Life Science Study Guide

METHODS OF REPRODUCTION

Asexual Reproduction

In Lesson 8, you learned about the cell cycle. Cell division, an important part of that cycle, enables multicellular organisms, such as humans, to grow by producing more cells. For single-celled organisms, cell division is often the only method of reproduction. Cell division does not involve the union of male and female sex cells. When new organisms are formed from a single parent, without the union of male and female sex cells, the process is known as "asexual reproduction." Asexual means "without sex."

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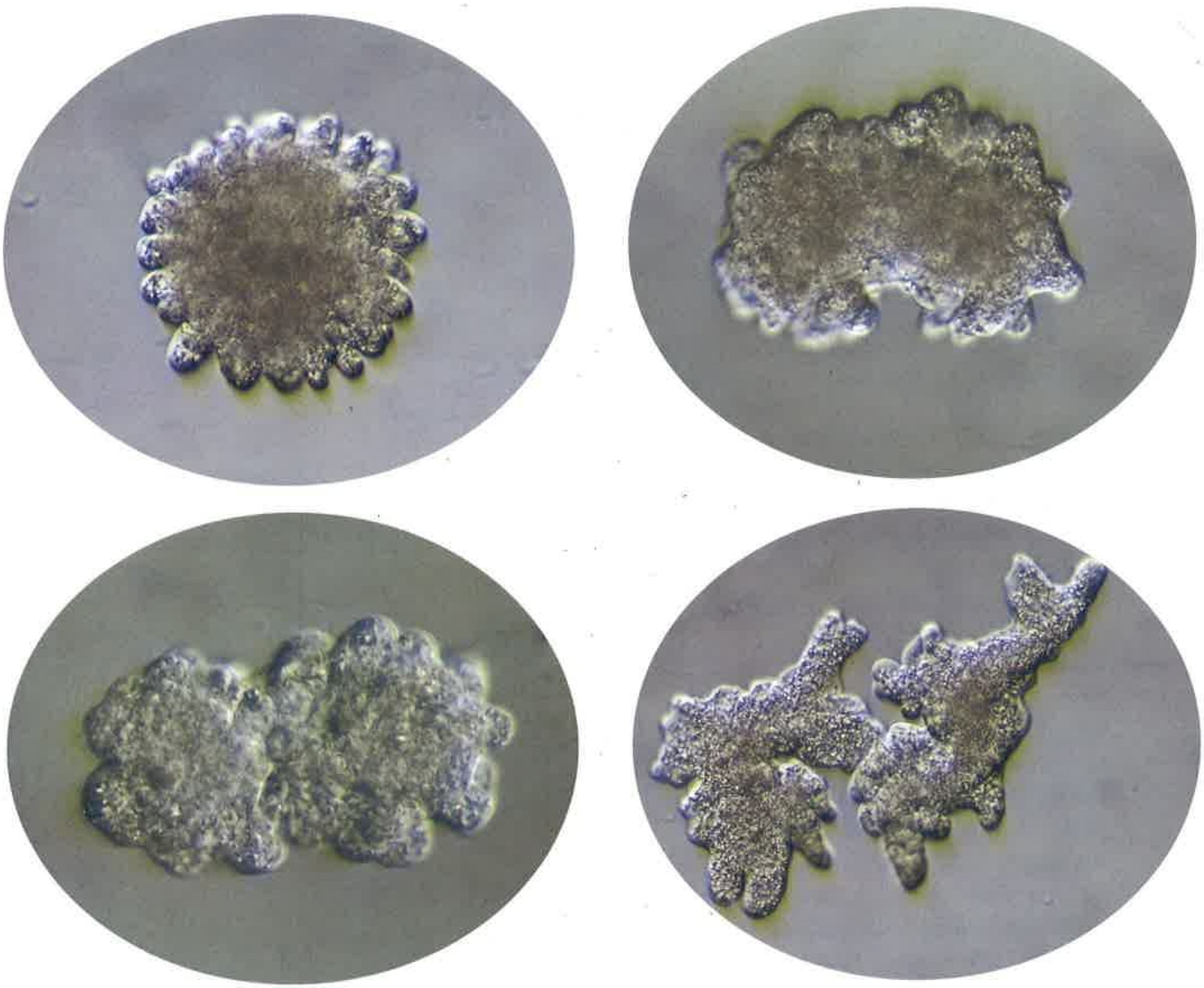
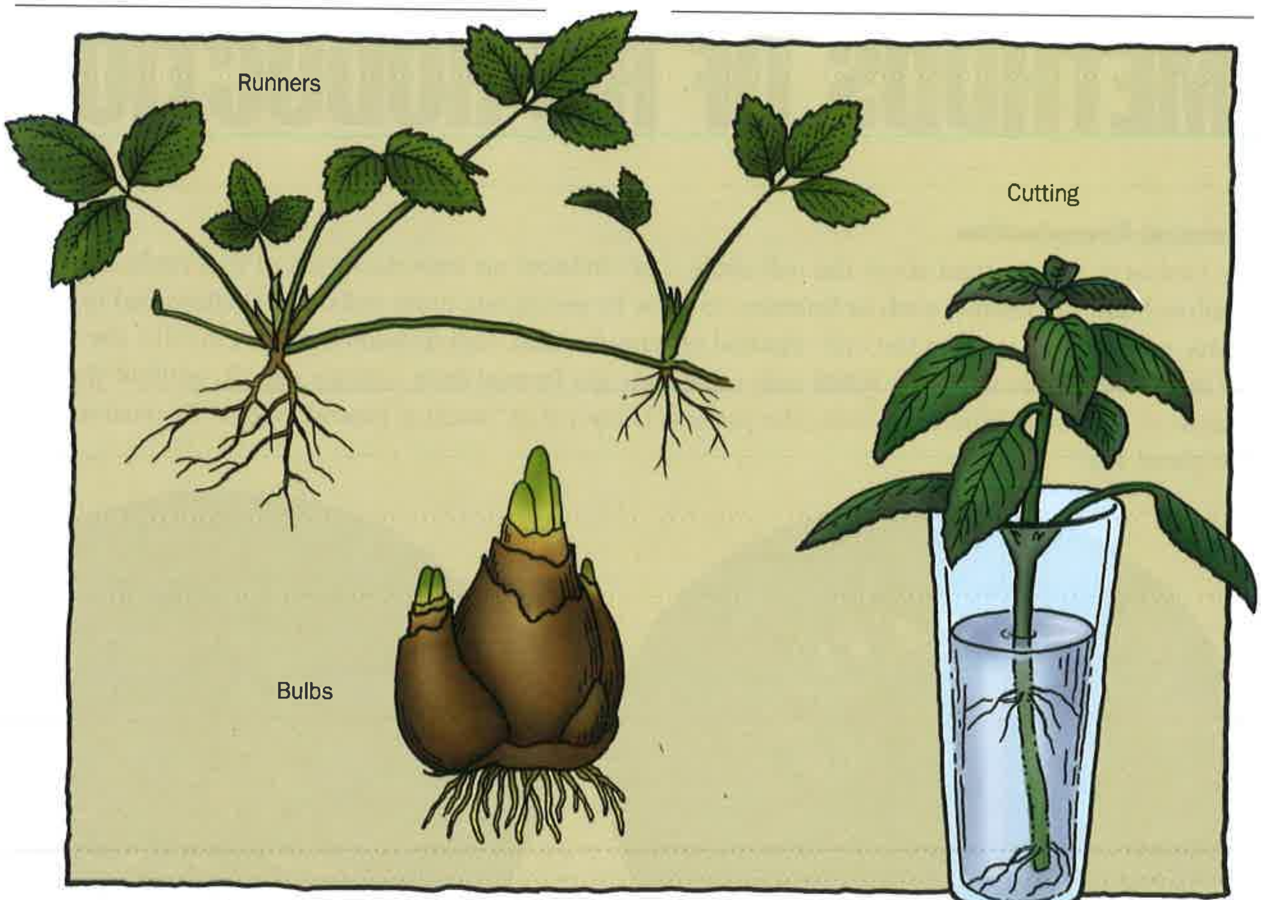


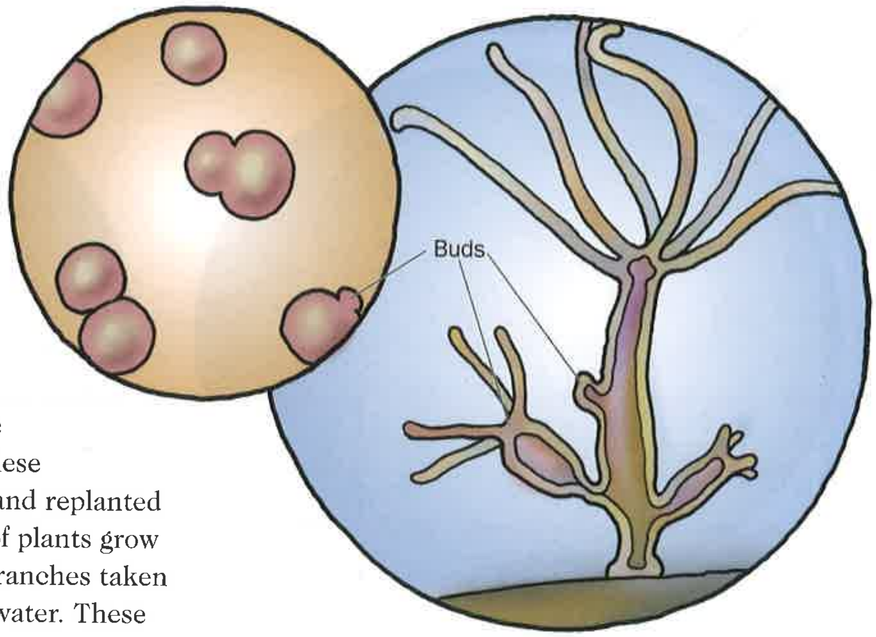
This is an amoeba reproducing by fission, a form of cell division and asexual reproduction.



