10.2 Sexual Reproduction and Meiosis

There are thousands of different species of organisms. Each species produces more of its own. A species of bacteria splits to make two identical bacteria. A eucalyptus tree produces more eucalyptus trees. Humans produce more humans. The formation of new organisms of the same species is called **reproduction**. Reproduction is an important life function. In this section, you will learn about the process of reproduction.

Two types of reproduction

Asexual reproduction

There are two types of reproduction: asexual and sexual. **Asexual reproduction** is reproduction that requires only one parent. Most single-celled organisms like bacteria and protozoans reproduce this way. Cell division is a type of asexual reproduction. Your body cells reproduce this way. In asexual reproduction, the DNA and internal structures are copied. Then the parent cell divides, forming two cells that are exact copies of the original.

Sexual reproduction

Sexual reproduction is a type of reproduction that involves special types of cells called sex cells. **Sex cells** (also known as *gametes*) contain half the number of chromosomes as *body cells* (all of the other cells in a multicellular organism). Human body cells have 46 chromosomes. Human sex cells have 23 chromosomes. The male sex cells are called *sperm*. The female sex cells are called *eggs*.

Homologous chromosomes

In body cells, the chromosomes occur in pairs. The chromosomes in each pair are called *homologous* (equivalent) pairs. Figure 10.6 shows a complete set of chromosomes found in a human body cell. **Each sex cell has only one of the chromosomes from each homologous pair**.

VOCABULARY

reproduction - the formation of new organisms of the same species.

asexual reproduction - a type of reproduction that requires only one parent.

sexual reproduction - a type of reproduction that involves special cells called sex cells.

sex cells - special cells that contain half the number of chromosomes as body cells.

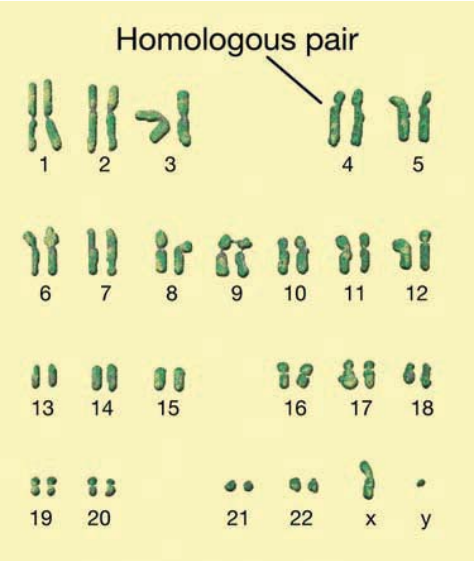


Figure 10.6: *A complete set of human chromosomes found in a body cell.*

Meiosis

What is meiosis?

A body cell has the same number of chromosomes as its parent cell. How do sex cells end up with only *half* the number of chromosomes? **Meiosis** is cell division that produces sex cells with half the number of chromosomes. During meiosis, a cell undergoes two divisions to produce four sex cells, each with half the number of chromosomes of the parent cell. Figure 10.7 shows slides of meiosis in the part of a plant that produces the male sex cells.

The first division of meiosis

In the first division of meiosis, the homologous pairs of chromosomes separate. Remember, just before a cell divides, the chromosomes double. The doubled chromosome pairs line up along the center of the cell. Spindle fibers attach and pull the pairs apart. Two cells form. Each cell contains one doubled chromosome from each homologous pair.

The second division of meiosis

In the second division of meiosis, the doubled chromosomes are split apart. The doubled chromosomes line up in the center of the cell. Spindle fibers pull the chromosomes apart at the center. The two halves move to opposite ends of the cell.

The final result of meiosis

The final result of meiosis is four sex cells, each with half the number of chromosomes of the original parent cell. Each cell has only one chromosome from each original homologous pair. When male and female sex cells combine to form offspring, each sex cell contributes half the normal number of chromosomes. The offspring has the normal number of chromosomes, half from the male parent and half from the female parent.

VOCABULARY

meiosis - cell division that produces sex cells with half the number of chromosomes.

