1. Gametes contain _______ the number of chromosomes found in somatic cells.
   a. the same
   b. twice
   c. half
   d. one fourth

   The correct answer is c—
   A. Answer a is incorrect. Gametes are the product of meiosis. Meiosis reduces the number of chromosome by half.

   The correct answer is c—
   B. Answer b is incorrect. A gamete functions by combining with another gamete to produce a new individual. The new individual must have the same total number of chromosomes as its parents.

   The correct answer is c—half
   C. Answer c is correct. The process of meiosis divides the total chromosome number of an organism in half, producing cells with one complete set of chromosomes.

   The correct answer is c—
   D. Answer d is incorrect. A gamete function by combining with another gamete to create a new individual. The new individual must have the same total number of chromosomes as its parents.

2. Somatic cells are ________, whereas gametes are _____________.
   a. haploid; diploid
   b. diploid; polyploid
   c. polyploidy; haploid
   d. diploid; haploid

   The correct answer is d—
   A. Answer a is incorrect. Somatic cells have twice the number of chromosomes as a gamete. They are said to be diploid (di meaning two).

   The correct answer is d—
   B. Answer b is incorrect. The term poly means many. Gametes have fewer chromosomes than the somatic cells.

   The correct answer is d—
   C. Answer c is incorrect. Although the somatic cells have more chromosomes than gamete cells, the term polyploidy refers to a condition in which the cell has too many chromosomes.

   The correct answer is d—diploid; haploid
   D. Answer d is correct. Somatic cells have twice the number of chromosomes as the haploid gamete cells.
3. An organism is said to be diploid if—
   a. it contains genetic information from two parents
   b. it is multicellular
   c. it reproduces
   d. undergoes mitotic cell division

The correct answer is a—it contains genetic information from two parents
   A. Answer a is correct. The combination of two haploid gametes results in the production of a diploid organism with two complete sets of chromosomes.

The correct answer is a—
   B. Answer b is incorrect. Some organisms (ferns, for example) have a multicellular haploid stage in their life cycle.

The correct answer is a—
   C. Answer c is incorrect. Some organisms produce gametes through mitosis from the haploid stage of their life cycle.

The correct answer is a—
   D. Answer d is incorrect. Mitotic cell division is not limited to diploid cells. Haploid organisms use mitosis to produce gametes to complete their life cycle.

4. What are homologous chromosomes?
   a. The two halves of a replicated chromosome
   b. Two identical chromosomes from one parent
   c. Two genetically identical chromosomes, one from each parent
   d. Two genetically similar chromosomes, one from each parent

The correct answer is d—
   A. Answer a is incorrect. The two halves of a replicated chromosome are called sister chromatids.

The correct answer is d—
   B. Answer b is incorrect. Homologous chromosomes are the equivalent genetic material from each parent.

The correct answer is d—
   C. Answer c is incorrect. Homologous chromosomes represent equivalent genetic material from each parent. It does not have to be identical.

The correct answer is d—Two genetically similar chromosomes, one from each parent
   D. Answer d is correct. Chromosomes are said to be homologous because they carry the equivalent, but not identical, genetic material.
5. When homologous chromosomes form chiasmata, they are—
   a. exchanging genetic information
   b. reproducing their DNA
   c. separating their sister chromatids
   d. replicating their chromatids

The correct answer is a—exchanging genetic information
   A. Answer a is correct. The formation of chiasmata during crossing over allows for the transfer and exchange of genetic information between two homologous chromosomes.

The correct answer is a—
   B. Answer b is incorrect. Reproduction of DNA precedes meiosis and occurs during S phase of the cell cycle.

The correct answer is a—
   C. Answer c is incorrect. The separation of sister chromatids occurs during anaphase of meiosis II and is not associated with the formation of chiasmata.

The correct answer is a—
   D. Answer d is incorrect. Replication of chromosomal material occurs during S phase.

6. Crossing over involves each of the following with the exception of—
   a. the transfer of DNA between two nonsister chromatids
   b. the transfer of DNA between two sister chromatids
   c. the formation of a synaptonemal complex
   d. the alignment of homologous chromosomes

The correct answer is b—
   A. Answer a is incorrect. Crossing over does occur between nonsister chromatids.

The correct answer is b—the transfer of DNA between two sister chromatids
   B. Answer b is correct. The transfer of DNA between sister chromatids would not represent a net change. Sister chromatids are identical copies. Crossing over between sister chromatids is suppressed during meiosis.

The correct answer is b—
   C. Answer c is incorrect. The synaptonemal complex is required for crossing over to occur.

The correct answer is b—
   D. Answer d is incorrect. Crossing over can only occur if the homologous chromosomes are aligned.

7. Terminal chiasmata are seen during which phase of meiosis?
   a. Anaphase I
   b. Prophase I
   c. Metaphase I
   d. Metaphase II
The correct answer is c—
A. Answer a is incorrect. Homologous chromosomes are separated during anaphase I.

The correct answer is c—
B. Answer b is incorrect. Crossing over has only begun during prophase I.

The correct answer is c—Metaphase I
C. Answer c is correct. The terminal chiasmata hold the homologous chromosomes together at the metaphase plate during meiosis I.

