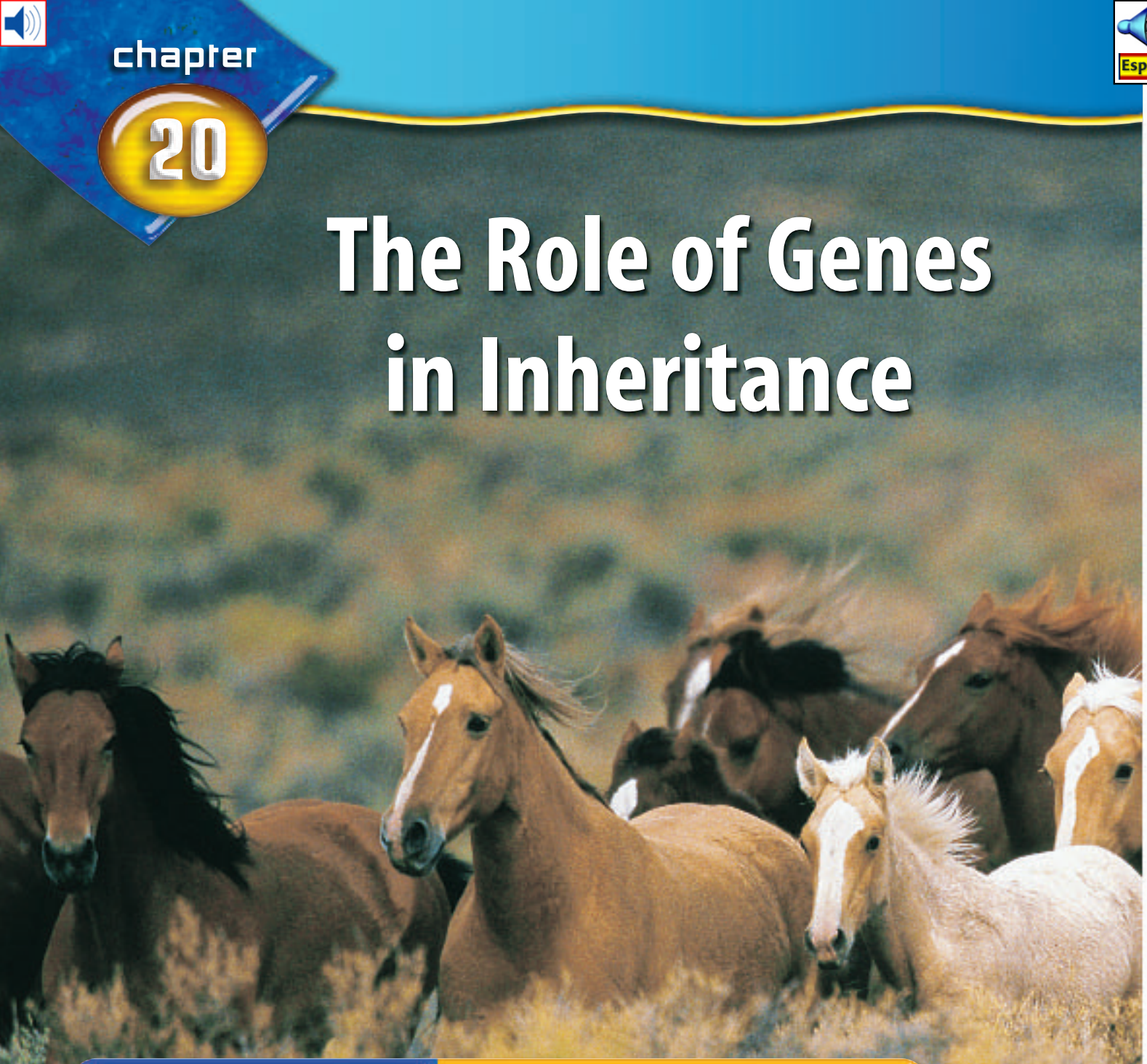
chapter 20

The Role of Genes in Inheritance



chapter preview

sections

Why do these horses look different from each other?

All living things obtain different characteristics from their parents. Knowing how organisms reproduce and what determines traits will help you understand why all horses in a herd of wild mustangs do not look exactly alike.

Science Journal Write three traits of horses that you could trace from parents to offspring.

Inga Spence/Tom Stack & Assoc.

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Start-Up Activities

Launch LAB

Why are seeds formed?

When you peel a banana or bite into an apple, you're probably only thinking about the taste and sweet smell of the fruit. You usually don't think about how the fruit was formed. Oranges, and most of the fruits you eat, contain seeds. Making seeds is one way that reproduction is carried out by living things. For life to continue, all living things must pass characteristics to their offspring.

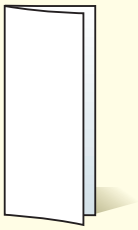
WARNING: *Do not eat the orange.*

1. Obtain half of an orange from your teacher. Peel the orange and remove all of the seeds.
2. Examine, count, and measure the length of each seed. Record these data in your Science Journal.
3. When you finish, dispose of your orange half as instructed by your teacher. Wash your hands.
4. **Think Critically** Write a paragraph in your Science Journal describing why you think the seeds are different from one another.

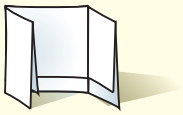
FOLDABLES™ Study Organizer

Inheritance Make the following Foldable to help identify what you already know, what you want to know, and what you learned about the role of genes in inheritance.

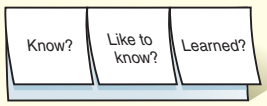
STEP 1 **Fold** a vertical sheet of paper from side to side. Make the front edge about 1.25 cm shorter than the back edge.



STEP 2 **Turn** lengthwise and **fold** into thirds.



STEP 3 **Unfold and cut** only the top layer along both folds to make three tabs. **Label** each tab as shown.



Identify Questions Before you read the chapter, write what you already know about the role of genes in inheritance under the left tab of your Foldable, and write questions about what you'd like to know under the center tab. After you read the chapter, list what you learned under the right tab.

ScienceOnline Preview this chapter's content and activities at red.msscience.com

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section 1

Continuing Life

as you read

What You'll Learn

- **Describe** how cells divide.
- **Identify** the importance of reproduction for living things.
- **Compare and contrast** sexual and asexual reproduction.
- **Describe** the structure and function of DNA.

Why It's Important

All living things, including you, inherit characteristics from their parents.

Review Vocabulary

chromosome: structure in a cell's nucleus that contains genetic material

New Vocabulary

- DNA
- mitosis
- asexual reproduction
- cloning
- sexual reproduction
- sex cell
- meiosis
- fertilization

Reproduction

If you look carefully in a pond in the spring, you may see frog or toad eggs. Frogs reproduce by laying hundreds of eggs in gooey clumps. Tadpoles can hatch from these eggs and mature into adult frogs, as shown in **Figure 1.** Some other kinds of organisms, including humans, usually produce only one offspring at a time. How do frogs and all of the other living things on Earth produce offspring that are similar to themselves?

The Importance of Reproduction Organisms produce offspring through the process of reproduction. Reproduction is important to all living things. Without reproduction, species could not continue. Hereditary material is passed from parent to offspring during reproduction. This material is found inside cells. It is made up of the chemical deoxyribonucleic (dee AHK sih ri boh noo klay ihk) acid, called DNA. **DNA** controls how offspring will look and how they will function by controlling what proteins each cell will produce. The DNA that all living things pass on determines many of their offspring's characteristics. Although organisms reproduce in different ways, reproduction always involves the transfer of hereditary information.

Figure 1 When frogs reproduce, they continue their species.

Adult frogs reproduce by laying and then fertilizing eggs.

These frog eggs can hatch into tadpoles.

These tadpoles can develop into adult frogs.

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Life's Code You've probably seen or heard about science fiction movies in which DNA is used to grow prehistoric animals. What makes up DNA? How does it work?