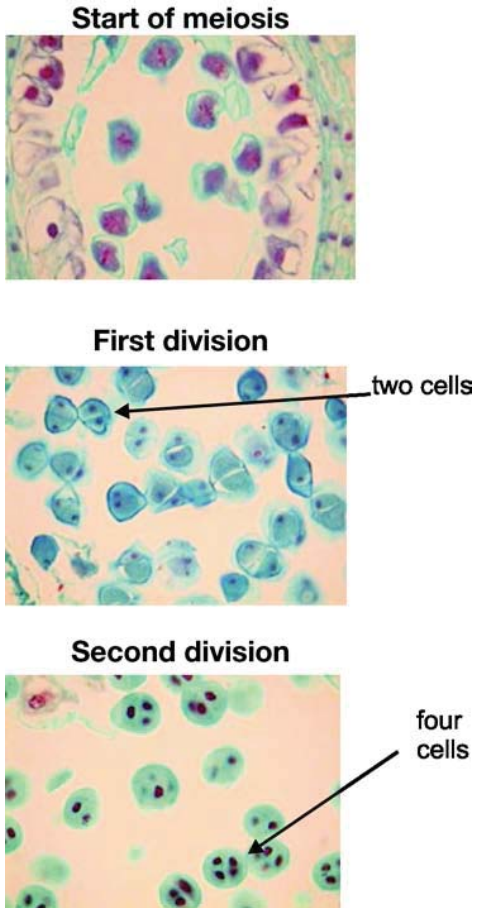
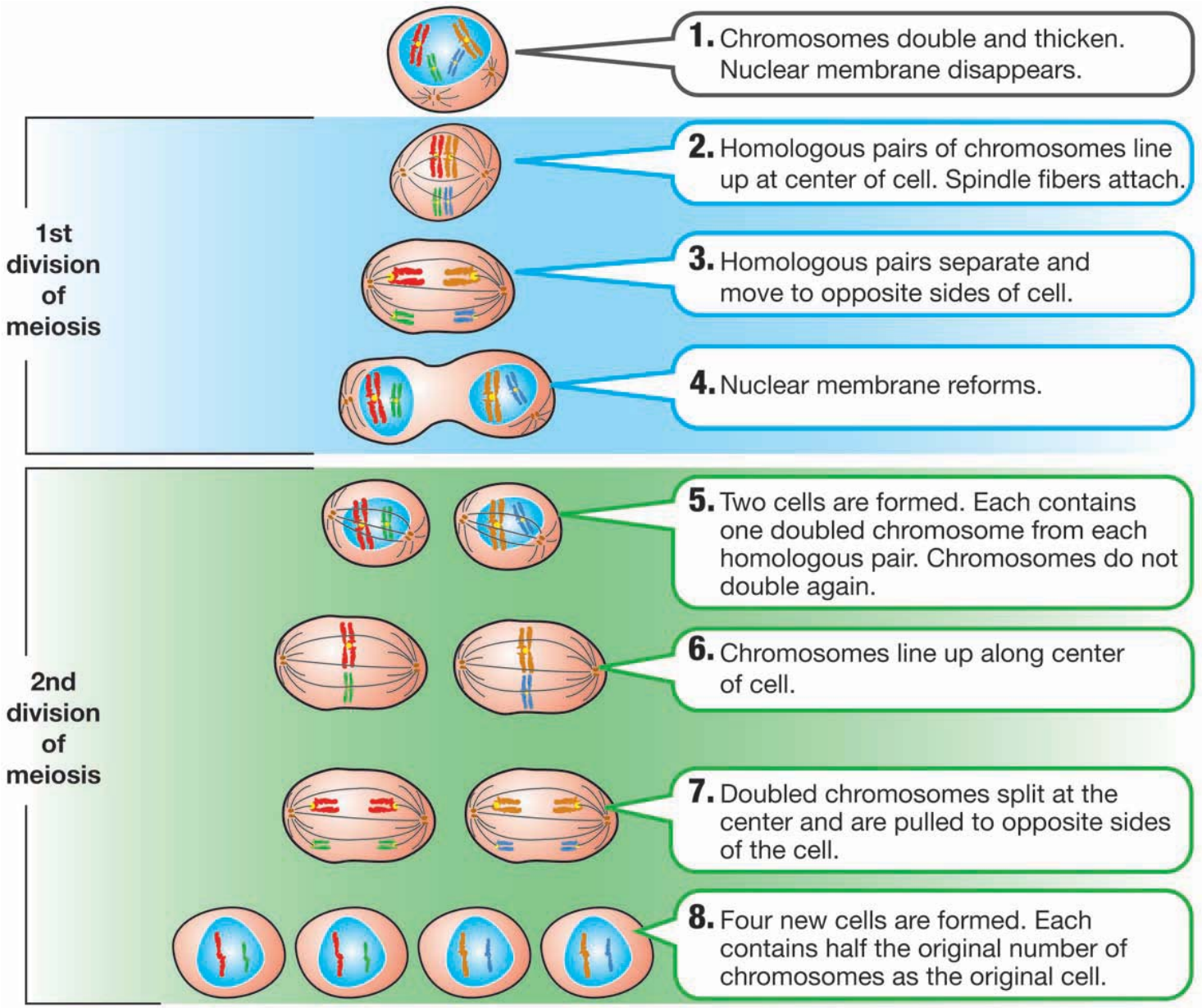


