Chapter 20

Inheritance and Adaptations

THE BIG IDEA

How do inherited traits become adaptations?

inquiry

Follow me?

The strong legs and hooves of these mountain goats enable them to climb up and down mountains with relative ease. Their thick, white fur helps keep them warm and blend in against a snowy background.

- How are offspring similar to but different from their parents?
- How do adaptations help species survive?
- How do inherited traits become adaptations?

Get Ready to Read

What do you think?

Before you read, decide if you agree or disagree with each of these statements. As you read this chapter, see if you change your mind about any of the statements.

1. Genes are made of chromosomes.
2. A mutation is a permanent change in a gene.
3. The environment cannot affect an inherited trait.
4. Mutations are a source of variation.
5. All species on Earth are uniquely adapted to their environments.
6. Plants have adaptations for movement.

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Lesson 1

Inheritance and Traits

Reading Guide

Key Concepts

ESSENTIAL QUESTIONS

- What is inheritance?
- What is the role of genes in inheritance?
- How do environmental factors influence traits?
- How do mutations influence traits?

Vocabulary

trait
inheritance
gene
genotype
phenotype
mutation

Multilingual eGlossary

Video BrainPOP®

Inquiry Dyed Blue?

No; due to a genetic mutation, about 1 in 5 million lobsters are naturally blue. What is a mutation? How do you think mutations affect traits?

Launch Lab

10 minutes

What role does chance play in inheritance?

You probably look like your parents in many ways, but you are not identical to them. For instance, you might have blue eyes like our father, but brown hair like your mother. Inheriting traits is a matter of chance.

1. Obtain two **dice** of different colors. With a partner, roll the dice 10 times. Make a data table in your Science Journal to record the number of dots on each die for each roll.
2. Discuss with your partner how this activity might model reproduction. What do the colors represent? What do the dots represent?

Think About This

1. Did you get the same combination for any of your rolls?
2. What if each die had 12 faces, or 100 faces? How do you think these changes would affect your chances of getting the same combination?
3. **Key Concept** In what ways do you think rolling dice models how traits are inherited? What role does chance play in inheritance?

What is inheritance?

You probably resemble your parents or grandparents. If you have brothers or sisters, they probably resemble your parents and grandparents, too. You all might have some of the same characteristics, such as being tall or having brown eyes. *A distinguishing characteristic of an organism is a* **trait.** During reproduction, many traits are passed from one generation to the next. *The passing of traits from generation to generation is* **inheritance.** Inheritance is the reason offspring resemble their parents, their grandparents, and even their distant ancestors.

Every organism has a range of inherited traits. The parrot shown in **Figure 1** has green feathers, wings, and a hooked beak. All of these traits can be passed to its offspring.

Not all traits are inherited. If the parrot in **Figure 1** lost a claw in an accident, its offspring would not be born missing a claw. Similarly, the parrot's offspring would not be born knowing how to put a ball into a basket. Losing a claw and learning tricks are examples of acquired traits. An acquired trait is a trait that an organism acquires or develops during its lifetime.

Key Concept Check What is inheritance?

Figure 1 This bird's color, shape, and body structure are inherited traits. However, the trick it has learned—putting a ball in a basket—is an acquired trait.

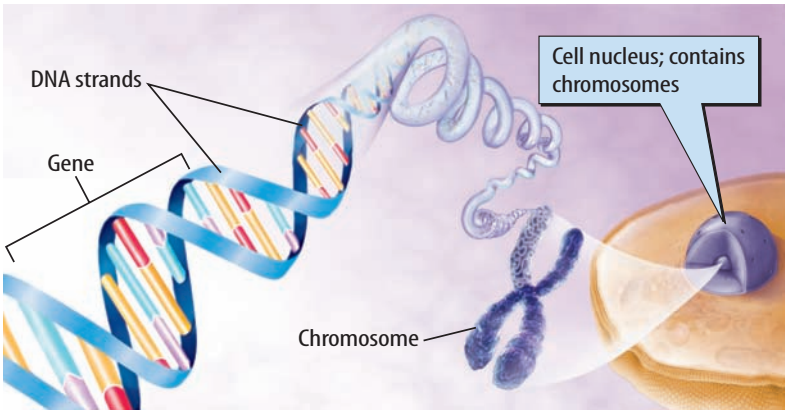


Figure 2 DNA is a molecule that contains genes. It is coiled inside a cell's nucleus and forms a chromosome. ▶

Concepts in Motion
Animation

Inheritance and DNA

Organisms pass inherited traits to their offspring in one of two ways, depending on whether they reproduce asexually or sexually. Some organisms, such as amoebas, bacteria, and some plants, pass traits to their offspring by cell division and mitosis. This process is called asexual reproduction. It produces offspring that are identical to the original organism. Many other organisms, including humans, reproduce sexually. This process produces offspring that are similar—but not identical—to the parent or parents.

DNA and Genes

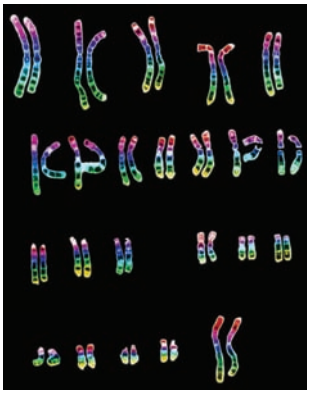
WORD ORIGIN
gene
from Greek *genea*, means "generation"

Sexual reproduction requires DNA from a sperm cell and an egg cell. DNA, shown in **Figure 2,** is a molecule inside a cell's nucleus that looks like a twisted zipper. Genes are distinct segments of DNA. *A* **gene** *is a section of DNA that has genetic information for one trait.* Genes carry this information in a unique sequence within DNA, much as words convey information by the unique sequence of their letters.