DNA is found in all cells in structures called chromosomes. All of the information that is in your DNA is called your genetic information. You can think of DNA as a genetic blueprint that contains all of the instructions for making an organism what it is. Your DNA controls the texture of your hair, the shape of your ears, your blood type, and even how you digest the food you had for lunch.

If you could look at DNA in detail, you would see that it is shaped like a twisted ladder. This structure, shown in **Figure 2,** is the key to how DNA works. The two sides of the ladder form the backbone of the DNA molecule. The sides support the rungs of the ladder. It is the rungs that hold all the genetic information. Each rung of the ladder is made up of a pair of chemicals called bases. There are only four bases in DNA, and they pair up very specifically. A DNA ladder has billions of rungs, and the bases are arranged in thousands of different orders. The secret of DNA has to do with the order or sequence of bases along the DNA ladder. The sequence forms a code. From this DNA code the cell gets instructions about what substances to make, how to make them, and when to make them.

Figure 2 The sequence of bases that are the rungs of the DNA molecule forms a code. This code contains the instructions for all of your body's characteristics and processes.
Identify *how many different bases make up DNA.*

Topic: Human Genome Project

Visit red.msscience.com for Web links to information about the Human Genome Project.

Activity List three genetic disorders and explain how the Human Genome project may help researchers who study these disorders.

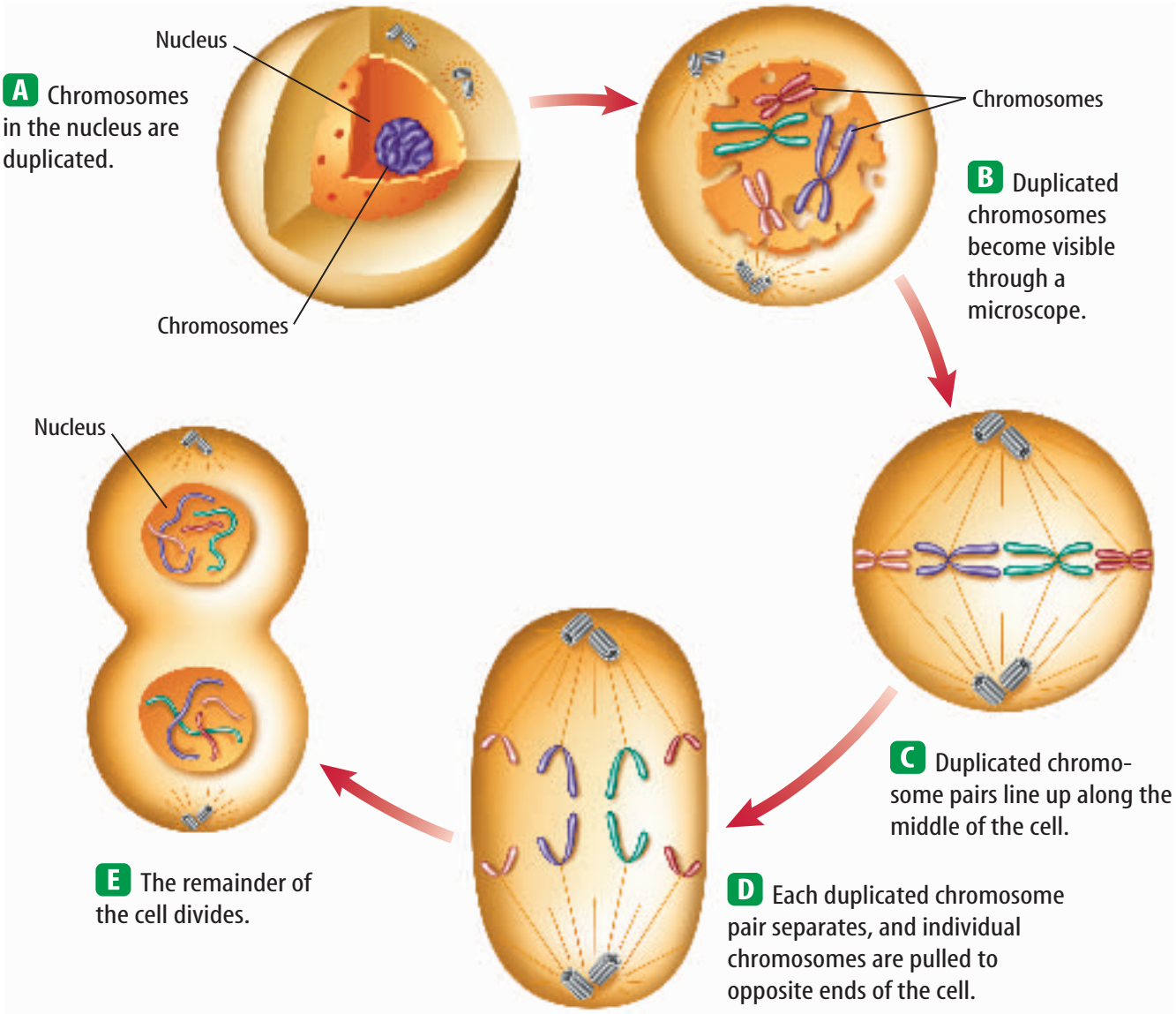


Figure 3 During cell division, cells go through several steps to produce two cells with identical nuclei.
Infer *what cell types undergo mitosis.*

Cell Division

How did you become the size you are now? The cells of your body are formed by cell division. Cell division has two big steps. First, DNA in the nucleus is copied. Then the nucleus divides into two identical nuclei. Each new nucleus receives a copy of the DNA. Division of the nucleus is called **mitosis** (mi TOH sus). Mitosis is the process that results in two nuclei, each with the same genetic information. You can follow the process of mitosis in **Figure 3.** After mitosis has taken place, the rest of the cell divides into two cells of about equal size. Almost all the cells in any plant or animal undergo mitosis. Whether it occurs in a plant or an animal, cell division results in growth and replaces aging, missing, or injured cells.

Reading Check ***During cell division, why must the DNA be duplicated before the nucleus divides?***

Reproduction by One Organism

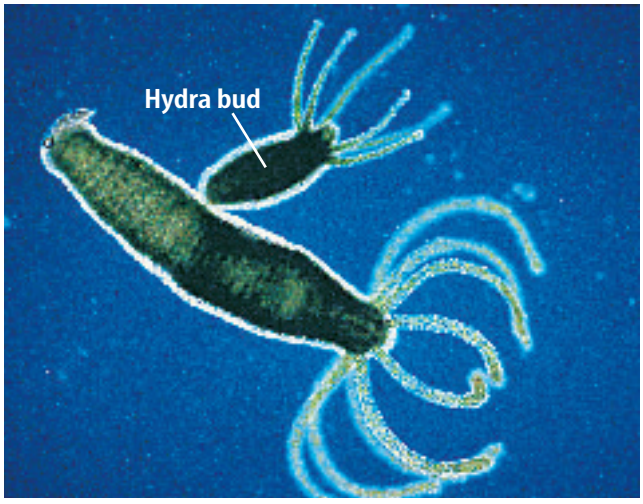
Shoots growing from the eyes of a potato are a form of reproduction. Reproduction in which a new organism is produced from a part of another organism by cell division is called **asexual** (ay SEK shoo ul) **reproduction.** In asexual reproduction, all the DNA in the new organism comes from one other organism. The DNA of the growing potato eye is the same as the DNA in the rest of the potato.

Some one-celled organisms, such as bacteria, divide in half, forming two cells. Before the one-celled organism divides, its DNA copies itself. After it has divided, each new organism has an exact copy of the first organism's DNA. The two new cells are alike. The first organism no longer exists.

Budding and Regeneration Many plants and species of mushroom, and even a few animals reproduce asexually. The photo on the left in **Figure 4** shows asexual reproduction in hydra, a relative of jellyfish and corals. When a hydra reproduces asexually, a new individual grows on it by a process called budding. As you can see, the hydra bud has the same shape and characteristics as the parent organism. The bud matures and eventually breaks away to live on its own.