Figure 10.7: *Prepared slides showing meiosis in plant tissues.*

What happens during meiosis?



Diploid, haploid, and fertilization

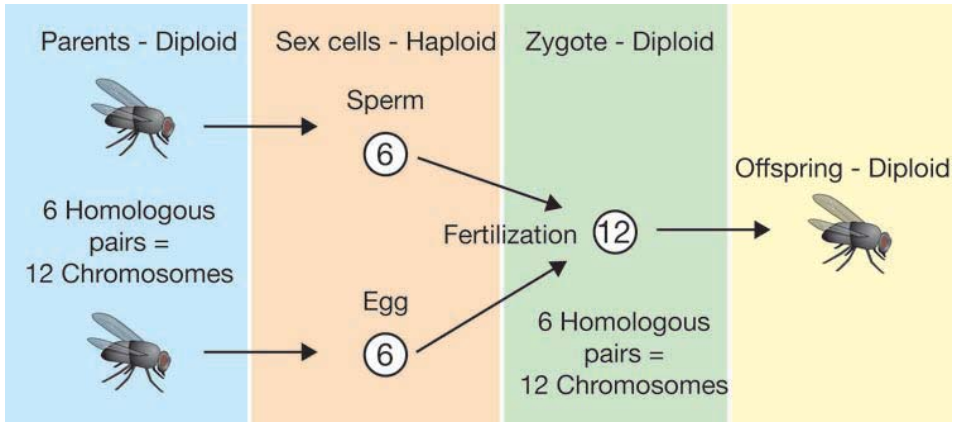
Diploid and haploid sets

A complete set of chromosomes is called a **diploid** set. Most animal cells except the sex cells have a diploid set of chromosomes. The diploid human set has 23 *pairs* of chromosomes (a total of 46). Sex cells have half of a complete set of chromosomes, or only one chromosome from each homologous pair. A half set of chromosomes is called a **haploid** set. Humans have 23 chromosomes in their sex cells—a haploid set. Figure 10.8 shows the diploid and haploid number of chromosomes for various organisms.

What is fertilization?

Fertilization is the union of egg and sperm to form a new organism. When an egg is fertilized by a sperm, the haploid set of chromosomes from the father unites with the haploid set of chromosomes from the mother. A fertilized egg, called a **zygote**, has a diploid set of chromosomes. For each homologous pair, one chromosome comes from the mother, and one from the father.

In a diploid set, chromosomes are found in homologous pairs. For each pair, one chromosome comes from each parent.



VOCABULARY

diploid - a double set of chromosomes.

haploid - a half set of chromosomes.

fertilization - the union of egg and sperm.

zygote - a fertilized egg.