DNA is long. If you stretched out the DNA in one of your cells, it would be almost 2 m long. DNA fits into a cell's nucleus because it is tightly coiled with proteins to form chromosomes. A chromosome is a structure made of long chains of DNA.

Key Concept Check How are traits and genes related?

Figure 3 Each of your body cells contains 23 pairs of chromosomes. ▼



Color-enhanced LM Magnification: 2,000×

Chromosomes

The number of chromosomes in a cell differs depending on the species. In most species, chromosomes come in pairs. Humans have 23 pairs of chromosomes in each body cell, as shown in **Figure 3.** Each pair contains one chromosome from the father and one chromosome from the mother. Human reproductive cells—called sperm and eggs—each contain only 23 single chromosomes. Along each of these chromosomes lies hundreds or thousands of genes.

Meiosis

Concepts in Motion Animation

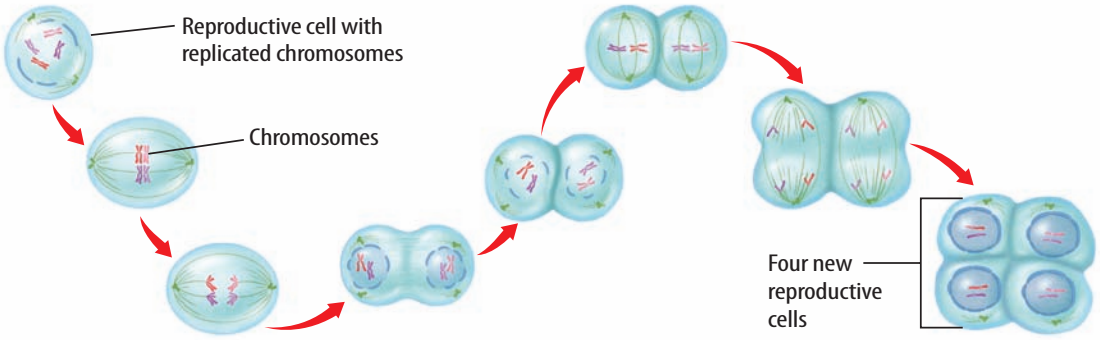


Figure 4 During meiosis, four new reproductive cells are formed, each with a single set of chromosomes.

Combining Genes

In sexual reproduction, an egg cell and a sperm cell each contribute one gene for a trait. Each gene for a single trait is called an allele (uh LEEL). How the alleles are sorted and combined into offspring during sexual reproduction is mostly a matter of chance.

Meiosis

Much of the randomness of sexual reproduction occurs during meiosis. Meiosis is the process during which sperm and egg cells form. During meiosis, the chromosomes in existing egg and sperm cells replicate and divide, as shown in **Figure 4.** Then they split into four separate cells, each with half the number of chromosomes—23 in human egg and sperm cells. Each sperm and egg cell contains a unique combination of genes on each chromosome.

Fertilization

During fertilization, a sperm and an egg unite. When this happens, the egg cell chromosomes and the sperm cell chromosomes combine to form an offspring with a full set of paired chromosomes. Because each sperm cell and egg cell is unique, the resulting offspring also is unique. In humans, there are many potential gene arrangements from the union of sperm and egg chromosomes. So many that if a mother and a father could have billions of offspring, each produced from a different fertilized egg, no two would be alike.

Reading Check Why is each sperm cell and egg cell produced by meiosis unique?

Math Skills

Use Probability

You can calculate the probability, or likelihood, of chromosome combinations using the formula 2^n where n = total number of chromosomes divided by 2. For example, fruit flies have 8 chromosomes. How many different combinations of chromosomes can be produced in the offspring?

1. Divide the number of chromosomes by 2.
$$\frac{8 \text{ chromosomes}}{2} = 4$$
2. Replace n in the formula with the answer to step 1 and calculate.
$$2^4 = 2 \times 2 \times 2 \times 2 = 16$$

Practice

The common housefly has 12 chromosomes. How many different chromosome combinations can form in the offspring?

Review
- Math Practice
- Personal Tutor

FOLDABLES®

Make a horizontal shutterfold book. Label it as shown. Use it to organize your notes on factors that influence traits.

Influencing Traits

An organism's complete set of genes is its **genotype** (JEE nuh tipe). Once inherited, this genotype remains unchanged. However, an organism's environment can influence traits expressed by the genotype. If a factor in the environment changes, the expression of a trait in an individual organism can be affected.

Phenotype and the Environment

Inherited traits are part of an organism's phenotype (FEE nuh tipe). *The* **phenotype** *of a trait is how the trait appears, or is expressed.* Phenotypes result from the interaction of an organism's genes and its environment. An organism's environment changes all the time. Light, temperature, moisture, nutrients, and social factors are not constant. These factors influence organisms in different ways. For example, because light is critical to plants, light levels have a strong effect on plant phenotype. Plants that grow tall in full sunlight might not grow as tall in low light.

Physical Factors There are many physical factors other than light that influence phenotype. For example, low levels of nutrients in soils, such as nitrogen or iron, might turn a plant's leaves yellow or cause them to fall off.

Nutrients can cause dramatic changes in the phenotype of some animals, too. The large honeybee shown in **Figure 5** has genes for the same traits as the smaller bees around it. But because it ate a special, nutrient-rich diet, it developed into the queen bee. Similarly, flamingos, also shown in **Figure 5,** are born white but turn pink because the food they eat, including algae and crustaceans, is rich in red pigment.

Figure 5 Phenotypes can change when the environment changes.

Visual Check How does diet affect the phenotype of flamingos?

The large bee in the middle—the queen—is larger because she ate a nutrient-rich diet.

Adult flamingos are pink because of their diet, but their offspring are born white.

Figure 6 When desert locusts are alone (solitary phase), they are green. When they are in a large group (social phase), their color changes to yellowish-brown, and they swarm.

