Science Ch.3

Reproduction

Biography

Rosalind Franklin

Rosalind Franklin was a key figure in what many call the most important discovery of the 20th century. She helped unlock the secrets of DNA!

Franklin had made a name for herself in the 1940s. This English scientist was one of the world's top experts on X-ray diffraction. In this technique, a powerful X-ray beam is aimed at a crystal, producing an image on film. Franklin perfected the technique when studying the structure of coal.

Then in 1951, Franklin turned her attention to DNA. In the early 1950s, scientists knew that DNA was the substance that carries traits from parents to offspring. But how did DNA actually pass on this genetic information? To answer that, scientists needed to know what DNA looked like. What was its structure?

The breakthrough came in 1953. Franklin produced her best X-ray photo of DNA. It showed clues to the DNA structure. A co-worker showed the photo to James Watson, who was trying to figure out DNA's structure by building models with his partner, Francis Crick. The photo gave Watson and Crick the clues they needed to finish their model correctly. They discovered the structure of DNA and were able to explain how it works. But Franklin's work was the key part to the puzzle.

Lab zone Take-Home Activity

The quest to figure out DNA's structure was an intense competition in the early 1950s. Make a poster that shows the role each of these scientists played in that quest: Rosalind Franklin, Maurice Wilkins, Linus Pauling, James Watson, and Francis Crick.

Chapter 3 Reproduction

You Will Discover

- how traits are passed from parent to offspring.
- how organisms reproduce.
- the differences between organisms produced by asexual reproduction and those produced by sexual reproduction.

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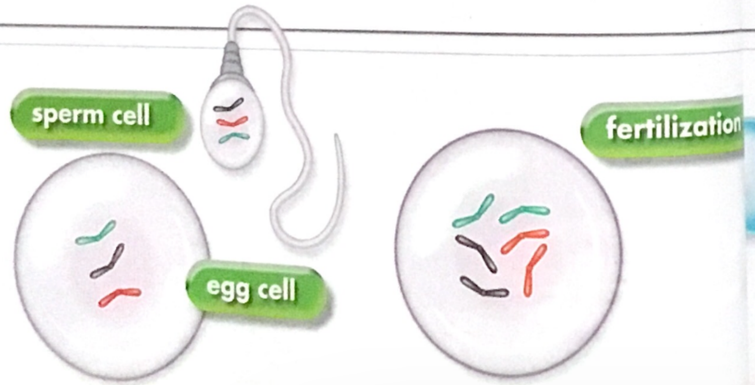
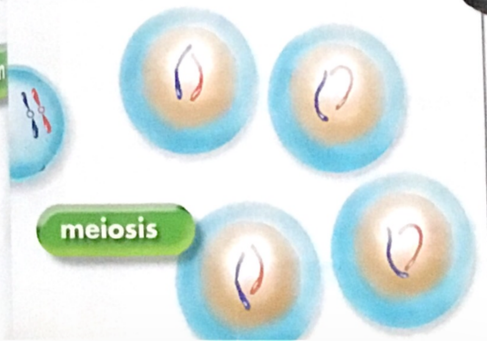
Build Background

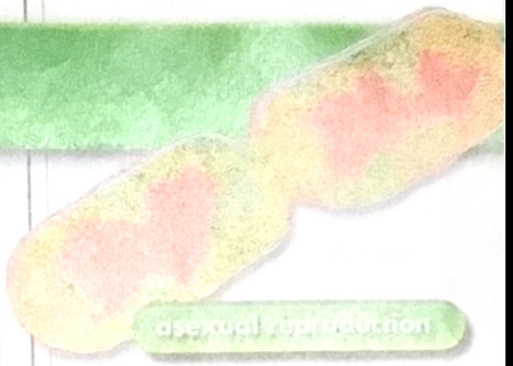
How do living things reproduce?

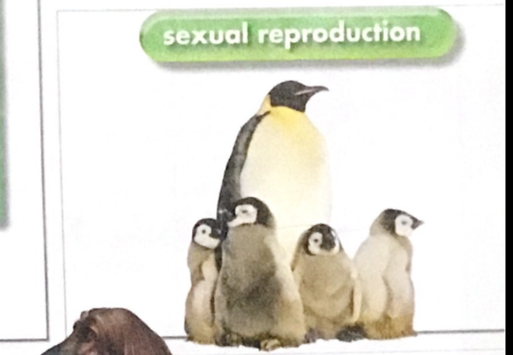
Chapter 3 Vocabulary

- **heredity** page 55
- **asexual reproduction** page 56
- **gene** page 59
- **sexual reproduction** page 62
- **egg cell** page 62
- **sperm cell** page 62
- **meiosis** page 62
- **fertilization** page 62
- **selective breeding** page 72









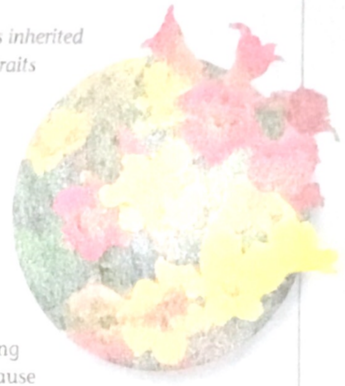
You Are There!

Hiding behind a tree, you scan the landscape with your binoculars. There! At the edge of a wooded area you see a pair of baboons—and they have a baby! The baby looks so small and helpless. Still, you know that this baby will grow up and have babies of its own someday. Will those babies look just like this little fellow?

AudioText

Lesson 1

What is asexual reproduction?



The colors of these snapdragons are traits that were inherited from the parent plants.

During asexual reproduction, a parent passes inherited traits to its offspring. An organism's inherited traits and environment work together to develop its characteristics. Learned traits are not passed from parent to offspring.

Heredity

If the baboons in the picture were grouped with other kinds of animals, you could easily tell which parents belonged with which offspring. **Heredity** is the passing of traits from parents to their offspring. Because parents and offspring share traits, they resemble each other. An organism may grow to be bigger, smaller, lighter, or darker than its parent, but the basic pattern is the same. Oak trees make acorns, which grow to become oak trees, not maple trees.

All organisms inherit traits. Heredity is the reason bacteria have a certain shape or absorb certain chemicals. Heredity gives a tiger stripes and a leopard spots—and never the other way around. Do you have dimples? What color are your eyes? These are just a few of the traits that humans inherit.

Inherited traits do not act alone to give an organism its traits. Environment also affects characteristics. Heredity and environment work together to produce a tree's height. For example, a tree may inherit the ability to grow 12 meters tall. However, if the tree doesn't get the nutrients it needs, it probably will not grow to 12 meters.