These forms of asexual reproduction in plants are types of "vegetative propagation."

Many multicellular organisms, including many species of plants, also reproduce asexually. Strawberry plants, for example, develop overground stems called runners, which run over the ground for a short distance, touch down and take root, and grow into new strawberry plants. Some plants, such as tulips, grow thick daughter bulbs beside the parent bulb underground. These bulbs can be dug up, separated, and replanted to grow new tulips. Many kinds of plants grow new plants from small twigs or branches taken from them and placed in soil or water. These pieces are called "cuttings."

Some organisms, such as the single-celled yeast and the multicellular *Hydra,* reproduce asexually by a process known as "budding."



The outgrowths on these organisms, called buds, are formed through cell division. The buds eventually will break off and become self-sufficient.

Asexual reproduction has advantages and disadvantages. On the one hand, it is convenient because it requires only one parent. The quality of an organism that results from asexual reproduction will remain more or less the same. For example, if a plant has fruit or flowers of exceptional quality, the quality of the fruit and flowers can be maintained over time through asexual reproduction. On the other hand, in nature, there are rarely improvements in a plant produced through asexual reproduction. Thus, if a plant has fruit or flowers of average or poor quality, so too will any plant produced from it by asexual means.

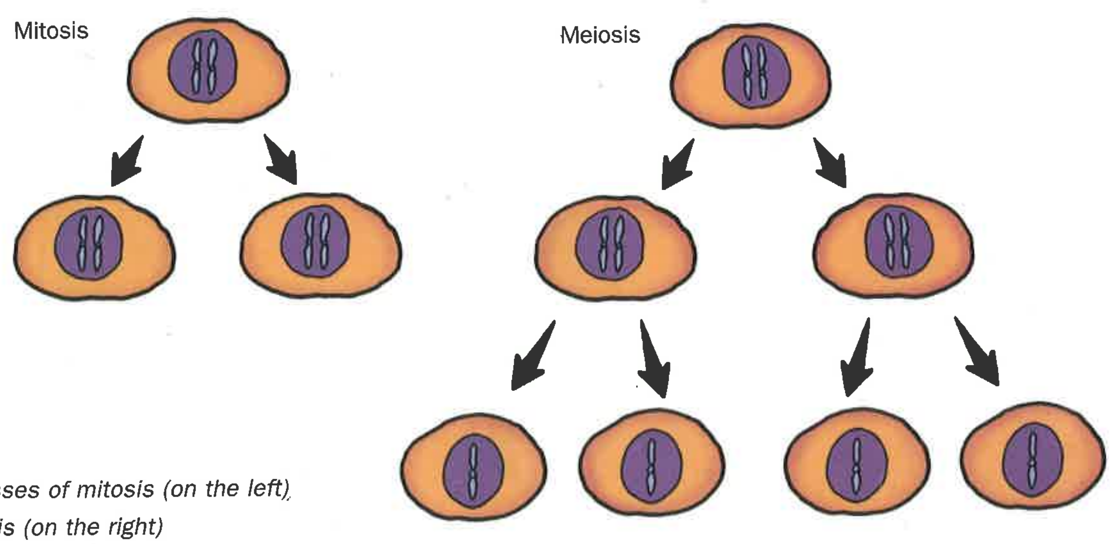
Sexual Reproduction

Many life processes enable an organism to live and grow. Reproduction enables a species to produce more of its own kind and persist through time. Sexual reproduction is accomplished through the union of a male sperm and a female egg, sex cells that form through a process called "meiosis."

Meiosis begins like cell division does: a cell that is destined to be a male or female sex cell divides, resulting in two cells that are genetically identical to it. But in meiosis, a second nuclear division follows, with each of the two daughter cells dividing again. During this second division, the members of each pair of chromosomes separate and each moves into one of the new cells. This means that the new sex cells—the male (sperm) or female (egg) cells—contain only half the number of chromosomes as do regular body cells. They also are no longer genetically identical. The same basic process of meiosis occurs in all animals and in flowering plants.

For example, Wisconsin Fast Plants cells normally have 10 pairs of chromosomes (a total of 20 chromosomes). When pollen grains (the male sex cells) or ovules (the female sex cells) are formed, each has only 10 single chromosomes. When fertilization takes place, the pollen grain contributes 10 chromosomes and the ovule contributes 10 chromosomes. The resulting seed has the normal 10 pairs of chromosomes. If the number of chromosomes in the sex cells were not halved, organisms would double their number of chromosomes every generation. After a few generations, this would result in very large numbers of chromosomes. Thus, meiosis serves to keep the number of chromosome pairs stable over time. Since heredity is determined by sections of the chromosomes called genes, it is this pairing up of chromosomes from different parents during sexual reproduction that makes each organism genetically unique among its species.

Your Fast Plants reproduce sexually. However, before they can do so, another process must first occur, as you will discover in this lesson. □

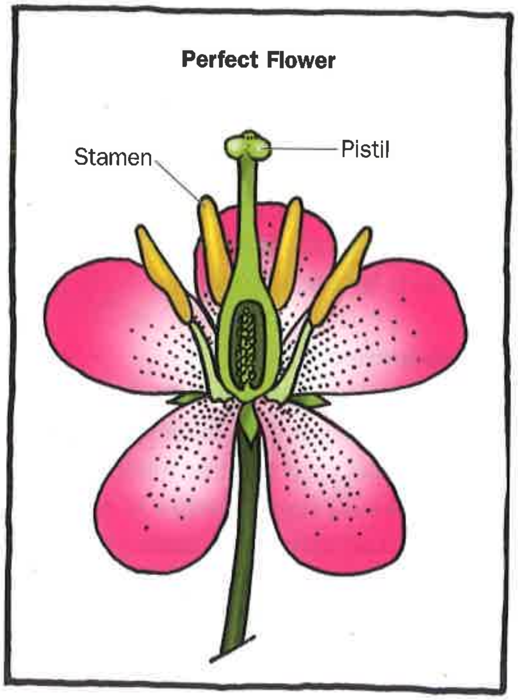


The processes of mitosis (on the left) and meiosis (on the right)

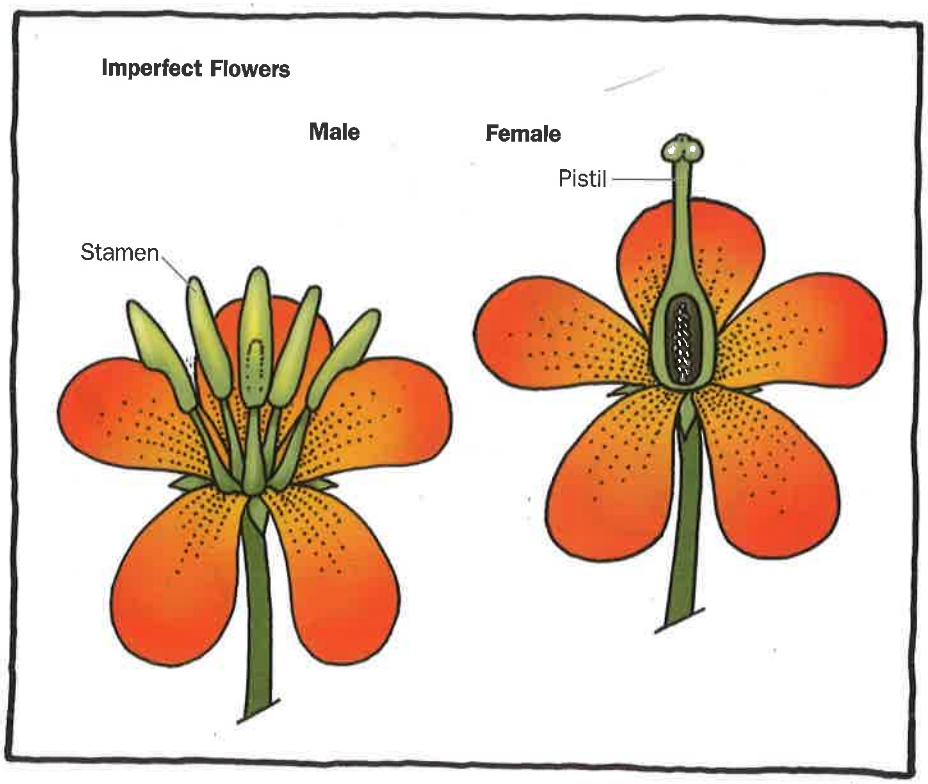
The Wonder of Flowering Plants

It takes both male and female sex cells to create a human being, through a process called "sexual reproduction." The same is true for many flowering plants. The flower is the reproductive organ of a flowering plant.

Within the flower are male structures called "stamens" and one or more female structures called "pistils." The stamen consists of the anther, which produces the pollen, and the filament, which supports the anther. The pollen contains the sperm nuclei. At the top of the pistil is the sticky stigma, which is supported by a structure called a style. At the bottom of the style is the ovary, which produces the eggs (ovules). Each egg contains an egg nucleus.