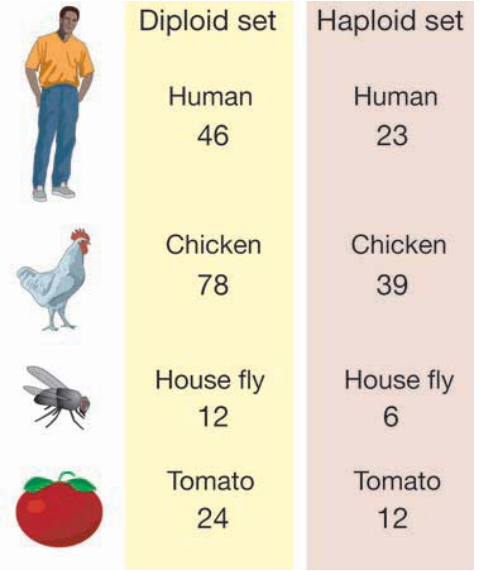
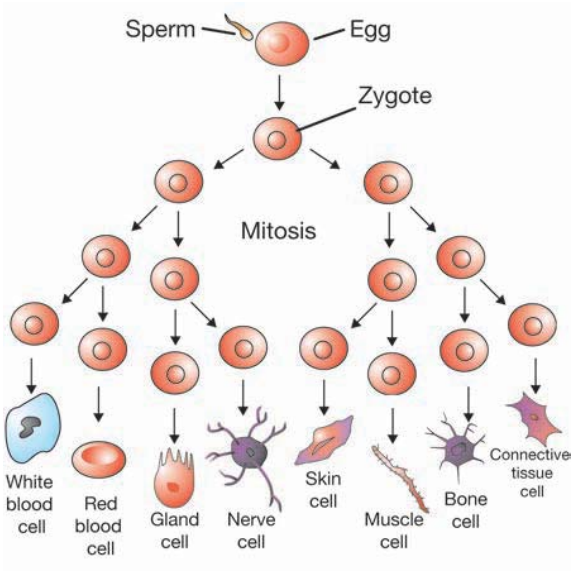


Figure 10.8: *The diploid and haploid number of chromosomes for various organisms.*

Cell differentiation

Specialized cells

After fertilization, the zygote rapidly divides by mitosis and becomes an embryo. An **embryo** is an organism in its earliest stages of development. Figure 10.9 shows embryo development of a fish, calf, and rabbit. The final outcome is a multicellular organism with many different types of *specialized* cells. You have brain cells, stomach cells, skin cells, and muscle cells to name just a few. All of those cells can be traced back to the zygote.



Differentiation

Where do all of the different types of cells come from? An organism that is not fully developed is called an *embryo*. In the developing embryo, cells begin to *differentiate*. **Cell differentiation** is the process of cell specialization. For example, cells that eventually divide to become part of the stomach are different from those that will become part of the nervous system. As cells differentiate, they give rise to different tissues. These tissues eventually form the organs.

Further specialization

As the embryo continues to develop, some cells become even more specialized. For example, some cells in the retina of your eye become *rod cells* (for vision in dim light) and others become *cone cells* (for color vision). After differentiation is complete, most cells lose the ability to become other types of cells.

VOCABULARY

embryo - an organism in its earliest stage of development.

cell differentiation - the process of cell specialization.

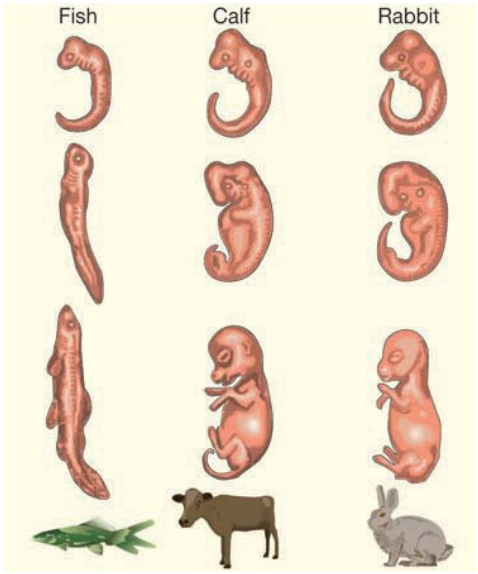


Figure 10.9: *An embryo is an organism in its earliest stages of development. The embryos of a fish, calf and rabbit, over time, develop into young organisms.*

10.2 Section Review

1. Fill in the table below for a human cell.

	Mitosis	Meiosis
Type of cell produced		
Number of cell divisions		
Number of cells produced		
Number of chromosomes in each cell (diploid or haploid)		

2. Look at Figure 10.10. Match each number on the diagram to the statements below.
   a. Cells contain half the number of chromosomes.
   b. Homologous pairs of chromosomes are pulled to opposite sides of the cell.
   c. The total amount of DNA is doubled.
   d. Doubled chromosomes are split apart.
3. A chicken has 78 chromosomes in its body cells. How many chromosomes are in its sex cells?
4. What is fertilization?
5. How does the process of fertilization explain the need to have half the number of chromosomes in sex cells?
6. You started out as a single cell and are now made of over 200 different types of cells. Explain how this happens.