The correct answer is c—
D. Answer d is incorrect. The homologous chromosomes have already separated during metaphase of meiosis I. The chiasmata are no longer visible during meiosis II.

8. Which of the following occurs during anaphase I?
   a. Sister chromatids are separated and move to the poles.
   b. Homologous chromosomes move to opposite poles.
   c. Homologous chromosomes align at the middle of the cell.
   d. All the chromosomes align independently at the middle of the cell.

The correct answer is b—
A. Answer a is incorrect. The sister chromatids remain connected at their centromeres through all of meiosis I.

The correct answer is b—Homologous chromosomes move to opposite poles.
B. Answer b is correct. Meiosis I is characterized by the separation of homologous chromosomes during anaphase. This is the step that reduces the number of chromosomes.

The correct answer is b—
C. Answer c is incorrect. The homologous chromosomes align during metaphase of meiosis I.

The correct answer is b—
D. Answer d is incorrect. Meiosis I is characterized by the pairing of homologous chromosomes.

9. Telophase 1 results in the production of—
   a. four cells containing one homologue of each homologous pair
   b. two cells containing both homologues of each homologous pair
   c. four cells containing both homologues of each homologous pair
   d. two cells containing one homologue of each homologous pair

The correct answer is d—
A. Answer a is incorrect. Meiosis I produces cells containing one homologue of each homologous pair, however, only two cells are produced at this stage.

The correct answer is d—
B. Answer b is incorrect. The first round of cell division results in the production of two daughter cells; however, the process of meiosis I results in the production of cells containing one homologue of each homologous pair.

The correct answer is d—

C. Answer c is incorrect. The first round of meiotic cell division produced two daughter cells containing one homologue of each homologous pair.

The correct answer is d—two cells containing one homologue of each homologous pair

D. Answer d is correct. Meiosis I separates the homologous chromosomes, resulting in two daughter cells containing one homologue of each homologous pair.

10. Which of the following does NOT contribute to genetic diversity?
   a. Independent assortment
   b. Recombination
   c. Metaphase of meiosis II
   d. Metaphase of meiosis I

The correct answer is c—

A. Answer a is incorrect. Independent assortment, the random alignment of chromosomes at the metaphase plate during metaphase I, generates genetic diversity by “shuffling” the maternal and paternal homologues between the two daughter cells.

The correct answer is c—

B. Answer b is incorrect. Recombination, or crossing over, generates genetic diversity by creating new combinations of genetic information.

The correct answer is c—Metaphase of meiosis II

C. Answer c is correct. Meiosis II is most like mitosis and does not result in any new combinations of genetic material.

The correct answer is c—

D. Answer d is incorrect. Homologous chromosomes randomly align on the metaphase plate during meiosis I. This independent assortment results in different distributions of maternal and paternal homologous chromosomes.

11. How does S phase following meiosis I differ from S phase in mitosis?
   a. DNA replication takes less time because the cell is haploid.
   b. DNA does not replicate during S phase following meiosis I.
   c. DNA replication takes more time due to cohesin proteins.
   d. There is no difference.

The correct answer is b—

A. Answer a is incorrect. The DNA is already replicated prior to beginning meiosis I. The sister chromatids are still connected.

The correct answer is b—DNA does not replicate during S phase following meiosis I.

B. Answer b is correct. DNA replication is suppressed between the two divisions of meiosis. The replicated sister chromatids are still attached.
The correct answer is b—
C. Answer c is incorrect. Although cohesin proteins are present in the chromosomes, there is no need to replicate the DNA.

The correct answer is b—
D. Answer d is incorrect. Replication does not occur during the S phase preceding meiosis II.

12. What occurs during anaphase of meiosis II?
   a. The homologous chromosomes align.
   b. Sister chromatids are pulled to opposite poles.
   c. Homologous chromosomes are pulled to opposite poles.
   d. The haploid chromosomes line up.

The correct answer is b—
A. Answer a is incorrect. The homologues have already been separated during anaphase of meiosis I.

The correct answer is b—Sister chromatids are pulled to opposite poles.
B. Answer b is correct. Sister chromatids are separated during meiosis II.

The correct answer is b—
C. Answer c is incorrect. The homologues have already been separated during anaphase of meiosis I.

The correct answer is b—
D. Answer d is incorrect. Anaphase is the process of separating chromatids to opposite poles.

13. What is an aneuploid gamete?
   a. A diploid gamete cell
   b. A haploid gamete cell
   c. A gamete cell with the wrong number of chromosomes
   d. A haploid somatic cell

The correct answer is c—
A. Answer a is incorrect. A cell with the complete diploid chromosome number cannot be called a gamete. Aneuploid gametes typically have one too few or one too many chromosomes—not a full extra set.

The correct answer is c—
B. Answer b is incorrect. A haploid gamete would have the correct number of chromosomes. Aneuploid gametes have an abnormal chromosome number.

The correct answer is c—A gamete cell with the wrong number of chromosomes
C. Answer c is correct. Aneuploid gametes occur when the proper segregation of the chromosomes is disrupted.