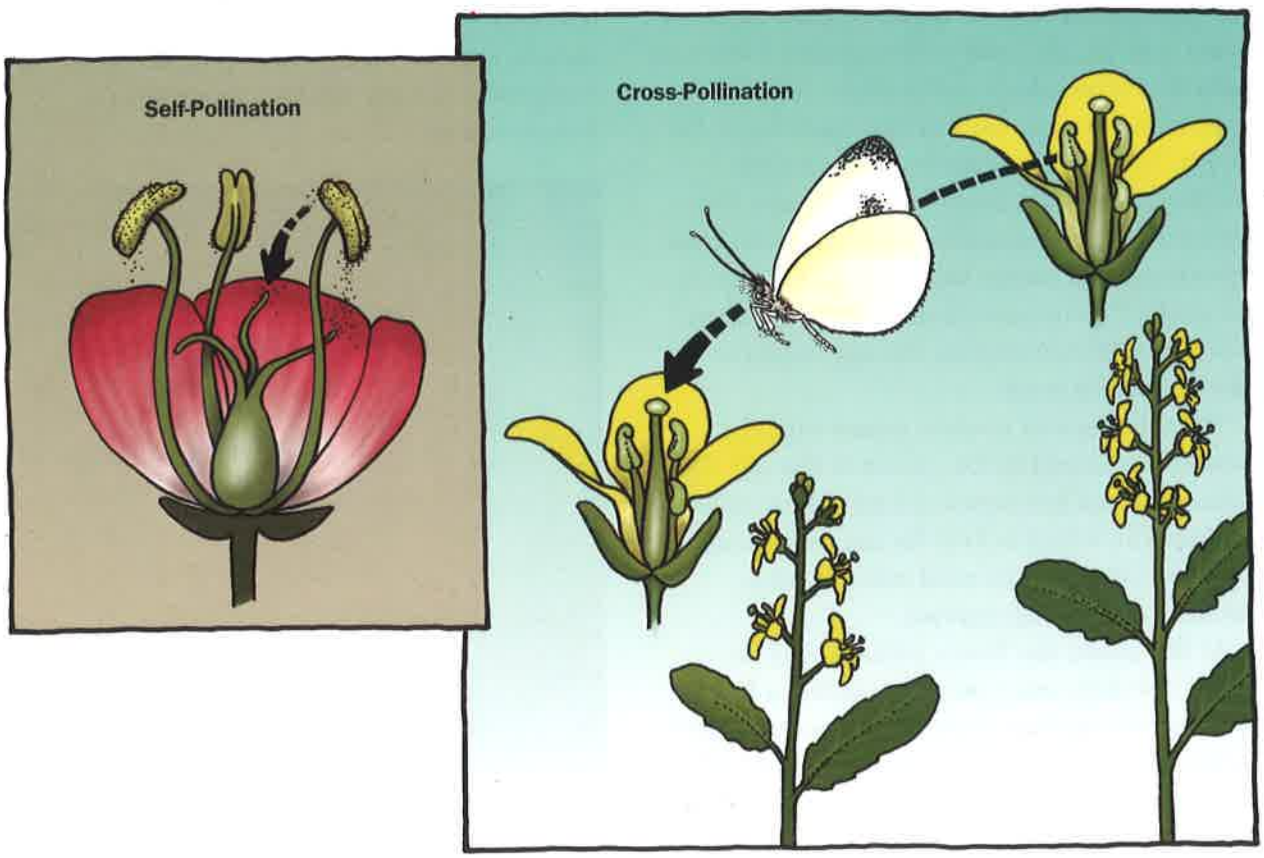
Some species of plants have flowers that include both male and female structures—that is, both stamen and pistil. Others have only the male or female structure. A flower that has both a male and female reproductive structure is called a "perfect flower." A flower that has only male or female reproductive structures is referred to as an "imperfect flower." (These names are historical ones. Perhaps if we named them now, we'd use the terms "complete" and "incomplete.") The illustration shows a perfect flower on the top and two imperfect flowers on the bottom.

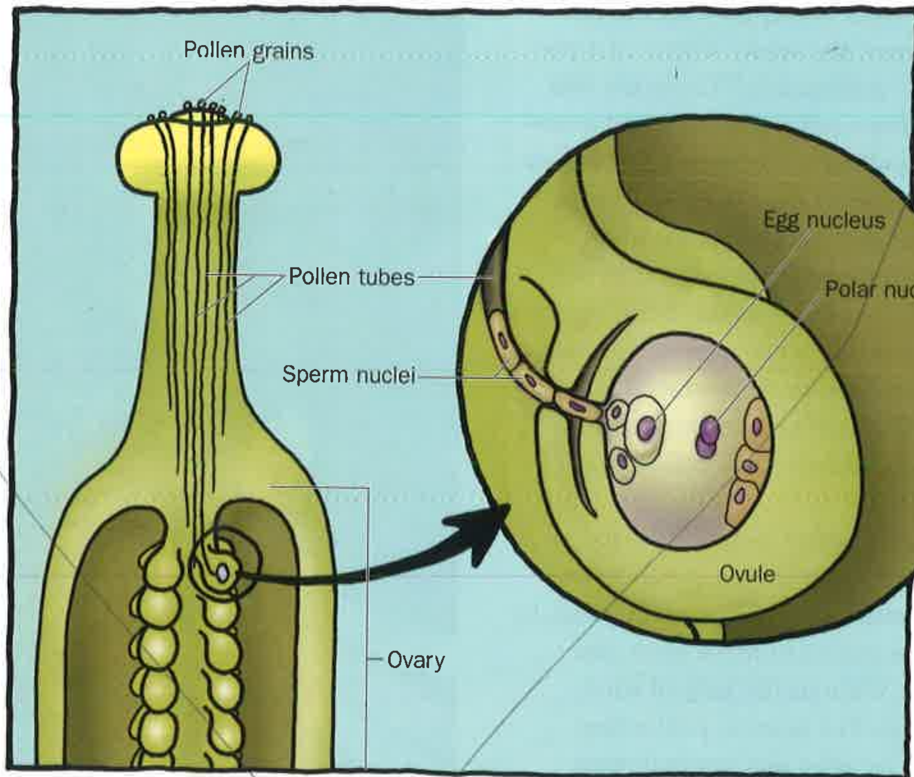


For a plant to make seeds, pollen from an anther must contact the sticky stigma of a pistil. This is called "pollination." There are two kinds of pollination—self-pollination and cross-pollination. Self-pollination occurs when pollen is transferred to the stigma of a flower on the same plant. Cross-pollination occurs when pollen is transferred to the stigma of a flower on another plant of the same species. Some species of plants, such as Fast Plants, cannot self-pollinate. In order for seeds to be produced in Fast Plants, cross-pollination must occur. In general, plants that cross-pollinate need pollen from their own species.

Self-pollination is pretty simple. Gravity, an insect, a gust of wind, or even a raindrop can accomplish the task easily. Cross-pollination, by contrast, requires pollen to move from one plant to another. Without the help of wind, water, and animals like insects, pollination would not occur as often and many flowers would fail to make seeds. Without seeds, there would be fewer new plants.

Notice the many pollen grains sticking to the hairs on the bee's body.





Pollen grains generally contain three nuclei—two sperm nuclei and one tube nucleus. When the pollen lands on the stigma of a flower of the same species, the tube nucleus begins forming a tube that grows down to the ovary. The two sperm nuclei then move down the tube to the ovary. The waiting ovule contains an egg nucleus, two polar nuclei that fuse, and five other nuclei that eventually disintegrate. One sperm nucleus unites with the egg nucleus in an ovule. This process is called "fertilization." After fertilization occurs, the egg begins to develop into a seed.

The other sperm nucleus unites with the fused polar nuclei in the center of the egg. This stimulates the formation of a substance called endosperm, which is food for the developing embryo. One or more seed coats develop around the growing embryo.

At this point, the flower withers, and the ovary develops into a structure called a fruit. Some fruits, such as cherries and oranges, are edible by humans, and some, such as the dry pods of the Fast Plants, are inedible. The fruit helps protect the seeds and serves as a way to disperse them. Some fruits, like cherries, contain only one seed; others, like oranges and squash, contain many seeds. A squash, cut lengthwise, has the familiar shape of most flower ovaries.

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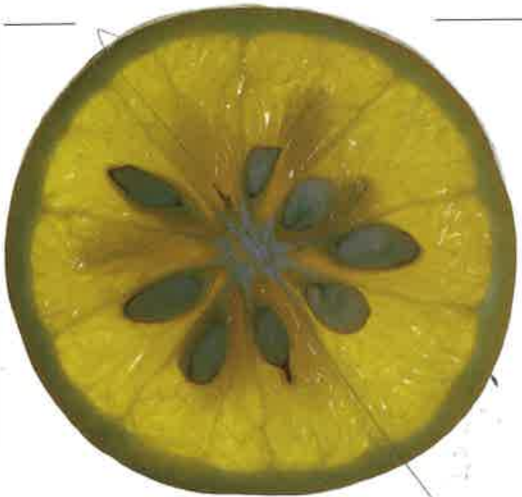
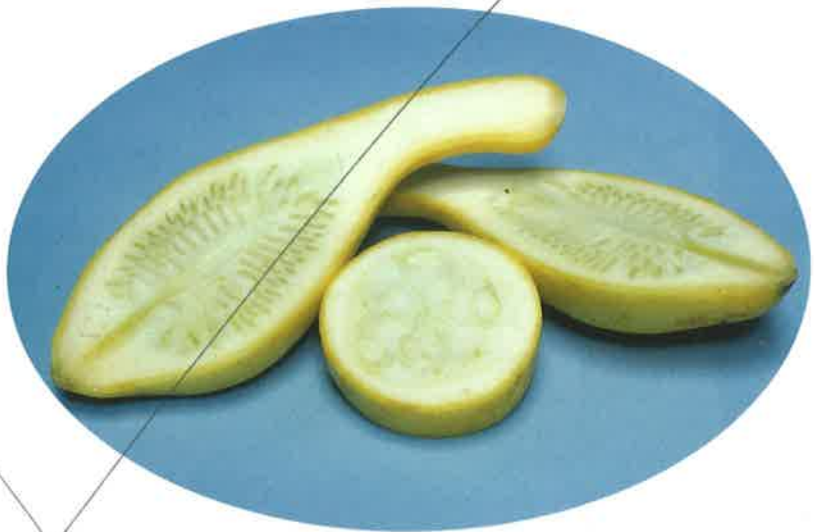
There was only one seed in this dissected cherry.