Social Factors An organism's social group also can affect color, body structure, or behavior. Desert locusts usually are solitary insects, which means they live alone. But when these locusts are in a large group, they apply pressure on each other's legs. This causes them to change color and to swarm, as shown in **Figure 6.** Flamingos are another example of animals that are influenced by social factors. Through studies conducted in zoos, scientists have learned that the large social group in which flamingos live is important because it triggers breeding among them. A flock consisting of at least 20 flamingos is needed for breeding to occur in zoos. Studies have shown that adding more birds to the flock leads to increased breeding success. In the wild, flamingos live in flocks of up to 10,000 birds.

Key Concept Check What are some environmental factors that can influence phenotype?

Inquiry MiniLab

20 minutes

How can the environment affect phenotypes?

You may have noticed that the same plant species grows better in a shady part of a yard than in a sunny part. The data in the table to the right describe the growth of 50 seeds over a period of 10 days. The seeds were planted in two different areas and began to emerge from the soil on day 4.

1. On **graph paper,** graph the average plant height for each area. Use different **colored markers** for each area and include a key.
2. Make a similar graph of the average number of leaves for each area over the 10 days.

Plant Height and Leaf Number

	Average Plant Height (cm)		Average Number of Leaves	
Day	Area 1	Area 2	Area 1	Area 2
4	2.9	2.9	2	2
5	6.1	5.1	3.5	4
6	9.0	8.3	5.5	6
7	11.0	9.9	7	9
8	12.0	11.1	8	10.5
9	12.8	11.4	9.5	11
10	13.6	12	9.5	12.5

Analyze and Conclude

1. **Infer** Based on the data, what inference can you make about the two areas?
2. **Key Concept** What environmental factors might have caused the differences in the phenotypes?

Figure 7 The middle penguin has a genetic mutation that affects the color of its feathers.

Visual Check How was the phenotype of the middle penguin affected by a mutation?

Phenotype and Mutations

When an organism's phenotype changes in response to its environment, the organism's genes are not affected and the change cannot be passed on to the next generation. The only way that a trait can change so that it can be passed to the next generation is by mutation, or changing an organism's genes.

Random Changes *A* **mutation** *is a permanent change in the sequence of DNA in a gene.* It is an error in the DNA's arrangement in a gene. Have you ever made an error when you were typing or texting? For example, you might use one letter instead of another in a word. This could change the meaning of the word. Similarly, a mutation can change the trait for which the gene holds information.

Although all genes can mutate, only mutated genes in egg or sperm cells are inherited. Some mutations in egg or sperm cells occur if an organism is exposed to harsh chemicals or severe radiation. But most mutations occur randomly. The color of the lobster shown in the photo at the beginning of this lesson occurred as a result of a **random** mutation in an egg or a sperm cell. The feather color of the penguin in the middle of **Figure 7** also is the result of a mutation.

Key Concept Check How can a mutation influence a trait?

Effects of Mutations Many mutations have no effect on an organism. They neither help nor hurt it. But some mutations change an organism's genes—and its traits—so much that they can affect an organism's ability to survive in its environment. Some mutations are harmful to an organism, but other mutations might help it survive. In Lesson 2, you will read how mutations that benefit an organism can spread to an entire **population.**

ACADEMIC VOCABULARY

random
(adjective) without a definite aim, rule, or method

SCIENCE USE V. COMMON USE

population
Science Use all the members of a species living in a given area

Common Use the number of people living in a country or other defined area

Lesson 1 Review

Assessment Online Quiz

Visual Summary

Traits are either inherited or acquired. Inherited traits are passed from one generation to the next.

An organism's phenotype can be influenced by factors in the environment, such as light, nutrients, or social interactions.

One result of a mutation could be a change in appearance, such as a change in feather color.

FOLDABLES®

Use your lesson Foldable to review the lesson. Save your Foldable for the project at the end of the chapter.

What do you think NOW?

You first read the statements below at the beginning of the chapter.

1. Genes are made of chromosomes.
2. A mutation is a permanent change in a gene.
3. The environment cannot affect an inherited trait.

Did you change your mind about whether you agree or disagree with the statements? Rewrite any false statements to make them true.

Use Vocabulary

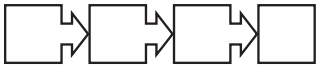
1. A distinguishing characteristic of an organism is a(n) _____.
2. A permanent change in the sequence of DNA in a gene is a(n) _____.
3. **Distinguish** between phenotype and genotype.

Understand Key Concepts

4. Which is an inherited trait?
   - **A.** learning to sing
   - **B.** losing a claw
   - **C.** having a hooked beak
   - **D.** learning a new trick
5. **Design an experiment** to determine the environmental factors that cause adult flamingos to turn pink.
6. **Compare and contrast** sexual reproduction and asexual reproduction.

Interpret Graphics

7. **Organize Information** Copy the graphic organizer below and use it to list *gene, chromosome, cell,* and *DNA* from smallest to largest.



Critical Thinking

8. **Propose** an explanation for why this wallaby lacks normal coloration in its fur.

Math Skills

Review Math Practice

9. The common hamster has 20 chromosomes. How many different types of hamster offspring could form?

SCIENCE & SOCIETY

Down the Drain

Flushing Chemicals into Fish Habitats

Anytime you flush a toilet or run a faucet, you produce wastewater. When chemicals are added to wastewater, they sometimes can end up in lakes and rivers, threatening wildlife. In recent years, scientists have discovered that when the chemical estrogen is in wastewater, it harms wild fish populations.

Estrogen is a chemical responsible for sexual development and reproduction in female vertebrates. It is produced naturally in the body, but it also is in medications that many women take. Like other chemicals in drugs, estrogen is released in urine and ends up in wastewater.