In a process called regeneration (rih je nuh RAY shun), some organisms are able to replace body parts that have been lost because of an injury. Sea stars can grow a new arm if one is broken off. Lizards, such as chameleons, can grow a new tail if theirs is broken off, as shown in **Figure 4** in the photo on the right.

Figure 4 Cell division can result in asexual reproduction or replacement of body parts.



Hydra reproduce asexually by budding.

A chameleon can regenerate, or regrow, a tail if it is broken off.

Mini LAB

Observing Yeast Budding

Procedure

1. Use a **dropper** to place a drop of a **prepared yeast** and **sugar mixture** onto a **microscope slide.** Place a **coverslip** on the slide.
2. Examine the slide with a **microscope** under low power, then high power.
3. Record your observations in your **Science Journal.**
4. Make a new slide after 5 min. Examine the slide under low power, then under high power.
5. Record your observations in your Science Journal.

Analysis

1. What did you observe on the first slide?
2. What might account for any differences between what you observed on the first slide and the second slide?

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Figure 5 These African violets are clones.
Infer *whether or not the plants all came from one plant. Explain.*

Cloning What would it be like if humans or other animals were exact copies of each other? Making copies of organisms is called **cloning.** The new organism produced is called a clone. The clone receives DNA from just one parent cell. It has the same DNA as the parent cell. In many ways, cloning is not a new technology. In the past, most cloning was done with plants. Gardeners clone plants when they take cuttings of a plant's stems, leaves, or roots. They can grow many identical plants from one, as shown in **Figure 5.**

Only since the 1990s has cloning large animals become possible. In 1997, it was announced that an adult Finn Dorset sheep had been cloned. The new sheep, named Dolly, was the first successfully cloned mammal. The real value of Dolly is that scientists now have a better understanding of how cells reproduce.

Sex Cells and Reproduction

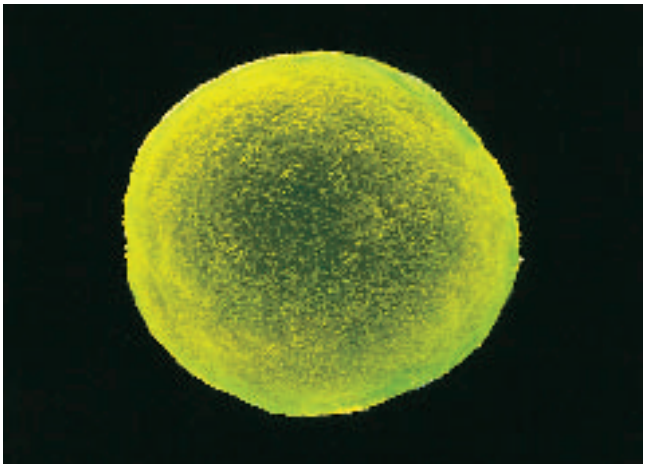
Does a human baby look exactly like its father or its mother? Usually, the baby has features of both of its parents. The baby might have her dad's hair color and her mom's eye color. However, the baby probably doesn't look exactly like either of her parents. That's because humans, as well as many other organisms, are the products of sexual (SEK shoo ul) reproduction. In **sexual reproduction** a new organism is produced from the DNA of two cells. **Sex cells,** as shown in **Figure 6,** are the specialized cells that carry DNA and join in sexual reproduction. During this process, DNA from each sex cell contributes to the formation of a new individual and that individual's traits.

Reading Check ***What results from sexual reproduction?***

Figure 6 Specialized cells called sex cells are involved in reproduction. A female sex cell usually is called an egg and a male sex cell is usually called a sperm. Each type of sex cell in a human contains 23 chromosomes.

A human egg cell

Magnification: 700×



Human sperm cells

Magnification: 4500×

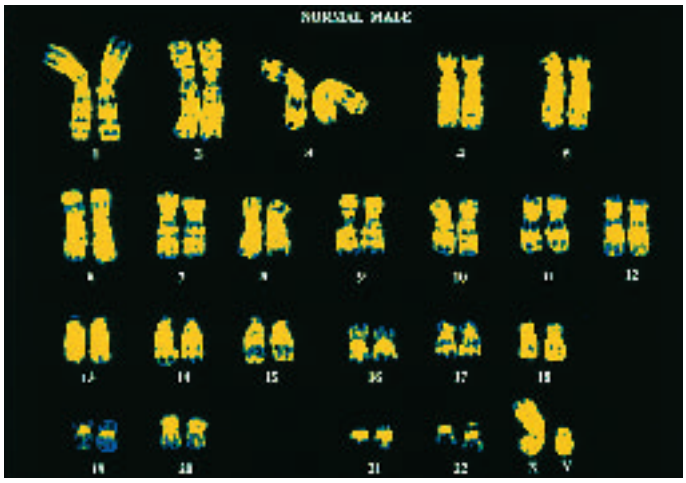


Figure 7 Each chromosome in a human body is made of DNA. All 23 pairs of chromosomes of one person are shown in this photograph.

Production of Sex Cells

Recall that your body is made up of different types of cells most of which were formed by mitosis. When a skin cell, a bone cell, or another body cell divides, it produces two new cells by cell division. Each cell has DNA that is identical to the original cell. Recall that DNA can be found in structures called chromosomes. A human body cell has 46 chromosomes arranged in 23 pairs, as shown in **Figure 7.** Each chromosome of a pair has genetic information about the same things. For example, if one chromosome has information about hair color, its mate also will have information about hair color.

Sex cells are different. Instead of being formed by cell division like body cells are, sex cells are formed by **meiosis** (mi OH sus). **Table 1** compares cell division and sex cell formation. Only certain cells in reproductive organs undergo the process of meiosis. Before meiosis begins, DNA is duplicated. During meiosis, the nucleus divides twice. Four sex cells form, each with half the number of chromosomes of the original cell. Human eggs and sperm contain only 23 chromosomes each—one chromosome from each pair of chromosomes. That way, when a human egg and sperm join in a process called **fertilization,** the result is a new individual with a full set of 46 chromosomes. **Figure 8** shows how sex cells join to form a cell that develops into a new human being.

Cigarette Smoking In humans, sex cell production and fertilization can be affected by cigarette smoking. Cigarette smoking can decrease the number of sperm produced in the male body. Also, some of the sperm produced by a male that smokes may be deformed and unable to fertilize an egg.

Table 1 Cell Division and Sex Cell Formation in Humans

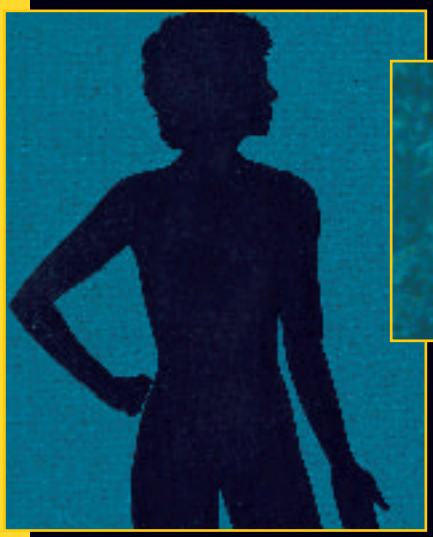
	Cell Division	Sex Cell Formation
Process used	Mitosis	Meiosis
DNA duplicated?	Yes	Yes
Nucleus divides	Once	Twice
Number of cells formed	2	4
Chromosome number of beginning cell	46	46
Chromosomes in each new cell	46	23

