Chapter 13: Meiosis and Sexual Life Cycles

13.1 Compare and contrast asexual and sexual reproduction with respect to inheritance of chromosomes by offspring.

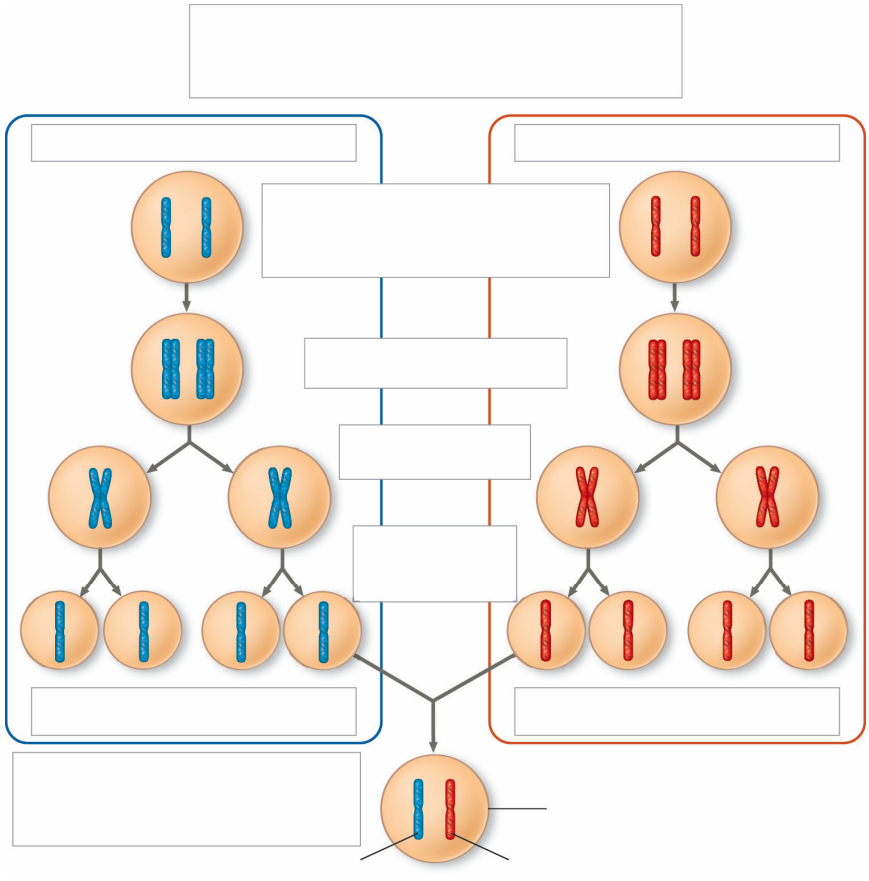
13.2 Explain the alternation of fertilization and meiosis in different types of sexual life cycles, using the terms haploid, diploid and zygote.

13.3 Describe the stages of meiosis, explaining how the process reduces the number of chromosome sets.

13.4 Identify the ways in which sexual life cycles generate genetic variation that contributes to evolution.

Meiosis accounts for much of the genetic diversity in sexually reproducing organisms, so focus on how this process results in offspring that are different from their parents. Be careful to note that although both mitosis and meiosis share many common features, the resultant daughter cells are very different. Keep this in mind throughout this chapter.

Study Tip: Figure 13.1 presents the "big picture" of inheritance from two parents in sexual fertilization. Work through it slowly by labeling the indicated boxes. When you complete this chapter, come back to this figure and review it again.



Concept 13.1 Offspring acquire genes from parents by inheriting chromosomes

LO 13.1: Compare and contrast asexual and sexual reproduction with respect to inheritance of chromosomes by offspring.

1. Let's begin with a review of several terms. Define:

   gene

   locus

   gametes

   male gamete

   female gamete

   somatic cells

   genome

   asexual reproduction

   sexual reproduction

2. How many chromosomes are in human cells? What *is* a chromosome?

3. Which type of reproduction will result in genetically identical offspring?

Concept 13.2 Fertilization and meiosis alternate in sexual life cycles

LO 13.2: Explain the alternation of fertilization and meiosis in different types of sexual life cycles, using the terms haploid, diploid and zygote.

4. How does a somatic cell compare to a gamete in terms of chromosome number?

5. What is a *karyotype*? How is it prepared?

6. What are two things that can be determined from a karyotype? (Study the Research Method, Figure 13.3, in your text carefully for this information.)

7. Explain what is meant by *homologous chromosomes*.

8. Distinguish between *sex chromosomes* and *autosomes*. How many of each are found in human cells?

	Description	# in Human Cells
Sex chromosome		
Autosome		

9. Cells that have only one of each homologous pair are said to be *haploid*, a condition that is represented by *n*. Cells that have two of each homologous pair are said to be *diploid* or 2*n*. For each of the following, is the cell haploid or diploid?

liver cell _____ gamete _____

egg cell _____ zygote _____

skin cell _____ sperm _____

somatic cell _____ stem cell _____

10. The muscle cells of a dog have 78 chromosomes. Fill in the correct chromosome number for the following cells in a dog: bone cell _____, sperm _____, haploid cell _____, somatic cell _____, and zygote _____.

11. In the cell below, the chromosomes are shaded in two colors to represent the parent of origin, red for maternal and blue for paternal. On this sketch, label the following:

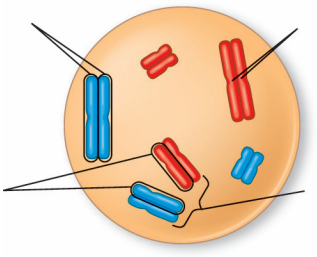
    a. sister chromatids

    b. homologous chromosomes

    c. centromere

    d. duplicated chromosome

    e. maternal chromosomes



12. How many chromosomes does the cell in question 11 have?_____

    How many homologous pairs? _____ How many chromatids? _____ Is this cell haploid (*n*) or diploid (2*n*)? _____

13. Where are the *gametes* of an animal produced? Be specific as to male and female gametes.

14. By what process are gametes produced? _____

15. What is the purpose of *meiosis*?

16. Study Figure 13.6 in your text. You will see that plants have a life cycle that involves spores, which form as a result of meiosis, so these spores are haploid. Notice also that *both* haploid and diploid cells can divide by mitosis. However, meiosis always begins with cells that are _____, and as a result of meiosis, daughter cells are formed that are always _____. These cells can be gametes (in animals) or spores (in plants).

17. Your study of plants this year will include knowing that they exhibit *alternation of generations*.

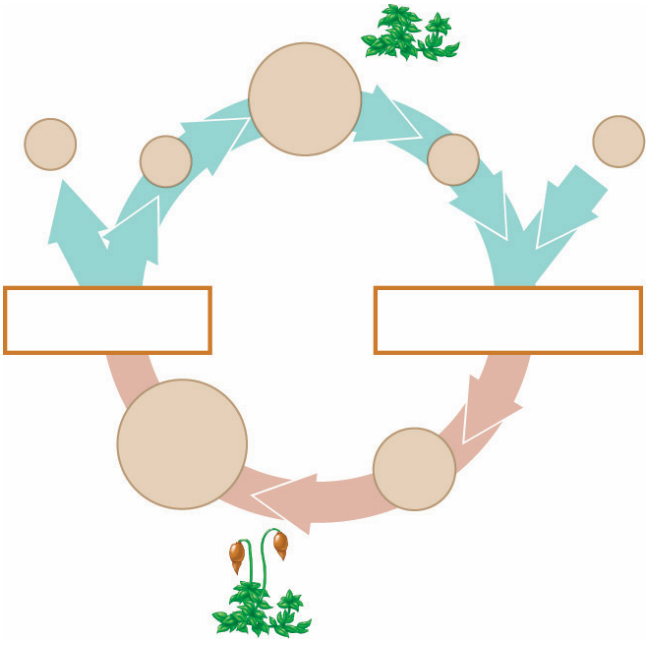
    a. What does this mean?

    b. What are the two generations?

    c. Which generation is haploid, and which is diploid?

    d. Use this information to label the moss life cycle here.

Moss Life Cycle



Concept 13.3 Meiosis reduces the number of chromosome sets from diploid to haploid

LO 13.3: Describe the stages of meiosis, explaining how the process reduces the number of chromosome sets.

18. Read the opening paragraph of this concept very carefully while you study Figure 13.7 in your text.

    a. In meiosis, what follows the duplication of chromosomes?

    b. How many daughter cells are formed at the conclusion of meiosis?

    c. Describe the chromosomes of the daughter cells.

19. What are *alleles*? Give an example.

Figure 13.8 in your text will require careful attention. In particular, note the ways in which meiosis differs from mitosis.