TOP PHOTOS COURTESY OF CAROLINA BIOLOGICAL SUPPLY COMPANY



Notice the orderly arrangement of seeds in this orange slice.



The squash, cut lengthwise, retains the original shape of the ovary. It's larger now because of the stored food.

SMITHSONIAN INSTITUTION, ARCHIVES OF AMERICAN GARDENS, MARY LIVINGSTON RIPLEY CENTER

While flowers are necessary for sexual reproduction in many plants, they also provide us with a source of natural beauty.

Because a flower's real function is to promote pollination, fertilization, and seed production, it is not surprising that flowers have developed many ways to make these processes more efficient. Since plants are rooted and cannot move about, flowers have adapted in ways that encourage visits by potential pollinators, such as bees or hummingbirds. In some ways, flowers are like people. When people want to attract attention, they may wear cologne and put on bright, colorful clothes. Some flowers, too, have strong scents and a rainbow of colors that attract attention from bees, butterflies, and other animals. ☐

LESSON **10**

Leaf Structure and Transpiration

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Leaves provide food and shade as well as fun, but what function do they serve for the plant?

INTRODUCTION

Have you wondered what happens to all that water that disappears from the reservoir of your growing system? Although some might have evaporated from the soil, you are probably aware that much of it is absorbed by the roots of your Fast Plants. But where does it go from there? Is it all used by the plant? Does any water escape from your plants? If so, how? Let's find out.

OBJECTIVES FOR THIS LESSON

Determine the change in volume of nutrient solution in the reservoir of your growing system over 24 hours.

Determine whether there is a relationship between the volume of nutrient solution that passes through your Fast Plants growing system in 24 hours and the number of leaves on the plants.

Observe and draw a stomatal unit from the epidermis of a lettuce leaf.

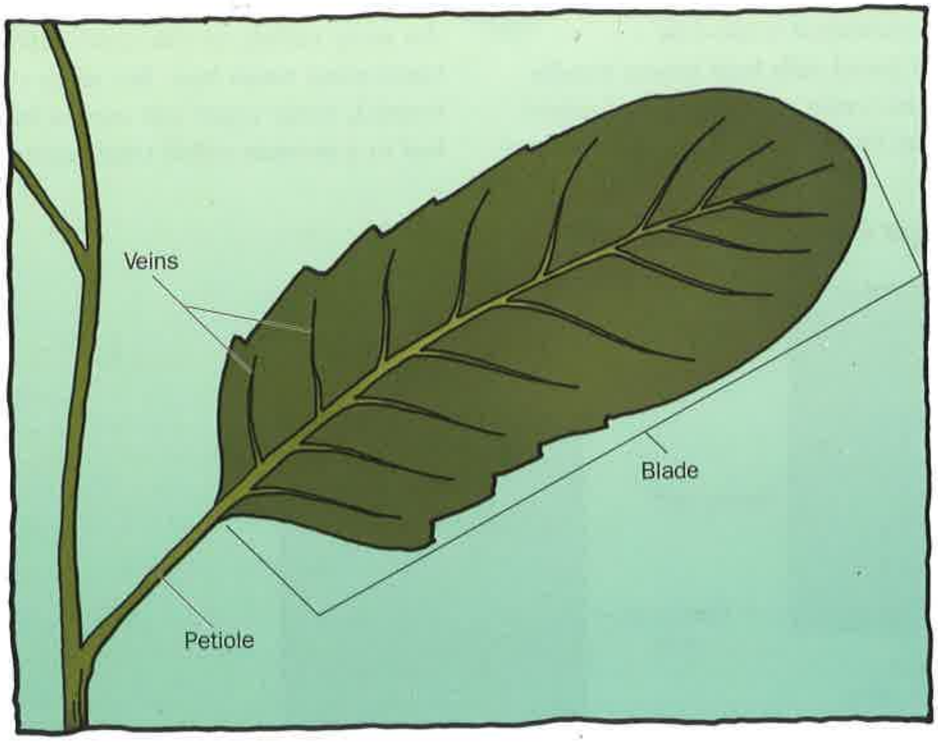
Use a model to demonstrate how guard cells operate to form a stoma.

Explain how the structure of a dicot leaf helps control the water flow in a plant.

Learn about photosynthesis, the process during which green plants produce glucose and release oxygen into the air.

Update your organism photo cards for *Lemna* and Wisconsin Fast Plants.

Looking at Leaves



If you live in a region with cold winters, you know what happens in spring. The air gets warmer; the days get longer. Green plants sprout in the garden and along roadsides. Everywhere you look outside, you see green as plants reveal their hidden treasures—leaves.

Leaves come in many shapes, sizes, and textures. But however different leaves may appear, their parts work in similar ways to accomplish their main task—making food for plants. Plants need food and water to survive and grow. Let's take a look at how the parts of a leaf work together to produce food and help regulate a plant's water content.

Parts You Can Easily See: Blades, Petioles, and Veins

What do you see when you look at a leaf? Most leaves have two basic parts: the blade and the petiole. The blade is usually broad and flat. The petiole is the narrow, stem-like part. It joins the blade to the stem or branch. You also might see the leaf's veins. Veins carry water and other substances throughout a plant.

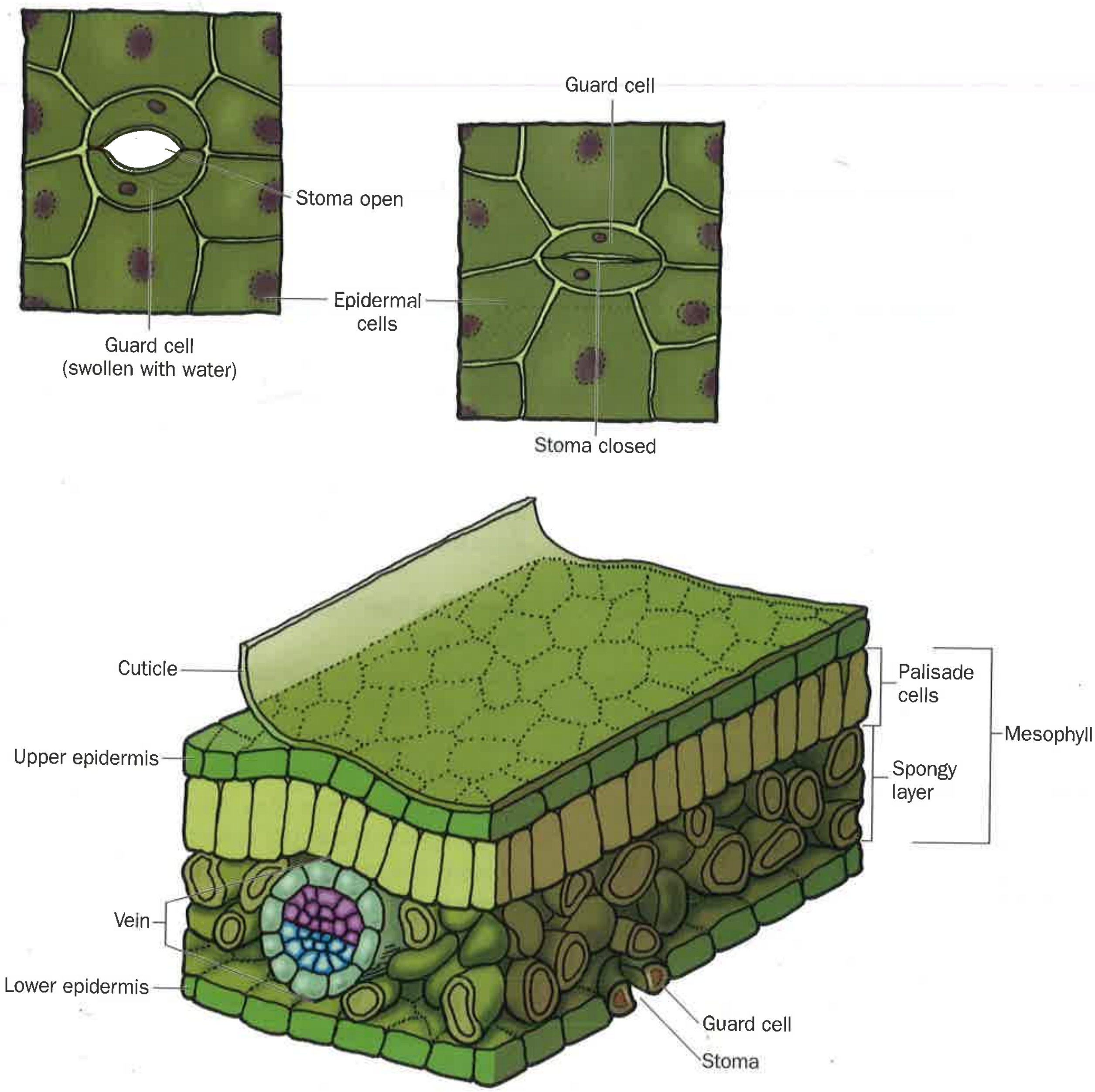
Parts You Can't Easily See: Stomata and Guard Cells

The outer surface of a dicot leaf's blade is called the epidermis. It is a thin, tough layer of cells that covers both surfaces of the blade. The epidermis is the leaf's "skin." Its cells often secrete a waxy film, called a cuticle, which covers the upper epidermis. The cuticle protects the leaf from being injured and from losing too much water.