If even a small amount of estrogen gets into waterways, it can have a huge impact on local fish. The chemical disrupts the organs that enable them to reproduce. Most fish are not born male or female. Instead, physical factors in the environment, such as temperature and diet, determine which sex organs they develop. In a healthy habitat, some fish produce eggs and others produce the sperm to fertilize eggs. However, increased levels of estrogen in the water can affect the expression of traits in fish. Data collected in the field and in the laboratory show that estrogen affects how fish develop. When exposed to estrogen, males produce fewer or no sperm and some even produce eggs. Many females stop producing eggs. Without healthy males and females to reproduce, these fish populations drop.

Lake Experiment

To understand estrogen's effects on wild fish, scientists released small amounts of the chemical into a lake in Ontario, Canada. They observed drastic changes in the fathead minnows that had been thriving in the lake. The females produced fewer eggs. The males produced fewer sperm or began to develop eggs. After 3 years, the minnow population had nearly disappeared. Once scientists stopped adding estrogen, the fish population began to recover.

It's Your Turn

RESEARCH With a partner, research how pesticides and other chemicals are affecting the expression of traits in frogs. Include the name of the chemical, how it is used, and how it affects the frogs. Report your findings to the class.

Lesson 2

Adaptations in Species

Reading Guide

Key Concepts

ESSENTIAL QUESTIONS

- How do mutations cause variations?
- How does natural selection lead to adaptations in species?
- What are some ways adaptations help species survive in their environments?

Vocabulary

variation
adaptation
natural selection
selective breeding
camouflage
mimicry

Multilingual eGlossary

Video

- Science Video
- What's Science Got to do With It?

Inquiry Why Blend In?

This snake, called an eyelash viper, blends in well with its environment. How does this adaptation help the snake survive? What are some other adaptations that help organisms survive?

Launch Lab

15 minutes

How alike are members of a population?

It is easy to see the differences among people, but what about plants or animals? Are all robins alike? What about sunflower seeds?

1. Read and complete a lab safety form.
2. Place 10 **sunflower seeds** on a **paper towel.** Number the seeds 1–10 by writing on the paper towel below each seed.
3. Use a **magnifying lens** to examine the seeds, focusing on how their coloration is alike and/or different. Record your observations in your Science Journal.
4. Copy the table on the right in your Science Journal. Perform the following steps and record your observations.
   - Use a **metric ruler** to measure the length of each seed.
   - Measure the thickness of each seed at its thickest point.
5. Compare the length and thickness of your 10 seeds with those of other teams.

Seed Variations

Seed	Length (mm)	Thickness (mm)
1		
2		
3		
4		
5		
6		
7		
8		
9		
10		

Think About This

1. Do all sunflower seeds have the same length and thickness? Why do you think the seeds differed in so many ways?
2. **Key Concept** If you were a bird, do you think you would be more or less attracted to any of the seeds? How might this affect the reproduction of the sunflowers?

What is adaptation?

Figure 8 Giraffes have variations in the patterns of their spots depending on the genes they inherit.

In all species that reproduce sexually, offspring are different from their parents. The giraffes in **Figure 8** are members of the same species, yet each one has a slightly different pattern of spots on its coat. *Slight differences in inherited traits among individual members of a species are* **variations.**

Variations occur through mutations. A mutation might harm an organism's chances of survival. However, many mutations, such as those that cause the unique pattern of spots on a giraffe, cause no harm. Still other mutations can benefit an organism. They produce traits that help an organism survive.

The giraffes in **Figure 8** have different spot patterns, but each has spots. The spots help the giraffes blend in with their environment—the grasslands of Africa. As a result, predators of giraffes, such as lions and hyenas, cannot see them as easily. The spotted coat of giraffes is an adaptation. *An* **adaptation** *is an inherited trait that helps a species survive in its environment.*

Key Concept Check How are mutations related to variations?

How Adaptations Occur

Giraffe spots were probably the result of a mutation that occurred in an individual giraffe many generations ago. The mutation produced a variation that helped the giraffe survive. Eventually, the mutated gene became part of the giraffe population genotype. How did this happen? How can a variation in a single individual become common to an entire population?

Natural Selection

Natural selection *is the process by which organisms with variations that help them survive in their environment live longer, compete better, and reproduce more than those that do not have the variation.* If a variation helps an organism survive or compete better in its environment, the organism with that variation lives longer. Because it lives longer, it has more offspring that also can have the variation. Over many generations, more and more offspring inherit the variation. Eventually, most of the population has the variation, and it becomes an adaptation, as shown in **Figure 9.**

Because mutations are random and occur continually, so do new variations. The variations that become adaptations depend on the environment. Over time, all environments change. Huge volcanic eruptions can change a climate rapidly. The movement of continents causes slow, gradual changes. When an environment changes, a population either adapts through natural selection or dies off. The repeated elimination of populations can lead to the extinction of a **species.**

Key Concept Check How does a variation become an adaptation?

Word Origin

adaptation
from Latin *adaptare*, means "to adjust"

Review Vocabulary

species
a group of organisms that share similar characteristics and can reproduce among themselves, producing fertile offspring

Review Personal Tutor

Figure 9 Through natural selection, a color variation in one or a few beetles can be inherited by many other beetles to become an adaptation.

❶ **Variation in Traits** In this population of beetles, some are yellow and some are brown. The color does not affect the ability of the beetles to survive in their environment.

❷ **Organisms Compete** A new predator eats yellow beetles more often because it sees the yellow beetles more easily than the brown beetles.

❸ **Traits are Inherited** The yellow beetles do not live as long as the brown beetles, and—since color is inherited—fewer yellow beetles hatch.

❹ **Adaptation over Time** Nearly all individuals in a population are brown. The color brown has become an adaptation that helps the beetles avoid predators in that environment.