The correct answer is c—
D. Answer d is incorrect. A somatic cell is not a gamete.
14. Which of the following is NOT a distinct feature of meiosis?
   a. Pairing and exchange of genetic material between homologous chromosomes
   b. Attachment of sister kinetochores to spindle microtubules
   c. Movement of sister chromatids to the same pole
   d. Suppression of DNA replication

The correct answer is b—
A. Answer a is incorrect. The exchange of genetic material between homologues is a unique property of meiotic cell division.

The correct answer is b—Attachment of sister kinetochores to spindle microtubules
B. Answer b is correct. Sister chromatids attach their kinetochores to the microtubule spindle during both mitosis and meiosis.

The correct answer is b—
C. Answer c is incorrect. The separation of homologues during anaphase I is a distinct feature of meiosis.

The correct answer is b—
D. Answer d is incorrect. DNA replication must occur between each mitotic cell division, but is not required during S phase between meiosis I and II.

15. Which phase of meiosis I is most similar to the comparable phase in mitosis?
   a. Prophase I
   b. Metaphase I
   c. Anaphase I
   d. Telophase I

The correct answer is d—
A. Answer a is incorrect. Prophase I of meiosis is different from prophase of mitosis because crossing over occurs during this meiotic phase.

The correct answer is d—
B. Answer b is incorrect. Homologous chromosomes align during metaphase I. The chromosomes do not align during mitosis.

The correct answer is d—
C. Answer c is incorrect. Anaphase I involves the separation of homologous chromosomes. There is no separation of homologues during mitosis.

The correct answer is d—Telophase I
D. Answer d is correct. Telophase of meiosis I and mitosis both involve the reformation of the nuclear envelope followed by cytokinesis.
Challenge Questions

1. Diagram the process of meiosis for an imaginary cell with six chromosomes in a diploid cell.
   a. How many homologous pairs are present in this cell? Create a drawing that distinguishes between homologous pairs.
   b. Label each homolog to indicate whether it is maternal (M) or paternal (P).
   c. Draw a new cell showing how these chromosomes would arrange themselves during metaphase of meiosis I. Do all the maternal homologues have to line up on the same side of the cell?
   d. How would this picture differ if you were diagramming anaphase of meiosis II?

Answer—Compare your figure with Figure 11.8.
   a. There would be three homologous pairs of chromosomes for an organism with a diploid number of six.
   b. For each pair of homologues, you should now have a maternal and paternal pair.
   c. Many possible arrangements are possible. The key to your image is that it must show the homologues aligned pairwise—not single-file along the metaphase plate. The maternal and paternal homologues do not have to align on the same side of the cell. Independent assortment means that the pairs can be mixed.
   d. A diagram of metaphase II would not include the homologous pairs. The pairs have separated during anaphase of meiosis I. Your picture should diagram the haploid number of chromosomes, in this case three, aligned single-file along the metaphase plate. Remember that meiosis II is most similar to mitosis.

2. Mules are the offspring of the mating of a horse and a donkey. Mules are unable to reproduce. A horse has a total of 64 chromosomes, whereas donkeys have 62 chromosomes. Use your knowledge of meiosis to predict the diploid chromosome number of a mule. Propose a possible explanation for the inability of mules to reproduce.

Answer—The diploid chromosome number of a mule is 63. The mule receives 32 chromosomes from its horse parent (diploid 64: haploid 32) and another 31 chromosomes from its donkey parent (diploid 61: haploid 31). 32 + 31 = 63. The haploid number for the mule would be one half the diploid number 63 ÷ 2 = 31.5. Can there be a 0.5 chromosome? When the homologues align during metaphase of meiosis I there will be one chromosome without a partner. The meiotic spindle will not work and so no gametes will be formed.

3. Compare the processes of independent assortment and crossing over. Which process has the greatest influence on genetic diversity?

Answer—Independent assortment involves the random distribution of maternal versus paternal homologues into the daughter cells produced during meiosis I. The number of possible combinations of maternal and paternal pairings is on the order of $2^n$, where $n$ is the diploid number of chromosomes. Crossing over involves the exchange of genetic material between homologous chromosomes, creating new combinations of genes on a single chromosome. Crossing over does not occur all the time, nor does it influence every homologous pair. For these
reasons, it is reasonable to conclude that independent assortment has the greatest influence on genetic diversity.

4. Aneuploid gametes are cells that contain the wrong number of chromosomes. Aneuploidy occurs as a result of nondisjunction, or lack of separation of the chromosomes during either phase of meiosis.
   a. At what point in meiotic cell division would nondisjunction occur?
   b. Imagine a cell had a diploid chromosome number of 4. Create a diagram to illustrate the effects of nondisjunction of one pair of homologous chromosomes in meiosis I versus meiosis II.

**Answer**—a. Nondisjunction occurs at the point when the chromosomes are being pulled to opposite poles. This occurs during anaphase.
   b. Use an image like Figure 11.8 and illustrate nondisjunction at anaphase I versus anaphase II.

**Anaphase I nondisjunction:**

![Diagram of Anaphase I Nondisjunction](image)
Anaphase II nondisjunction: