If the reproductive cycle is going to occur, specialized diploid cells called adult stem cells must carry out a process called meiosis. In males, the adult stem cells are called spermatogonia and lead to the production of gametes called sperm. In females, these cells are called oogonia and lead to the production of female gametes called eggs or ova.

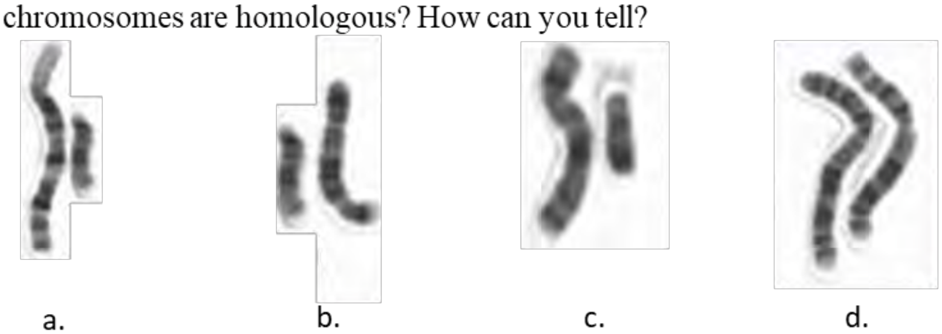
Plants do not reproduce the same way as animals; however, they still produce two separate and distinct gametes. In flowering plants, the male gametes form in the anthers and are enclosed within a pollen grain. Flowering plants make their female gametes in a structure called the ovary and the gametes are called ovules.

Meiosis is the process that produces haploid gametes by reducing the number of chromosome pairs by half. If this did not occur, the number of chromosomes would double with every future round of fertilization. Meiosis includes many of the same cellular events as mitosis. However, as you have learned, mitosis produces daughter cells who are genetically identical to one another. In mitosis, both the parent and the daughter cells should have the same genetic material and, therefore, the same chromosome number. Both the parent cell and the daughter cells are said to have the same “ploidy level.” This means that a diploid parent cell will produce daughter cells that are also diploid. The process of mitosis should result in the ploidy level remaining the same.

In meiosis, the starting adult stem cell is always diploid. The daughter cells that are produced are haploid; therefore, with meiosis, the ploidy level changes. To achieve this reduction in chromosome number, meiosis consists of one round of chromosome replication followed by two rounds of chromosome division. Because the events that occur during each of the stages are similar to the events of mitosis, the same stage names are assigned. However, because there are two rounds of division, the major processes and the stages are designated with a “I” or a “II.” Thus, **meiosis I** is the first round of meiotic division and consists of prophase I, prometaphase I, and so on. Likewise, **meiosis II**, during which the second round of meiotic division takes place, includes prophase II, prometaphase II, and so on. Let's take a closer look at the stages that make up meiosis (Figure 8.23).

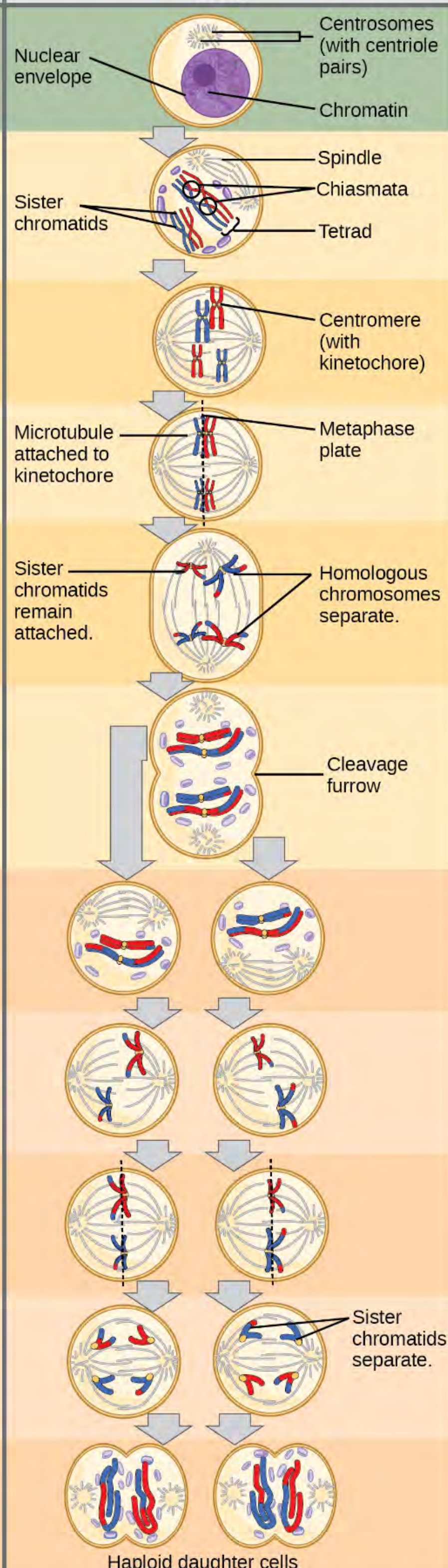
Check your knowledge

Which chromosomes are homologous? How can you tell?



Chromosome images modified by Marsha Hay from Figure 8.22

Answer: d are homologous chromosomes. They are the same size and shape so will carry similar gene sequences.