Organisms also have traits that they didn't inherit. Perhaps you are good at basketball. Heredity may have given you athletic ability. Even so, you still had to practice playing the game. Playing basketball well is a learned trait. Learned traits cannot pass from parent to offspring through heredity.

1. **Checkpoint** What factors influence an organism's characteristics?
2. **Writing in Science** **Descriptive** Describe yourself as if you were writing to a pen pal you have never met. Tell about some inherited traits, such as your eye color, as well as some learned traits.

Asexual Reproduction

Individual organisms do not live forever. For that reason, the passing of traits from parents to offspring is necessary in order for a species to survive. A parent might have traits that help it survive in its environment. These traits can be passed to offspring so that they too can live successfully and reproduce.

The organisms shown on these pages are producing new individuals. Although the processes they use may seem different, each is doing so by asexual reproduction. In **asexual reproduction**, offspring come from a single parent. Organisms reproduce asexually by mitosis. The offspring will have the same DNA as the parent.

This bacterium cell is splitting into two cells. The red areas show the cells' DNA.

Kinds of Asexual Reproduction

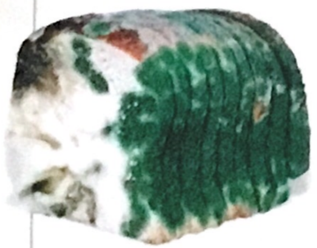
Some organisms, such as the bacterium on this page, reproduce when a parent cell splits to produce two offspring cells of the same size. Each offspring cell has the same traits as the parent cell. This kind of asexual reproduction, called fission, often is a fast way to reproduce. Think about it—the number of offspring keeps doubling. Some bacteria can reproduce in as little as 20 minutes if they have the right conditions. Within 20 minutes, one cell becomes two. In 40 minutes, four cells result, and so on. In only eight hours, the original cell will have multiplied to nearly 17 million new bacteria! Of course, conditions usually do not remain right for reproduction to continue at that rate.

Yeasts, some plants, and the hydra on the left reproduce asexually by a process called budding. During this process, a cell in the parent's body produces a small version of the parent. Many buds can form on a single parent, and each bud has DNA identical to the parent.

Forming spores is another kind of asexual reproduction. A spore is a reproductive cell that has a nucleus and a little bit of cytoplasm. A hard coat covers most spores. This coat protects the spore when conditions in the environment might be harmful.

When conditions are right, a spore develops into a new individual with the same DNA as the parent. Most organisms that reproduce by spores produce many spores at the same time. Molds reproduce by forming spores. Spores are light, so they are easily spread by wind.

Buds have formed on this hydra's side. These buds will break free of the parent.

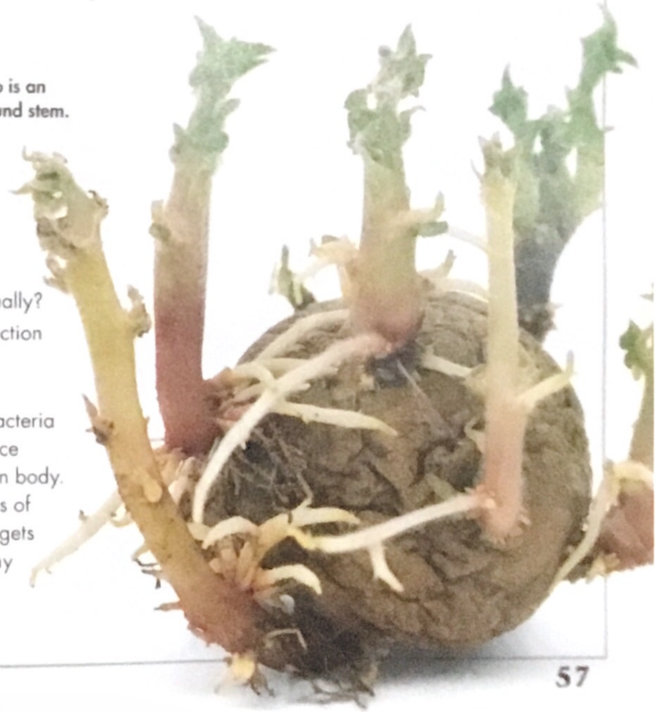


Conditions around the bread were right for mold spores to reproduce.

Some sea stars can reproduce asexually by forming new individuals from body parts. In the past, oyster fishers tried to protect their oyster beds from sea stars that ate the oysters. The fishers captured the sea stars, chopped them into pieces, and then threw them back into the water. The problem only got worse. Many of the chopped-up parts of the sea stars grew into new individuals. Soon there were many more sea stars than before the fishers began chopping them up!

In a similar way, new plants can grow from pieces of a plant. Did you ever see a potato that has begun to grow sprouts like the one shown on this page? The buds form on the plant through the process of mitosis. Each bud can be cut from the plant and planted. It will grow into a new potato plant. In a similar way, many weeds can grow a whole new plant from a small bit of root that a gardener misses. Anyone who has tried to get rid of dandelions by pulling them out soon learns that!

This northern sea star is growing four new arms from the one remaining arm.



The potato is an underground stem.

Lesson Checkpoint

1. What are four ways that organisms reproduce asexually?
2. Why does asexual reproduction produce offspring with identical DNA?
3. **Health** in Science The bacteria that produce tetanus produce spores that infect the human body. Find out what the symptoms of tetanus are, how a person gets a tetanus infection, and why getting vaccinated against it is important.

Lesson 2

How are traits passed on?

The instructions for an organism's traits can be found in its DNA. The structure of DNA makes it possible for organisms to pass traits to their offspring.

Each *E. coli* bacterium has 1 chromosome, which contains 3,000 genes that are made of 4 million base pairs.

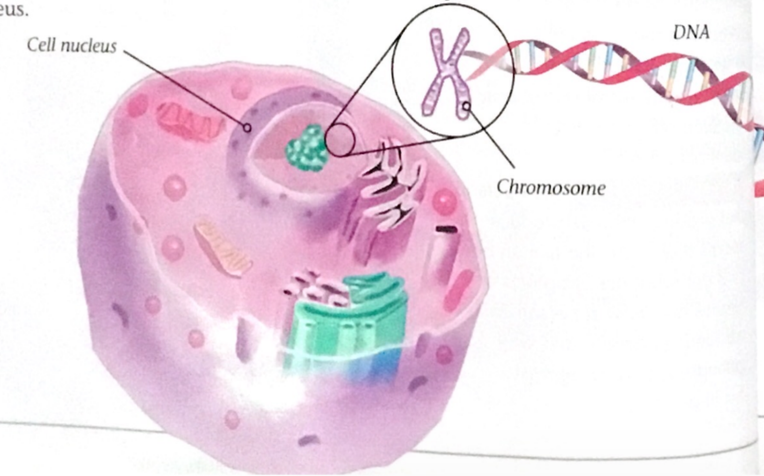
Structure of DNA

When new organisms result from asexual reproduction, why do the two new cells share the same traits? The answer is in the nucleus of the parent cell.

