

**The BIG Idea**

The environment and changes over time can affect genetic traits.

**SECTION 1**  
**Traits and the Environment**

**Main Idea** The interaction of the environment with alleles and genes affects phenotypes.

**SECTION 2**  
**Genetics**

**Main Idea** Genetics is the science that studies how genetic traits pass from parents to offspring.

**SECTION 3**  
**Environmental Impact over Time**

**Main Idea** If an environment changes over time, species adapt to the changes, move to a new environment, or become extinct.

# Traits and How They Change



## Are these dogs related?

It hardly seems possible that these dogs are members of the same species. In this chapter, you will learn how the differences among members of a species develop over time, about the effects of the environment on traits, and how to predict traits of offspring.

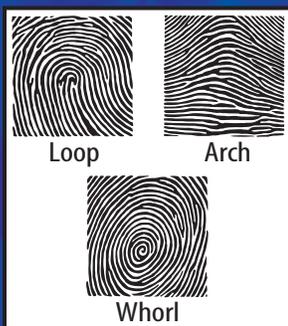
**Science Journal** List two traits that a dog inherits, and two that are determined by the environment.

# Start-Up Activities



## How are people different?

Some of your unique qualities were present before you were born. You can observe one unique quality by studying your own fingerprints. Do the lab below to compare the fingerprint patterns labeled in the photograph with your fingerprints and those of your classmates. 

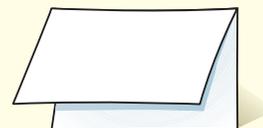


1. Press the thumb and fingertips of one hand on a washable ink pad.
2. Gently roll each fingertip on a sheet of blank paper to produce a set of fingerprints.
3. Use a magnifying lens to observe your fingerprints and those of others in your class to find whorl, arch, and loop patterns.
4. **Think Critically** Write a paragraph in your Science Journal suggesting why no two people in your class have exactly the same fingerprints.

## FOLDABLES™ Study Organizer

**Traits** Make the following Foldable to help you classify your traits into groups.

- STEP 1** **Fold** a vertical sheet of paper from top to bottom.



- STEP 2** **Fold** it in half from side to side with the fold at the top.



- STEP 3** **Draw** a picture of yourself and write your name and a short biography on the front of your Foldable.

**Classify Traits** Before you read the chapter, make a list on the inside of your Foldable of the traits that you think are inherited from your parents. Decide if each trait you listed is a phenotype or genotype and write your decision next to each.



Preview this chapter's content and activities at [blue.msscience.com](http://blue.msscience.com)

# Get Ready to Read

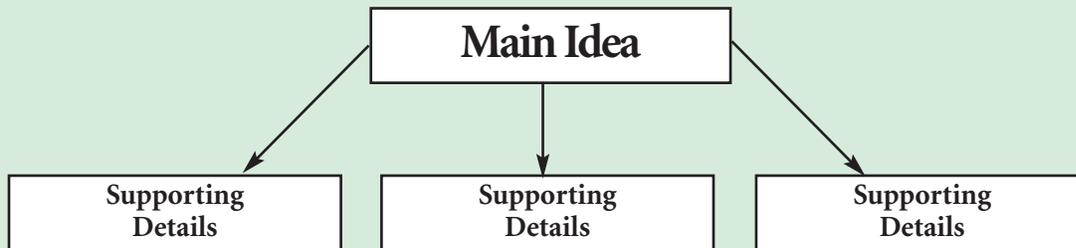
## Identify the Main Idea

**1 Learn It!** Main ideas are the most important ideas in a paragraph, section, or chapter. Supporting details are facts or examples that explain the main idea. Understanding the main idea allows you to grasp the whole picture.

**2 Picture It!** Read the following paragraph. Draw a graphic organizer like the one below to show the main idea and supporting details.

Many environmental factors other than seasonal temperatures and rainfall influence the survival of a species. Some environmental factors, like pollution, limit whether a species can survive in a habitat. Other factors can influence a species so that it changes in appearance. Fire, height of mountains, volcanic eruptions, and periodic flooding of rivers can have influences on the animals and plants in an area significantly.

—from page 49



**3 Apply It!** Pick a paragraph from another section of this chapter and diagram the main ideas as you did above.

## Reading Tip

The main idea is often the first sentence in a paragraph but not always.

### Target Your Reading

Use this to focus on the main ideas as you read the chapter.

- 1 Before you read** the chapter, respond to the statements below on your worksheet or on a numbered sheet of paper.
  - Write an **A** if you **agree** with the statement.
  - Write a **D** if you **disagree** with the statement.
- 2 After you read** the chapter, look back to this page to see if you've changed your mind about any of the statements.
  - If any of your answers changed, explain why.
  - Change any false statements into true statements.
  - Use your revised statements as a study guide.

Before You Read A or D	Statement	After You Read A or D
	1 Your genetic traits are the same as one of your parents.	
	2 An organism's internal and external environments can influence its genetic traits.	
	3 The two alleles for a gene can be the same or different.	
	4 A Punnett square shows the actual offspring of two parents.	
	5 The color markings of an adult Siamese cat result from environmental effects.	
	6 An organism's genotype depends on its phenotype.	
	7 The environment and other species affect the number of species present in an environment.	
	8 Each present-day species evolved from a different ancient species.	
	9 Adapted species are selected naturally and increase in number more than other species.	



Print out a worksheet of this page at [blue.msscience.com](http://blue.msscience.com)

# Traits and the Environment

## as you read

### What You'll Learn

- **Compare and contrast** phenotype and genotype.
- **Describe** some effects the environment has on traits.
- **Explain** how traits are formed.

### Why It's Important

The features of many organisms, including humans, are partly determined by the environment.

### Review Vocabulary

**variations:** inherited trait that makes an individual different from other members of the same species and results from a mutation in the organism's genes

### New Vocabulary

- trait
- genotype
- gene
- phenotype

## What are traits?

Every living thing has many inherited features—characteristics that came from its parents. For example, if you have a cat, its coloration, length of hair, and many other features came from its parents. All of the features that an organism inherits are its **traits**. The color of your eyes and the shape of your ears are two of your traits.

**Observing Traits** People observed the inheritance of traits long before scientists understood how the inheritance occurred. Many breeds of domestic animals and crops were developed based on these observations. For example, over thousands of years, Native Americans developed maize (MAYZ) from a wild grass called teosinte (tay oh SIHN tee), shown in **Figure 1**. By carefully selecting and breeding individual plants with desired traits, modern corn was developed.

When people wanted to improve an existing plant or animal, they based breeding on observable traits. The Native Americans may have based their breeding of maize on the number and size of kernels each plant produced. But, what would have happened if environmental factors, like the amount of rain and temperature, determined the number and size of kernels instead of the traits from the parent plants? The breeding of maize would not have been successful. Sometimes it is obvious how the environment affects traits, but other times it is not.