	Stage	Event	Outcome
INTERPHASE	**S phase**	Nuclear envelope; Centrosomes (with centriole pairs); Chromatin	Chromosomes are duplicated during interphase. The resulting sister chromatids are held together at the centromere. The centrosomes are also duplicated.
MEIOSIS I	**Prophase I**	Sister chromatids; Spindle; Chiasmata; Tetrad	Chromosomes condense, and the nuclear envelope fragments. Homologous chromosomes bind firmly together along their length, forming a tetrad. Chiasmata form between non sister chromatids. Crossing over occurs at the chiasmata. Spindle fibers emerge from the centrosomes.
	Prometaphase I	Centromere (with kinetochore)	Homologous chromosomes are attached to spindle microtubules at the fused kinetochore shared by the sister chromatids. Chromosomes continue to condense, and the nuclear envelope completely disappears.
	Metaphase I	Microtubule attached to kinetochore; Metaphase plate	Homologous chromosomes randomly assemble at the metaphase plate, where they have been maneuvered into place by the microtubules.
	Anaphase I	Sister chromatids remain attached.; Homologous chromosomes separate.	Spindle microtubules pull the homologous chromosomes apart. The sister chromatids are still attached at the centromere.
	Telophase I and Cytokinesis	Cleavage furrow	Sister chromatids arrive at the poles of the cell and begin to decondense. A nuclear envelope forms around each nucleus, and the cytoplasm is divided by a cleavage furrow. The result is two haploid cells. Each cell contains one duplicated copy of each homologous chromosome pair.
MEIOSIS II	**Prophase II**		Sister chromatids condense. A new spindle begins to form. The nuclear envelope starts to fragment.
	Prometaphase II		The nuclear envelope disappears, and the spindle fibers engage the individual kinetochores on the sister chromatids.
	Metaphase II		Sister chromatids line up at the metaphase plate.
	Anaphase II	Sister chromatids separate.	Sister chromatids are pulled apart by the shortening of the kinetochore microtubules. Non kinetochore microtubules lengthen the cell.
	Telophase II and Cytokinesis	Haploid daughter cells	Chromosomes arrive at the poles of the cell and decondense. Nuclear envelopes surround the four nuclei. Cleavage furrows divide the two cells into four haploid cells.

8.23 An animal cell with a diploid number of four (2n = 4) proceeds through the stages of meiosis to form four haploid daughter cells. (credit: Clark et al. / Biology 2E OpenStax)

Interphase

Meiosis is preceded by an interphase consisting of the G_1, S, and G_2 phases, which are nearly identical to the phases preceding mitosis. The G_1 phase is the first phase of interphase and is focused on cell growth. In the S phase, the DNA of the chromosomes is replicated. Finally, in the G_2 phase, the cell undergoes the final preparations for meiosis.

During DNA duplication of the S phase, each chromosome becomes composed of two identical copies called sister chromatids. Once this occurs, the chromosomes are said to be in the duplicated state. Chromosomes in the duplicated state are held together at the centromere until they are pulled apart during meiosis II. In an animal cell, the centrosomes that organize the microtubules of the meiotic spindle also replicate during interphase. This prepares the cell for the first meiotic phase.

Meiosis I

Prophase I

Prophase I is the first phase of meiosis. Early in prophase I, the chromosomes begin to condense, and the nuclear envelope begins to break down. Homologous chromosomes are brought together with the help of unique proteins. Each homologous chromosome pair is held together by proteins forming a **tetrad**, a complex consisting of four sister chromatids (Figure 8.24). Recall that in mitosis, homologous chromosomes do not pair together.

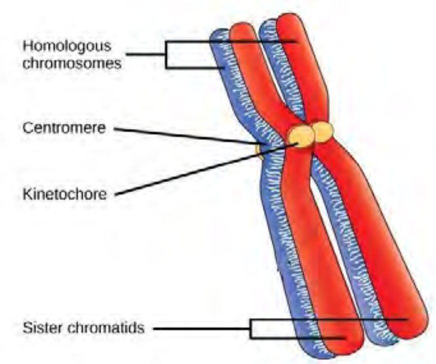


Figure 8.24 Homologous chromosomes pair together during prophase I to form a tetrad. (credit: Clark et al./ Biology 2E OpenStax)

When the tetrad is formed, the genes on the non-sister chromatids of the homologous pair are precisely aligned with each other. This alignment allows for chromosome segments to be exchanged between non-sister chromatids; a process called **crossing over** or **recombination**. Crossing over occurs at precise locations called **chiasmata** (singular = *chiasma*) (Figure 8.25).

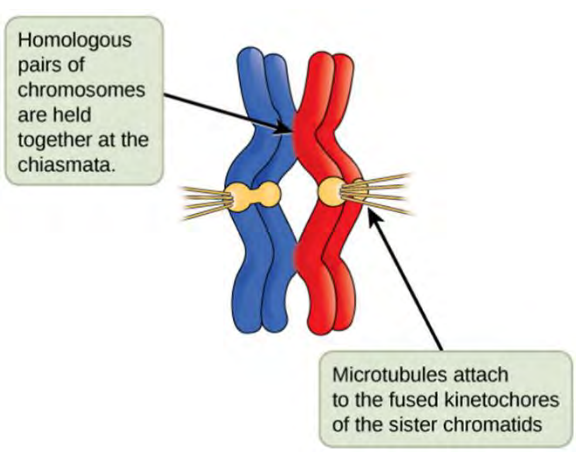


Figure 8.25 Chiasmata hold the homologous chromosomes together. (credit: Biology OpenStax / Wikimedia Commons)