Figure 10 The frizzle chicken is the result of breeding birds with a mutation—outward-curling feathers.

Selective Breeding

Watching natural selection in action is like watching mountains grow taller. It occurs over so many generations that it usually cannot be seen. It is easier to observe a type of selection practiced by humans. When humans breed organisms for food or for use as pets, they are selecting variations that occur naturally in populations. *The selection and breeding of organisms with desired traits is* **selective breeding.** Selective breeding is similar to natural selection except that humans, instead of nature, do the selecting. By breeding organisms with desired traits, humans change traits just as natural selection does. Cows with increased levels of milk production, dogs of different sizes, and roses of unique colors are products of selective breeding. So is the chicken shown in **Figure 10.**

Reading Check How is selective breeding different from natural selection?

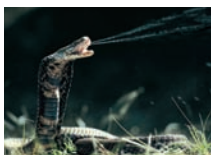
Types of Adaptations

Through natural selection or selective breeding, all species on Earth are uniquely adapted to their environments. Chickens are adapted to life in a henhouse just as giraffes are adapted to life in the grasslands. Adaptations enable species to maintain homeostasis, avoid predators, find and eat food, and move. There are three main categories of adaptations: structural, behavioral, and functional. Examples of each are shown in **Table 1.**

Table 1 Types of adaptations include structural, behavioral, and functional.

Visual Check What are some examples of behavioral adaptations?

Table 1 Types of Adaptations

Type of Adaptation	Description	Example
Structural	a physical trait, such as color, shape, or internal structure, that increases survival	The color and shape of this insect's eyes are structural adaptations. 
Behavioral	a behavior or action, such as migration, hibernation, hunting at night, or playing dead, that increases survival	This snake is playing dead, a behavioral adaptation to fool predators. 
Functional	a biochemical change, such as hibernating, shedding, or spitting, that enables a species to increase survival or maintain homeostasis	Spraying venom, as this cobra is doing, is a functional adaptation. 

Maintaining Homeostasis

The ability of an organism to keep its internal conditions within certain limits is homeostasis. Sweating on a hot day is an adaptation that helps you maintain your internal body temperature when external temperatures increase. All species have adaptations that help them survive temporary changes in their environments. Species also have adaptations specific to their environments. Plants living in deserts store water in their leaves. Fish in the ocean have gills that remove oxygen from water.

Protection from Predators

Species also have adaptations that protect them from predators. For example, sharp quills protect porcupines. Sometimes, through natural selection, variations are selected that make an organism resemble something else. **Camouflage** (KAM uh flahj) *is an adaptation that enables a species to blend in with its environment.* The stonefish in **Figure 11** resembles a rock. This makes it less visible to predators. **Mimicry** (MIH mih kree) *is an adaptation in which one species looks like another species.* The scarlet kingsnake is a nonpoisonous snake that looks like, or mimics, the poisonous coral snake. Predators often avoid the kingsnake because they cannot tell the two snakes apart.

Key Concept Check Give an example of how adaptations help species survive.

Figure 11 Can you see the fish? The stonefish is well-camouflaged in its environment.

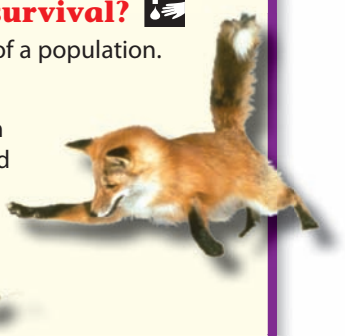
Inquiry MiniLab

20 minutes

How do species' adaptations affect one another's survival?

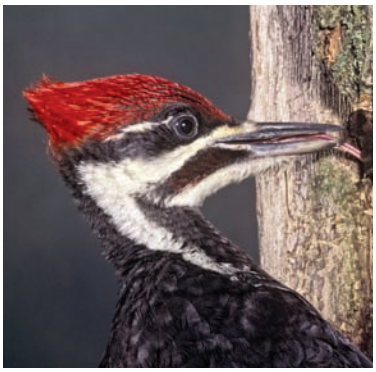
In a predator-prey relationship, adaptations can greatly affect the survival of a population.

1. Read and complete a lab safety form.
2. Obtain a **bag with cards** according to your assigned group. Each card in your bag represents the speed of one individual in your population. Find and record the average speed of the ten individuals in your population.
3. Shuffle your cards and place them face down between your team and the opposing team (predator v. prey).
4. At the same time, each team turns over the top card. The team with the faster speed on its card places its card face-up in a separate pile, representing surviving individuals. The slower team places their card face-down in a separate pile. In case of a tie, flip a **coin.** Continue playing through ten rounds.
5. Count your surviving individuals, and calculate the new average speed of the survivors.



Analyze and Conclude

1. **Draw Conclusions** Based on your results, how did natural selection affect your population?
2. **Key Concept** How would the survival of either population be affected if one population developed a large adaptive advantage over the other? Explain your answer.



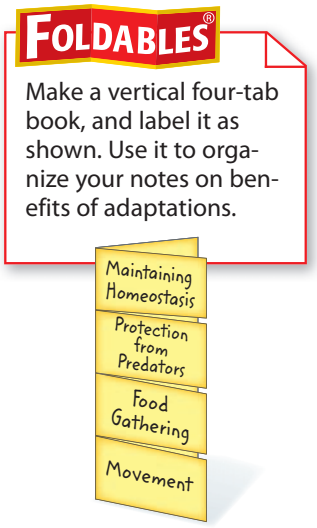
Woodpeckers use their long, thin beaks to search for insects in tree bark.

Parrots have strong beaks that help them crack nuts and seeds.

The condor uses its long, powerful beak to tear the flesh from dead organisms.

Figure 12 Though all birds have wings, beaks, and feathers, each species is adapted to a different environment. Each uses its beak in a different way to gather food.