For most organisms, a cell nucleus contains its chromosomes. The chromosomes contain a set of instructions that control all the activities of a cell. These instructions tell individual cell parts what to do. They also tell cells of multicellular organisms how to work together to form an individual organism. For example, the chromosomes in each cell of a gorilla contain all the instructions to make a gorilla.

Chromosomes are made up of proteins and DNA, which is short for deoxyribonucleic acid. The DNA strands in chromosomes are tightly coiled. If you were able to stretch out the 46 chromosomes in a single human cell and lay them end to end, the strand would be about two meters long. Although the strands are long, they are very thin.

Even under a microscope, you cannot see the chromosomes in most cells except during cell division. Other times, the DNA and proteins that make up chromosomes are spread throughout the nucleus.

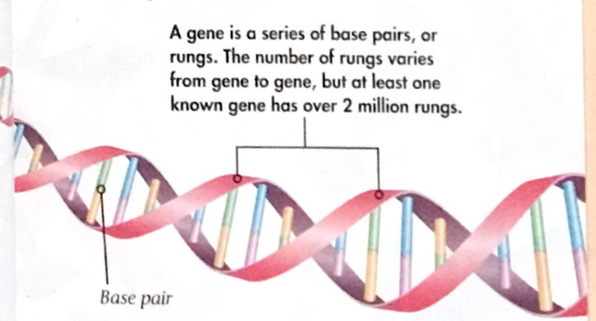


Scientists have been able to see chromosomes for more than 100 years. But until the 1950s, no one understood the importance of DNA. Around that time, the works of several scientists were used to show that DNA carries all the instructions for a cell. Their works also showed that DNA is passed from a parent cell to its offspring.

In 1953 two scientists, James Watson and Francis Crick, described the structure of DNA. To do this, they used X-ray photographs made by Rosalind Franklin, an English chemist. If you looked at a strand of DNA, you would see that it looks like a twisted ladder. This "ladder" contains millions of "rungs." These rungs are made up of just four kinds of materials, called bases. The bases are known by the letters *A*, *T*, *C*, and *G*. Each rung is made up of two bases, called base pairs.

The DNA of a chromosome is divided into sections called genes. A **gene** is a series of base pairs, or rungs. The number of rungs varies from gene to gene. One known gene has over 2 million rungs. Each gene controls what substances the cell makes and when it makes them. These substances determine an organism's traits. For example, the genes in the cells of a rose determine the plant's flower color by telling the flower cells what pigments to make.

1. **Checkpoint** What is a gene?
2. **Technology in Science** Use the Internet to find out how Watson and Crick used Franklin's X rays to figure out the structure of DNA.



A gene is a series of base pairs, or rungs. The number of rungs varies from gene to gene, but at least one known gene has over 2 million rungs.

How Many Chromosomes?

Members of the same species have the same number of chromosomes. That's because each species has its own unique number of chromosomes. As you can see from the pictures, the number of chromosomes each cell of a species has tells you nothing about the size of the individuals.

Gorilla: 48 chromosomes, two more than each human cell

Crayfish: 200 chromosomes

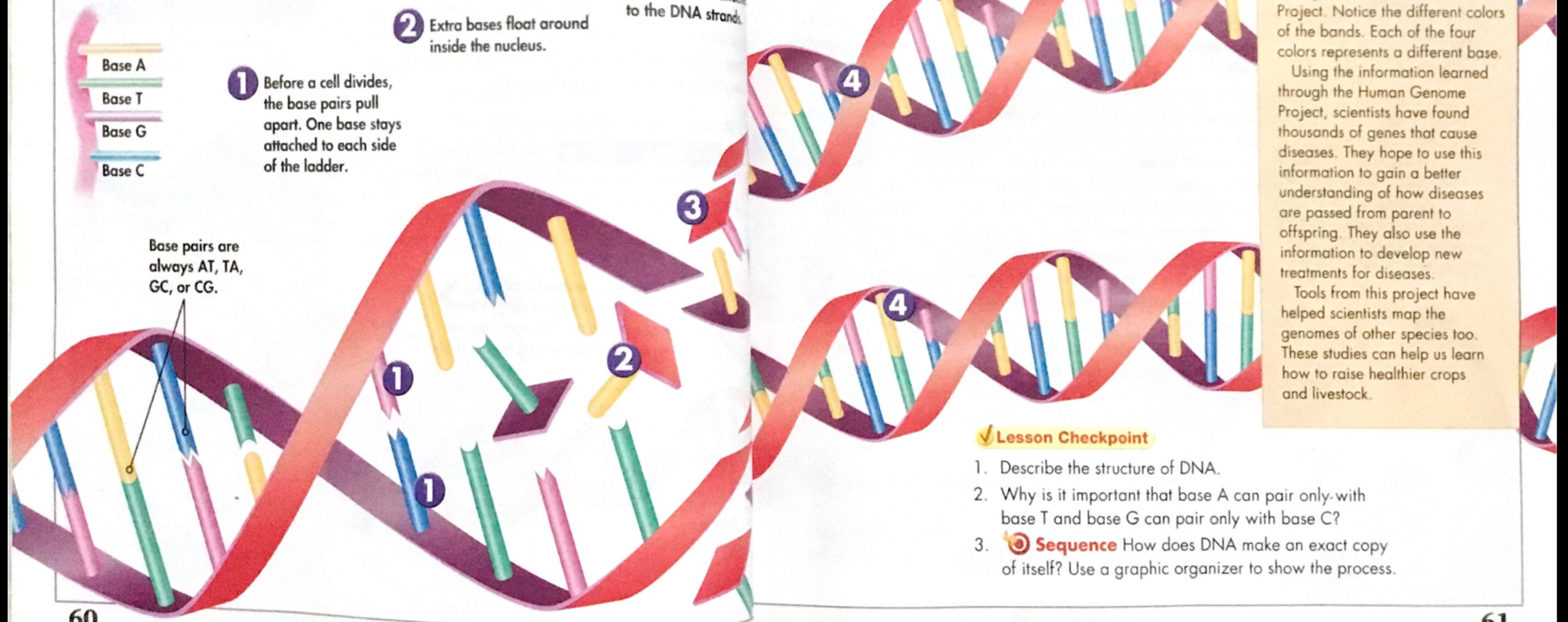
Horsetail: 216 chromosomes

This baby camel has a condition called albinism. Its white coloring is caused by a change in the gene that is responsible for making the substances that produce pigments.