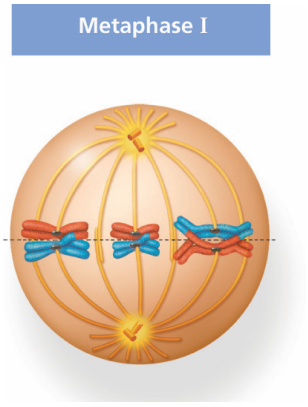
20. In meiosis, the DNA is replicated during interphase, followed by two divisions of the nucleus. The first division is meiosis I. Use Figure 13.8 on p. 260 to study the events of *prophase I,* as they are significant. A more detailed discussion of the process can be found on p. 262. Explain each of these:

    synapsis

    crossing over

    chiasmata

21. The figure below shows metaphase I of meiosis. How is the arrangement of chromosomes here different from the metaphase of mitosis?



22. There are two divisions in meiosis. What will separate in the first division in meiosis I?

23. Now study the chromosomes in *anaphase I* and *telophase I* carefully (Figure 13.8 in your text).

    a. How many chromosomes are present at the end of anaphase I?

    b. How many chromosomes are present at the end of telophase I?

    c. At the end of the first meiotic division, are the daughter cells haploid or diploid?

24. During meiosis I, homologous chromosomes separate. What separates during meiosis II?

25. To check that you have the big picture, here are some quick review questions.

    a. What happens to the chromosome number in meiosis?

    b. During which division is the chromosome number reduced?

    c. What is the purpose of meiosis?

    d. How many times does the cell divide in meiosis?

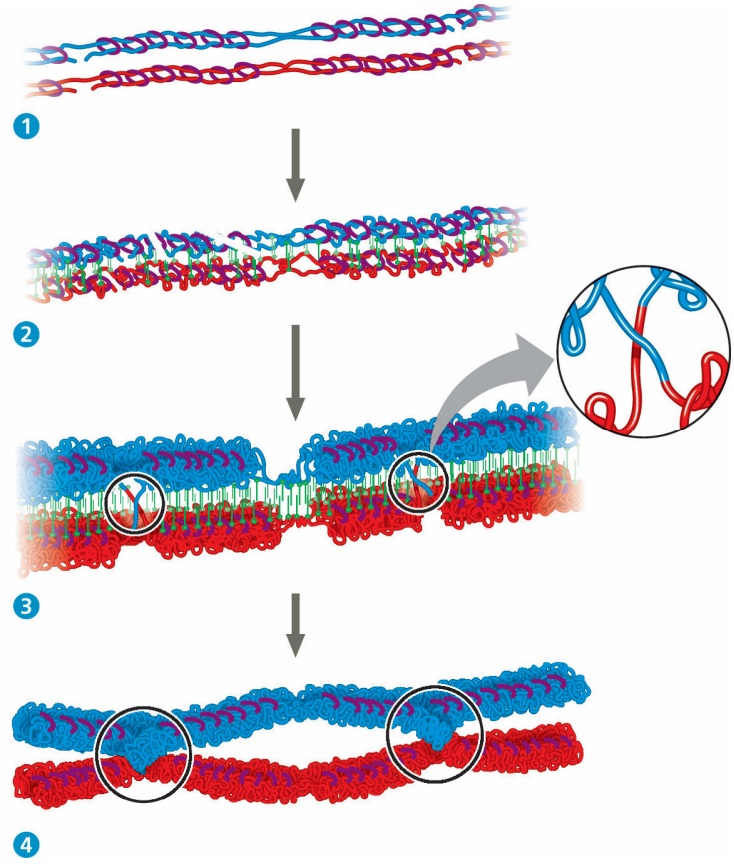
    e. How many times do the chromosomes duplicate?

    f. How many daughter cells are formed?

    g. What is the chromosome number of the daughter cells of meiosis?

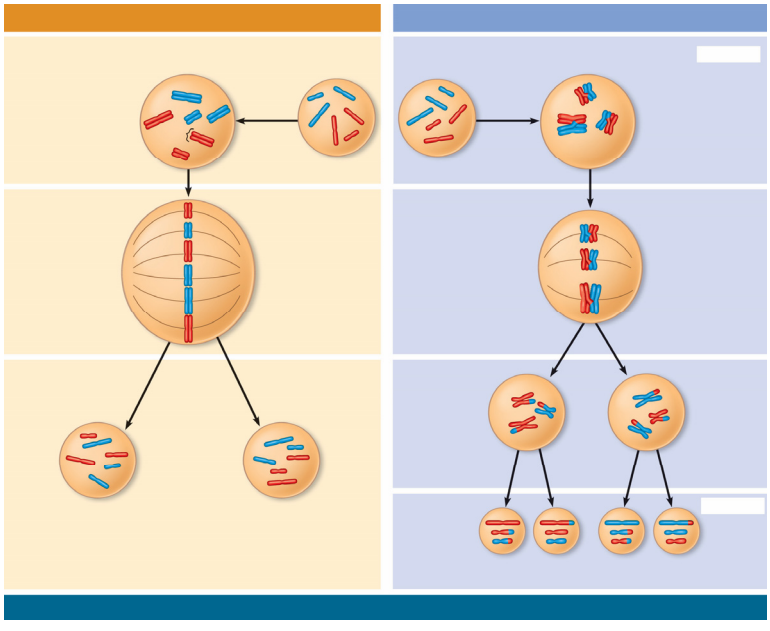
    h. What are *homologs (homologous chromosomes)*?