Visual Check How is a condor's beak adapted for the food it eats?



Food Gathering

As you have just read, camouflage and mimicry protect species from predators. These same adaptations also can help species find food. The camouflaged stonefish in **Figure 11** is hidden not only from predators, but also from its prey. Many other kinds of adaptations help species gather and eat food. An anteater has a long nose and a long tongue for gathering ants. Each of the birds shown in **Figure 12** has a beak that helps it gather a different type of food. Some plants also have adaptations that enable them to store food. Potatoes, onions, and tulips all have modified underground stems that store food for the plants.

As predators develop adaptations for hunting their prey, the species they hunt develop adaptations for avoiding them. A cheetah is a fast runner. But so are the gazelles it chases as prey. Over time, cheetahs might become even faster due to chance variations and natural selection. But faster gazelles also might arise from the same process. In this way, species adapt to each other.

Movement

Cheetahs and gazelles have long, powerful legs adapted to running fast. Legs, wings, flippers, fins, and even tails are adaptations that help species move. Movement helps species search for food, avoid predators, and escape unpleasant stimuli. Even plants have adaptations for movement. Their leaves turn to face the Sun as it moves across the sky.

Lesson 2 Review

Assessment Online Quiz
Inquiry Virtual Lab

Visual Summary

Variations in populations occur because of mutations. Variations can lead to adaptations.

Through natural selection, a variation that helps organisms survive and reproduce eventually is inherited by most members of the population.

Adaptations may be structural, behavioral, or functional. Structural adaptations help organisms blend in with their environments.

FOLDABLES®

Use your lesson Foldable to review the lesson. Save your Foldable for the project at the end of the chapter.

What do you think NOW?

You first read the statements below at the beginning of the chapter.

4. Mutations are a source of variation.

5. All species on Earth are uniquely adapted to their environments.

6. Plants have adaptations for movement.

Did you change your mind about whether you agree or disagree with the statements? Rewrite any false statements to make them true.

Use Vocabulary

1. Slight differences in inherited traits are _____.
2. **Describe** natural selection in your own words.
3. **Distinguish** between mimicry and camouflage.

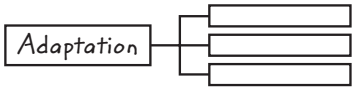
Understand Key Concepts

4. A nonpoisonous butterfly has coloration and markings similar to a poisonous butterfly. This an example of
   A. camouflage. **C.** behavioral adaptation.
   B. mimicry. **D.** functional adaptation.
5. **Compare and contrast** natural selection and selective breeding.
6. **Explain** how two species might trigger adaptive changes in each other.

Interpret Graphics

7. **Identify** the type of adaptation the insect at right exhibits, and explain how the insect might benefit from the adaptation.

8. **Organize Information** Copy the graphic organizer below. Use it to list three ways that an organism you choose is adapted to its environment. Classify each adaptation as structural, behavioral, or functional.



Critical Thinking

9. **Evaluate** the role of the environment in natural selection.
10. **Assess** the role of mutations in adaptations.

inquiry **Lab** 40 minutes

Model Natural Selection

The interaction between predators and their prey is a driving force for natural selection. There are many other forces in nature, such as changes in environment, that act on natural selection. However, predation provides a good model to explore how natural selection works.

Materials


paper bag


marker


red beans, white beans, and black beans

Safety

⚠ Do not taste or eat any material used in the lab.

Ask a Question

What happens to a population when a mutation occurs in an individual that helps it survive in its environment?

Make Observations

1. Read and complete a lab safety form.
2. Obtain a paper bag and write *Rabbit Gene Pool* on the front of the bag.
3. Place 10 red beans and 10 white beans in the bag.
4. Make a table like the one below in your Science Journal. Use the table to record the genotype and the phenotype of individuals in each generation of the population. Assume that a pair of beans is the genotype of an individual rabbit. The phenotype of a pair of red beans is brown fur. The phenotype of a red bean and a white bean is gray fur, and the phenotype of a pair of white beans is white fur.
5. Without looking in the bag, take out two beans to represent an offspring. Record the colors in your table. Continue taking beans out of the bag two at a time and recording the results for the first generation of rabbits. Determine and record the phenotype of each rabbit.
6. To model selection, predators eat 100 percent of the white rabbits, which do not blend in well with the environment, 50 percent of the gray rabbits, and 25 percent of the brown rabbits. In the case of an odd number of individuals, flip a coin to determine whether an individual will survive.
7. After you have eliminated the correct number of individuals, place two offspring per surviving individual in the bag, along with the surviving parent. In this activity, each offspring should have the same genotype as its parent.
8. Repeat steps 4–7. Then repeat steps 4–6 again.

Rabbit Population—Generation 1

Rabbit #	1st Bean Color	2nd Bean Color	Phenotype
1			
2			
3			
4			
5			

Form a Hypothesis

9 Review the data you have collected so far. Suppose one of the gray rabbits from the third generation had a mutation on one of its genes, and its fur is multicolored. A multicolored rabbit blends in well with its environment, and predators eat 0 percent of the multicolored rabbits in successive generations. Formulate a hypothesis that explains how the population will change over the next three generations of rabbits.

Test Your Hypothesis

10 Determine which rabbits in the third generation will survive predation. Choose a gray rabbit. Replace the red bean in its genotype with a black bean. This represents the multicolored rabbit.

11 Continue step 7 with the third generation by placing two offspring per surviving individual in the bag, along with the surviving parent. Each offspring should have the same genotype as its parent.

12 Repeat steps 4–7 three more times, using these new rules for eliminating rabbits: predators eat 100 percent of the white rabbits, 60 percent of the gray rabbits, 35 percent of the brown rabbits, and 0 percent of the multicolored rabbits. Assume that the multicolored gene is dominant over the other colors. End the model with six generations of rabbits.