Copying DNA

The DNA of all living things is made up of pairs of the same four bases. Notice in the diagram that the order of the base pairs varies from place to place on the DNA ladder. The order determines exactly what instructions each gene gives to an organism's cells. For example, an arrangement of TA-CG-GC-TA will give different instructions than an arrangement of TA-AT-GC-TA. Different organisms have different arrangements of base pairs. That's what makes organisms different.

Two bases fit together to form each rung, but they fit together only in certain ways. Base T can only pair with base A, and bases G and C can only pair with each other. This pairing allows DNA to make an exact copy of itself when a cell divides through mitosis.



When a cell undergoes mitosis, its DNA "unzips," and the base pairs come apart. Free-floating bases within the cell's nucleus pair with the separated bases on the DNA strand. The process continues until two complete double strands of DNA are formed. The two strands are identical to the original DNA. In this way, an organism that reproduces asexually gives exact copies of its genes to each new cell.

Sometimes an error occurs, and a strand of DNA does not make an exact copy of itself. A base might be added or deleted, or one base may replace another. This change is called a mutation. A mutation can change the instructions a gene sends. Sometimes a changed gene is passed to an organism's offspring.

The Human Genome Project

In 1990 a group of scientists set out to map all the genes that make up the human chromosomes. A map of the full set of genes that make up a species is called a genome. By 2003 this team had charted the more than three billion base pairs that make up more than 30,000 genes in human DNA.

The computer screen display above shows part of a human DNA strand that was mapped during the Human Genome Project. Notice the different colors of the bands. Each of the four colors represents a different base.

Using the information learned through the Human Genome Project, scientists have found thousands of genes that cause diseases. They hope to use this information to gain a better understanding of how diseases are passed from parent to offspring. They also use the information to develop new treatments for diseases.

Tools from this project have helped scientists map the genomes of other species too. These studies can help us learn how to raise healthier crops and livestock.

Lesson Checkpoint

1. Describe the structure of DNA.
2. Why is it important that base A can pair only with base T and base G can pair only with base C?
3. **Sequence** How does DNA make an exact copy of itself? Use a graphic organizer to show the process.

Lesson 3

What is sexual reproduction?

Only one of these sperm cells can fertilize this egg.

During sexual reproduction, organisms get genes from two different parents. When that happens, the organism shares some traits with each parent.

Reproduction by Two Parents

You know that asexual reproduction results in two cells with the same DNA as the parent cell. Have you ever seen a mother cat and her kitten? You probably noticed that the kitten didn't look exactly like its mother. That is because cats produce offspring by **sexual reproduction**, or reproduction by two parents. The kitten gets half its DNA from one parent and half from the other. How does that work?

Living things that reproduce sexually have special cells called sex cells. The sex cells of the female parent are called **egg cells.** The sex cells of the male parent are called **sperm cells.** Sex cells have only half as many chromosomes as other cells in the organism's body. For example, the body cells of a house cat each have 38 chromosomes. But a cat's sex cells each have only 19 chromosomes.

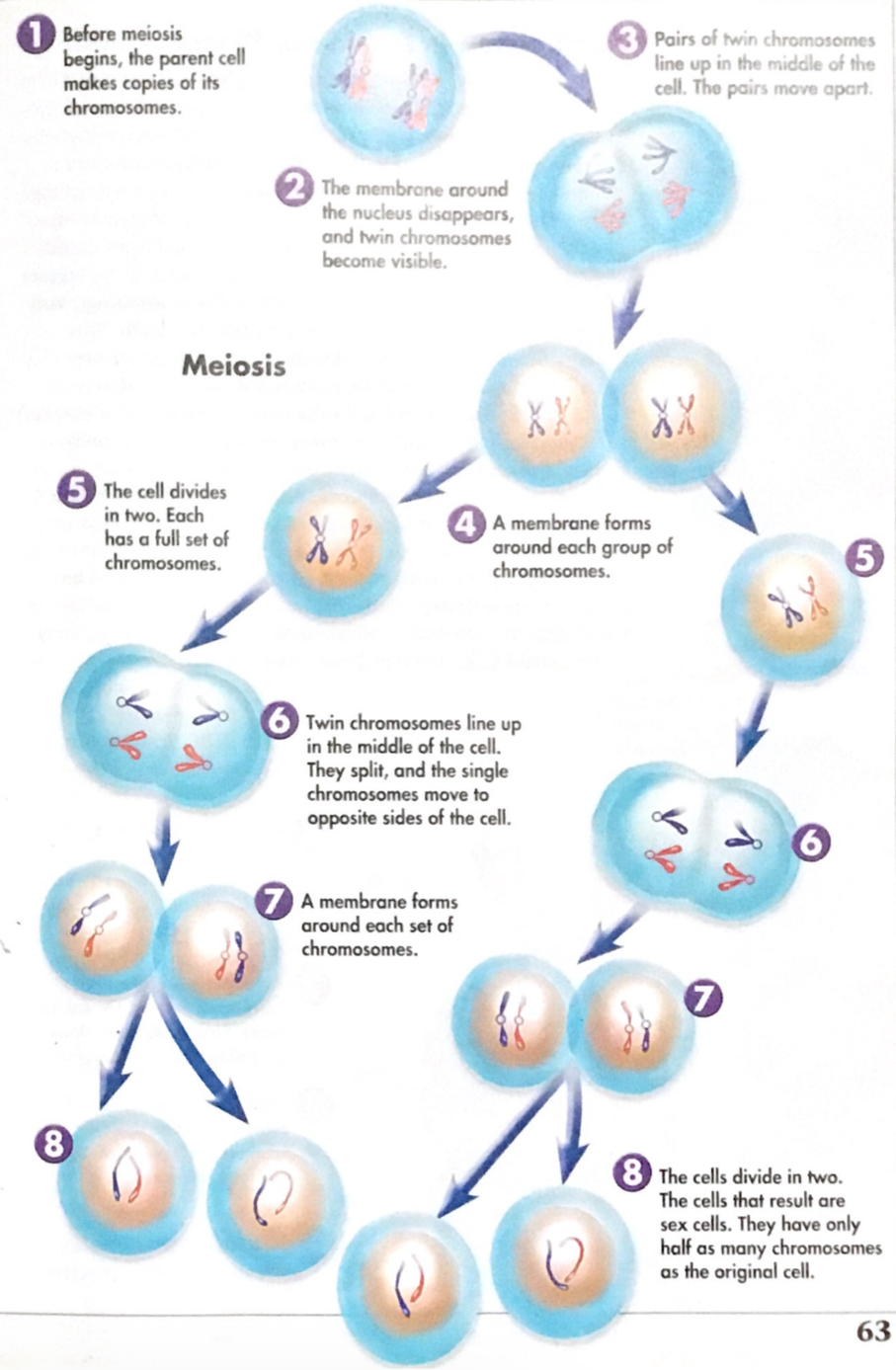
Sex cells form by a process called **meiosis.** In meiosis, one cell divides into four new cells. Each new cell has only half the number of chromosomes as the parent cell. Study the diagram on the next page to see how this happens.