Scattered mostly throughout the lower epidermis of dicot leaves are tiny openings called stomata (the singular is stoma). How does a stoma form? The guard cells, a pair of sausage-shaped cells that lie against each other, take in water by diffusion from their neighboring epidermal cells. As a result, the guard cells swell up and buckle and an opening develops between them. This opening is the stoma. When the guard cells lose water, they move back together. This action closes the stoma and prevents additional water loss.

Stomata and guard cells help leaves handle water. A leaf gets water and a supply of minerals from the soil by way of the plant's roots and stem. Bundles of veins called xylem carry water and minerals up from the roots to the leaves. Vein bundles called phloem carry food from the leaves to the rest of the plant. The stomata of most plants are formed during the day and are closed at night. When the sun shines on leaves, the waxy cuticle on the upper epidermis prevents some water loss. But when stomata are formed, water vapor can escape from inside the leaf in a process called transpiration.

The structure of a leaf



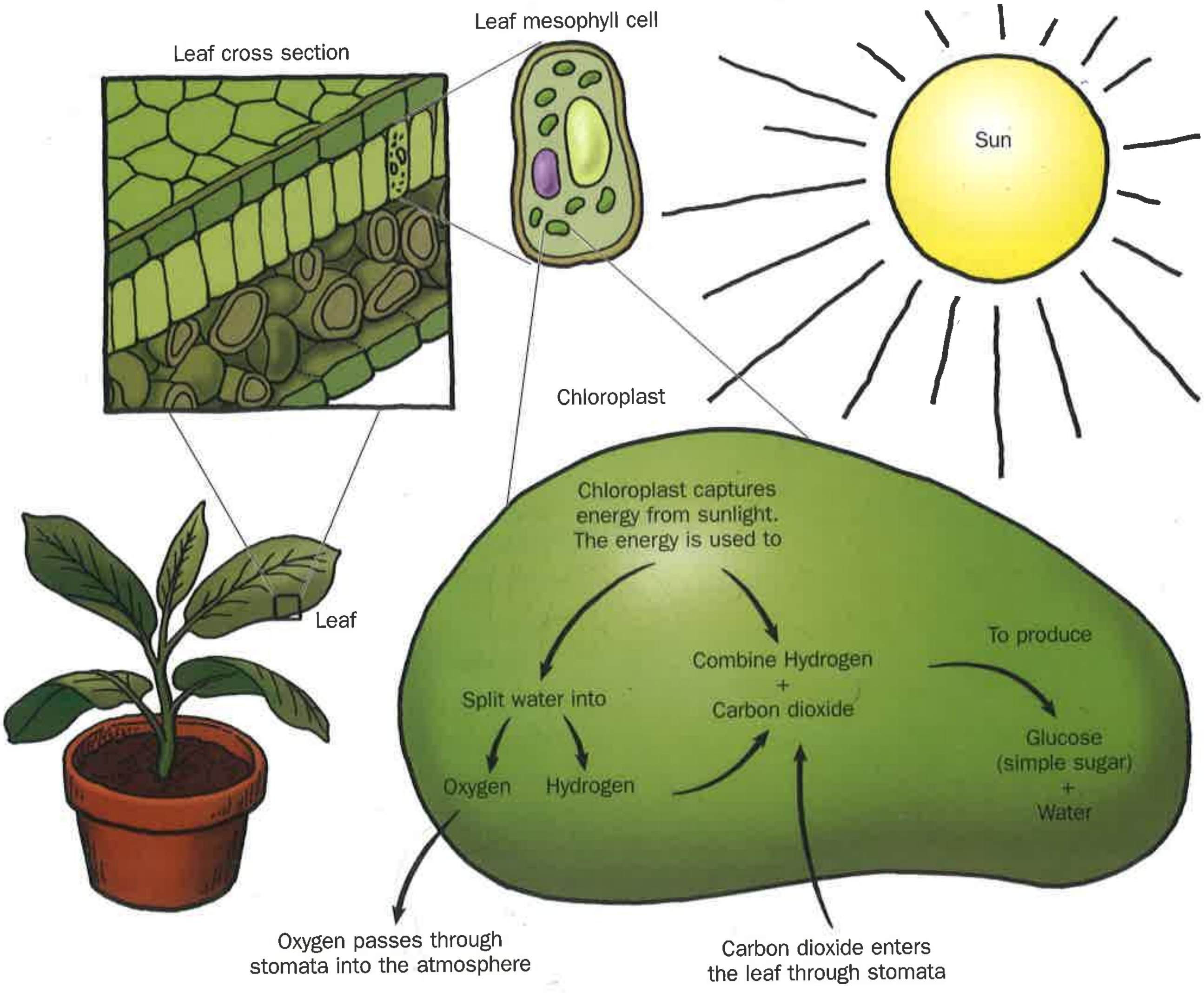
The Mesophyll: Where the Food-Making Action Is

Between the upper and lower epidermis is a region called the mesophyll. In the leaves of many flowering plants and trees, the mesophyll includes an upper layer of tightly packed palisade cells and one or more lower layers of spongy tissue.

In the mesophyll, a leaf makes food through a process known as photosynthesis. Mesophyll cells contain special structures called chloroplasts. Chloroplasts contain a green pigment called chlorophyll. Chlorophyll gives leaves their green color. The spongy layer provides room for water and gases, such as oxygen and carbon dioxide, to travel within the leaf.

Photosynthesis begins when chlorophyll captures energy from sunlight. Using this energy, plant leaves are able to take water and combine it with the carbon dioxide that enters through the stomata to make a simple form of sugar called glucose. Glucose is the plant's food—its source of energy. Oxygen is released to the atmosphere as a by-product of photosynthesis. In fact, the balance of oxygen in our atmosphere is dependent on the oxygen produced and released during photosynthesis in plants, algae, and other organisms on land and in water. □

The process of photosynthesis



LESSON **11**

Exploring Microorganisms

DWIGHT R. KUHN

You'll often see a variety of organisms in just one drop of water!

INTRODUCTION

In Lesson 4, you created your own pond ecosystem. Soon you will revisit your pond to observe any new developments. This lesson will prepare you to make those observations. During this lesson, you will observe four types of microorganisms and decide whether their characteristics are more animal-like or plant-like. You also will draw and label the microorganisms and estimate their lengths. You will create a cartoon featuring one of the microorganisms you observe. You will learn about the effects that microorganisms have had on our world. Finally, you will read about a kingdom of organisms whose benefits to humans are often misunderstood—kingdom Monera.

OBJECTIVES FOR THIS LESSON

Make a list of things you already know about microorganisms.

Observe four species of living microorganisms called protists and identify their animal-like and plant-like characteristics.

Observe, draw, and estimate the length of four protists.

Create a cartoon using an *Amoeba, Euglena,* or *Paramecium* as the main character.

Read about the importance of microorganisms in history.

Read about the kingdom Monera and its significance to humans.

Update your organism photo cards for *Amoeba, Euglena,* and *Paramecium.*

INTRODUCING YEAST

There are many species of yeasts. They are divided among three different phyla of the Fungi kingdom. Most yeast species, however, belong to the phylum Ascomycetes. In addition to yeasts, this phylum includes truffles, morels, and mildew. Most fungi are multicellular and relatively large. Yeast cells are unusual because they are unicellular and microscopic. Scientists believe that yeast once had the typical fungi's ability to form hyphae—the tubes that root fungi to the surface of an object—but gradually lost that ability.

Dry granules of yeast contain tiny spore sacs. In a moist, warm environment in which a food source is available, the spores become active; during this period they grow into new yeast organisms and begin to reproduce. Although yeast cells can reproduce sexually, they usually reproduce asexually through a form of cell division called "budding." In this process, a new cell forms by cell division and produces a small outgrowth on an older cell. Eventually, the smaller cell breaks off and becomes self-sufficient.

