article is that biological evolution is a fact.

Which key detail from the section "What Is A Theory?" supports this MAIN idea?

(A) When most people use the word "theory," what they mean is guesswork.

(B) Scientific theories are backed up with mathematical formulas.

(C) The evidence comes from many different fields of science.

(D) In the same way, our understanding of the process of evolution has changed over time.

2 Read the paragraph from the introduction [paragraphs 1-4].

> *Charles Darwin lived in the 1800s. He was a naturalist. That is a scientist who studies natural history. He is given credit for the theory of evolution. This is not because he was the first person to suggest that evolution happens. Rather, it's because he described how evolution works. He did this in his book, "On the Origin of Species."*

What is the MAIN idea of this paragraph?

(A) Charles Darwin explained how evolution works.

(B) Charles Darwin was the first person to discover evolution.

(C) Charles Darwin did not find enough evidence for the theory of evolution.

(D) Charles Darwin wrote a book called "On the Origin of Species."

3 Read the paragraph from the section "What Is A Theory?"

> *When scientists use the word "theory," however, they aren't referring to guesswork. They are referring to the laws of nature. A theory is developed over many years. It takes detailed hypothesis testing. A hypothesis is an explanation based on evidence. Scientific theories are backed up with mathematical formulas. They are supported by evidence. All of this together explains observations.*

Fill in the blank.

A "theory" is ____.

(A) a scientific experiment

(B) a difficult math problem

(C) a fact proven by scientists

(D) a guess based on data

4 Read the selection from the section "Nature Of Inheritance."

> *The nature of inheritance has changed since then. It is much more advanced. Now we have a greater understanding of genes. We also understand DNA.*

Which word could replace "greater" WITHOUT changing the meaning of the selection above?

(A) bigger

(B) better

(C) cooler

(D) kinder

Use your notes from the Khan Academy reading and the article above to summarize the Theory of Evolution. Include details on how Natural Selection leads to evolution.

Extension:

The ancestors of giraffes originally were the size of small deer. These organisms ate leaves on trees just like giraffes. Use the Theory of Evolution to explain how and why giraffes evolved to be so tall.

The anatomical evidence of evolution

By ThoughtCo.com, adapted by Newsela staff on 09.12.19

Word Count **910**

Level **590L**

Image 1. Fossils can help us paint a picture of what life was like in time periods from long ago. They also give us clues about organisms that are long extinct. Photo by: E. R. Degginger/Science Source

Today, scientists continue to find more evidence to help them better understand evolution. New technologies allow them to do this. Scientists can compare the DNA similarities between species. They can also track microevolution; however, they did not always have these technologies. Scientists used other forms of evidence. They used this evidence to support the theory of evolution by natural selection.

Anatomical Evidence For Evolution

Scientists have studied evolution for many years. They have gathered large amounts of evidence. The most important evidence came from anatomical similarities. Scientists studied how the body parts of species were similar.

Scientists also tracked adaptations in species. Adaptations are changes. They help a species become better suited for its environment. Scientists can see how organisms adapt to challenging environments. These adaptations keep adding up. They accumulate. Soon, physical structures in one species can change. In some cases, they become similar to the structures of other species that live in similar environments.

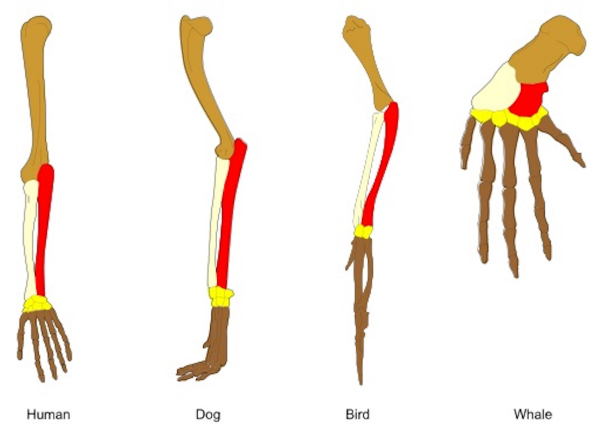
Fossil Record

Fossils are naturally preserved remains of organisms. They provide evidence of life evolving through natural selection. Fossils can be bones, teeth or shells. They may even be entire organisms. These all paint a picture of life from long ago. Fossils provide evidence of organisms that are extinct. They also show how species change over time. Fossils can show us how new species formed.

Scientists can figure out the ages of fossils. The fossils are dated. Scientists may use different techniques to date the fossils. Knowing a fossil's age can help fill in gaps in our understanding. It shows scientists when a species changed. It can also show them how a species changed.