During sexual reproduction, the male cell and the female cell join in a process called **fertilization.** During fertilization, an egg cell and a sperm cell unite to form a new cell. This cell, called a zygote, is the first cell of a new organism. Since each sex cell has only half the usual number of chromosomes, the new organism receives a complete set. The zygote will divide by mitosis to form the many cells that make up the adult body of the organism.

These offspring were produced by sexual reproduction.

1. **Checkpoint** How are sex cells different from other cells in an organism?
2. **Math in Science** A dog has 78 chromosomes. How many chromosomes would you expect to find in a dog's sex cells?

Meiosis



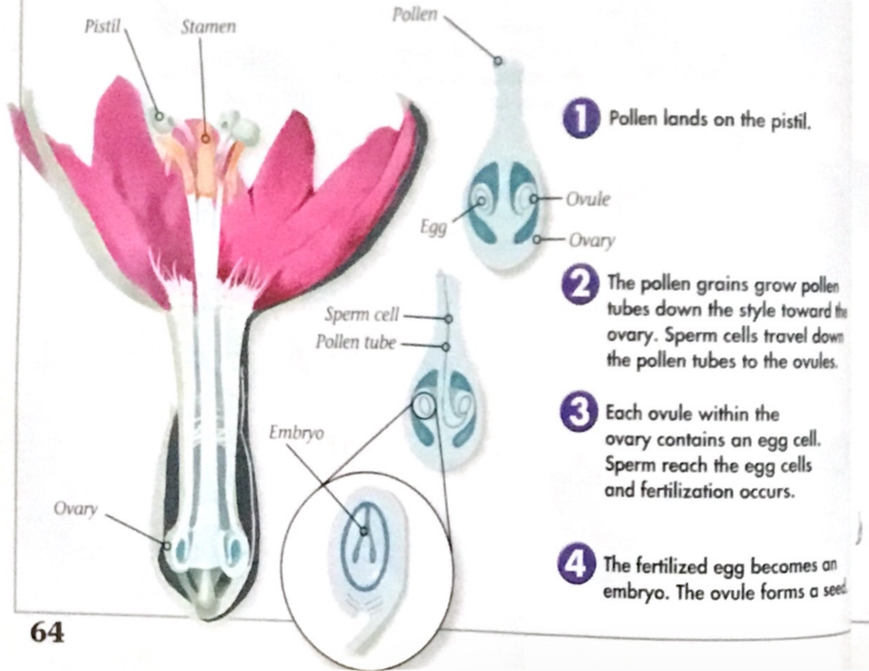
Fertilization in Flowering Plants

Red, blue, yellow, pink—these are just a few of the many colors that flowers come in. They come in a seemingly endless variety of shapes and sizes too. Why do flowers have so much variety?

A flower is an adaptation that allows a plant to reproduce sexually. In flowering plants, fertilization takes place within the flower. The male sex cells of flowering plants are in pollen—the powdery substance found on many flowers. Pollen is produced by the flower's stamen. The female egg is produced at the bottom of the female part of the flower—the pistil. For a flowering plant to reproduce, pollen must get from a stamen to a pistil. This process is called pollination. Look at the diagram to see how pollen gets from the top of the pistil to the egg of the flower.

A plant's flower is adapted for the way that pollination occurs. For example, some plants depend on insects to transfer pollen from a stamen to a pistil—either on the same plant or on different plants. These kinds of plants have flower adaptations that attract insects. The adaptations might be brightly colored petals or strong fragrances that appeal to insects. When an insect visits a plant, pollen can rub off onto the insect and be carried to other flowers. Birds and mammals can carry pollen too. Plants that depend on wind, water, or other sources to carry pollen would have different flower adaptations.

Compare the pollen from a goldenrod flower at the top with that of the lily on the bottom.



1. Pollen lands on the pistil.
2. The pollen grains grow pollen tubes down the style toward the ovary. Sperm cells travel down the pollen tubes to the ovules.
3. Each ovule within the ovary contains an egg cell. Sperm reach the egg cells and fertilization occurs.
4. The fertilized egg becomes an embryo. The ovule forms a seed.

Fertilization in Animals

When animals reproduce sexually, they too must join a sperm cell and an egg cell. Fertilization can take place inside or outside the body of the female.

Many animals that live in or near water use fertilization that takes place outside the female's body. This type of fertilization is called external fertilization. During external fertilization, animals release sperm and eggs into the water. The sperm swim to the eggs, and fertilization takes place. Each time a sperm and egg unite, a zygote forms and a new individual starts to develop.

The staghorn corals shown in the picture are animals that use external fertilization. They live in the waters around the Florida Keys, the Bahamas, the Caribbean Islands, and other areas of the world. In August or September of each year, they release sperm and eggs into the water at the same time. Billions of sperm and eggs can be released at one time.

Animals like the staghorn coral that use external fertilization usually produce large numbers of sperm and eggs. But only a few of the fertilized eggs will survive to become adults. Many will die because of environmental conditions, such as severe weather or pollution. Others will be eaten by predators.

External fertilization would be difficult for land animals because the sperm and eggs would dry out too quickly. For most species of animals that live on land, fertilization takes place inside the female's body.

Fertilized eggs also need moisture. In some animals, the zygote develops in the female's body where it is moist. Other animals, such as birds and turtles, have eggs with shells that protect the animals developing within the eggs from drying out. The shells also provide protection from other damage.

Staghorn coral

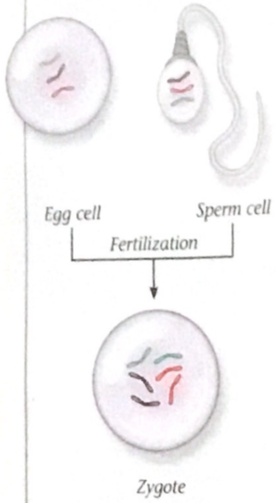
These dark gray eggs will protect the developing bird until it hatches.

1. **Checkpoint** What is the difference between internal fertilization and external fertilization?
2. **Sequence** Draw and label a picture of the parts of a flower. Then write the steps that happen between pollination and fertilization.

Individuals Differ

Unlike individuals produced by asexual reproduction, offspring produced by sexual reproduction share characteristics of both parents. Each individual has its own set of traits. The individuals may look very similar to their parents, but each has a unique set of DNA. Meiosis is the reason.