Analyze and Conclude

13 **Analyze** How did the rabbit population change during the first three generations of rabbits?

14 **Analyze** How did the rabbit population change after the mutation occurred and multicolored fur became a phenotype? Was your hypothesis correct? Why or why not?

15 **Draw Conclusions** What explains the changes to the rabbit population over the six generations you tested?

5

16 **Describe** how this model is similar to and different from the way that natural selection occurs in nature.

17 **The Big Idea** Predict what the population of rabbits would be like after ten generations, assuming conditions remain the same as they are in step 12.

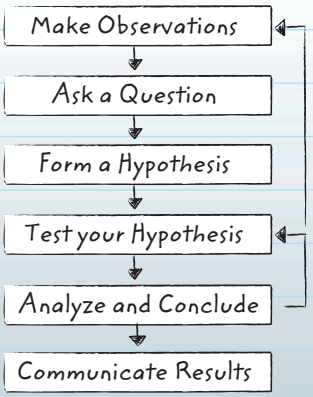
Communicate Your Results

Compare your results with those of other groups. Did any groups have results that were significantly different than yours? Why or why not?

Inquiry Extension

Design your own model to mimic natural selection.

Remember to use scientific methods.



Chapter 20 Study Guide

Inherited mutations can lead to variations, which can become adaptations through natural selection over many generations.

Key Concepts Summary

Lesson 1: Inheritance and Traits

- The passing of **traits** from generation to generation is **inheritance.**
- Information about traits is passed from parents to offspring on **genes.**
- An organism's **phenotype** can be influenced by environmental factors, such as temperature, nutrients, and social interaction.
- Only traits affected by **mutation** can be passed to offspring.

Lesson 2: Adaptations in Species

- **Variations** arise when mutations cause changes in the sequence of an organism's DNA.
- **Natural selection** explains how variations that help organisms survive are passed to offspring and eventually become **adaptations.**
- Adaptations help species maintain homeostasis, protect themselves from predators, gather food, and move.

Vocabulary

trait
inheritance
gene
genotype
phenotype
mutation

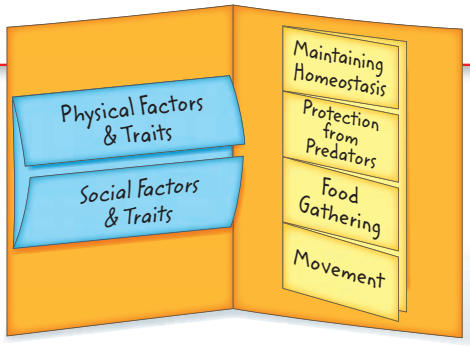
variation
adaptation
natural selection
selective breeding
camouflage
mimicry

Study Guide

Review
- Personal Tutor
- Vocabulary eGames
- Vocabulary eFlashcards

FOLDABLES® Chapter Project

Assemble your lesson Foldables as shown to make a Chapter Project. Use the project to review what you have learned in this chapter.



Use Vocabulary

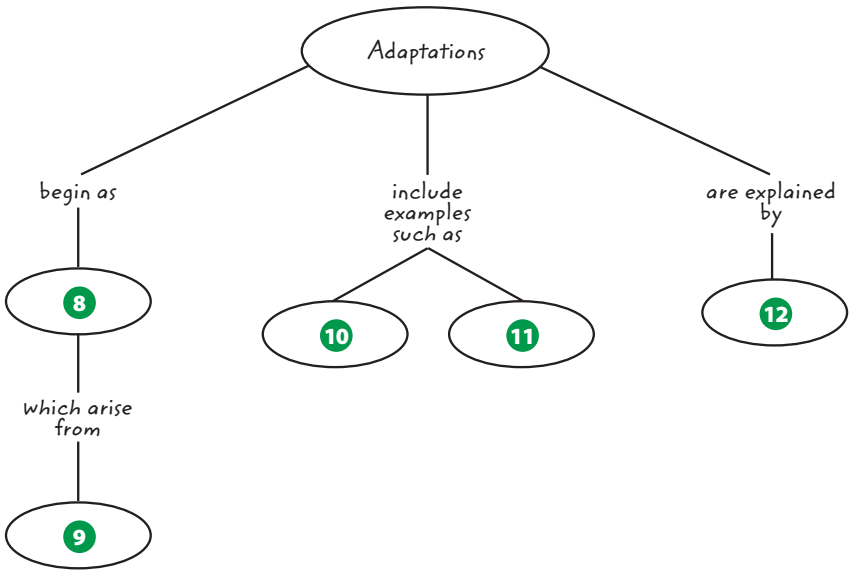
Choose the vocabulary term that best matches the descriptions below.

1. slight differences in inherited traits
2. a distinguishing characteristic of an organism
3. all of an organism's genes
4. how a trait appears, or is expressed
5. adaptation that helps an organism blend in with its surroundings
6. the human practice of breeding organisms with desired characteristics
7. resembling another species

Link Vocabulary and Key Concepts

Concepts in Motion Interactive Concept Map

Copy this concept map, and then use vocabulary terms from the previous page to complete the concept map.



Chapter 20 Review

Understand Key Concepts

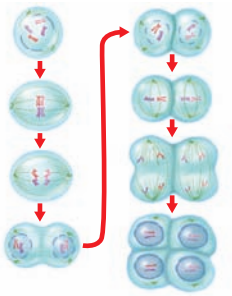
1. In which way does asexual reproduction differ from sexual reproduction?
   - A. Genes are not involved in asexual reproduction.
   - B. No traits are passed to offspring in asexual reproduction.
   - C. Offspring are identical to the parent in asexual reproduction.
   - D. There are no mutations in asexual reproduction.