(continued)

Yeast granules

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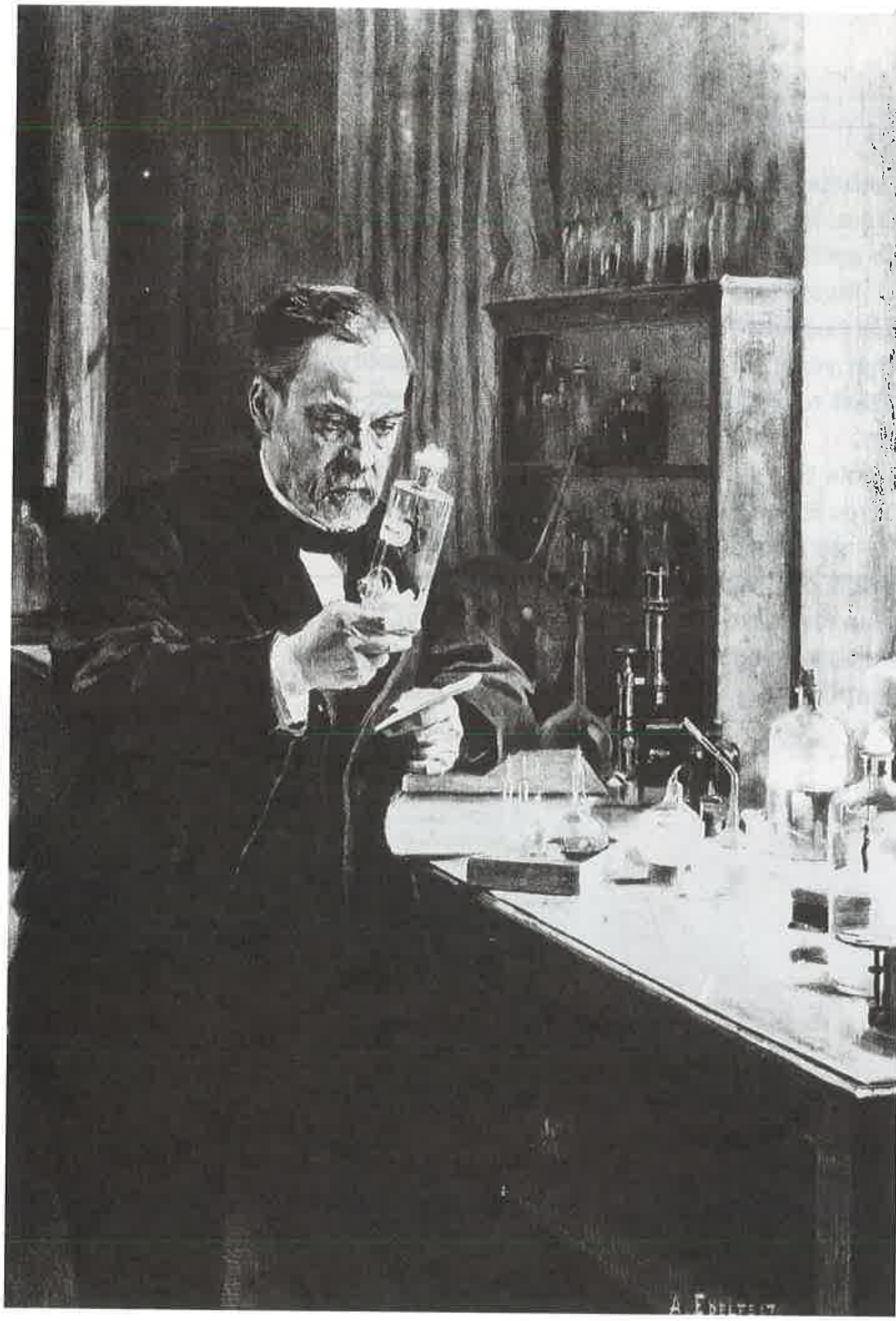
When yeast cells become active and feed, they undergo a process called "fermentation." During this process, sugar is broken down and carbon dioxide and alcohol are formed. In this lesson, you will see and measure evidence of yeast activity as yeast grains are added to different substances.



Nineteenth-century microbiologist Louis Pasteur first cultivated yeast cells and used them for scientific purposes.

G. Hanging earlobes (H) are dominant over attached earlobes (h). Complete a Punnett square showing the possible offspring from an Hh male and an hh female. Then answer the following questions:

- What are the chances of these parents having an offspring with hanging earlobes?
- If these parents have four offspring, will two definitely have hanging earlobes and two definitely have attached earlobes? Explain.
- If an offspring has attached earlobes, can we assume its genotype is hh? Explain.
- If an offspring has hanging earlobes, can we assume its genotype is Hh? Explain.

H. Occasionally a trait that was not observed in either parent appears in an offspring. Explain how this can happen.

I. Which parent actually determines the sex of an offspring? Explain.

J. Each time the spinner was used in Inquiry 19.3, Clyde or Claire had the potential to be homozygous dominant, heterozygous, or homozygous recessive for a trait. What must be true about the genotypes of both of their parents for each trait?

K. Look again at the photo of genetic corn on the first page of this lesson. Explain why there are two colors of seeds on the same ear of corn. Also explain which color is dominant and why.

Mendel's Discoveries

Gregor Mendel

As you begin your study of heredity, you may be feeling like many scientists did until a man named Gregor Mendel came along. Mendel was born in 1822 and spent most of his adult life as a monk in Austria. Mendel's studies of garden peas started to lift the cloud of confusion about how traits are passed on from one generation to the next.

At first, Mendel was bewildered by the behavior of certain traits of pea plants. For example, when he grew pea plants from seeds produced by certain tall pea plants that he had pollinated with pollen from short pea plants, Mendel expected all of the offspring to be of medium height. Instead, all of the offspring were tall. Every time he repeated this procedure with the same plants, he got the same results. It seemed that there was something about the tall trait that overwhelmed, or dominated, the short trait. Mendel called this stronger trait the "dominant trait." He called the trait that was dominated the "recessive trait," because it seemed to recede, or vanish.

These pea plants display the ideal ratio of tall to short plants for offspring of parents that each had a dominant and recessive gene for height.

Mendel then decided to try something different. He took a group of the tall offspring and cross pollinated them, using a process similar to the one you used to cross pollinate your Fast Plants. He harvested the seeds and replanted them. Surprisingly, he found some short pea plants among the offspring. Mendel detected a pattern to his results that helped him to recognize some of the fundamental principles of heredity.

Mendel was convinced that the male and the female pea plant each contributed something during fertilization that helped determine a trait. Since each parent contributed something, he concluded there had to be a pair of these "somethings" that determined, for example, whether the plant would be tall or short. We now know that these "somethings" are genes. The traits that Mendel observed in pea plants are each determined by a pair of genes—one gene from the male and one from the female.

Mendel used an upper case letter to represent the dominant gene. For example, he used "T" as the symbol for the tallness gene in pea plants. He used a lower case "t" as the symbol for shortness in pea plants. Mendel believed that whenever an organism expresses, or displays, a dominant trait, at least one dominant gene must be present. For example, if a pea plant is tall, its gene pair has to be either "TT" or "Tt." Table 19.1: Mendel's Study of Traits in Pea Plants describes the dominant and recessive forms of seven traits of pea plants that Mendel studied. It also shows the number of offspring from Mendel's research that express the dominant or recessive form of each trait. Each results from a cross between two parents that had one dominant and one recessive gene for the trait—Tt × Tt, for example. □

Table 19.1 Mendel's Study of Traits in Pea Plants

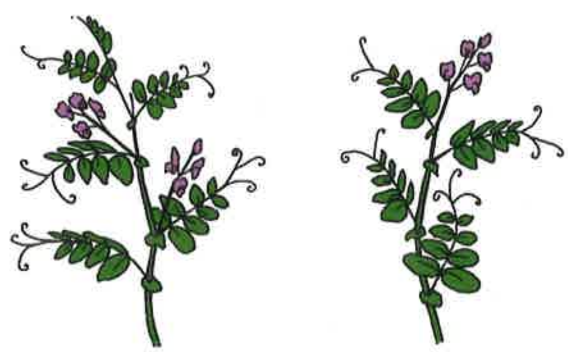
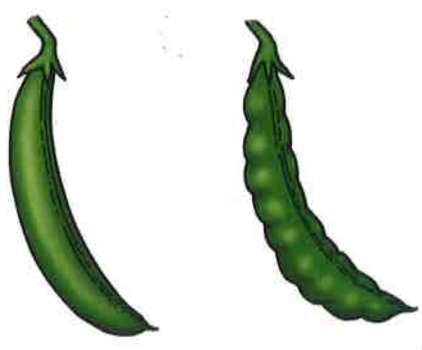
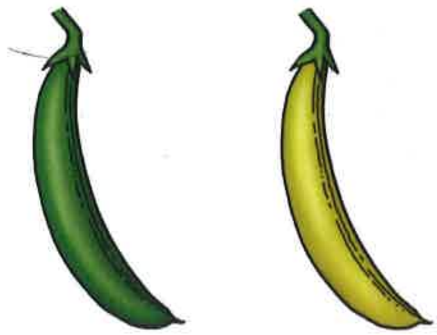
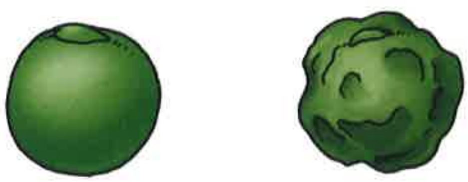
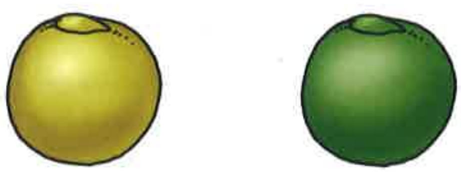
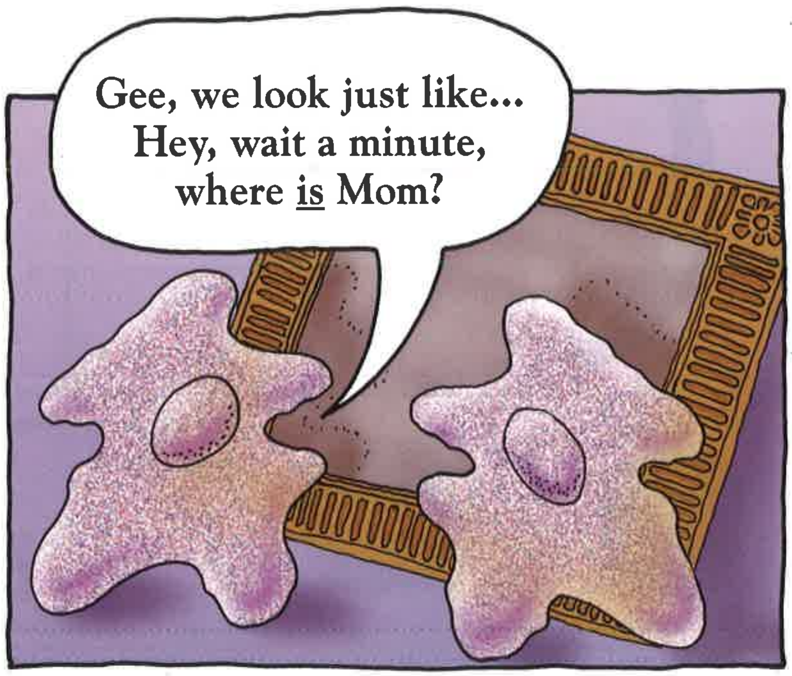
Trait	Illustration of Trait	Offspring Expressing Dominant Trait	Offspring Expressing Recessive Trait	Total Number of Offspring
Plant height		787 tall (T)	277 short (t)	1064
Flower position		651 axial flowers along stem (A)	207 terminal flowers at the tip of stems (a)	858
Flower color		705 purple flowers (P)	224 white flowers (p)	729
Pod shape		882 smooth pods (S)	299 bumpy pods (s)	1181