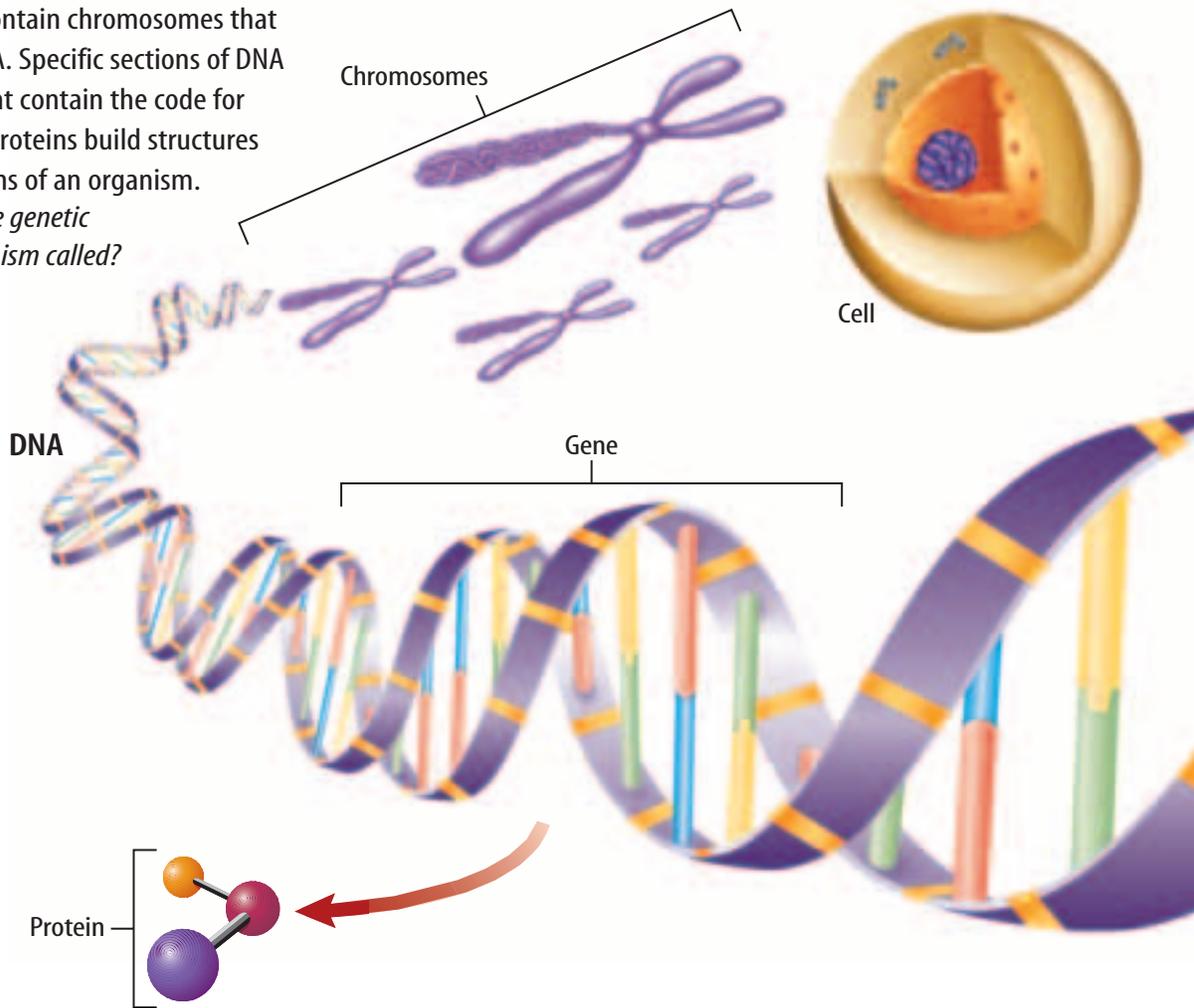
**Figure 1** Teosinte, below, an ancestor of modern corn, had few kernels on each plant. This modern corn, *Zea mays*, to the right, has many kernels on each ear.





**Figure 2** Cells contain chromosomes that are made up of DNA. Specific sections of DNA are called genes that contain the code for building proteins. Proteins build structures and control functions of an organism.

**Define** What is the genetic makeup of an organism called?



**Phenotypes and Genotypes** A cat, a plant, or even you can be thought of as a collection of thousands of traits. Each trait results from the coded information in the hereditary material called DNA, which is found in every cell. DNA is a complex molecule, shaped like a twisted ladder. It contains all of the information required to produce a living organism.

In cells that have a nucleus, DNA is found in chromosomes (KROH muh sohmz). A **gene** is a part of the DNA code on a chromosome. Humans have tens of thousands of genes on their chromosomes. The genes that an organism has—its genetic makeup—are called its **genotype** (JEE nuh tipe). Within each cell, the DNA code directs the production of specific proteins, as shown in **Figure 2**.

**Reading Check** How are genes, DNA, and chromosomes related?

When you look at an organism, you see the organism's phenotype (FEE nuh tipe). A **phenotype**, like hair color in humans, is the combination of genetic makeup and the environment's effect on that makeup.



**DNA Structure** DNA is a unique molecule that has a twisted-ladder shape. The uprights of the ladder are made of repeating molecules of a phosphate and deoxyribose, a sugar. The rungs of the ladder are made of four bases that contain nitrogen. Use reference materials to find out what the four bases of DNA are called. List the four bases in your Science Journal.



## Mini LAB

### Observing Gravity and Stem Growth

#### Procedure

1. Plant popcorn or other seeds in a pot of soil.
2. Water thoroughly.
3. When the plants begin to sprout, turn the pot on its side for three days. You may turn the pot upright to water the plant but return it to the same position each time.

#### Analysis

1. Predict what eventually would happen if you rolled the pot so that the stems were growing downward.
2. Does gravity affect phenotype? Explain.



## Effects of the Environment

How much the environment affects phenotype varies from organism to organism. The environment doesn't have much effect on some phenotypes, such as the color of a person's eyes. However, other phenotypes are mostly due to the environment's influences. For example, a big-leaf hydrangea plant's flower color will vary from blue to pink depending on the conditions of the soil in which it grows.

Some influences are external, such as the amount of light an organism receives or the temperature in which the organism lives. For example, tree leaves that grow in full sunlight are thicker than those that grow in shadier conditions, even though their genetic makeups are the same.

Other environmental influences are internal. Human brain cells will not develop normally unless they are acted on by a thyroid hormone during their development. The hormone is a part of the body's internal environment.

**Growth** Suppose you wanted to plant an oak tree. Where would be the best place to plant it? If you wanted the tree to grow faster than normal, you probably would plant it away from other plants, as shown in **Figure 3**. This would allow the tree to receive full sunlight. Its roots would be able to absorb water and minerals without competition from other trees. Trees grow differently in a dense forest from the way that they grow when they are alone. The competition for environmental factors in a forest—light, water, soil minerals, and many others—have significant effects on the populations of trees in it.

**Figure 3** Many plants, such as the oak tree shown here, grow faster when they are planted away from other plants.

**Infer** In a forest, what environmental factors slow tree growth?





**Figure 4** Water buttercup leaves are finely divided below the water level. Leaves that grow above the water level are not as finely divided.

**Explain** what causes these differences.

**Appearance** The water buttercup shown in **Figure 4** has leaves that are shaped differently depending on where the leaves develop. Although the cells of the plant have the same genes, leaves that grow submerged in water are threadlike and those that grow above the water are broad. What environmental factor do you think determines the difference? The presence of water makes the difference because a leaf that grows halfway in the water is half threadlike and half broad.

**Reading Check** What causes water buttercup cells with the same genotype to have different phenotypes?

The color markings on a Siamese cat are another phenotype affected by the environment. Siamese kittens, like the one shown in **Figure 5**, are pure white at birth. Because the gene for colored fur is less active in heat, colored markings, as shown in **Figure 5**, develop more quickly on cooler parts of the cat's body, such as the ears. In warmer climates the fur color might not develop fully until the cat is more than a year old.

The arctic fox's fur color is a phenotype that changes with the seasons. During the winter months the arctic fox does not produce pigment that colors fur, so the fox's fur is white. As a result, the fox blends with the snowy ground helping it avoid predators. In warmer summer months, the arctic fox produces fur pigment. Then, the arctic fox's fur is brown, which is perfect for blending with the tundra.

**Figure 5** This Siamese kitten has not developed markings. An adult Siamese cat has darker markings on the cooler parts of its body.

Kitten



Adult cat





**Figure 6** The large clownfish is female. This fish was a top-ranking male earlier in its life. It changed into a female when the female who occupied this territory died.

**Gender** Most living things are born male or female and remain that way for life. However, some species of fish, including many clownfish, parrot fish, wrasses, and sea bass, are born with the ability to change sex. This allows these

species to maintain a desired male-to-female ratio in a group under different conditions. For example, as shown in **Figure 6**, one large female clownfish lives near a sea anemone. Several males, including one top-ranking male, might share the territory with the female. Only the top ranking male mates with the female to produce offspring. When the female dies, the top-ranking male changes phenotype to become a female. All of the other males then move up in the social order. In some of these species, sex changes are not reversible. A few fish have the ability to switch back and forth between sexes, depending on the number of males and females in the population.