2. Which is a source of variations?
   - A. adaptations
   - B. mutations
   - C. phenotype
   - D. traits

3. Which is the sequence by which natural selection works?
   - A. selection → adaptation → variation
   - B. selection → variation → adaptation
   - C. variation → adaptation → selection
   - D. variation → selection → adaptation

4. Which adaptation is functional?
   - A. a lizard playing dead
   - B. a monkey swinging by its tail
   - C. a skunk spraying a predator
   - D. a wolf hunting in a pack

5. Which process is illustrated below?



   - A. meiosis
   - B. mutation
   - C. asexual reproduction
   - D. natural selection

6. Which trait cannot be inherited?
   - A. scars
   - B. shyness
   - C. big feet
   - D. red hair

7. The photo below is a leaf butterfly. Which explains how the butterfly came to resemble a leaf?

   - A. The butterfly's shape is the result of an exchange of genes with plants over many generations.
   - B. The butterfly's shape is the result of the environment causing mutations over many generations.
   - C. The butterfly's shape is the result of the environment influencing its phenotype over many generations.
   - D. The butterfly's shape is the result of the environment selecting variations over many generations.

8. Giraffes range in color from orange to yellow. Which explains these color differences?
   - A. adaptations
   - B. variations
   - C. natural selection
   - D. selective breeding

Chapter Review

Assessment
Online Test Practice

Critical Thinking

9 **Design** an organism adapted to a murky lake with many plants. The organism's major predator is a large fish that swims slowly.

10 **Assess** how mutations can be beneficial.

11 **Differentiate** among mutation, variation, and adaptation, and explain how they are related to one another.

12 **Classify** the following adaptations as structural, behavioral, or functional: robins migrating, llamas spitting, bats hibernating, a beetle's color, wolves hunting in packs.

13 **Predict** what might happen to a species of ground plants over many generations when leaf-eating tortoises move into its range.

14 **Design an experiment** to test whether a trait in an animal is inherited or the result of an environmental factor.

15 **Interpret Graphics** The seal on the left has normal coloration. The seal on the right does not. What could explain why the seal on the right has abnormal coloration?

Writing in Science

16 **Write** Scientists have determined that all dogs were bred from wolves. Think about how wolves might have become tame enough to be pets. Then write a paragraph explaining how dogs became so different over time. Include a main idea, supporting details, and a concluding sentence.

REVIEW THE BIG IDEA

17 Adaptations help species survive in their environments. Choose two species that live near you, and list at least three ways—one structural, one behavioral, and one functional—that each is adapted to its environment. Explain how each adaptation helps the species survive.

18 In what ways does the juvenile mountain goat look like its mother? In what ways might the offspring be different from its mother? Explain how differences in individual mountain goats could help the species survive if its environment suddenly changed.

Math Skills

Review
Math Practice

Use Probability

19 A dandelion has 24 chromosomes. How many possible combinations of chromosomes can form in the offspring?

20 A human has 46 chromosomes. How many different combinations of chromosomes can be produced during reproduction?

21 A radish has 18 chromosomes. How many possible combinations can the chromosomes make during reproduction?

Standardized Test Practice

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

Multiple Choice

1 Two black dogs produce a litter of black puppies. This is an example of

A camouflage.
B chromosomes.
C inheritance.
D mimicry.

Use the image below to answer question 2.

2 The sunflower plants shown are the same species. The differences in height among the plants is an example of

A adaptation.
B fertilization.
C population.
D variation.

3 Which explains how variations arise within a population of organisms?

A asexual reproduction
B behavioral adaptation
C natural selection
D random mutation

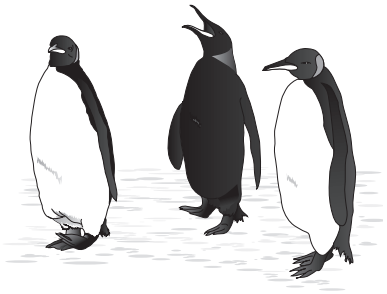
4 Which carry information about traits from parent to offspring?

A genes
B meiosis
C mutations
D variations

5 Which results from the interaction of genes and environment?

A genotype
B phenotype
C chromosome number
D sequence of DNA

Use the image below to answer question 6.



6 Feather color is an inherited trait in penguins. What most likely caused the differences shown?

A change in environment
B DNA sequence error
C physical factor
D social factor

7 Which statement about mutations is NOT true?

A Genes in any cell type can mutate.
B Most mutations are harmful.
C Most mutations occur randomly.
D Some mutations help organisms survive.

Standardized Test Practice

Assessment
Online Standardized Test Practice

8 The giraffe's long neck helps this species reach food that animals with short necks cannot reach. What type of adaptation is the long neck?

A behavioral adaptation
B biochemical adaptation
C functional adaptation
D structural adaptation

Use the diagram below to answer question 9.

9 The plant shown above is responding to light in its environment. This is an example of

A an adaptation.
B a population.
C selection.
D variation.

10 Which describes a mutation?

A a change in a gene's DNA sequence
B a trait that helps a species survive
C a change due to an environmental factor
D a distinguishing inherited characteristic

Constructed Response

Use the figure to answer questions 11 and 12.

11 Use the images to explain the process of natural selection. In your answer, briefly explain what happens in each step.

12 Classify the adaptation shown above as structural, behavioral, or functional. Briefly explain your reasoning.

13 Predators avoid the scarlet king snake because it looks like the coral snake. Is this similarity in coloring an example of camouflage or mimicry? Explain your reasoning.

14 Give an example of an adaptation that helps a species maintain homeostasis. In your response, briefly explain the environmental conditions that select for the adaptation.

NEED EXTRA HELP?														
If You Missed Question...	1	2	3	4	5	6	7	8	9	10	11	12	13	14
Go to Lesson...	1	2	2	1	1	1	1	2	2	1	2	2	2	2