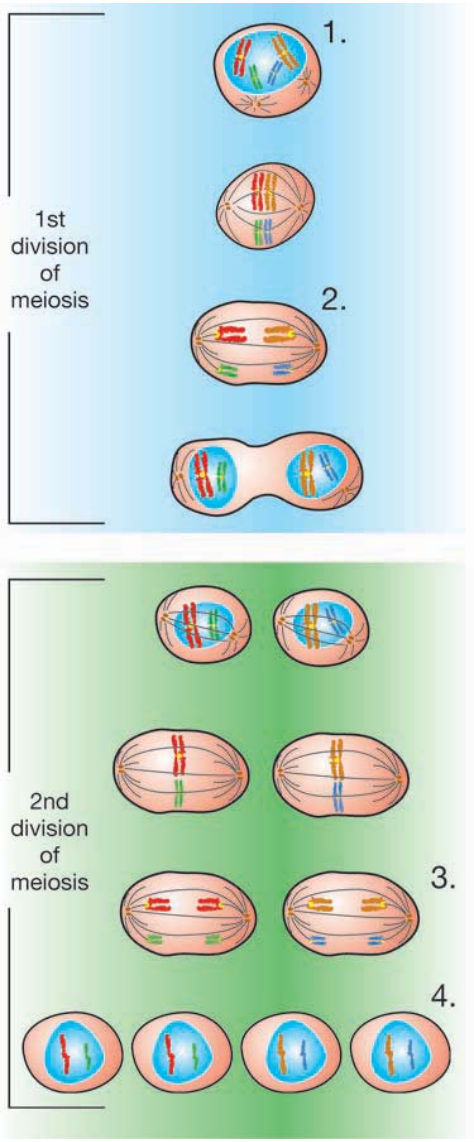


Figure 10.10: *Use this diagram to answer question 2.*

MEDICINE CONNECTION

Differences Between Twins Start With Cells

You are a completely unique individual. No one is just like you. Yet what if there was an exact duplicate of you? Same hair, nose and size. You look exactly the same. No one can tell the two of you apart. You even have the same genes. There is only one way that can happen. If you and another person have the same genes, you are identical twins.

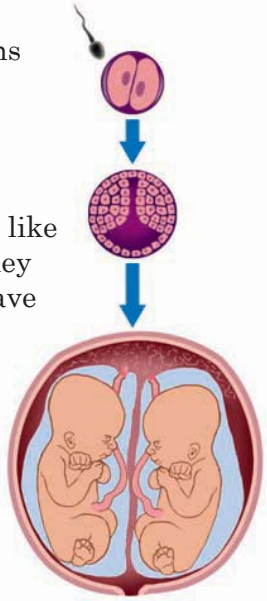
Identical Twins

Identical twins develop from an egg that has been fertilized by a single sperm. The zygote divides into two separate zygotes.

Out of every thousand births in the United States, about 25 will be twins. Of these, some are identical twins. The rest are fraternal twins. The difference comes from how the twins formed.

Fraternal twins start as two

The word fraternal comes from a word meaning "brother." Fraternal twins are like any brothers and sisters, except that they are born on the same day. They each have some the same genes as their parents. But they do not share an identical genetic makeup. Fraternal twins may resemble each other, but they usually will not be mistaken for each other. Fraternal twins might both be girls. They could both be boys, or one girl and one boy.



How do fraternal twins happen? It's simple. Two different sperm cells fertilize two different eggs. Each fertilized egg develops into an embryo. Each embryo becomes a fetus. The mother gives birth to both babies on the same day.

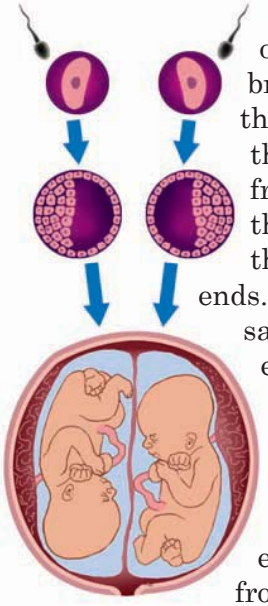
Fraternal twins are also called dizygotic twins. When an egg cell and a sperm cell join, the resulting cell is called a zygote. It is a fertilized egg. The prefix *di* means "two." Dizygotic twins develop from two zygotes, or two fertilized eggs. In other words, the mother has produced two eggs. Each joins with a sperm cell. Each becomes a fetus. The two babies are born one right after the other.