## ScienceOnline

### Topic: Changing Gender

Visit [blue.msscience.com](http://blue.msscience.com) for Web links to recent news or magazine articles about animals that can change their gender.

**Activity** List two animals whose gender can change and describe the conditions under which it changes.

## section 1 review

### Summary

#### What are traits?

- All living things inherit features that come from its parents.
- DNA contains all of the information that is needed to produce a living organism.
- There are tens of thousands of genes on human chromosomes.

#### Effects of the Environment

- Some environmental influences are external and some are internal.
- The competition for environmental factors can affect growth.
- The appearance of an organism can be different depending on its environment.
- The gender of some living things can change under different conditions.

### Self Check

1. **Describe** two factors that determine the phenotype of a trait.
2. **Identify** a phenotype that changes as seasons change.
3. **Explain** the difference between an organism's genotype and its phenotype.
4. **Think Critically** The environment can affect phenotypes in desirable and undesirable ways. Describe an example of each.

### Applying Skills

5. **Record Observations** Observe a family pet or other organism. List five traits that could be influenced by the environment and explain why you think so for each one.
6. **Communicate** Sickle-cell disease is inherited. Research then explain in your Science Journal how the environment can affect this human disorder.

# Jelly Bean Hunt

The environment plays an important role in the development of some phenotypes. In this lab, you will observe how camouflaged animals are less likely to be captured by predators.

## Real-World Question

How do differences in animal coloration camouflage some but expose others to predation?

### Goals

- **Model** camouflage and predation.
- **Infer** how the effect of the environment on phenotype helps some animals survive.

### Materials

five shades of green jelly beans (10 each)  
*\*five shades of another color (10 each)*  
 green poster board  
*\*poster board that matches chosen color*  
*\*Alternative materials*

### Safety Precautions



**WARNING:** *Never eat or drink anything in the lab.*

## Procedure

1. Copy the data table on this page in your Science Journal. Determine which shade is which number.
2. Put the poster board on the desk. Have your partner turn his or her back to the poster.
3. Arrange the 50 jelly beans on the poster. Mix up the different shades of jelly beans.

### Jelly Bean Data

	Shade #1	Shade #2	Shade #3	Shade #4	Shade #5
Hunt #1					
Hunt #2	Do not write in this book.				
Hunt #3					
Hunt #4					
Hunt #5					

4. Have your partner, who is the hunter, turn and pick up one at a time, as many jelly beans as possible in 3 s.
5. **Count** the number of each shade of jelly bean the hunter caught. Record these numbers in the *Hunt #1* row.
6. Mix up the jelly beans and have the hunter make four more hunts.

## Conclude and Apply

1. **Observe** Which shade of jelly bean did the hunter select most often? Least often?
2. **Explain** why the hunter caught more of certain shades of green jelly beans than others.
3. **Predict** your results with a different shade of poster board.
4. **Infer** how your experiment could explain the specific green color of tropical lizards.

### Communicating Your Data

**Describe** how the environment's effect on some phenotypes can help animals survive. For more help, refer to the **Science Skill Handbook**.

# Genetics

## as you read

### What You'll Learn

- **Differentiate** between genetics and heredity.
- **Explain** the results of Mendel's pea plant experiments.
- **Identify** the results shown by a Punnett square.

### Why It's Important

The transfer of genetic information from one generation to the next allows traits to change over time.

### Review Vocabulary

**cloning:** making copies of organisms, each of which is a clone that receives DNA from only one parent cell

### New Vocabulary

- genetics
- allele
- dominant
- recessive
- Punnett square

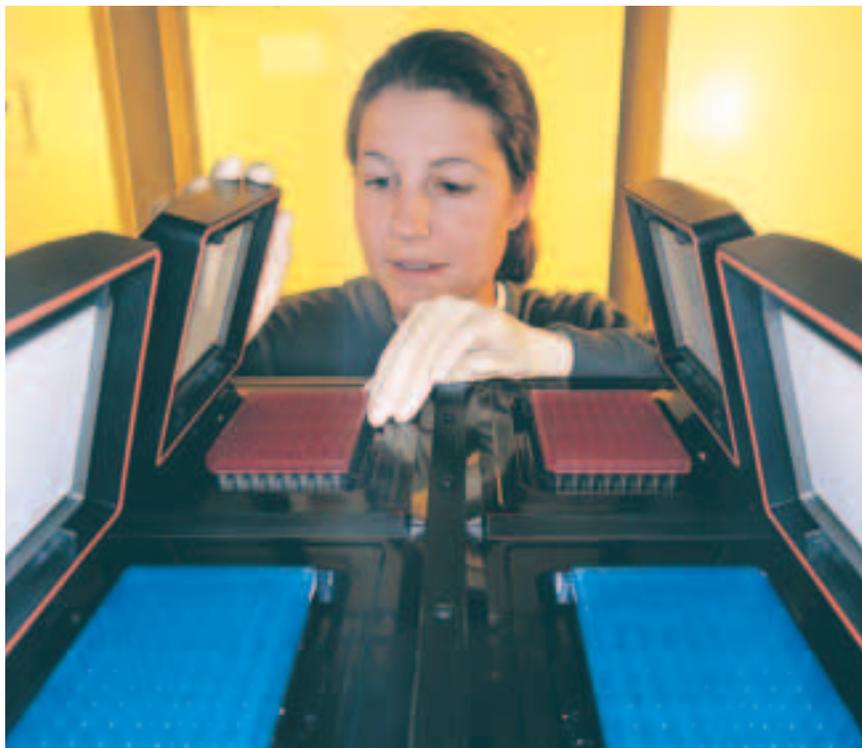
## Science of Genetics

Long before scientists understood genes, chromosomes, or how sex cells are produced, they tried to figure out heredity. Some early scientists proposed that the male parent contributed all of the traits and that the female parent was only a supplier of food for the new organism. While observing sperm through a microscope, they even imagined that they could see a tiny human curled up in the head of sperm. Other early scientists hypothesized that the traits of the parents blended to form those of the offspring. Only within the past 200 years have scientists begun to understand the true nature of how organisms inherit traits.

**What is genetics?** Heredity is the passing of traits from parents to offspring. Eventually, the study of heredity developed into a science called **genetics**. Researchers in the field of genetics, as shown in **Figure 7**, are rapidly providing more information about the genetics of humans and other organisms. Studies in genetics, combined with an understanding of chemical interactions and other cell processes, provide an explanation of how species can change through the generations.

**Reading Check** Why is genetics important?

**Figure 7** The Human Genome Project is an international effort to provide information about the genetics of humans. In the photo to the right, a technician prepares DNA samples for sequencing trials. **Infer** why medical doctors might be interested in results from the Human Genome Project.



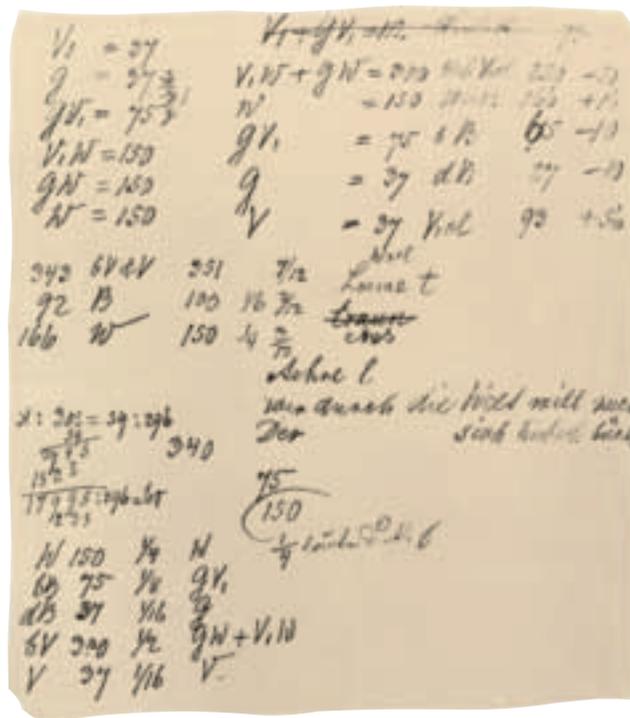
## Beginning with Mendel

Gregor Mendel was the first researcher to use numbers to describe the results of genetics experiments, as shown in **Figure 8**. Mendel's work was presented in the 1860s, but its importance was not recognized for many years. Although Mendel did not know about chromosomes or genes, he was able to develop principles of genetics by experimenting with thousands of pea plants.