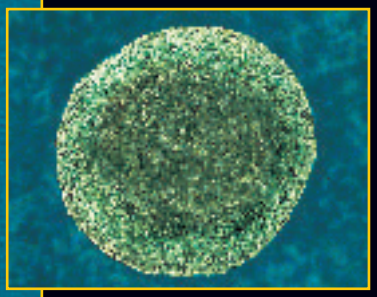
NATIONAL GEOGRAPHIC

VISUALIZING HUMAN REPRODUCTION

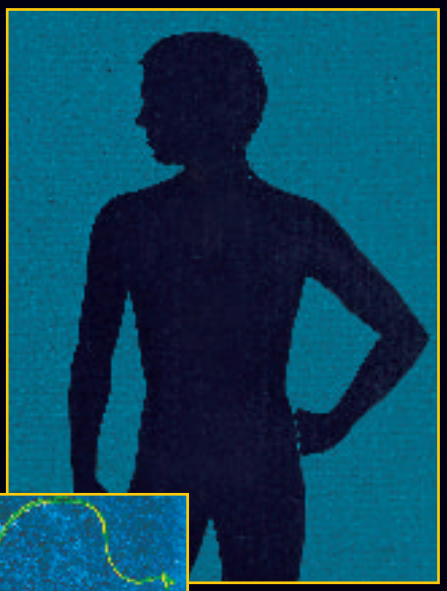
Figure 8

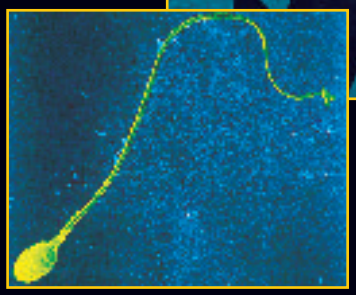
Humans, like most animals and plants, reproduce sexually. In sexual reproduction, a new and genetically unique individual is produced when a female sex cell and a male sex cell join in a process called fertilization.



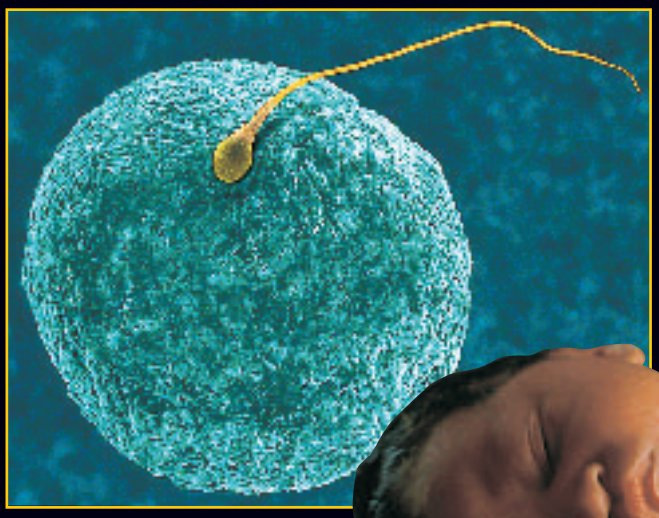


▲ A female's sex cell, an egg, has only 23 chromosomes—half the amount contained in human body cells.





◀ A male's sex cell, a sperm, also contains only 23 chromosomes.



◀ When an egg and a sperm unite during fertilization, a new cell results that has a full set of 46 chromosomes.

▶ This new cell divides again and again, developing over time into a fully formed baby.

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Sex Cells in Plants

Plants can reproduce sexually. How this occurs is different for each plant group. But in every case, a sperm and an egg join to create a new cell that eventually becomes a plant.

It may seem that flowers are just a decoration for many plants, but flowers contain structures for reproducing. Male flower parts produce pollen, which contains sperm cells. Female flower parts produce eggs. When a sperm and an egg join, a new cell forms. In most flowers, rapid changes begin soon after fertilization. The cell divides many times and becomes enclosed in a protective seed. The petals and most other flower parts fall off. A fruit that contains seeds soon develops, as shown in **Figure 9.**

Figure 9 An apple flower will develop into an apple containing seeds if the eggs in the female reproductive structure are fertilized.

section 1 review

Summary

Reproduction

- Reproduction always involves the transfer of hereditary information.

Cell Division

- Mitosis results in two nuclei, each with the same genetic information.

Reproduction by One Organism

- There are two types of asexual reproduction—budding and regeneration.

Sex Cells and Reproduction

- DNA from each sex cell contributes to the formation of a new individual.

Production of Sex Cells

- Human eggs and sperm each contain only 23 chromosomes.

Sex Cells in Plants

- Flowers contain structures for reproduction.

Self Check

1. **Compare and contrast** the outcome of meiosis and the outcome of mitosis.
2. **Infer** why reproduction is an important process.
3. **Explain** why offspring produced by asexual reproduction are usually identical to the parent that produced them.
4. **Describe** how DNA controls how an organism looks and functions.
5. **Think Critically** For a species, what are some advantages of reproducing asexually? Of reproducing sexually? Of having the ability to do either?

Applying Math

6. **Calculate** A female bullfrog produces 350 eggs. All of the eggs are fertilized and hatch in one season. Assume that half of the tadpoles are male and half are female. If all the female tadpoles survive and, one year later, produce 350 eggs each, how many eggs would be produced?

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LAB

Getting DNA from Onion Cells

DNA contains the instructions for the processes that occur in a cell. In this lab, you will see the actual DNA of one living thing—an onion.

Real-World Question

How is DNA taken out of cells?

Goals

- **Separate** DNA from onion cells.
- **Practice** laboratory skills.

Materials

prepared onion mixture (125 mL)
toothpicks
small beaker
**measuring cup*
rubbing alcohol (125 mL)
large beaker
**other glass container*
magnifying lens
**microscope*
**Alternate materials*

Safety Precautions

Be sure to wear an apron and goggles throughout this lab. Keep hands away from face.

Procedure

1. Obtain 125 mL of prepared onion mixture from your teacher. Empty it into the large glass beaker or container.
2. Slowly pour 125 mL of rubbing alcohol down the side of the container onto the mixture. The alcohol should form a layer on top of the onion mixture.
3. **Observe** the gooey strings floating to the top. These strings are DNA.
4. Use a toothpick to gently stir the alcohol layer. Use another toothpick to remove the gooey DNA.
5. **Observe** DNA with a magnifying lens or a microscope. Record your observations in your Science Journal.
6. When you're finished, pour all liquids into containers provided by your teacher.

Conclude and Apply

1. Based on what you know about DNA, predict whether onion DNA is different from the DNA of other types of plants.
2. **Infer** whether this method of taking DNA out of cells could be used to compare the amount of DNA between different organisms. Explain your answer.

Communicating Your Data

Compare and contrast your findings with those of other students in your class. Explain in your Science Journal why your findings were the same or different from those of other students. **For more help, refer to the Science Skill Handbook.**

Timothy Fuller
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section 2

Genetics—The Study of Inheritance

Heredity

When you go to a family reunion or browse through family pictures, like the one in **Figure 10,** you can't help but notice similarities and differences among your relatives. You notice that your mother's eyes look just like your grandmother's, and one uncle is tall while his brothers are short. These similarities and differences are the result of the way traits are passed from one generation to the next. **Heredity** (huh REH duh tee) is the passing of traits from parents to offspring. Solving the mystery of heredity has been one of the great success stories of biology.

Look around at the students in your classroom. What makes each person an individual? Is it hair or eye color? Is it the shape of a nose or the arch in a person's eyebrows? Eye color, hair color, skin color, nose shape, and many other features, including those inside an individual that can't be seen, are traits that are inherited from a person's parents. A trait is a physical characteristic of an organism. Every organism, including yourself, is made up of many traits. The study of how traits are passed from parents to offspring is called **genetics** (juh NE tihks).

Reading Check *What traits could you pass to your offspring?*

Figure 10 Family members often share similar physical features. These traits can be something obvious, like curly hair, or less obvious, such as color blindness.

as you read

What You'll Learn

- **Explain** how traits are inherited.
- **Relate** chromosomes, genes, and DNA to one another.
- **Discuss** how mutations add variation to a population.

Why It's Important

You will understand why you have certain traits.

Review Vocabulary

genotype: the genetic makeup of an organism

New Vocabulary

- heredity
- genetics
- gene
- variation
- mutation

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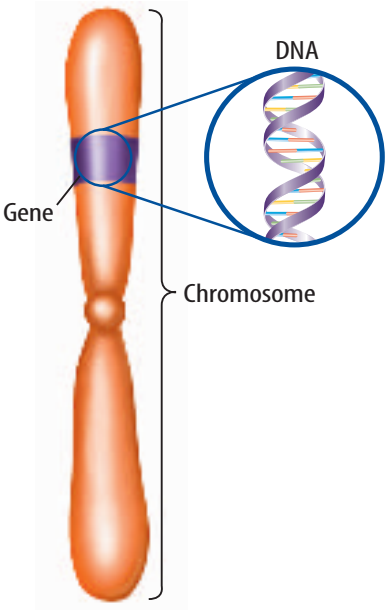

Figure 11 Hundreds of genes are located on each chromosome.