Table 19.1 Mendel's Study of Traits in Pea Plants (continued)

Trait	Illustration of Trait	Offspring Expressing Dominant Trait	Offspring Expressing Recessive Trait	Total Number of Offspring
Pod color		428 green pods (G)	152 yellow pods (g)	580
Seed shape		5474 round seeds (R)	1850 wrinkled seeds (r)	7324
Seed color		6002 yellow seeds (Y)	2001 green seeds (y)	8003

Heredity—Passing It On



In Lesson 8, you learned about mitosis. When mitosis occurs in humans, all 23 pairs of chromosomes duplicate and a full set of chromosomes passes into each daughter cell. Mitosis is important because we need exact copies of cells to replace old or dying cells throughout our bodies. These cells need to be exactly like their parent cells so they are able to continue doing their jobs. If offspring were produced through mitosis, as they often are in single-celled organisms, each offspring would be identical to its parent.

In sexual reproduction, a new individual is formed that has different looks, abilities, and behaviors from its parents. This occurs because one type of cell in an organism's body undergoes a process somewhat similar to mitosis—but with a different outcome.

During this process, called "meiosis," parents produce sex cells (eggs or sperm) that contain exactly half as many chromosomes as body cells. In humans, each male sex cell, or sperm, has 23 single chromosomes—one from each original chromosome pair. Each female sex cell, or egg, also has 23 single chromosomes. Human sex cells have only half as many chromosomes as body cells because when the sperm fertilizes the egg to form a new individual, the chromosomes unite to form 23 pairs. The offspring receives half of his or her chromosomes from the mother and half from the father. The traits of the offspring are determined by the genes that pair during fertilization. Each parent donates one chromosome from each pair; therefore, only one gene from each pair is donated as well.

Genes can be paired in four possible combinations, as shown in Table 19.2: Gene Pair Possibilities. When *both* genes in a pair are the same for a trait, the condition is called "homozygous." Using height in pea plants as an example, if both parents donated a dominant gene, the offspring would have a homozygous condition. The symbol for this trait in the offspring would be "TT." If both parents donated a recessive gene, the symbol would be "tt." This condition also would be homozygous because both genes would be the same.

When one parent donates a dominant gene and the other donates a recessive gene, the resulting condition is called "heterozygous." It can be symbolized by "Tt" or "tT." The order in which the upper- and lower-case symbols are written is irrelevant; however, the dominant gene is often written first.

The term describing the gene pairs found in the DNA is "genotype." The genotype is the internal code for a trait in an organism. The way the trait is expressed, or displayed, in the organism is called the "phenotype." The phenotype, therefore, is the result of having a specific genotype, as shown in Table 19.3: Height in Pea Plants. For example, when the genotype is "Tt" for height in pea plants, the phenotype is tall because the gene for tall pea plants (T) dominates the gene for short pea plants (t). The "TT" gene pair gives the same phenotype, tall, even though the genotype is different. □

Table 19.2 Gene Pair Possibilities

Homozygous	**TT or tt**
Heterozygous	**Tt or tT**

Table 19.3 Height in Pea Plants

Genotypes	**TT or Tt**	~~Tt~~ tt
Phenotypes	**Tall**	**Short**

What Are the Chances?

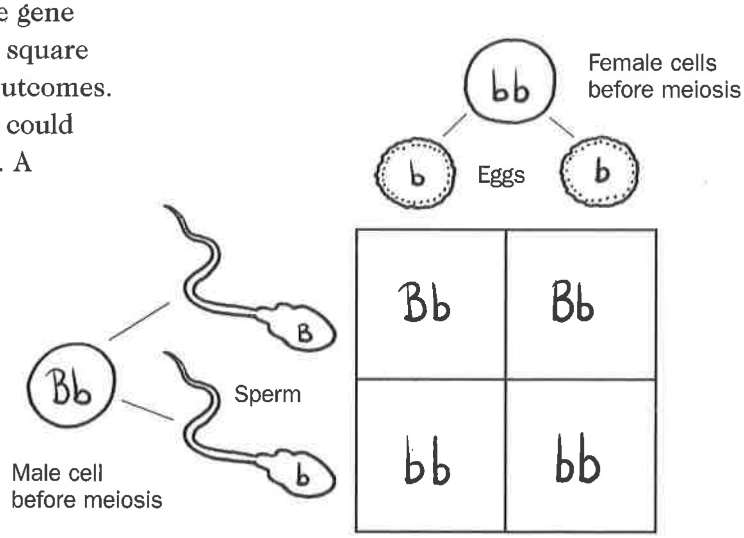
Reginald Punnett

Early in the 20th century, an English geneticist at Cambridge University developed a tool to display the possible ways that genes could pair during a genetic cross. His name was Reginald Punnett, and the tool came to be known as the "Punnett square."

Punnett used the square to illustrate the probability of the outcomes that could result from a cross, or mating, between two parents, primarily in sweet peas. The simplest Punnett square consists of a large box divided into four small boxes. To use it, you would write the genes for a trait from one parent (usually the female) above the square, and the genes for the same trait from the male on the left side of the square. Because only one chromosome from each pair passes into an offspring's sex cell during sexual reproduction, each egg above the square would contain only one gene from the female's genotype, while each sperm to the left of the square would contain only one gene from the male's genotype. Inside the square itself, you would write the possible outcomes.

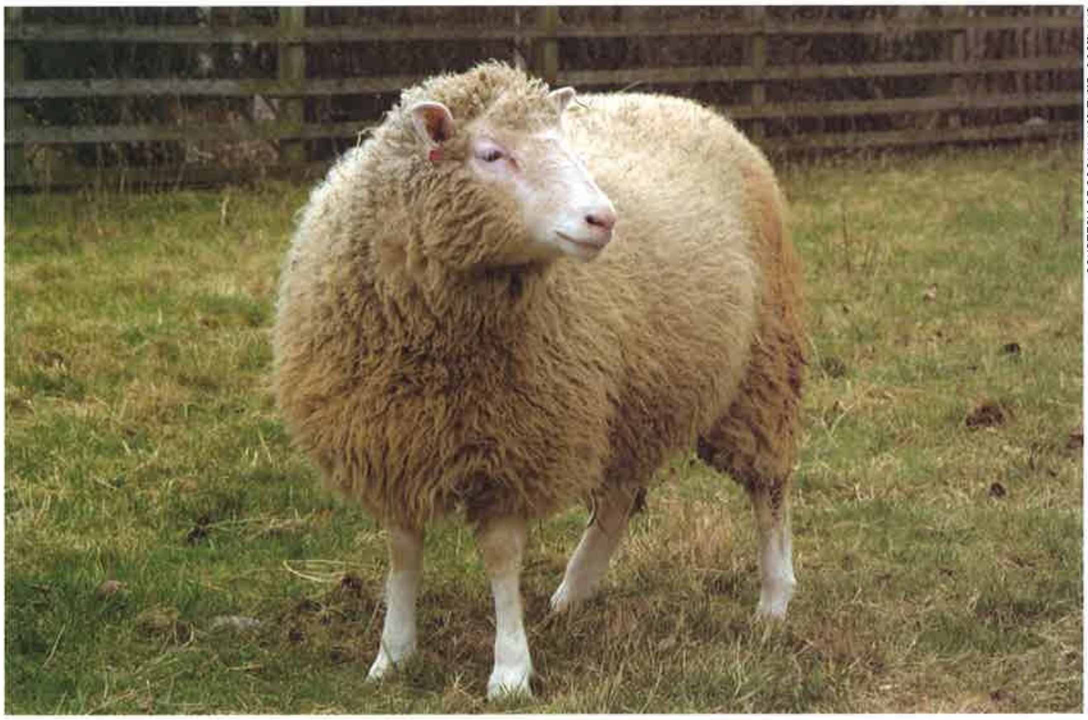
As an example, a brown-eyed male could have the genotype "Bb" for eye color. A blue-eyed female could have the genotype "bb." To use a Punnett square to illustrate a cross between these parents, you would take each gene for eye color from the male and show how it could combine with each gene for eye color from the female. The shortcut for writing the cross between these parents would be "Bb × bb."