26. Prophase I of meiosis is a very busy time! The signature event of crossing over occurs during prophase I. Using Figure13.9, label then thoroughly explain what occurs in the four steps shown by the numbers in the diagram.



27. Why must crossing over occur with a nonsister chromatid?

28. Use Figure 13.10 in your text to compare mitosis and meiosis. Add these labels: *parent cell, mitosis, meiosis, synapsis, homologous chromosomes, duplicated chromosomes, sister chromatids, daughter cells, meiosis I, meiosis II,* and *crossing over.*



29. Students often get confused about the differences between mitosis and meiosis. To help with this, fill out the following chart:

	Mitosis	Meiosis
Role in the animal body		
Number of DNA replications		
Number of divisions		
Number of daughter cells		
Chromosome number of daughter cells		
Are the daughter cells identical to or different from the parent cell?		

30. At this point, perhaps you feel that we have been hitting you over the head to be sure you understand how meiosis differs from mitosis. That is because our students often get confused here, and we want you to be 100% confident you have this all straight. Let's do one more comparison.

    Describe the three events unique to meiosis that occur during meiosis I.

Event	Description

Concept 13.4 Genetic variation produced in sexual life cycles contributes to evolution

LO 13.4: Identify the ways in which sexual life cycles generate genetic variation that contributes to evolution.

31. An important idea for you to understand is that new alleles arise by changes in the DNA or mutation, but genetic diversity also occurs when the deck is simply reshuffled. So, there are three ways that sexually reproducing organisms "shuffle the deck." They are listed below. Explain what occurs in each, and *how this increases diversity*.

    1. **independent assortment of chromosomes**

    2. **crossing over**

    3. **random fertilization**

32. Here is a fun exercise to drive this point home. Pull out your calculator, and try your hand at this: When you were conceived, what were the odds that, of the many possibilities, your parents would come up with *you*?

    a. The number of different gametes that can be formed because of independent assortment is

    2^n, where n = the number of homologous pairs

    Therefore, because humans have 46 chromosomes or 23 homologous pairs, what is the number of possible gametes that can be formed due to independent assortment of chromosomes?

    b. Now, this is the number of unique gametes your mom could have made. Your father could have made the same number. To see the effect of random fertilization, multiply the number of gametes one parent could make by the number of unique gametes the other parent could make.

    Your answer should be in the *trillions*, and all of this is *without* crossing over. See how special you are?

33. It is easy to have the misconception that the chromosomes inherited from our parents are exclusively maternal or paternal. The chromosomes we inherit are actually recombinant chromosomes. Explain what this means and clarify the misconception.

34. Let's take a moment to consider the question "why sex?" Any individual passes on more of its genes through asexual reproduction, so there must be some advantage to sexual reproduction, as it is almost universal among animals. Under what conditions is sexual reproduction most advantageous, and why?

35. As we noted earlier, students often confuse the two types of cell division, so let's close with a final exercise. Compare mitosis and meiosis by selecting either term to answer the following questions.

_____ By what process are the damaged cells in a wound replaced?

_____ By what process are eggs formed?

_____ By what process does a zygote develop into a multicellular organism?

_____ In which process are identical daughter cells produced?

_____ Which process reduces the chromosome number of daughter cells?

36. Opening Figure 13.1 should now be as familiar as an old friend. What processes that play a role in sexual reproduction are not shown in the introductory figure?

Test Your Understanding, p. 268

Now you should be ready to test your knowledge. Place your answers here:

1. _____ 2. _____ 3. _____ 4. _____ 5. _____

Follow the directions for Self-Quiz question 6, DRAW IT, by labeling the appropriate structures on the figure below with these terms, drawing lines or brackets as needed: *chromosome* (label as duplicated or unduplicated), *centromere*, *kinetochore*, *sister chromatids*, *nonsister chromatids*, *homologous pair*, *homologs*, *chiasma*, *sister chromatid cohesion.* Finally, identify the stage of meiosis shown.