Genes All traits are inherited. Half of your genetic information came from your father, and half came from your mother. This information was contained in the chromosomes of the sperm and egg that joined and formed the cell that eventually became you.

Inherited traits, such as hair and eye color, are controlled by genes on chromosomes. Characteristics such as manners are called acquired skills. Acquired skills are not determined by genes.

As **Figure 11** shows, all chromosomes contain genes (JEENZ). A **gene** is a small section of DNA on a chromosome that has information about a trait. Humans have thousands of different genes arranged on 23 pairs of chromosomes. Genes control all of the traits of organisms—even traits that can't be seen, such as the size and shape of your stomach and your blood type. Genes provide all of the information needed for growth and life.

What determines traits?

Recall that in body cells, such as skin cells or muscle cells, chromosomes are in pairs. One pair of chromosomes can contain genes that control many different traits. Each gene on one chromosome of the pair has a similar gene on the other chromosome of the pair. Each gene of a gene pair is called an allele (uh LEEL), as shown in **Figure 12.** The genes that make up a gene pair might or might not contain the same information about a trait. For example, the genes for the flower color trait in pea plants might be purple or white. If a pair of chromosomes contains different alleles for a trait, that trait is called a hybrid (HI brud). When a trait has two identical alleles, it's called pure.

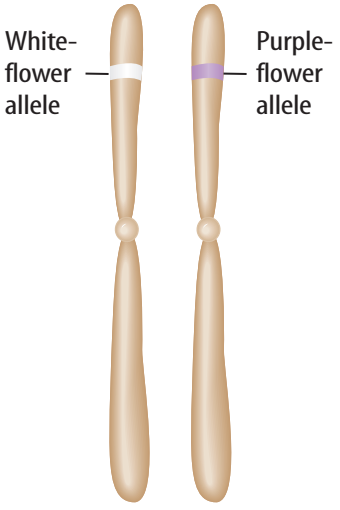

Figure 12 Pea flowers can be purple or white. The chromosome pair from a pea plant shows that both chromosomes have an allele for the flower color trait. A pea plant with this chromosome pair would have purple flowers.

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Figure 13 Widow's peak is a dominant allele in humans. **Infer** *how many alleles for widow's peak this person might have.*

Dominant and Recessive Alleles

The combination of alleles in a gene pair determines how a trait will be shown, or expressed, in an organism. In pea plants and other organisms, that depends on something called dominance (DAH muh nunts). Dominance means that one allele covers over or masks another allele of the trait. For instance, if a pea plant has one purple-flower allele and one white-flower allele or two purple-flower alleles, its flowers will be purple. Purple is the dominant flower color in pea plants. The dominant allele is seen when the trait is hybrid or dominant pure. White flowers, the masked allele, are said to be recessive. Recessive alleles are seen only when a trait is recessive pure.

Humans also have traits that are controlled by dominant and recessive alleles. These traits are controlled in the same way that dominant and recessive alleles are controlled in plants. To show a recessive allele, a person needs to inherit two copies of the recessive allele for that trait—one from their mother and one from their father. To show a dominant allele, a person can have either one or two alleles for the trait. One dominant allele in humans is the presence of a widow's peak, as shown in **Figure 13.**

Expression of Traits

The traits of an organism are coded in the organism's DNA. However, the environment can play an important role in the way that a trait is shown, or expressed. You may know a person whose dark hair lightens when exposed to sunlight, or a person whose light skin darkens in sunlight. Human hair color and skin color are traits that are coded for by genes, but the environment can change the way that the traits appear. The environment can affect the expression of traits in every kind of organism, including bacteria, fungi, plants, and animals.

Sometimes the effect of the environment allows adaptations that aid in a species survival. For example, the arctic fox's fur color depends on the environment. In the winter months, the arctic fox does not produce fur pigment, and the fox's fur appears white. As a result, the fox blends with the snow, helping it to avoid predators. In the warmer months, the fox produces brown pigment, and the fox blends with the tundra.

Mini LAB

Modeling Probability

Procedure

1. Flip a **coin** ten times. Count the number of heads and the number of tails.
2. Record these data in a data table in your **Science Journal.**
3. Now flip the coin twenty times. Count the number of heads and tails.
4. Record these data in a data table in your Science Journal.

Analysis

1. What results did you expect when you flipped the coin ten times? Twenty times?
2. Were your observed results closer to your expected results when you flipped the coin more times?
3. How is the flipping of a coin similar to the joining of egg and sperm at fertilization?

Try at Home

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Passing Traits to Offspring

How are traits passed from parents to offspring during fertilization? The flower color trait in pea plants can be used as an example. Suppose a hybrid purple-flowered pea plant (one with two different alleles for flower color) is mated with a white-flowered pea plant. What color flowers will the offspring have?

The traits that a new pea plant will inherit depend upon which genes are carried in each plant's sex cells. Remember that sex cells are produced during meiosis. In sex cell formation, pairs of chromosomes duplicate, then separate as the four sex cells form. Therefore, gene pairs also separate. As a result, each sex cell contains one allele for each trait. Because the purple-flowered plant in **Figure 14** is a hybrid, half of its sex cells contain the purple-flower allele and half contain the white-flower allele. On the other hand, the white-flowered plant is recessive pure. The gene pair for flower color has two white alleles. All of the sex cells that it makes contain only the white-flower allele.

In fertilization, one sperm will join with one egg. Many events, such as flipping a coin and getting either heads or tails, are a matter of chance. In the same way, chance is involved in heredity. In the case of the pea plants, the chance was equal that the new pea plant would receive either the purple-flower allele or the white-flower allele from the hybrid plant.