A Punnett square does not predict which genes actually will become part of the offspring's genotype. It only shows the probability that specific genotypes will occur. In this illustration, only one trait is shown in each sperm and egg. However, most organisms pass on thousands of traits during fertilization. □



This example of a completed Punnett square shows the possible genotypes from a cross between a brown-eyed male with the genotype "Bb" and a blue-eyed female with the genotype "bb."

Hello, Dolly!


COURTESY OF ROSLIN INSTITUTE, SCOTLAND

Although Dolly looked like any other white Finn Dorset, genetically she was very special.

To us, she might have looked just like any other sheep of her species on the green hills of Scotland. But this sheep, named Dolly and born in March 1997, was special. Dolly was the first animal to be created by a process called "cloning."

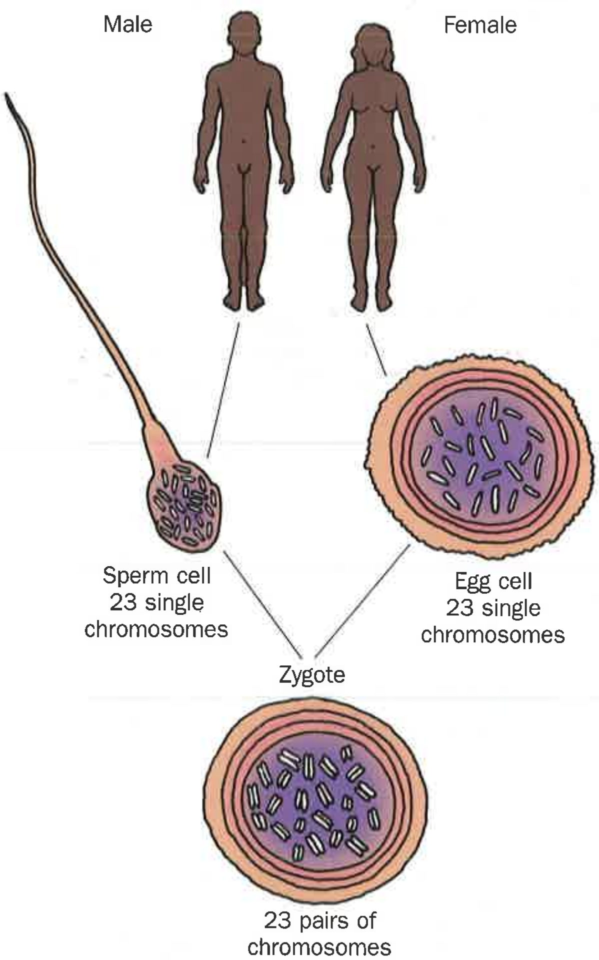
Instead of having two biological parents, Dolly was created from the DNA of just one parent—a six-year-old female sheep, or ewe. This meant that Dolly had the same genes as the ewe, a species of white sheep called a Finn Dorset. She was a genetic copy—a clone—of the ewe. News of Dolly's birth rocked the world.

The Usual Way

During normal reproduction in mammals, a male sperm and a female egg unite at the moment of fertilization and a new cell, called a "zygote," forms. The zygote contains DNA from both the male and female. The number of chromosome pairs varies with the species; for example, a human zygote receives 23 single chromosomes from each parent, giving it a total of 23 pairs.

The zygote begins to divide and grow and in time—about nine months for a human and about five months for a sheep—a baby is born.

The DNA received from both parents will determine its skin, hair, and eye colors, along with many other traits.



Each parent contributes an equal number of chromosomes to the offspring.

The Cloning Way

Dolly did not come about in the "usual way." To create Dolly, scientists first removed the nucleus from an egg cell of a Scottish Blackface sheep. The nucleus of a cell contains its DNA. Without its nucleus, a cell is sort of like a head without a brain.

But scientists didn't leave the egg cell without a nucleus for long. Into it, they put a nucleus from a body cell of the Finn Dorset. This nucleus, like the nucleus of a body cell of every mammal, contained a complete set of chromosome pairs needed for new life. Scientists zapped the egg cell with a tiny charge of electricity to stimulate the custom-made zygote to begin dividing.

The zygote was then implanted into the reproductive organ of the Scottish Blackface ewe. Dolly was born 148 days later. She was all white, just like her genetic mother. Scientists knew immediately that she was a clone. Why? Because Scottish Blackface sheep do not normally produce all-white offspring.

COURTESY OF ROSLIN INSTITUTE, SCOTLAND

As you can see, Dolly and her surrogate mother are quite different in appearance.

Clones and Twins

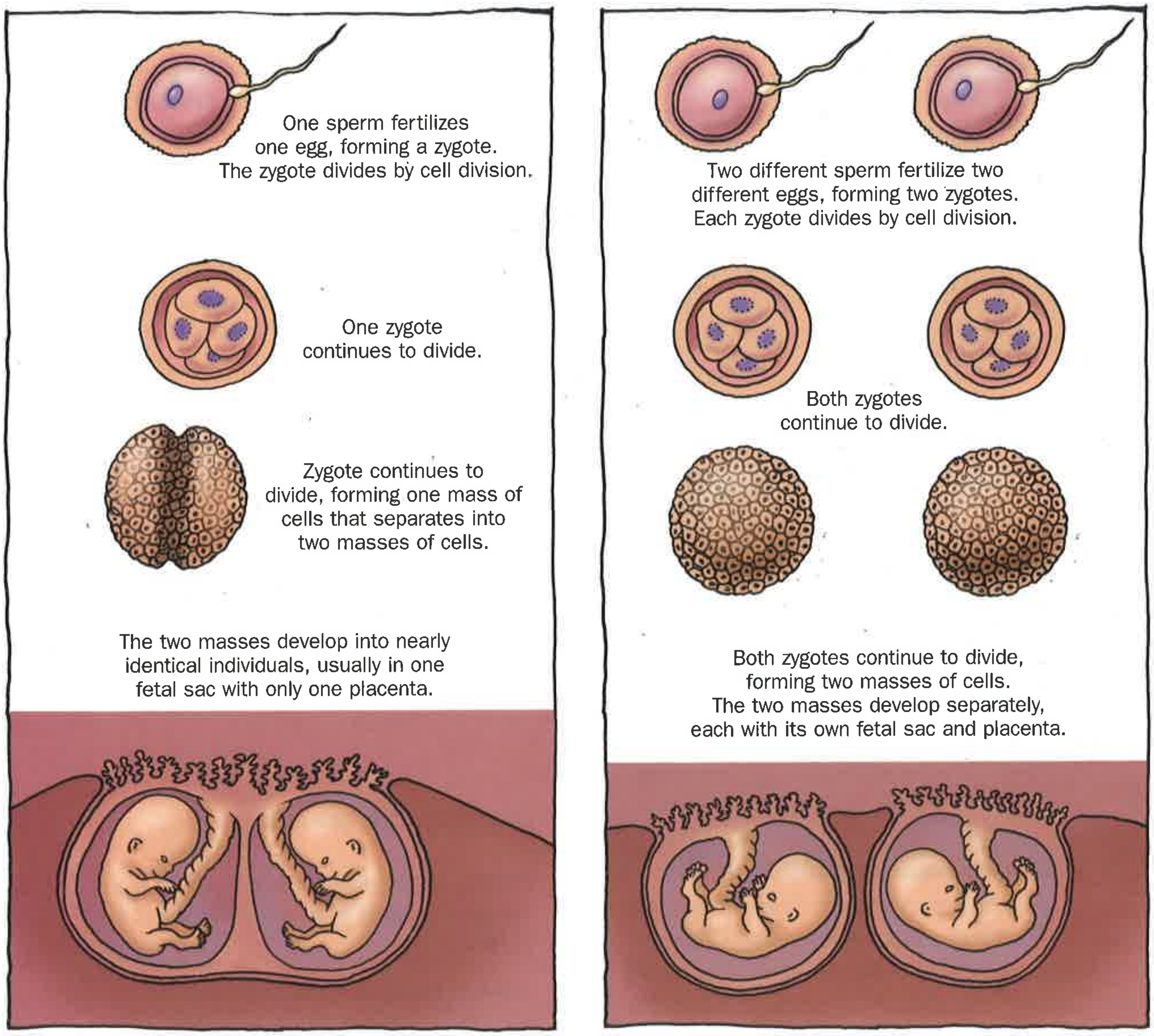
Genetically, being a clone is like being an identical twin. Identical twins, like clones, form from a single zygote. So identical twins have identical genes. Yet they often grow up to be very different from each other. That's because we—people *and* other animals—are more than just our genes. Our external environment, our upbringing, our experiences, and even the food we eat all influence who we become.

Fraternal twins form from simultaneous fertilization of two different eggs by two different sperm; therefore, they are no more alike genetically than siblings conceived at different times.

The Future of Cloning

Successful cloning of sheep didn't happen overnight. In fact, scientists had tried unsuccessfully to clone sheep 276 times before Dolly was born. The process is complicated and expensive, and many things can go wrong. Several sheep, as well as pigs, mice, and other animals, have been cloned since Dolly. Most have serious problems with their hearts, livers, and immune systems.

So, what about cloning humans? A few scientists think they have the expertise to do it. But many people think this is a very bad idea. What do you think? □



Identical twins (on the left) develop when a zygote divides once and each daughter cell forms an identical human being. Fraternal twins (on the right) develop when two sperm fertilize two separate eggs.