**Dominant and Recessive Traits** One of Mendel's conclusions from his experiments was that traits are determined by different factors. Mendel explained that each trait of an individual is determined by at least two of these factors, as shown in **Figure 9**. Today, Mendel's factors are called genes. The different forms of a gene are each called an **allele** (uh LEEL).

Mendel's principle of dominance explains why only one form of a trait is expressed even when both alleles are present. **Dominant** (DAH muh nunt) alleles will show their effect on the phenotype whenever they are present in the genotype. These traits often are seen in each generation. **Recessive** (rih SE sihv) alleles will show their effect on the phenotype only when two of them for a trait are present in the genotype.

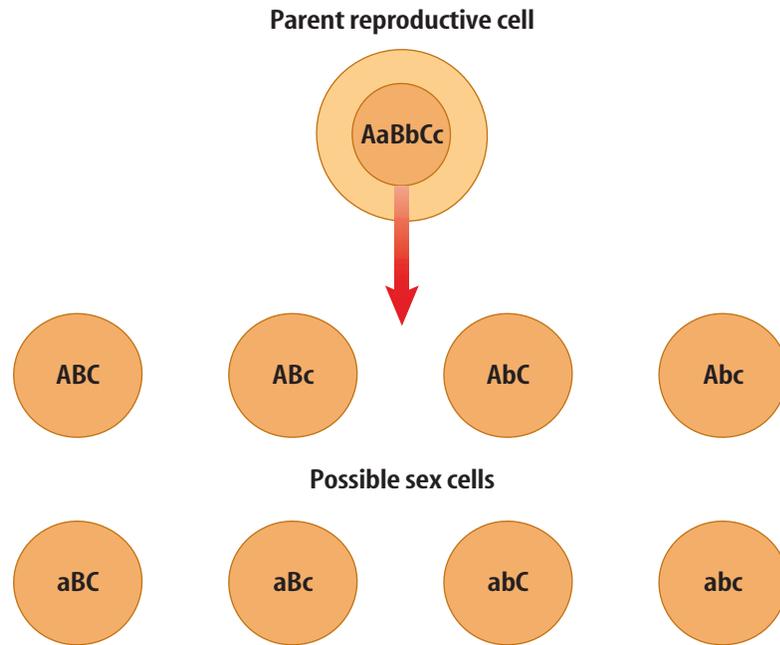
Understanding how dominant and recessive alleles show their effects has helped scientists figure out how some genetic diseases are passed down through families.





**Figure 10** A parent with three traits on three different chromosomes could produce eight genetically different sex cells.

**Explain** how this creates variation among offspring.



**From Parents to Offspring** Mendel also concluded that each parent passes only one of the alleles for a trait to its offspring. This is known as the principle of segregation. This explains why variation exists among the offspring of parents. Suppose that a parent has three pairs of chromosomes with a different trait on each pair. The traits can be called A, B, and C. Each trait has two different alleles—A and a, B and b, and C and c. When sex cells—eggs or sperm—form in the parent, each sex cell will have three chromosomes, each with one form of the A, B, or C trait. The three chromosomes and their alleles can combine in eight possible ways, as shown in **Figure 10**. Humans have 46 chromosomes, so more than 8 million combinations are possible every time an egg or sperm forms. That’s why variation is seen among offspring in one family.

**Reading Check** *In a family you know with two or more siblings, why are there variations among siblings?*

Mendel examined the inheritance of traits in pea plants. He found that when two plants with different alleles for a trait are crossed, three fourths of the offspring will show the dominant trait and one fourth will show the recessive trait.

In his experiments with pea plants, Mendel also found that the alleles for one trait have no effect on how alleles for another trait are inherited. This discovery led to Mendel’s law of independent assortment. Mendel experimented with two traits at the same time, and his law of independent assortment helped him understand how traits from both parents can appear in future generations.

## Mini LAB

### Observing Fruit Fly Phenotypes

**Procedure**   

1. Obtain a container of **fruit flies** from your teacher.
2. Use a **magnifying lens** to observe the eyes and wings of the flies.

### Analysis

1. What variations did you find in the eyes and wings of the flies?
2. Hypothesize what caused the variations.

## Predicting Genetic Outcomes

Mendel's greatest achievement might have been his ability to apply mathematics to scientific problem solving. He stated predictions about his experiments in terms of probability. Almost 50 years after Mendel's work was published, Reginald C. Punnett developed a chart called a Punnett square. A **Punnett square** can help you understand and make genetic predictions.

### Applying Math Find a Percentage

**PERCENT OF OFFSPRING WITH CERTAIN TRAITS** In mice, black fur color is dominant and white fur color is recessive. If both parent mice have different alleles for the trait, what percent of their offspring would have white fur?

#### Solution

1 *This is what you know:*

- Each parent has different alleles for fur color, Bb.
- Offspring with BB or Bb will have black fur; offspring with bb will have white fur.

2 *This is what you need to find:*

percent of white fur offspring

3 *This is the procedure you need to use:*

- Complete the Punnett square by combining the letter in each column with the letter in each row.

	B	b
B	BB	Bb
b	Bb	bb

- $\frac{\text{number of offspring with white fur}}{\text{total number of possible offspring}} = P/100$
- Substitute the known values:  $1/4 = P/100$ .
- Find the cross products:  $1 \times 100 = P \times 4$ .
- Divide each side by 4:  $25 = P$ .

4 *Check your answer:*

Substitute your answer into the proportion. You should get 1/4.

### Practice Problems

1. Suppose a male mouse is Bb and a female is bb. What percent of the mice offspring from these two mice would you expect to have black fur?
2. One fruit fly is heterozygous for long wings, and another fruit fly is homozygous for short wings. Long wings are dominant to short wings. Using a Punnett square, find out what percent of the offspring are expected to have short wings.



For more practice, visit  
[blue.msscience.com/  
math\\_practice](http://blue.msscience.com/math_practice)

	Female (XX)	
	X	X
Male (XY)	X	XX
	Y	XY

**Figure 11** Females have the genotype XX, and males have the genotype XY.

**Punnett Square** The hereditary traits in organisms can be predicted using a Punnett square. It is a model that is used to predict the possible offspring of crosses between different organisms of known genotypes. When an organism has two different alleles for a trait, the organism is called a hybrid. For example, a pea plant with an allele for purple flowers and an allele for white flowers is a hybrid. A monohybrid cross is one that includes one trait, such as flower color. The ability to predict the possible offspring becomes more complex as more traits are involved.

**Understanding Results** When you use a Punnett square, like the one shown in **Figure 11**, to predict the sex of one offspring, the results are one-half males and one-half females. Suppose a mother has given birth already to three boys and is expecting a fourth child. What are the chances that it will be a girl? You might expect that the chances would be increased that the next baby would be a girl, but the chances are still only one in two. Each result is independent of the others that came before or come after it.

When Mendel was studying heredity in garden peas, his results were close to his predicted outcomes. This was because he studied large numbers of pea plants in each experiment. When large numbers are studied, the probability increases that the predicted result will occur.

## section 2 review

### Summary

#### Science of Genetics

- Only within the last 200 years have scientists begun to understand the inheritance of traits.
- Genetic researchers are rapidly providing more information about the genetics of humans.