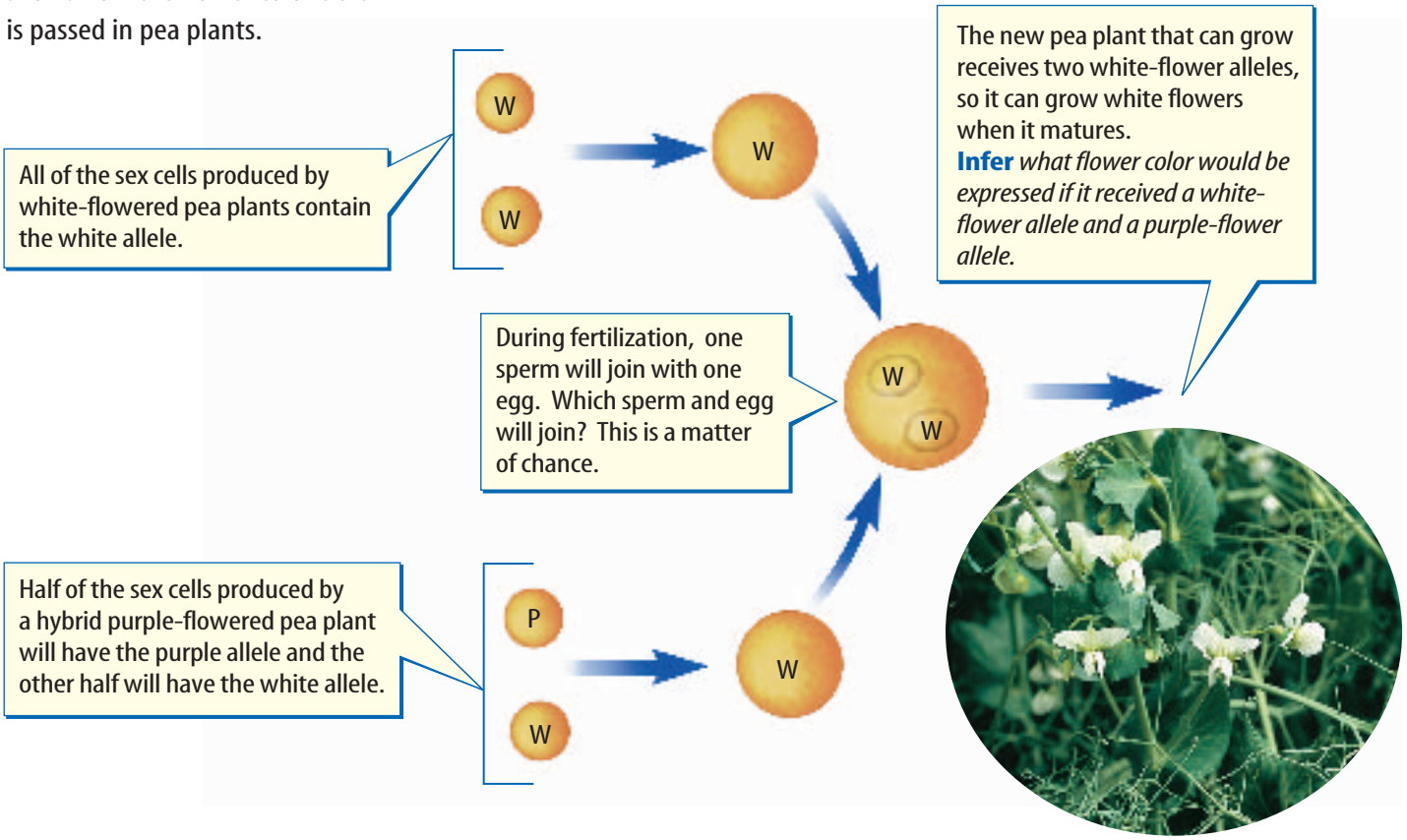

Figure 14 The traits an organism has depends upon which genes were carried in the parents' sex cells. This diagram shows how the flower color trait is passed in pea plants.

Nigel Cattlin, Holt Studios International/Photo Researchers

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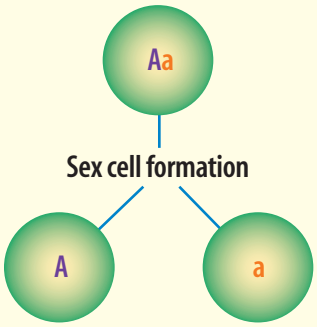
Differences in Organisms

Now you know why a baby can have characteristics of either of its parents. The inherited genes from his or her parents determine hair color, skin color, eye color, and other traits. But what accounts for the differences, or variations (vayr ee AY shuns), in a family? **Variations** are the different ways that a certain trait appears, and they result from permanent changes in an organism's genes. Some gene changes produce small variations, and others produce large variations.

Applying Math — Find a Percentage

ALLELES IN SEX CELLS When sex cells form, each allele separates from its partner. Each sex cell will contain only one allele for each trait. Assume that a parent is a hybrid for a certain trait. That means that the parent has a dominant and a recessive allele for that trait. What percent of the parent's sex cells will contain the dominant allele?



Solution

1 *This is what you know:* there are 2 possible alleles for the trait from the parent

2 *This is what you need to find out:* percent of sex cells with the dominant allele

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

- Use the following equation:

$$\frac{100\%}{\text{number of possible alleles}} = x$$

- Substitute in the known value and solve.

$$\frac{100\%}{2} = x \qquad x = 50\%$$

4 *Check your answer:* Multiply the number of possible alleles from the parent by the percent of sex cells with the dominant allele. You should get 100%.

Practice Problems

1. The attached-earlobes trait in humans is a recessive trait. What percent of the sex cells produced by a parent with attached earlobes would have an allele for this trait?
2. Assume one parent is a hybrid for a trait, and the other parent has 2 dominant alleles for the same trait. When the sex cells from the parents join, what is the percent chance that the offspring will have the recessive trait?

ScienceOnline For more practice, visit red.msscience.com/math_practice

Height is a trait that has many variations.

Figure 15 Traits in humans that show great variation usually are controlled by more than one gene pair.

The members of this family have different hair color.

Multiple Alleles and Multiple Genes

Earlier, you learned how the flower color trait in pea plants is passed from parent to offspring. Flower color in pea plants shows a simple pattern of inheritance. Sometimes, though, the pattern of inheritance of a trait is not so simple. Many traits in organisms are controlled by more than two alleles. For example, in humans, multiple alleles A, B, and O control blood types A, B, AB, or O.

Traits also can be controlled by more than one gene pair. For humans, hair color, as shown in **Figure 15,** height, also shown in **Figure 15,** weight, eye color, and skin color, are traits that are controlled by several gene pairs. This type of inheritance is the reason for the differences, or variations, in a species.

Mutations—The Source of New Variation

If you've searched successfully through a patch of clover for one with four leaves instead of three, you've come face-to-face with a mutation (myew TAY shun). A four-leaf clover is the result of a mutation. The word *mutate* simply means "to change." In genetics, a **mutation** is a change in a gene or chromosome. This can happen because of an error during meiosis or mitosis or because of something in the environment. Many mutations happen by chance.

Reading Check ***What is a mutation?***

What are the effects of mutations? Sometimes mutations affect the way cells grow, repair, and maintain themselves. This type of mutation is usually harmful to the organism. Many mutations, such as a four-leaf clover, have a neutral effect. Whether a mutation is beneficial, harmful, or neutral, all mutations add variation to the genes of a species.

INTEGRATE Career

Genetic Counselor A genetic counselor is a medical professional who can help determine the chances of having a child with a genetic disorder. Genetic counselors test for genetic disorders and can provide help with treatment options. Investigate genetic disorders that can be tested for by a genetic counselor. In your Science Journal, write about one of the disorders.

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Figure 16 Dairy cattle are bred selectively for the amount of milk that they can produce.

Selective Breeding Sometimes, a mutation produces a different version of a trait that many people find attractive. To continue this trait, selective breeding is practiced.

Nearly all breeding of animals is based on their observable traits and is controlled, instead of being random. For many years, cattle, like the one in **Figure 16,** have been bred on the basis of how much milk they can produce. Racehorses are bred according to how fast they run. It eventually was learned that in a few generations, breeding closely related animals produced an increased percentage of offspring with the desired traits.

ScienceOnline

Topic: Selective Breeding

Visit red.msscience.com for Web links to information about selective breeding.

Activity List one type of plant and one type of animal that are bred selectively. Include the specific traits for which each is bred.

section 2 review

Summary

Heredity

- Genetics is the study of how traits are passed from parents to offspring.
- Genes control all the inheritable traits of organisms.

What determines traits?

- The expression of a trait is determined by the combination of alleles in a gene pair.
- A hybrid has a pair of chromosomes with different alleles for a trait.

Passing Traits to Offspring

- Traits of an offspring are determined by which genes are carried by its parents' sex cells.

Differences in Organisms

- Many traits are controlled by more than two alleles.
- More than one gene pair can control a certain trait.
- Mutations can happen by chance.

Self Check

1. **Define** the term *heredity*.
2. **State** which alleles for a trait must be present for a recessive allele to be expressed.
3. **Describe** how the chromosomes in human body cells are arranged.
4. **Explain** how mutations add variation to the genes of a species.
5. **Think Critically** What might happen if two hybrid purple-flowered pea plants are mated? What possible flower colors could the offspring have? Explain.

Applying Skills

6. **Concept Map** Make a concept map that shows the relationships between the following concepts: *genetics, genes, chromosomes, DNA, variation,* and *mutation*.
7. **Communicate** Research to find what a transgenic organism is, then find books or articles about these organisms. In your Science Journal, write a paragraph summary of your findings.

LAB

Use the Internet

Genetic Traits: The Unique You

Goals

- **Identify** genetic traits.
- **Collect** data about three specific human genetic traits.
- **Investigate** what are dominant and recessive alleles.
- **Graph** your results and then communicate them to other students.

