EXPLORATION 2

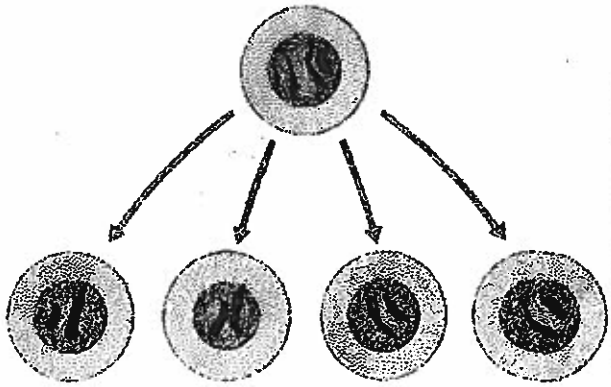
The Process of Meiosis

DNA that is passed on to offspring is contained in the gametes, which are formed by germ cells in reproductive organs. So, how exactly are gametes made? Germ cells undergo an essential process called meiosis to form gametes. Meiosis is a form of nuclear division that divides one diploid cell into four haploid cells. There are two rounds of cell division—meiosis I and meiosis II. This process divides the DNA and reduces each resulting cell's chromosome number by half.

INFER Meiosis divides one cell into four cells, but the resulting cells have half the amount of DNA as compared to the original cell. How do you think this is possible?

- ○ **a.** The DNA is copied twice before cell division.
- ○ **b.** The DNA is copied once before cell division.
- ○ **c.** The DNA fuses in two of the cells.
- ○ **d.** The cell divides twice and fuses once.

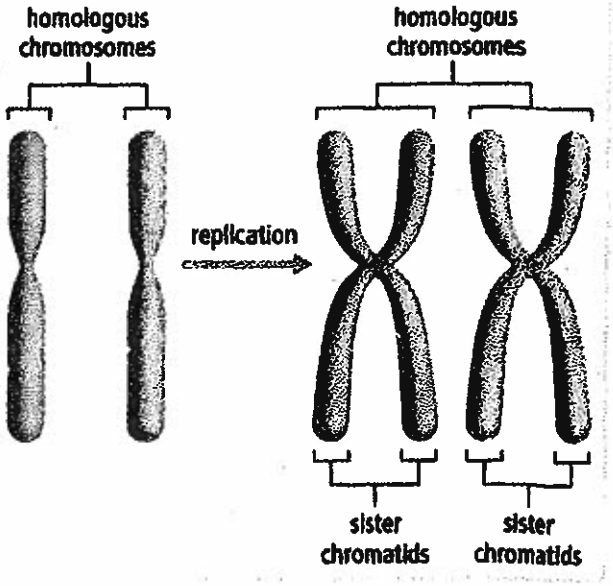
FIGURE 5: Meiosis has many stages and produces four haploid cells from one diploid cell.



Chromosomes and Replication

To understand meiosis, it is necessary to distinguish between homologous chromosomes and sister chromatids. Recall that homologous chromosomes are two separate chromosomes, one from your mother and one from your father. Homologous chromosomes are similar to each other because they are the same length and carry the same genes. However, they are not exact copies of each other. In contrast, a *chromatid* is one half of a duplicated chromosome. The term *sister chromatids* refers to the duplicated chromosomes that remain attached. Homologous chromosomes divide during meiosis I, and sister chromatids are split and separated into new gametes during meiosis II.

FIGURE 6: Homologous chromosomes are two separate chromosomes, while sister chromatids are duplicated chromosomes that remain attached to one another.

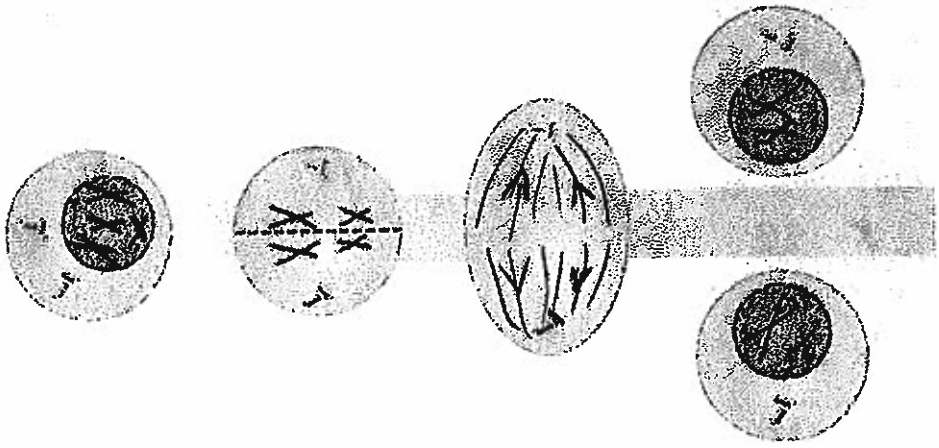


In addition to chromosomes and chromatids, specialized structures called centrosomes are involved in meiosis in animal cells. The centrosome is a small region of the cell that produces protein fibers called microtubules. Centrioles are cylinder-shaped cell structures made of short microtubules. Before an animal cell divides, the centrosome, including the centrioles, doubles and the two new centrosomes move to opposite ends of the cell. Microtubules grow from each centrosome, forming spindle fibers. These fibers attach to the DNA and help it divide between the two cells.