#### Beginning with Mendel

- Mendel developed genetic principles by experimenting with pea plants.
- Two recessive alleles are needed in the genotype to show an effect in the phenotype.
- Each parent passes only one allele for a trait to its offspring.

#### Predicting Genetic Outcomes

- When an organism has two different alleles for a trait, it is called a hybrid.
- Predicting the traits of an offspring becomes more complex as more traits are involved.

### Self Check

1. **State** some of the early beliefs about human heredity.
2. **Contrast** heredity and genetics.
3. **Explain** why some people call Mendel the “Father of Genetics.”
4. **Describe** the primary purpose of using a Punnett square.
5. **Think Critically** Which of Mendel’s principles would apply to mating two organisms that have two different alleles for three different traits?

### Applying Math

6. **Calculate a Ratio** Long wings (L) are dominant to short wings (l) in fruit flies. Make a Punnett square to show the predicted outcome of a cross between two parents that have both alleles for wing length. What is the ratio of flies produced?

# Environmental Impact over Time

Ken Lucas/Visuals Unlimited

## Survival and the Environment

Would you be more likely to see a blue jay or a cactus where you live? Depending on where you live, winters might be long and cold or they might be short and mild. More than 125 cm or less than 25 cm of rain might fall in a year. Over a long period of time, the environment influences which organisms can live in an area. You wouldn't expect to find many cacti where it rains a lot, and you would never see giant evergreen trees growing in a desert.



**Nonliving Influences** Many environmental factors other than temperature and rainfall influence the survival of a species. Some environmental factors, like pollution, limit whether a species can survive in a habitat. Other factors can influence a species so that it changes in appearance. Fire, height of mountains, volcanic eruptions, and periodic flooding of rivers can influence the animals and plants in an area significantly.

The chaparral shrub land of California, as shown in **Figure 12**, and forests of Yellowstone National Park require periodic fires to survive. Some of the plant species in these areas have seeds that can germinate only after fire. Some trees, such as aspen trees, can sprout from underground roots when fire has burned away competing plants.

If you travel up a mountain's slopes, you will notice that the environment gradually changes. Temperature decreases and wind usually increases. At high elevations, the trees can be short and stubby, and above certain elevations, trees don't grow at all. The types of animals found also vary at different elevations on a mountain.

**Figure 12** In California, plants and animals are adapted for periodic, destructive fires.



### as you read

#### What You'll Learn

- **Explain** how living and nonliving environmental factors impact evolution.
- **Describe** how natural selection occurs in a species.
- **Compare and contrast** selective breeding and natural selection.

#### Why It's Important

Species can evolve over time due to the impact of the environment.



#### Review Vocabulary

**environment:** the objects and conditions that surround an organism

#### New Vocabulary

- evolution
- natural selection
- mutation
- adaptive radiation
- extinction



**Figure 13** Raccoons prey on insects, fish, crayfish, and other small organisms.

**Describe** what might happen to the population of crayfish as the population of raccoons increases.

## Interactions with Other Organisms

Living factors in the environment also affect the species that are present. Predators, availability of food, and how many of the same species that live in an area have an effect. Predators, as shown in **Figure 13**, often limit the number of individuals. Over generations, groups can adapt to the presence of predators. They might evolve ways to escape detection, defenses against predators, or ways to increase their number.

### Reading Check

What are some effects of predation?

## Species and the Environment

About the same time that Gregor Mendel was discovering the rules of genetics, Charles Darwin and Alfred Russell Wallace, two British biologists, were separately hypothesizing about how so many living things came to exist on Earth. Darwin studied the diversity of living things while sailing aboard the HMS *Beagle*. After visiting the Galápagos Islands off the coast of South America, Darwin began to hypothesize about reasons for the diversity he observed and recorded. Wallace came to the same conclusions as Darwin while studying in the East Indies. Darwin and Wallace concluded that different, long-term, environmental influences on populations produced the variety of species they observed.

**Natural Selection** According to Darwin and Wallace, changes happen from generation to generation that result in adaptations to the environment. This process is called evolution.

**Evolution** is the change in the genetics of a species over time. Darwin's theory, the theory of evolution by natural selection, is an explanation of how, over time, several factors can act together and result in a new species. This theory provides an explanation of how organisms could have changed to produce the several million species that are alive today.

The big question for Darwin and Wallace was how evolution happens. They proposed that organisms that are better adapted to an environment survive and reproduce at a greater rate than organisms that are not. They called this **natural selection**, as shown in **Figure 14**, because the adapted organisms are selected naturally to survive and increase in number. Natural selection can produce new organisms or new species.



**Volcanologist** Volcanic activity changes the landscape. Scientists who study volcanoes are called volcanologists. To become a volcanologist it is necessary to study many areas of science. Research to find out what classes are required to become a volcanologist. In what parts of the United States would it be easiest to study volcanoes?

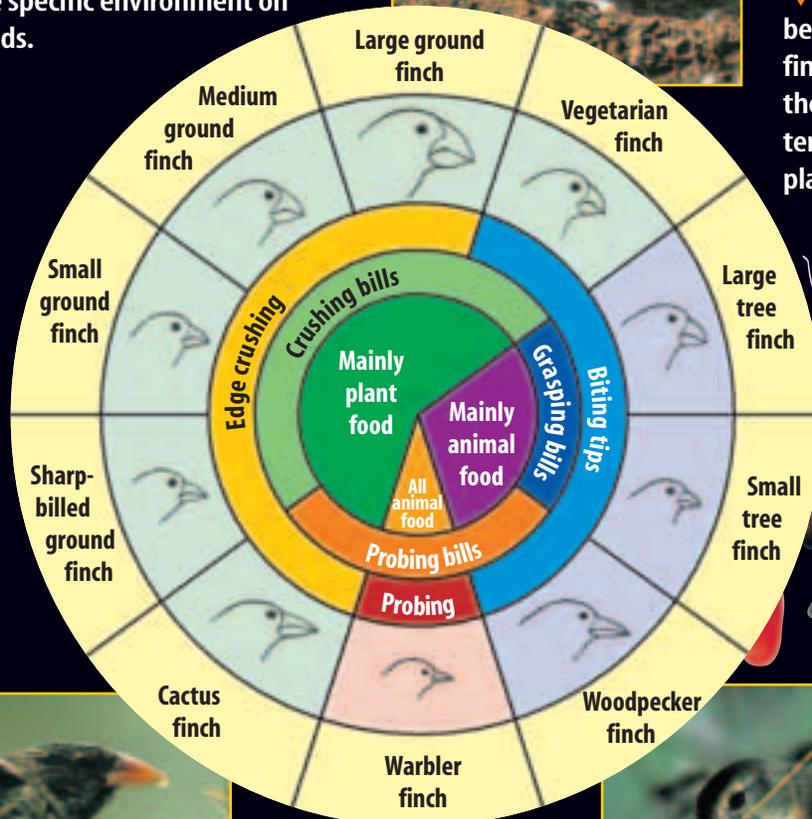
**Figure 14**

**B**ritish naturalist Charles Darwin hypothesized that the 14 species of finches he found on the Galápagos Islands developed from a common ancestor through a process of natural selection. "Darwin's finches," as they became known, probably developed their different beak structures and feeding habits over time, as a result of the specific environment on each of the islands.



◀ **LARGE GROUND FINCH** Ground finches have short, stout "crushing" beaks, useful for breaking seeds. They spend much of their time foraging on the ground.

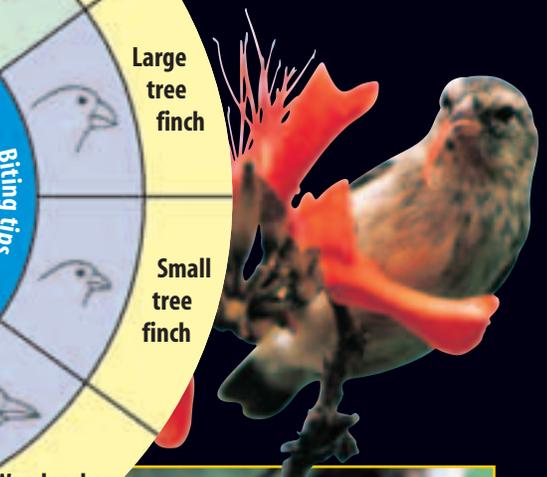
▼ **SMALL TREE FINCH** The beak of this tree-dwelling finch is sharper than that of the ground finch—and better suited to the tree finch's plant and insect diet.