Fraternal Twins

Fraternal twins develop from two different eggs that have been fertilized by two different sperms.

Identical twins start as one

Identical twins are not like other brothers and sisters. Other brothers and sisters share half of their genes. Identical twins have the same genetic makeup. Like fraternal twins, they are born on the same day. But that's where the similarity to fraternal twins ends. Identical twins are always the same sex. They will always be either two boys or two girls. The twins usually look very much the same. Many people cannot tell them apart at first.



Fraternal twins come from two eggs. Identical twins develop from a single fertilized egg. Shortly after the egg cell and sperm cell join, the zygote splits into two parts. Each new part is an identical copy of the original. Each has identical genetic material. After the split, each new part develops into an embryo. From that point on, each fetus grows just like fraternal twins.

Finally, two babies are born. With identical twins, the births are usually just minutes apart. The two babies have the same genes. As they grow, they usually appear to be identical to each other. People who know identical twins well can tell who is who, but a stranger may not be able to tell identical twins apart.

Identical twins are also called monozygotic twins. The prefix mono means "one." These twins develop from one zygote.

The same genes

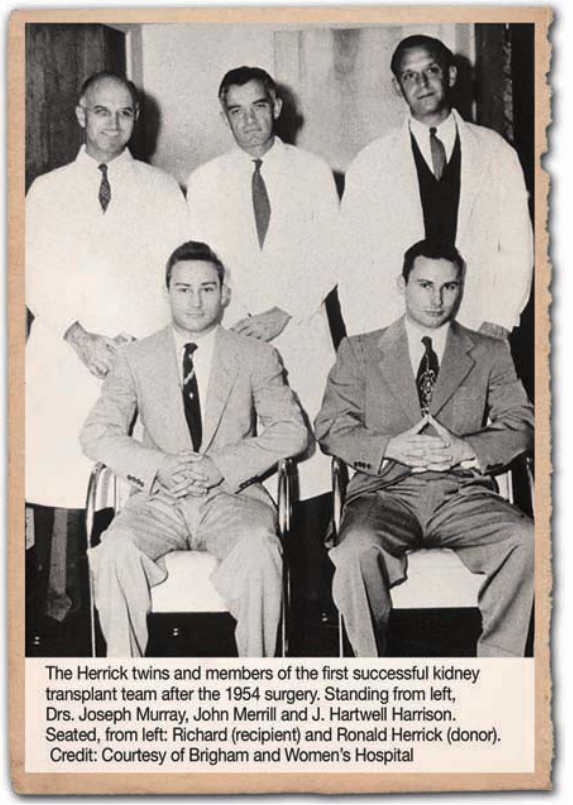
What does it mean to have the same genes? It means that identical twins have the same genetic potential. Other factors affect how individuals develop. The environment plays a part. For example, identical twins may have different weights at birth. This is because each fetus may develop in slightly different conditions inside the mother. Identical twins that grow up in different homes often develop differently. Their diets may be different and they might not get the same exercise. If these twins come together later in their lives, they may not look alike. They may not seem to be identical twins at all.

Scientists want to know more about how our environment affects the way we develop. For this reason, identical twins are often studied. They start out with the same genes. However, differences that occur may be caused by environmental factors.

Transplants and tissue matching

Organ transplants save many lives. The science of transplants has benefited by the study of identical twins. In the early 1950s, scientists observed that most donated organs were rejected. Then in 1954, a kidney transplant was done between identical twins.

Richard Herrick was dying of kidney disease. Ronald, his identical twin brother gave one of his kidneys to him. Both twins had the same genetic makeup. Richard's body recognized Ronald's kidney as being the same tissue as itself. It did not reject the kidney and the transplant was a success.



The Herrick twins and members of the first successful kidney transplant team after the 1954 surgery. Standing from left, Drs. Joseph Murray, John Merrill and J. Hartwell Harrison. Seated, from left: Richard (recipient) and Ronald Herrick (donor). Credit: Courtesy of Brigham and Women's Hospital

This case was very important in the understanding of organ transplants. It helped scientists know more about matching tissue. Since then, many of the problems of organ rejection have been overcome with the use of tissue matching.

Questions:

1. What is a zygote?
2. In terms of zygotes, how are fraternal twins and identical twins different?
3. How does the genetic makeup of fraternal and identical twins differ?
4. What could explain differences in appearance between 50-year old identical twins?