Recall that when male and female sex cells form by meiosis, each cell receives only half the DNA that is found in other cells of the individual's body. During fertilization, the sperm cell and egg cell unite, and the DNA of the two cells combines. The zygote that forms has a combination of DNA from the mother and the father. For example, the puppies in the picture have the same mother and father. How many differences can you see among the four puppies? Each puppy is unique because each is formed from the combination of a different sperm and egg. That means that each puppy inherited a different combination of DNA. Those different combinations give the puppies different characteristics.



Comparing Sexual and Asexual Reproduction

You might wonder which type of reproduction is better—sexual or asexual. The answer is that each type has both advantages and disadvantages.

Asexual reproduction is the simpler form of reproduction. It often can occur very quickly, producing many offspring in a short time. And one lone organism can reproduce even if the closest individual of its species is hundreds of kilometers away.

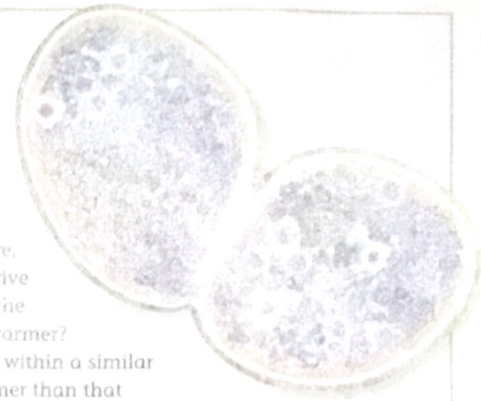
Asexual reproduction takes less energy than sexual reproduction. The reason is that in asexual reproduction, organisms do not have to use energy to make sex cells. This can be an advantage when energy-supplying food is scarce.

Puppies inherit some DNA from each parent. Notice that no two of the puppies look exactly alike.

Because all organisms produced by asexual reproduction have the same DNA as the parent cell, their survival in an environment may be threatened if conditions change. Think about a group of amebas living in a pond. Suppose most of the amebas are offspring of the same parent ameba. Those amebas will have identical DNA and, therefore, the same traits. The traits enable them to survive in their environment. What would happen if the water the amebas lived in suddenly became warmer?

Since the amebas are alike, all can only live within a similar temperature range. If the water becomes warmer than that range, all the amebas probably will die.

Now think about another group of organisms living in the same environment. The difference is that those individuals resulted from sexual reproduction. Each individual has traits that are slightly different from those of other individuals. Some may be able to survive in water that is a little warmer or a little cooler. When a temperature change happens, some individuals have a better chance to survive and reproduce. They will be able to pass on this trait to their offspring, who also will be able to live in the warmer water. In other words, individuals who have traits that make them most suited to the environment survive to pass the traits on to offspring.



Paramecia can reproduce very quickly through asexual reproduction.

Asexual Reproduction	Sexual Reproduction
• Can happen quickly	• Is a slow process
• Requires less energy	• Requires more energy
• Needs just one parent cell	• Must have two parent cells
• Produces offspring with DNA identical to parent	• Produces offspring with unique DNA

Lesson Checkpoint

1. Why is each individual produced by sexual reproduction unique?
2. What are some advantages of asexual reproduction?
3. Writing in Science **Expository** Some species, such as sponges, can reproduce both sexually and asexually. Write a paragraph that explains how being able to reproduce both ways might help these species' survival. Use the terms *DNA*, *traits*, and *environment*.

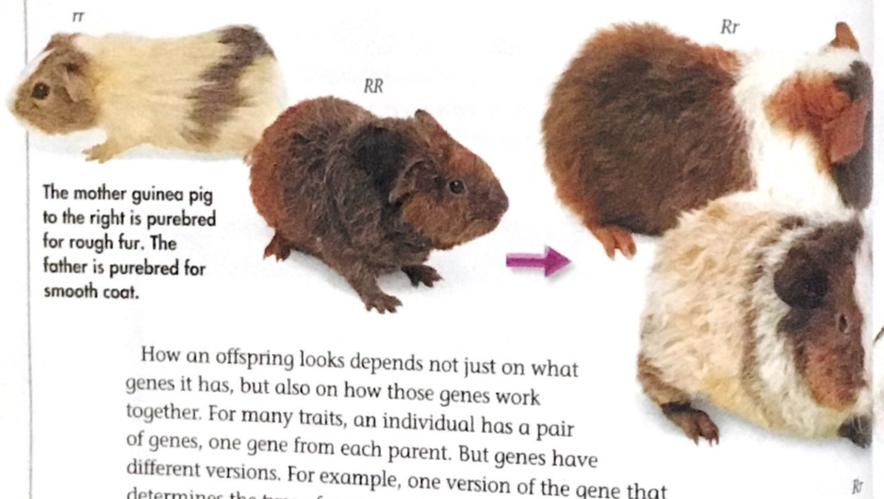
Lesson 4

How do genes determine traits?

Genes work together to determine individual traits. Scientists can use what they know about how genes work to produce organisms that are more useful.

Dominant and Recessive Traits

An individual formed by sexual reproduction gets traits from both parents. What determines which trait will show up in offspring? For example, the parent guinea pigs shown on the left have two different types of fur. One parent has smooth fur. The other has rough fur. What kind of fur will their offspring have?



The mother guinea pig to the right is purebred for rough fur. The father is purebred for smooth coat.

The offspring of the mother and father are hybrid

How an offspring looks depends not just on what genes it has, but also on how those genes work together. For many traits, an individual has a pair of genes, one gene from each parent. But genes have different versions. For example, one version of the gene that determines the type of coat in guinea pigs is for smooth coat. The other version is for rough coat. When the two different versions of a gene occur together, one version may show up. The other may not.

A version of a gene that masks the effect of another version is called a dominant trait. The trait that is hidden is called a recessive trait. In guinea pigs, rough fur is a dominant trait. Smooth fur is a recessive trait. That means an offspring with a version of the gene for rough fur and a version for smooth fur will have rough fur. The only way a guinea pig can have smooth fur is if both versions of the gene are for smooth fur.

Both versions of the gene for fur type in the mother guinea pig in the picture are dominant. These versions are represented by *RR*. Each *R* represents a gene for rough coat. The father's genes are both for smooth fur, which is shown as *rr*. An organism with two versions of a dominant trait or two versions of a recessive trait is called purebred for that trait.

Because guinea pigs reproduce sexually, each of their babies will get one dominant version of the gene, *R*, from the mother and one recessive version, *r*, from the father. The offspring's genes will be *Rr*, and they will have rough fur. An organism with one dominant and one recessive version of a trait is called a hybrid.