▼ **CACTUS FINCH** The long beak of the cactus finch allows it to eat the fruit of the prickly pear cactus.



▼ **WARBLER FINCH** The smallest of Darwin's finches, the warbler finch, has a long, narrow beak for insect eating.



▲ **WOODPECKER FINCH** This finch uses twigs or cactus spines to pry insects or their larvae out of small holes in cacti or from beneath bark.



Fantail pigeon



Frillback pigeon



Homing pigeon



Rock dove

**Figure 15** The rock dove is the common ancestor of all pigeon breeds, such as the three shown here.

**Mutation** You read in the last section that different forms of alleles produce variations in traits. **Mutation** is the process in which DNA changes result in new alleles. Some variations produced by mutation are advantageous for survival and reproduction. Other variations keep an organism from surviving or reproducing. In this way, advantageous mutations are passed to future generations, and new species can be produced.

**Selective Breeding** Charles Darwin was well aware of the methods of selective breeding. One of his hobbies was breeding pigeons. From the rock dove, a wild pigeon ancestor that looks much like some pigeons you would see in a city park, many different pigeon breeds have been selectively bred, as shown in **Figure 15**. Darwin inferred that if humans could select so many different variations to produce so many different breeds of organisms, perhaps the same thing could happen naturally in the different environments where organisms live.

**The Direction of Evolution** Darwin's theory of evolution by natural selection is one explanation of how variations can lead to the development of a new species. New species can form when natural selection favors members of a population with a variation in a trait. In another way, more than one variation of a trait is favored. This can lead to two or more new species from one ancestral species.

The production of several species from one ancestral species is called **adaptive radiation**. Darwin observed many species of finches and tortoises when he visited the Galápagos Islands. He concluded that one ancestral population of finches and tortoises had reached the islands. Because they were isolated geographically from the same species on the mainland, they adapted to the various conditions of the islands. Eventually, each ancestral species produced several different species; each adapted to the different environments on each island.

ScienceOnline

**Topic: Different Species**

Visit [blue.msscience.com](http://blue.msscience.com) for Web links to information about other theories of how different species came about.

**Activity** List and describe two theories on the formation of different species.

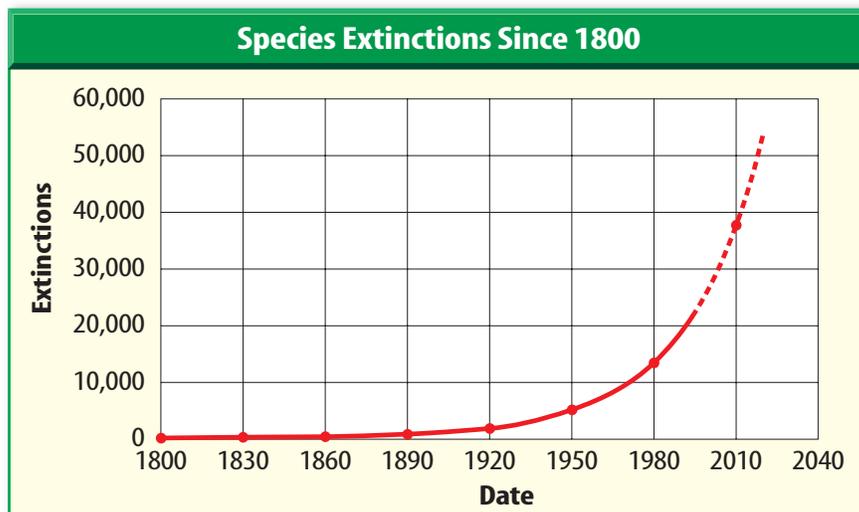
## Extinction of Species

All individuals experience a life cycle that includes birth and death. **Extinction** occurs when the last individual of a species dies. During Earth's history, millions of species have become extinct. Fossils are evidence of these species. The rate of extinction today of known species is as great or greater than at any time in the recent past, as shown in **Figure 16**. Extinction can

occur for many reasons, including the destruction of habitat and the introduction of new species.

Humans impact environments when they construct buildings, recreational areas, or roads, and when they farm or mine land. Some species increase in number because of changes, but others cannot cope and either leave the area or die.

Sometimes newly introduced species prey on organisms that do not have defenses against them. The introduced species also might produce many offspring that crowd out other species. In either case, some species might become extinct. Zebra mussels were accidentally introduced into the Great Lakes. They have affected food webs and some species are disappearing.



**Figure 16** The rate at which species have become extinct has risen rapidly.

### section 3 review

#### Summary

##### Survival and the Environment

- Nonliving influences can affect species survival in a habitat.
- Predators, availability of food, and how many of the same species that live in an area can affect the species that are present.

##### Species and the Environment

- The process in which changes result in adaptations to the environment is called evolution.
- Organisms that are better adapted to the environment survive and reproduce at a greater rate than organisms that are not.
- Variations can result in new species.
- Millions of species have become extinct during the history of Earth.

#### Self Check

1. **List** some nonliving factors in the environment that can cause change in species over several generations.
2. **Differentiate** between selective breeding and natural selection.
3. **Describe** how evolution and extinction are related.
4. **Think Critically** What are some changes made by humans in the area where you live that might affect other species there?

#### Applying Skills

5. **Relate Cause and Effect** Members of a butterfly species are blown onto an island. Over many generations, they evolve into a new species. What environmental factors might explain the evolution?

## Toothpick Fish

### Goals

- **Identify** how the environment can affect a gene pool.
- **Demonstrate** how the law of independent assortment is random.
- **Distinguish** between the number of phenotypes and genotypes.

### Materials

petri dish  
toothpicks (24)  
(8 green, 8 red,  
8 yellow)

### Safety Precautions

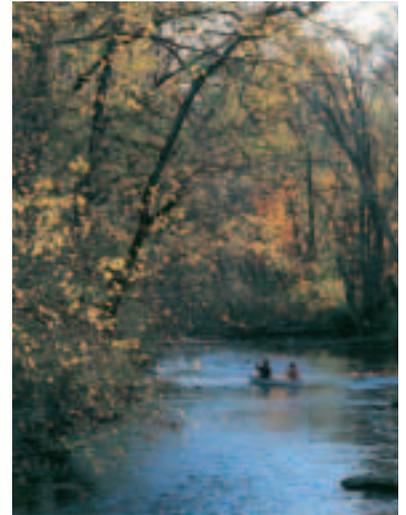


### Real-World Question

The genotypes and phenotypes in a population can be affected by environmental changes. In this lab, you will simulate how the environment can affect the genetics and population of a species. How can the environment affect a species' gene pool?

### Procedure

1. The petri dish represents a fish gene pool and the colored toothpicks represent the alleles that control fish skin color. The green allele is dominant. The red and yellow alleles are recessive to green, but fish with a red allele and a yellow allele have orange skin. List all of the genotypes for the four fish skin colors in your Science Journal.
2. Copy Table A and Table B in your Science Journal. Select an allele pair (2 toothpicks) without looking and record the results in Table A. Continue selecting and recording pairs until the gene pool is empty. Do not mix up the pairs.
3. Count and record in Table B the numbers of each color of fish offspring in the first generation.
4. Predators easily spot yellow fish in the green seaweed. Remove the yellow fish and put the remaining alleles back in the gene pool. Select a second generation of fish without looking. Record your results in Table A. Repeat step 3.



**Table A Allele Pairs and Fish Offspring Skin Colors**

Generations									
First		Second		Third		Fourth		Fifth	
Allele pair	Skin color	Allele pair	Skin color	Allele pair	Skin color	Allele pair	Skin color	Allele pair	Skin color
		Do not write in this book.							