Meiosis I

Before meiosis begins, the cell makes a copy of its DNA. Meiosis I separates homologous chromosomes, producing two haploid cells with duplicated chromosomes. Meiosis I can be described in four distinct phases, each of which is a series of gradual changes.

FIGURE 7: Meiosis I



1 Prophase I 2 Metaphase I 3 Anaphase I 4 Telophase I

1. Prophase I
During this first phase of meiosis, the membrane around the nucleus breaks down, the centrosomes and centrioles move to opposite sides of the cell, and spindle fibers start to assemble. The duplicated chromosomes condense, and homologous chromosomes pair up. They appear to pair up precisely, gene for gene, down their entire length. The sex chromosomes also pair with each other, and some regions of their DNA appear to line up.

2. Metaphase I
The homologous chromosome pairs randomly line up along the middle of the cell, or the cell equator, by spindle fibers. The result is that 23 chromosomes—some from the father, some from the mother—are lined up along each side of the cell equator. This arrangement mixes up the chromosomal combinations and helps create and maintain genetic differences.

3. Anaphase I
Next, the paired homologous chromosomes separate from each other and move toward opposite sides of the cell. The sister chromatids remain together during this step and throughout meiosis I.

4. Telophase I
The membrane around the nucleus forms again in some species, the spindle fibers break apart, and the cell divides into two daughter cells.

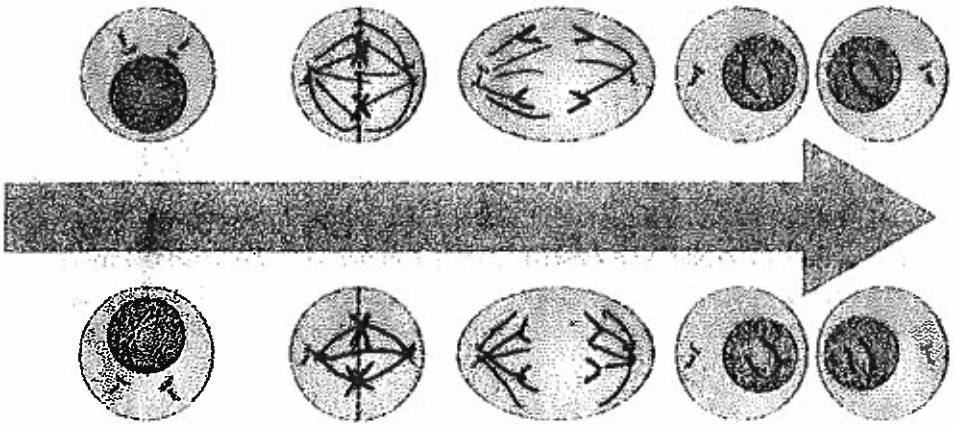
EXPLAIN Complete the statement about the model of meiosis I.

The products of meiosis I are two | four | six | eight cells with identical | different combinations of chromosomes. One advantage | disadvantage of this model is that it shows the phases of meiosis I very clearly. One advantage | disadvantage is that it does not show the full set of 46 chromosomes found in a human body cell.

Meiosis II

Meiosis II separates sister chromatids, which results in cells with chromosomes that are not doubled. The diagram of this process applies to both of the cells produced in meiosis I. The end result of meiosis II is four haploid cells. It is important to note that DNA is not copied between meiosis I and meiosis II.

Meiosis II



5 Prophase II 6 Metaphase II 7 Anaphase II 8 Telophase II

5. Prophase II
The membrane around the nucleus breaks down, centrosomes and centrioles move to opposite sides of the cell, and spindle fibers assemble.

6. Metaphase II
Spindle fibers align the 23 chromosomes at the cell equator. Each chromosome still has two sister chromatids at this stage.

7. Anaphase II
Next, the sister chromatids are pulled apart from each other and move to opposite sides of the cell.

8. Telophase II
Finally, nuclear membranes form around each set of chromosomes at opposite ends of the cell, the spindle fibers break apart, and the cell divides into two daughter cells.

ASK What questions do you have about how the chromosomes are sorted during meiosis? Discuss the answers to your questions with a partner.

Evidence Notebook According to this model of meiosis, do all the gametes produced by an organism have the same genetic material? Use evidence to support your claim.