However, if two *Rr* guinea pigs mate, each baby can receive an *R* or an *r* from each parent. The offspring can have one of three possible gene combinations: *RR*, *Rr*, and *rr*. Only the *rr* combination will show up as a smooth coat.

When two hybrids produce offspring, there is only a 1-in-4 chance that offspring will have smooth fur.

1. **Checkpoint** What is a dominant trait?
2. **Art in Science** Gregor Mendel experimented with thousands of pea plants to study heredity. Find out about Mendel's famous pea plant experiments. Summarize your findings in a visual display.

Sharing Dominance

Not all gene pairs follow the dominant-recessive pattern. Some traits, such as the color of the Erminette chicken pictured below, show both versions of a gene at work. The chicken has genes for both black and white feathers. But neither color is dominant. Instead the colors share dominance.

As you can see in the diagram, the Erminette chicken was produced by a parent with white feathers and a parent with black feathers. The diagram is called a Punnett square. It is used to show all the possible offspring with a particular trait that can result when two individuals mate. In this Punnett square, one parent chicken was purebred for black feathers, which is represented by two genes for black feathers—*bb*. The other parent was purebred for white feathers—*ww*. The possible offspring from these two parents would all be hybrids. Each would have one gene for white feathers and one for black feathers—*bw*. Offspring with those two versions of the gene would have both black and white feathers like the Erminette chicken.

Black chicken

White chicken	*b*	*b*
w	*bw* Erminette	*bw* Erminette
w	*bw* Erminette	*bw* Erminette

What would happen if two Erminette chickens mated and produced offspring? Study the second Punnett square to find out.

Erminette

Erminette	*b*	*w*
b	*bb* Black chicken	*bw* Erminette
w	*bw* Erminette	*ww* White chicken

Erminette chicken

Now look at the Punnett square for color in four o'clock plants. One parent has red flowers, and the other has white. You probably would expect the offspring to have red or white flowers. But in this case, neither color is present in the offspring. Instead of red or white, the offspring are pink. Four o'clock plants do not follow the dominant-recessive pattern.

With some traits, such as color in four o'clock plants, the effects of two genes appear to blend. The red four o'clock parent and the white four o'clock parent produced pink offspring—a blending of the red and white colors of the parent plants.

But what would happen if the pink offspring reproduced? As you can see, the possible offspring could be red, white, or pink! Look at the second Punnett square to see how that could happen.

You can see a similar example in humans. A child of a straight-haired parent and a curly-haired parent will have wavy hair. Two parents with wavy hair can have children with wavy hair, straight hair, or curly hair.

Red flowers

White flowers	*r*	*r*
w	*rw* pink	*rw* pink
w	*rw* pink	*rw* pink

Pink flowers

Pink flowers	*r*	*w*
r	*rr* red	*rw* pink
w	*rw* pink	*ww* white

1. **Checkpoint** The offspring of two snapdragon plants with pink flowers had red flowers or white flowers. What can you infer from these results about how flower color is inherited in pink snapdragons? Draw a Punnett square to show your results.
2. **Math in Science** Suppose you had a group of hybrid guinea pigs, each with one gene for rough fur and one for smooth fur. If together they had 100 offspring, about how many of the offspring would you expect to have smooth fur?

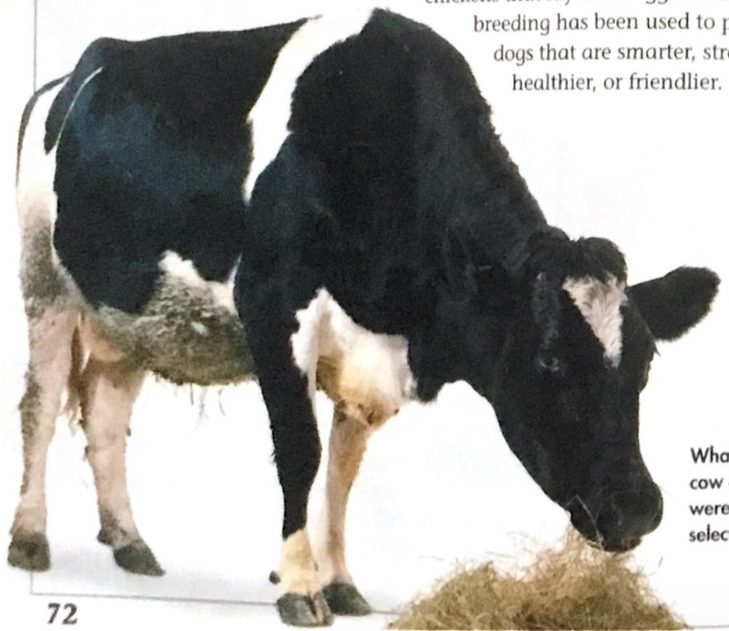
Choosing Traits

The corn we eat today is the result of selective breeding.

The familiar ear of corn shown to the left is probably not much like its wild ancestor. Around 8,000 to 10,000 years ago, people in what is now Mexico began to change a grass-like plant they had been gathering in nature for food. They did this by choosing and planting seeds from plants that had traits they liked. When the new plants produced seeds, the people again chose the best seeds. This process continued for many generations of plants. Over time, a plant that served as better food resulted—an early version of the corn we eat today. Selecting a few organisms with desired traits to serve as parents of offspring is called **selective breeding**.

People around the world use selective breeding to produce plants and animals with traits that are valuable to humans. Cows have not always produced as much milk as they do now. In the early 1800s, most dairy cows made only about 1,500 liters of milk a year. Today, some kinds of cows can make as much as 10,000 liters a year! Other kinds produce milk with certain traits, such as a high amount of fat. How did these changes happen? The traits were produced through selective breeding and better nutrition.

Selective breeding also helps produce crops with more food per plant. Many varieties of fruits and vegetables are bred to resist diseases, insect pests, and drought. People have raised chickens that lay more eggs. Selective breeding has been used to produce dogs that are smarter, stronger, healthier, or friendlier.



What traits of this cow do you think were produced by selective breeding?

Writings and sculptures of the Afghan hound date back to 3500 B.C. The Afghans of the deserts of Egypt were bred to hunt gazelle, deer, and leopards. In the mountains of Afghanistan, the Afghan hound was used to guard sheep and cattle. It also was a hunter of small game.

The Shetland sheepdog was developed in the Shetland Islands to help herd sheep. The winters on the Shetland Isles are long, and little plant life grows. The farmers of the area developed the Shetland sheepdog to herd sheep and to keep the gardens safe from the flocks.