## Using Scientific Methods

**Table B Number of Fish Offspring**

Environment	Generation	Green	Red	Orange	Yellow
Green seaweed grows everywhere.	First				
	Second				
	Third				
	Fourth				
The seaweed dies.	Fifth	0			

Do not write in this book.

- Remove yellow fish again and return the surviving fish alleles to the petri dish. Repeat step 4 two more times to model the third generation and fourth generation.
- Draw a fifth generation from the gene pool. Record the data in Table A.
- Factory wastes are dumped into the stream and kill the seaweed. The green fish now are easily seen by predators. Remove the green fish and record the number of surviving offspring in the last row of Table B.

### Analyze Your Data

- Compare** the population in the fourth generation to the first, second, and third generation. Explain any differences.
- Determine** if any alleles have disappeared. Describe why it did or did not occur.

### Conclude and Apply

- Explain** how the environment affected the fish population.
- Infer** how environmental changes could lead to the extinction of a species.

### Communicating Your Data

Combine the data in **Table B** from all students in your class. Calculate the average number of each fish color for each generation. How do your data compare to the class averages?



# Genetic Engineering

Genetically modified “super” corn can resist heat, cold, drought, and insects.



**W**hat would happen if you crossed a cactus with a rose? Well, you’d either get an extra spiky flower, or a bush that didn’t need to be watered very often. Until recently, this sort of mix was the stuff science fiction was made of. But now, with the help of genetic engineering, it may be possible.

Genetic engineering is a way of taking genes—sections of DNA that produce certain traits, like the color of a flower or the shape of a nose—from one species and giving them to another.

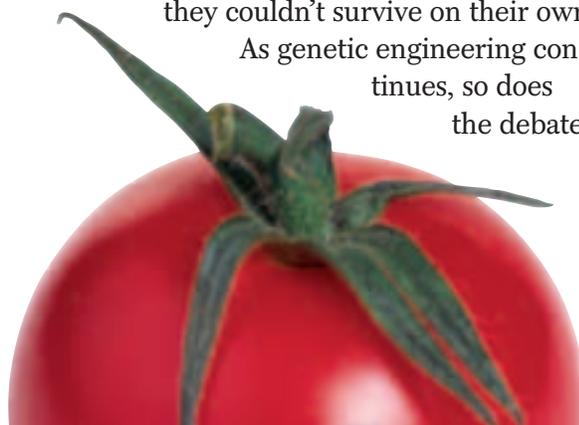
In 1983, the first plant was genetically modified, or changed. Since then, many crops in the U.S. have been modified in this way, including soybeans, potatoes, tomatoes, and corn.

One purpose of genetic engineering is to transfer an organism’s traits. For example, scientists have changed lawn grass by adding to it the gene from another grass species. This gene makes lawn grass grow slowly, so it doesn’t have to be mowed very often. Genetic engineering can also make plants that grow bigger and faster, repel insects, or resist herbicides. These changes could allow farmers to produce more crops with fewer chemicals. Scientists predict that genetic engineering soon will produce crops that are more nutritious and that can resist cold, heat, or even drought.

Genetic engineering is a relatively new process, and some people are worried about the long-term risks. One concern is that people might be allergic to modified foods and not realize it until it’s too late. Other people say that genetic engineering is unnatural. Also, farmers must purchase the patented genetically modified seeds each growing season from the companies that make them, rather than saving and replanting the seeds from their current crops.

People in favor of genetic engineering reply that there are always risks with new technology, but proper precautions are being taken. Each new plant is tested and then approved by U.S. governmental agencies. And they say that most “natural” crops aren’t really natural. They are really hybrid plants bred by agriculturists, and they couldn’t survive on their own.

As genetic engineering continues, so does the debate.



**Debate** Research the pros and cons of genetic engineering at the link shown to the right. Decide whether you are for or against genetic engineering. Debate your decision with a classmate.

Science **online**

For more information, visit  
[blue.msscience.com](http://blue.msscience.com)

### Reviewing Main Ideas

#### Section 1 Traits and the Environment

1. Traits are the features that are coded for in DNA and can be inherited.
2. Genes are segments of DNA on chromosomes.
3. Phenotypes are observed traits. Genotypes are the genes an individual has.
4. The environment can affect phenotypes.

#### Section 2 Genetics

1. Genetics is the study of heredity.
2. Mendel discovered and stated these important conclusions about genetics:
  - The principle of dominance explains how one allele can be responsible for producing a trait.

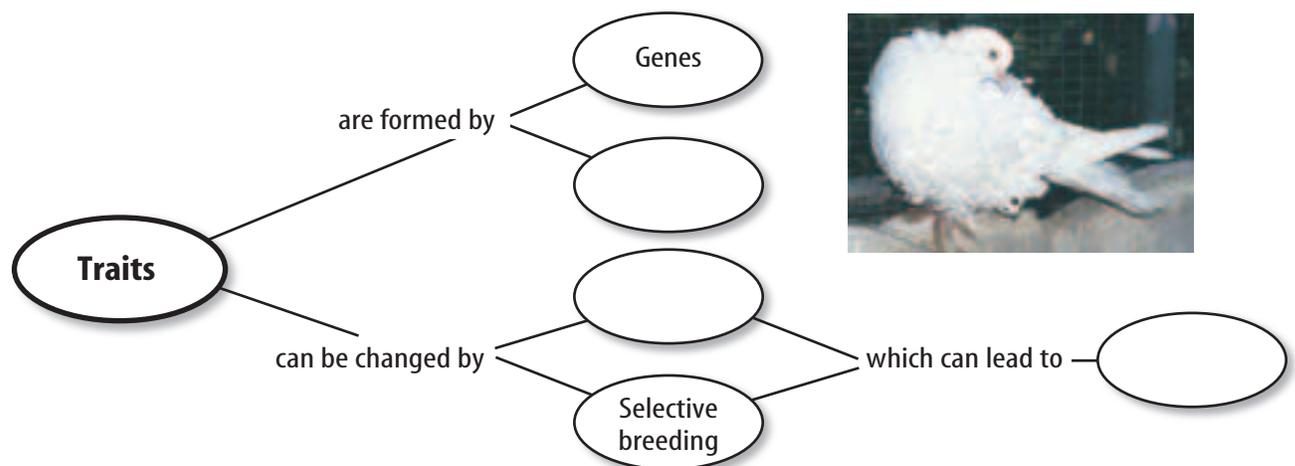
- The law of segregation states that a parent can pass on only one allele for each trait to its offspring.
  - The law of independent assortment explains how traits from both parents can appear in their offspring.
3. A Punnett square is a model for predicting the offspring of known genotypes.

#### Section 3 Environmental Impact over Time

1. Environmental factors might cause species to change gradually over time and determine which species survive in an area.
2. Natural selection can lead to evolution. Mutations can result in new variations.
3. The death of an entire species is called extinction. Extinctions cause a loss of biological diversity.

### Visualizing Main Ideas

Copy and complete the following concept map about traits.



**Using Vocabulary**

- |                         |                        |
|-------------------------|------------------------|
| adaptive radiation p.52 | genotype p.39          |
| allele p.45             | mutation p.52          |
| dominant p.45           | natural selection p.50 |
| evolution p.50          | phenotype p.39         |
| extinction p.53         | Punnett square p.47    |
| gene p.39               | recessive p.45         |
| genetics p.44           | trait p.38             |

Fill in the blank with the correct vocabulary word or words.

- Any feature of an organism that is inherited is a(n) \_\_\_\_\_.
- The visible product of a gene and the environment's influences is a(n) \_\_\_\_\_.
- An alternate form of a gene is a(n) \_\_\_\_\_.
- \_\_\_\_\_ is the result of the death of the last member of a species.
- \_\_\_\_\_ is the study of heredity.
- The mechanism of evolution is \_\_\_\_\_.
- A model used to predict the offspring of known genotypes is a(n) \_\_\_\_\_.
- \_\_\_\_\_ is the change in traits over several generations.