Data Source

Science Online

Visit red.msscience.com/internet_lab to get more information about human genetic traits and for data collected by other students.

Real-World Question

What makes you unique? Unless you have an identical twin, no other person has the same combination of genes as you do. To learn more about three human genetic traits, you will collect data about your classmates. When you compare the data you collected with data from other students, you'll see that patterns develop in the frequency of types of traits that are present within a group of people. How are three genetic traits expressed among your classmates? Genetic traits can be dominant or recessive. Form a hypothesis about which trait, dominant or recessive, will be expressed by more people.

Make a Plan

1. **Research** general information about human genetic traits.
2. Search reference sources to find out which form of each characteristic being studied is dominant and which form is recessive.
3. **Survey** the students in your class to collect data about the three genetic traits being studied.

Attached earlobe

Detached earlobe

CONTENTS

Follow Your Plan

1. Make sure your teacher approves your plan before you start.
2. **Record** your data in your Science Journal. Use frequency data tables to organize your data.

Genetic Traits	
Dimples	No Dimples
Attached Earlobes	Detached Earlobes
Widow's Peak	No Widow's Peak

Analyze Your Data

1. **Record** the total number of people included in your survey.
2. **Calculate** the number of people who show each form of each of the three traits that are being studied. Record each of these numbers in your Science Journal.
3. **Graph** the data you collected on a bar graph. Bars should represent the numbers of students exhibiting each of the different genetic traits you investigated.
4. **Compare** the data among each of the three genetic traits you explored.

Conclude and Apply

1. **Determine** Think about the genetic traits you investigated. Which traits were most common in the people you surveyed?
2. **Infer** Might surveying a larger group of people give different results?
3. **Analyze Results** Which genetic traits are least commonly found?
4. **Interpret Data** In the people you surveyed, were dominant alleles present more often than recessive alleles?

Communicating Your Data

Find this lab using the link below. **Post** your data in the table provided. **Compare** your data to that of other students. Combine your data with that of other students and **graph** the combined data on a bar graph.

ScienceOnline

red.msscience.com/internet_lab

Jeff Smith/Fotosmith

SEPARATED AT BIRTH

Are genes or the people who raised you important in determining personality?

These twins, separated at birth and reunited as adults, had the same kind of job, drove the same kind of car, and had the same hobbies.

When Barbara Herbert was about 40, she met her long lost twin sister, Daphne Goodship. She had not seen her since infancy. The two grew up in separate homes with separate families. Because they are identical twins, it makes sense that they look alike. What was shocking, however, was the number of coincidences in their lives. Although they were not in contact while growing up, they shared identical experiences. Both women:

- dropped out of school at age 14,
- got jobs working for the local government,
- met their future husbands at age 16,
- gave birth to two boys and one girl,
- are squeamish about blood and heights, and
- drink their coffee cold.

In the genes?

Barbara and Daphne are part of an ongoing scientific study at Minnesota's Center for Twin and Adoption Research, which examines twins who were separated at birth. This research is helping scientists to understand better what is stronger in a person's development—genetic makeup, or how and by whom twins are raised.

Identical twins make ideal subjects for this research because their genetic makeups are identical. First, a psychological assessment is made, using personality tests, job interest questions, mental ability, and I.Q. Tests. Then scientists analyze the twins' backgrounds, including where they were raised, what their parents were like, and what schools they attended. These help determine whether a person's habits and personality are based on genetic makeup or social interactions.

Recently, a pair of twins were reunited after more than 30 years. Both twins said they felt like they have known each other all their lives. And, perhaps, thanks to their genes, they have!

Interview **Find a pair of identical twins that go to your school or live in your community. Make a list of 10 questions and interview each of the twins separately. Write down their answers, or tape-record them. Compare the responses, then share your findings with the class.**

ScienceOnline
For more information, visit red.msscience.com/time

Arnold Zann/Black Star

Reviewing Main Ideas

Section 1 Continuing Life

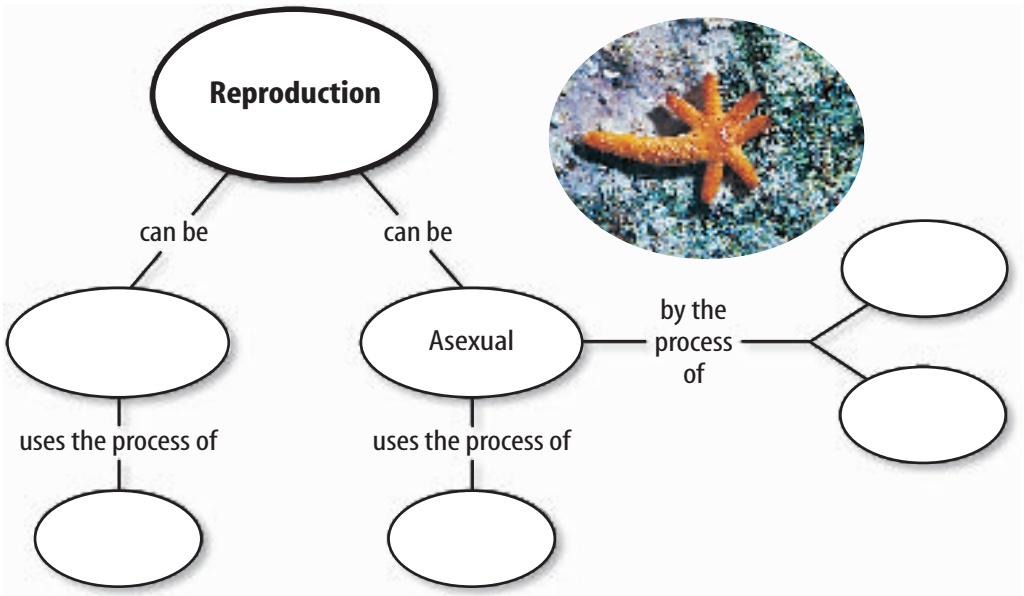
1. Reproduction is an important process for all living things.
2. During reproduction, information stored in DNA is passed from parent to offspring.
3. Mitosis is the process that results in two nuclei with the same genetic information.
4. Organisms can reproduce sexually or asexually.
5. DNA is shaped liked a twisted ladder. An organism's DNA contains all of the information about how it will look and function.

Section 2 Genetics—The Study of Inheritance

1. Genetics is the study of how traits are passed from parent to offspring.
2. Genes are small sections of DNA on chromosomes. Each gene has information about a specific trait.
3. Chromosomes are found in pairs. For each gene on a particular chromosome, a gene with information about the same trait can be found on the other chromosome of the chromosome pair. Each gene of a gene pair is called an allele.
4. The way a trait is shown depends on the combination of dominant and recessive alleles carried on the chromosome pair.
5. Mutations are changes in a gene or chromosome. Mutations are a source of variation in populations.
6. Selective breeding allows favorable traits of organisms to be passed from one generation to the next.

Visualizing Main Ideas

Copy and complete the following concept map on reproduction.



Robert F. Myers/Visuals Unlimited

chapter 20 Review

Using Vocabulary

asexual reproduction p. 593
cloning p. 594
DNA p. 590
fertilization p. 595
gene p. 600
genetics p. 599
heredity p. 599
meiosis p. 595
mitosis p. 592
mutation p. 604
sex cell p. 594
sexual reproduction p. 594
variation p. 603

Explain the differences between the vocabulary words in each of the following sets.

1. mitosis—meiosis
2. asexual reproduction—sexual reproduction
3. cloning—variation
4. fertilization—sexual reproduction
5. mutation—variation
6. gene—DNA
7. asexual reproduction—mitosis
8. sex cells—meiosis
9. genetics—gene
10. DNA—mutation

Checking Concepts

Choose the word or phrase that best answers the question.