Some people do not believe the evidence of organisms changing over time. They say that the fossil record supports their argument. They argue that there is no evolution. They say this is because there are "missing links." They are referring to the links between modern species and extinct species in the fossil record. This argument is not scientific. Fossil formation is complicated. Conditions need to be just right for fossils to form. Not every organism shows up in fossils. Nevertheless, year after year, more fossils are found. Some of them fill gaps in the fossil record.

Homologous Structures



Scientists can track how closely related species are to each other. To do this, they use the phylogenetic tree of life. It is like a family tree. It lays out the evolutionary relationships between species. To determine these relationships, scientists study homologous structures. These are structures that are similar in two different species. The structures were inherited from a common ancestor.

You can compare homologous structures in dolphins and hippos. These two species are closely related. Scientists can see evidence of this relationship. They compare hippo and dolphin limbs.

Dolphins have pectoral fins. These are the flippers at their chests. They help dolphins steer as they swim. These fins look very different from a hippo's forelimbs. But scientists looked at the bones within the flipper. They found the same bones in the hippo forelimb and foot. Comparing homologous structures is one way that scientists classify organisms. They place organisms in phylogenetic groups. The groups branch off from a common ancestor.

Analogous Structures

Animals can look alike even if they are not closely related. Consider the example of dolphins and sharks. They look similar in body shape, size and color; however, they are not closely related. Why do they look so much alike?

The answer lies in evolution. Species change in response to their environments. They do this in order to fill a niche. A niche involves a species' role in an environment. It is decided by environmental conditions. These conditions include where it will live and what it will eat. Dolphins and sharks live in similar conditions. They both eat fish. They fill a similar niche. Unrelated species can fill similar niches. They tend to accumulate similar adaptations. These adaptations can add up, making the species resemble each other.

Scientists have a name for similarities in unrelated species. They are called analogous structures. They are not like homologous structures. They do not come from a common ancestor. For example, dolphins have fins and tails. Sharks also have fins and tails. They look similar, but they developed differently. Both sharks and dolphins developed these structures to help them swim quickly and catch prey. This helps them survive in their environments. But dolphins and sharks did not inherit these structures from a common ancestor.

These developments show us evolution at work. They show us species changing independently to fill their niches. These changes drive speciation. This is the change in a species over time.

Vestigial Structures

Some parts of an animal's body no longer have any use. These are leftovers from an earlier form of the species. The species accumulated several adaptations over time. Eventually, some body part was no longer useful. It didn't, however, completely disappear.

These body parts are called vestigial structures. Humans have these, too. One example is the tailbone. It is all that's left of an ancestor species' tail. Another example is the appendix. Some scientists say it no longer serves a purpose. Vestigial structures are like fossils within an organism's body. They give us clues to past forms of the species.

Quiz

1 Read the paragraph from the section "Fossil Record."

> *Fossils are naturally preserved remains of organisms. They provide evidence of life evolving through natural selection. Fossils can be bones, teeth or shells. They may even be entire organisms. These all paint a picture of life from long ago. Fossils provide evidence of organisms that are extinct. They also show how species change over time. Fossils can show us how new species formed.*

Which question is answered in this paragraph?

(A) When did the first fossil get found?

(B) How do fossils preserve remains?

(C) Why are fossils useful to scientists?

(D) Where are most fossils discovered?

2 Read the paragraph from the section "Homologous Structures."

> *Scientists can track how closely related species are to each other. To do this, they use the phylogenetic tree of life. It is like a family tree. It lays out the evolutionary relationships between species. To determine these relationships, scientists study homologous structures. These are structures that are similar in two different species. The structures were inherited from a common ancestor.*

Which sentence from this paragraph explains how species get homologous structures?

(A) To do this, they use the phylogenetic tree of life.

(B) To determine these relationships, scientists study homologous structures.

(C) These are structures that are similar in two different species.

(D) The structures were inherited from a common ancestor.

3 Read the selection from the section "Analogous Structures."

> *Unrelated species can fill similar niches. They tend to accumulate similar adaptations. These adaptations can add up, making the species resemble each other.*

What is the definition of "resemble" based on the context clues?

(A) learn about

(B) work with

(C) look like

(D) fight against

4 Read the following selection from the introduction [paragraph 1].

> *Today, scientists continue to find more evidence to help them better understand evolution. New technologies allow them to do this. Scientists can compare the DNA similarities between species.*

Fill in the blank. "Evidence" is ____.

(A) proof of something

(B) an important question

(C) problems that happen

(D) a place to study

Summarize the fossil and anatomical evidence that supports the Theory of Evolution.