**Checking Concepts**

Choose the word or phrase that best answers the question.

- What is the term used for the different forms of a gene?
 

A) phenotypes	C) genetics
B) genotypes	D) alleles
- What is a trait called that appears only when both alleles are present?
 

A) dominant	C) genetic
B) recessive	D) environmental

- Which is a sequence of DNA that directs a cell to make a protein?
 

A) chromosome	C) nucleus
B) gene	D) recessive
- What is the study of heredity called?
 

A) genetics
B) environmental
C) evolution
D) natural selection
- How was the species of corn shown in the photo developed?
 

A) by natural selection
B) by selective breeding
C) by evolution
D) by extinction



- Which would NOT be evidence of evolution?
 

A) similar structures in two different species
B) variations in a species in two environments
C) a bird that is the same in two different areas of its range
D) a species that can avoid a predator
- What is the production of several species from one ancestral species called?
 

A) adaptive radiation
B) heredity
C) extinction
D) phenotypes
- What results in the formation of new alleles?
 

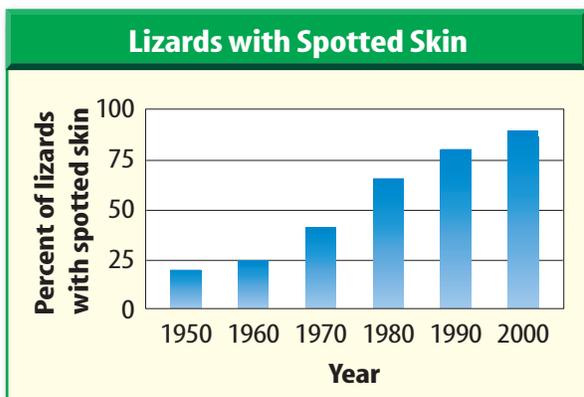
A) mutation	C) dominant
B) genetics	D) recessive
- Which is NOT a way that humans influence the rate of species extinction?
 

A) mining	C) volcanic eruptions
B) farming	D) construction

## Thinking Critically

18. **Apply** Suppose you raise tropical fish that are black. How could you explain a white fish among the newly hatched young?
19. **Infer** why a mutation that results in larger-than-normal corn kernels might be helpful.
20. **Determine** which of Mendel's principles is most important in explaining the production of males and females.
21. **Communicate** Use an example to explain natural selection.
22. **Draw Conclusions** Huntington's disease is a human disorder caused by a dominant allele, *H*. If a person does not have Huntington's disease, what is his or her genotype for this trait?
23. **Predict** Red flowers are dominant to white flowers in a particular species of plants. Predict the possible genotypes of the parent plants that were crossed to produce a white-flowered plant.

Use the graph below to answer question 24.



24. **Interpret Data** A population of lizards has been studied for the past 50 years. Study the graph above. Explain what might be happening and why.

## Performance Activities

25. **Letter** Imagine that you were living in England and read a newspaper article that announced Darwin's return to England from his voyage on the HMS *Beagle*. Write a letter to a friend telling about Darwin's experiences.

## Applying Math

Use the diagram below to answer question 26.

	R	r
r		
r		

Do not write in this book.

26. **Wrinkled Seeds** In pea plants, the trait for round seeds (*R*) is dominant to wrinkled seeds (*r*). Using the Punnett square above, predict the percent of offspring that will have wrinkled seeds when a parent with both alleles is crossed with a parent that has only the wrinkled allele.

Use the diagram below to answer question 27.

	T	t
T		
T		

Do not write in this book.

27. **Different Alleles** The trait for a tall plant (*T*) is dominant to short (*t*). What percent of offspring will have two different alleles when a parent with both alleles for plant height is crossed with a parent that has two tall alleles?

## Part 1 Multiple Choice

Record your answers on the answer sheet provided by your teacher or on a sheet of paper.

Use the photo below to answer question 1.



- The fur color changes seen in the cat above are determined by body temperature. What is this an example of?
  - environmental influences on gene expression
  - expression of a dominant allele
  - expression of a recessive allele
  - climate control
- If a parent has the genotype CcBB, how many different sex cells will be produced?
  - 2
  - 4
  - 1
  - 7
- For which did Darwin propose natural selection as an explanation?
  - selective breeding
  - evolution
  - predation
  - mutation
- What explains all of the different breeds of dogs and cats?
  - phenotype
  - genes and the environment
  - dominant alleles
  - selective breeding
- What provides evidence of an extinct species?
  - fossils
  - genetics
  - natural selection
  - evolution

Use the table below to answer questions 6 and 7.

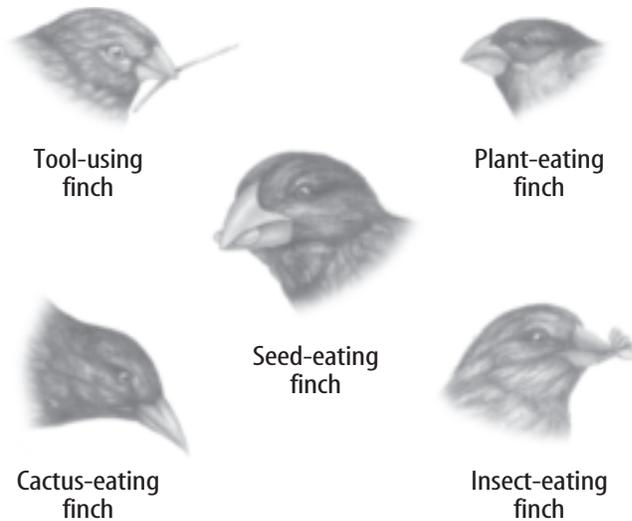
Traits	Shape of Seeds	Color of Seeds	Plant Height
<b>Dominant Trait</b>	 Round	 Yellow	 Tall
<b>Recessive Trait</b>	 Wrinkled	 Green	 Short

- If you cross a tall plant with a dwarf plant and all of the offspring are tall, what was the genotype of the tall parent?
  - T
  - Tt
  - tt
  - TT
- If one parent has two dominant alleles and the other parent has one dominant and one recessive allele for seed shape, what percentage of offspring will be wrinkled?
  - 100%
  - 0%
  - 50%
  - 25%
- Mendel observed what types of alleles?
  - high and low
  - genotype and phenotype
  - natural and unnatural
  - dominant and recessive
- What scientific field specializes in the study of heredity?
  - botany
  - cell biology
  - genetics
  - astronomy

## Part 2 Short Response/Grid In

Record your answers on the answer sheet provided by your teacher or on a sheet of paper.

Use the illustration below to answer questions 10 and 11.



- Describe how mutation might have influenced the development of different species of finches that Darwin observed on the Galápagos Islands.
- If fire destroyed the leafy vegetation on the islands, which of the finches would be most affected? Explain.
- Genes that are inherited together or linked violate which of Mendel's laws?
- How does predation limit the number of a species in a given area?
- How can the introduction of a new species into a habitat help to cause the extinction of a species?
- If a parent had the genotype  $XxYYZz$ , list the genotypes found in its sex cells.
- What environmental factors might cause a species of insects to have mostly individuals that are light colored or dark colored, but few intermediate-colored individuals?

## Part 3 Open Ended

Record your answers on a sheet of paper.

- How are genes, chromosomes, DNA, and proteins related to the genotype and phenotype of a trait?
- List environmental factors that Mendel had to keep the same while growing his pea plants. How would these factors have effected growth or appearance of the plants?
- In mice, brown fur is dominant over white fur. How can you determine the unknown genotype of a brown mouse by crossing it with a white mouse?
- Explain why a variation that caused a fur color change in the arctic fox was favored over remaining the same color throughout the year.

Use the photo below to answer question 21.



- Explain why there is so much variation among the kittens in this litter.

### Test-Taking Tip

**Practice** Remember that test-taking skills can improve with practice. If possible, take at least one practice test and familiarize yourself with the test format and instructions.