11. Which of the following is reproduction that requires male and female sex cells?
A) asexual reproduction
B) sexual reproduction
C) mitosis
D) heredity

12. What is any change in the DNA of a gene or chromosome called?
A) an embryo **C)** a clone
B) sex cells **D)** a mutation

13. What is the small section of DNA that contains the code for a trait?
A) a gene **C)** a variation
B) heredity **D)** a cell

14. Which of these is another name for an observable feature or characteristic of an organism?
A) sex cell **C)** trait
B) embryo **D)** gene

15. How are specialized breeds of dogs, cats, horses, and other animals produced?
A) regeneration
B) asexual reproduction
C) selective breeding
D) budding

16. What is the passing of traits from parent to offspring called?
A) genetics **C)** heredity
B) variation **D)** meiosis

17. What are sperm and eggs?
A) variations **C)** mutations
B) sex cells **D)** genes

18. What is formed during meiosis?
A) heredity **C)** clones
B) sex cells **D)** fertilization

Use the photo below to answer question 19.

19. What flower color trait(s) would be in the sex cells of the above pea plant?
A) purple only **C)** purple and white
B) white only **D)** pink only

Richard Sheill/Earth Scenes

Thinking Critically

20. Explain the relationship among DNA, genes, and chromosomes.

21. Communicate Two brown-eyed parents have a baby with blue eyes. Explain how this could happen.

22. Describe how the process of meiosis is important in sexual reproduction.

23. Explain how a mutation in a gene could be beneficial to an organism.

24. Draw Conclusions Some mutations are harmful to organisms. Others are beneficial, and some have no effect at all. Which type of mutation would be least likely to be passed on to future generations?

25. Compare and contrast sexual and asexual reproduction.

26. Recognize Cause and Effect What is the role of meiosis and mitosis in the fertilization and development that results in a human baby?

Use the photo below to answer question 27.

27. Infer why this plant is an example of asexual reproduction. How could the plant reproduce through sexual reproduction?

Performance Activities

28. Scientific Drawing Use your imagination and make illustrations for each of the following vocabulary words: *asexual reproduction*, *genetics*, and *mutation*.

29. Newspaper Article Many scientists have reported that it is possible to get DNA from prehistoric creatures. Go to the library and find a newspaper article that describes the discovery of ancient DNA. Write a summary of the article in your Science Journal.

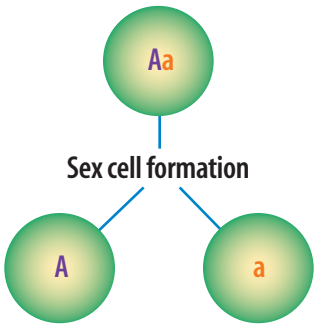
Applying Math

30. Cell Division If a cell undergoes cell division every 20 minutes, how many cells will there be after 24 hours?

31. Meiosis Five cells undergo meiosis to form sex cells. How many sex cells are formed?

32. Human Genome Assume the human genome is 3 billion base pairs. If one million base pairs of DNA take up 1 megabyte of storage space on a computer, how many gigabytes (1,024 megabytes) would the whole human genome fill?

Use the illustration below to answer question 33.



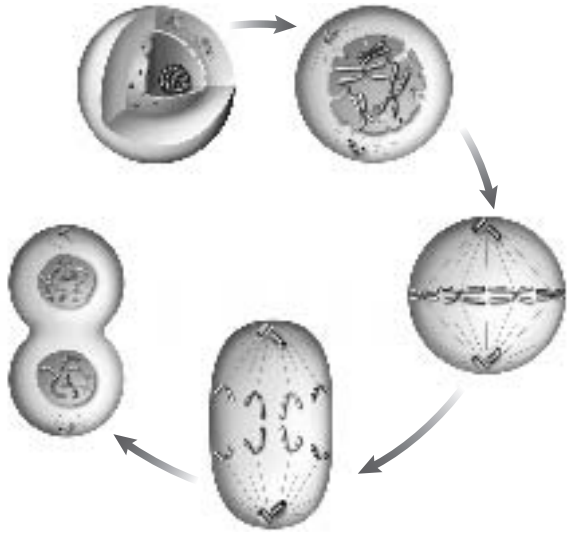
33. Wrinkled Seeds In pea plants, wrinkled seeds are recessive to round seeds. If two hybrid pea plants are crossed, what is the percent chance that the offspring will have the wrinkled-seed trait?

Part 1 Multiple Choice

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

1. What are the specialized cells involved in sexual reproduction called?
- **A.** prokaryotic cells
- **B.** mitotic cells
- **C.** eukaryotic cells
- **D.** sex cells

Use the figure below to answer questions 2 and 3.

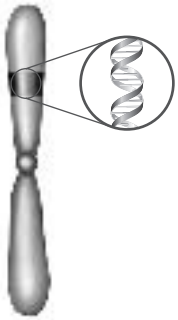


2. During cell reproduction, each new cell receives a copy of
- **A.** mitotic cells.
- **B.** hereditary material.
- **C.** egg cells.
- **D.** proteins.

3. This diagram illustrates a process that is used for all of the following except
- **A.** asexual reproduction.
- **B.** regeneration.
- **C.** photosynthesis.
- **D.** budding.

4. In a hybrid, which allele type is masked?
- **A.** recessive
- **B.** dominant
- **C.** pure
- **D.** clone

Use the figure below to answer questions 5 and 6.



5. What is a small section of DNA on a chromosome that has information about a trait?
- **A.** gene
- **B.** cell
- **C.** protein
- **D.** egg

6. In body cells, chromosomes are found in
- **A.** pairs.
- **B.** singles.
- **C.** triplets.
- **D.** ribosomes.

Use the figure below to answer question 7.

7. This figure represents the structure of
- **A.** RNA.
- **B.** DNA.
- **C.** sex cells.
- **D.** budding.

8. What part of DNA determines the instructions for a body's characteristics and processes?
- **A.** the backbone
- **B.** the sequence of bases
- **C.** the twisted ladder
- **D.** its duplication

Part 2 Short Response/Grid In

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

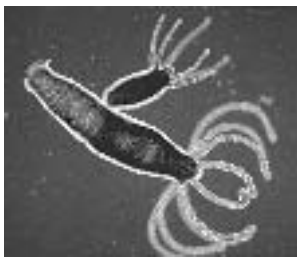
9. What is the difference between a mutation found in a skin cell and a mutation found in a sex cell?

10. Describe how meiosis and fertilization keep the chromosome number the same during sexual reproduction.

11. Would you want to use sex cells for cloning? Why or why not?

12. What are some examples of human characteristics that are controlled by more than one gene pair? Does this increase or decrease variation?

Use the figure below to answer question 13.



13. What form of reproduction is shown in this picture? Compare the DNA in the new organism to the DNA in the parent organism.

14. For a hybrid trait, what is the chance that the offspring will receive that dominant allele? What is the chance that the offspring will receive the recessive allele?

15. Why is reproduction important for a species?

16. What are the two parts of cell division? What does cell division result in?

17. Explain how a lizard can replace an injured tail.

18. What parts of a flower are involved in reproduction?

Part 3 Open Ended

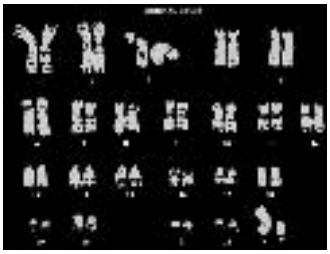
Record your answers on a sheet of paper.

19. Discuss the difference between traits that have multiple alleles and those that are controlled by multiple gene pairs. What are some examples? How do these types of inheritance effect variation in species?

20. Explain the difference between cloning and selective breeding. How would a gardener use both of these processes?

21. Compare and contrast the structure of a ladder to the structure of DNA.

Use the picture below to answer question 22.



22. Trace the path of these human chromosomes as sex cells are formed.

23. In the pea plant, the genes for the flower color trait are purple and white. Using this example, explain the difference between hybrid, dominant pure, and recessive pure pea plants.

24. Discuss how a mutation can affect an organism and the variation in the genes of a species.

25. How does chance contribute to variation within a species?

26. Discuss some of the advantages and disadvantages of asexual reproduction.

Test-Taking Tip

Read Carefully Read each question carefully for full understanding.