Today's dogs come in many shapes and sizes—from the tiny Chihuahua to the large Saint Bernard. But they are also some of humans' oldest friends. Ancient clues in cave paintings and burials reveal that dogs and people have lived together for thousands of years. Dogs of many sizes and shapes appear in the archaeological records of almost all human cultures from thousands of years ago. Selected for hunting, herding, protection, companionship, or looks, dogs were welcomed into many homes.

Over the years, people have used selective breeding to produce the characteristics they choose. Most of today's almost 400 different dog breeds were produced after 1850.

Lesson Checkpoint

1. Explain how offspring can have traits that show both versions of a gene.
2. Why do people use selective breeding?
3. **Sequence** Explain the process of selective breeding.

Luther Burbank

In the history of selective breeding, perhaps no one has been more successful than Luther Burbank, who was born in Massachusetts in 1849. Luther Burbank developed more than 800 varieties of plants. You may have eaten some of the new varieties of plums, pineapples, walnuts, and almonds that he developed.

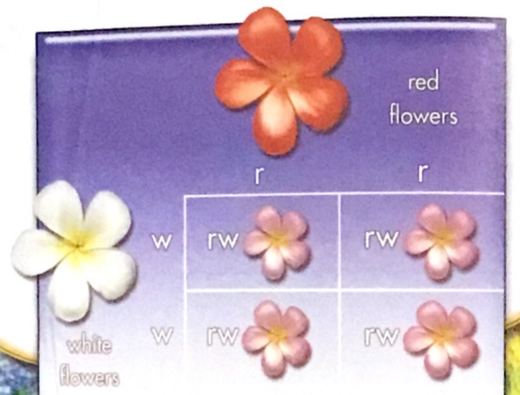
One of Burbank's most important successes was the development of the Burbank potato. At the time, the potato was an important food for many people in Ireland. When a disease called potato blight killed potato crops in Ireland for several years, these people did not have enough to eat. Eventually as many as one million people in Ireland died because of this potato disease. The Burbank potato was resistant to potato blight. It was shipped to Ireland to be planted in place of the diseased potatoes. The potato helped prevent even more deaths.

Math in Science

Probability of INHERITING TRAITS

You have learned how Punnett squares can be used to show the possible combinations of genes in the offspring of two organisms. They can help us answer questions about heredity in terms of probability or ratios. Remember, probabilities and ratios can be expressed as fractions or as percents.

The following Punnett square represents the possible offspring of two four o'clock plants, discussed earlier in this chapter. The Punnett square below shows the possible offspring of a red plant and a white plant. Remember, neither red nor white flowers are dominant.



The ratio of possible pink offspring to all offspring is 4:4, or $\frac{4}{4}$. We can also say that the probability of an offspring being pink is $\frac{4}{4}$, or 1. In other words, 100% of the offspring will be pink. The only possible gene combination for offspring of these two plants is *rw*.

It is likely that 1 out of 4 offspring will be red, 1 will be white, and 2 will be pink. The probability of an offspring being red is $\frac{1}{4}$. So, the probability that offspring will be red is 25%. The same can be said for white. The probability for pink offspring is $\frac{2}{4} = \frac{1}{2} = 50\%$.

The Punnett square above shows the possible offspring of two pink plants.

1. Make a Punnett square for the offspring of two guinea pigs, both with one gene for rough fur and one for smooth fur, as discussed earlier in this chapter. Let *R* = rough fur, *r* = smooth fur, and *Rr* = rough fur, because rough fur is dominant.

Use the Punnett square you made to answer these questions. For Questions 2 and 3, give each answer as a fraction and as a percent.

2. What is the probability of an offspring having smooth fur?
3. What is the probability of an offspring having rough fur?
4. What is the ratio of the possibility of offspring with rough fur to the possiblity of offspring with smooth fur?

Lab zone Take-Home Activity

Use a library or the Internet to research various human traits, such as being left-handed or right-handed or having blue eyes or brown eyes. Write a report about your findings, including the probability of at least one possible outcome for a given situation.

Chapter 3 Review and Test Prep

Use Vocabulary

asexual reproduction (p. 56)	**meiosis** (p. 62)
egg cell (p. 62)	**selective breeding** (p. 72)
fertilization (p. 62)	**sexual reproduction** (p. 62)
genes (p. 59)	**sperm cell** (p.62)
heredity (p. 55)	

Write the vocabulary word from the list above that best completes each sentence.

1. During _____, a sperm cell joins with an egg cell.
2. The process of selecting a few organisms with desired traits to serve as parents of offspring is called _____.
3. An organism uses _____ to produce offspring by itself.
4. Sex cells are created by a process called _____.
5. A male's sex cell is called a(n) _____.
6. Offspring receive DNA from two parents through _____.
7. The passing of traits from parent to offspring is called _____.
8. A(n) _____ is a female's sex cell.
9. Chromosomes are divided into sections of DNA called _____.

Explain Concepts

10. Explain why sex cells have only half as many chromosomes as the other cells in an organism's body.
11. Why don't offspring of two parents look exactly like either parent?
12. The Punnett square below shows the possible offspring for two parent guinea pigs. Parent A is hybrid for rough fur. Parent B has smooth fur. What percentage of the possible offspring are likely to have smooth fur?

		Parent A: *R*	Parent A: *r*
Parent B	*r*	*Rr*	*rr*
Parent B	*r*	*Rr*	*rr*

Process Skills

13. **Predict** Species A lives successfully in a cornfield. It reproduces asexually. Species B, which reproduces sexually, also lives in the cornfield. Which species would be more likely to survive in that cornfield if a drought hit the area one season? Explain your answer.
14. **Infer** What kind of reproduction—sexual or asexual—is happening in the bacterium in the picture? How do you know?

Sequence

15. Make a graphic organizer like the one below. Fill in the steps to show what happens when DNA copies itself.

First, base pairs pull apart. One base stays attached to each side of ladder

↓

Next,

↓

Finally,

Test Prep

Choose the letter that best completes the statement or answers the question.

16. All living things share the same
    - Ⓐ dominant genes.
    - Ⓑ way of producing offspring.
    - Ⓒ number of chromosomes.
    - Ⓓ four bases in their DNA.
17. A dog may inherit the potential to grow to 22 kg but may not reach that weight because of its
    - Ⓕ genes.
    - Ⓖ environment.
    - Ⓗ learning.
    - Ⓘ parents.
18. One advantage of sexual reproduction is
    - Ⓐ speed of reproduction.
    - Ⓑ variation among offspring.
    - Ⓒ identical DNA.
    - Ⓓ better base pairs.
19. Explain why the answer you chose for Question 16 is best. For each of the answers you did not choose, give a reason why it is not the best choice.
20. **Writing in Science** **Expository** Write a summary of what happens when the genes that determine the color of flowers share dominance. Explain how you could prove that the flowers' traits are determined by two different genes.