Review the Concepts

Work through the following exercises to review the concepts in this chapter. For additional review, refer to the activities at www.mybiology.com. The website offers a pre-test that will help you plan your studies.

Exercise 1 (Introduction–Module 8.3)

Review the concepts introduced in these modules by filling in the blanks.

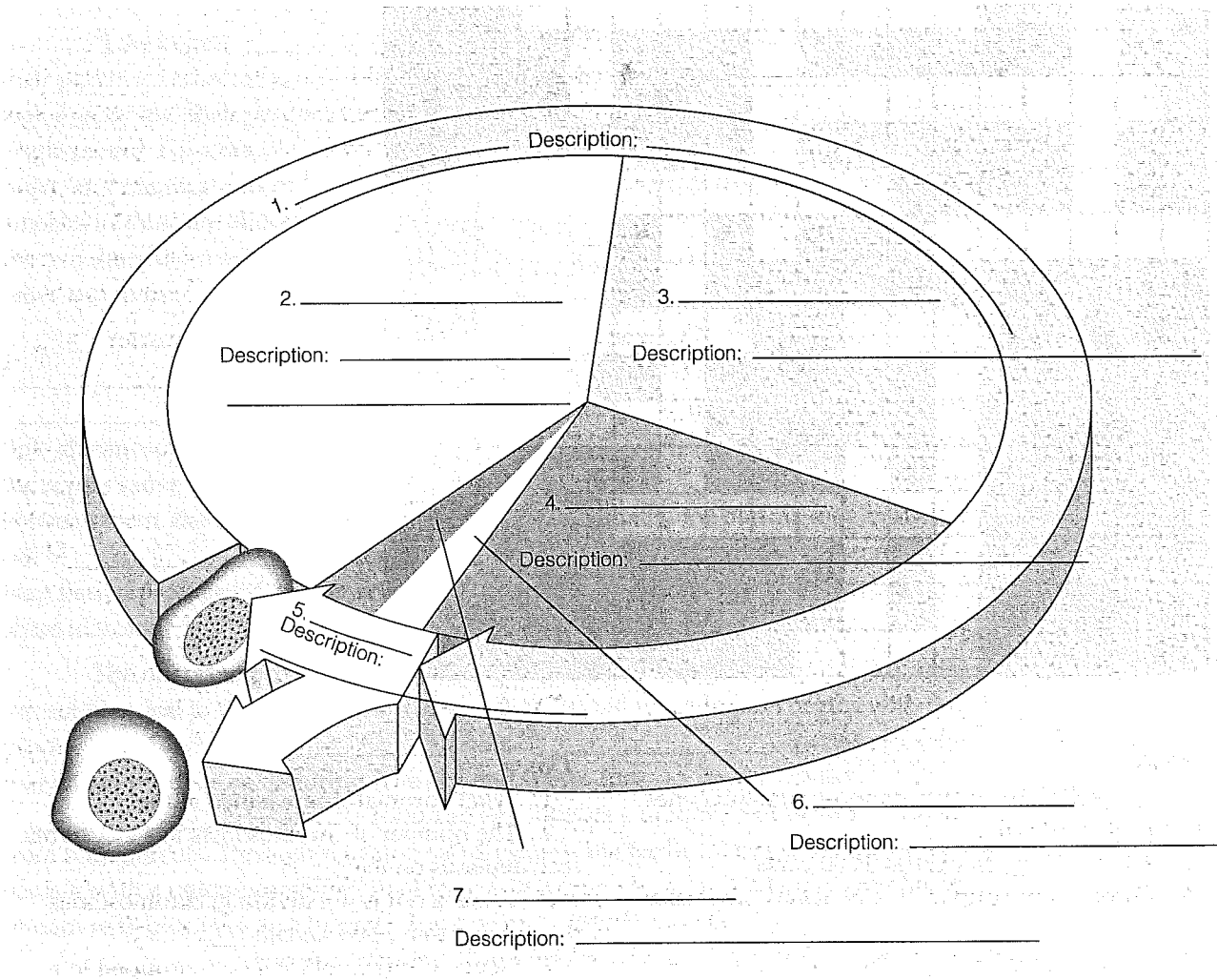
"Like begets [1]_____." This old saying means offspring look like their parents. Technically, only offspring produced by [2]_____ reproduction look exactly like their parents, because they inherit all their [3]_____ from a single parent. For example, when an amoeba divides, its [4]_____ is duplicated, and identical sets of [5]_____ (the structures that contain most of the amoeba's DNA) are allocated to opposite sides of the cell. The parent amoeba splits, and the two daughter amoebas that are formed are genetically [6]_____ to each other and to the [7]_____ cell.

Prokaryotes also reproduce asexually, via a type of cell division called [8]_____. Most genes in a prokaryote are carried on a single [9]_____ DNA molecule, which is much [10]_____ than the multiple chromosomes of eukaryotes. The prokaryote [11]_____ its DNA, and the copies move toward opposite ends of the cell. As new [12]_____ grows between them, the chromosomes become separated. Finally, the plasma membrane and cell [13]_____ split the cell in two. Like the reproduction of an amoeba, binary fission produces daughter cells identical to the parent cell. Parent and offspring share identical [14]_____, or sets of genetic information.

The offspring produced by sexual reproduction resemble their parents, but they are not identical to their parents or to each other. Sexual reproduction begins with the production of an [15]_____ and a [16]_____, specialized cells that join to produce an offspring. The egg and sperm fuse—a process called [17]_____—and the fertilized egg inherits a unique combination of genes from both parents. Through repeated cell divisions, the fertilized egg develops into an organism with a unique combination of traits—for example, a cat with long, gray fur or a human with blue eyes and freckles. Thus, sexual reproduction produces [18]_____ among offspring. Through sexual reproduction "like begets like," but not exactly.

Exercise 3 (Module 8.5)

Review the cell cycle: First identify the parts of the cycle and place them in order by writing the name of each phase or process on the diagram. Choose from **S, interphase, mitosis, G_1, mitotic phase, cytokinesis,** and **G_2.** Then add a brief description of what is happening during that portion of the cycle. Choose from **growth and DNA synthesis, cell growth following division, division of cytoplasm, activity between divisions, division of nucleus and chromosomes, growth and activity between DNA replication and division,** and **mitosis plus cytokinesis.**



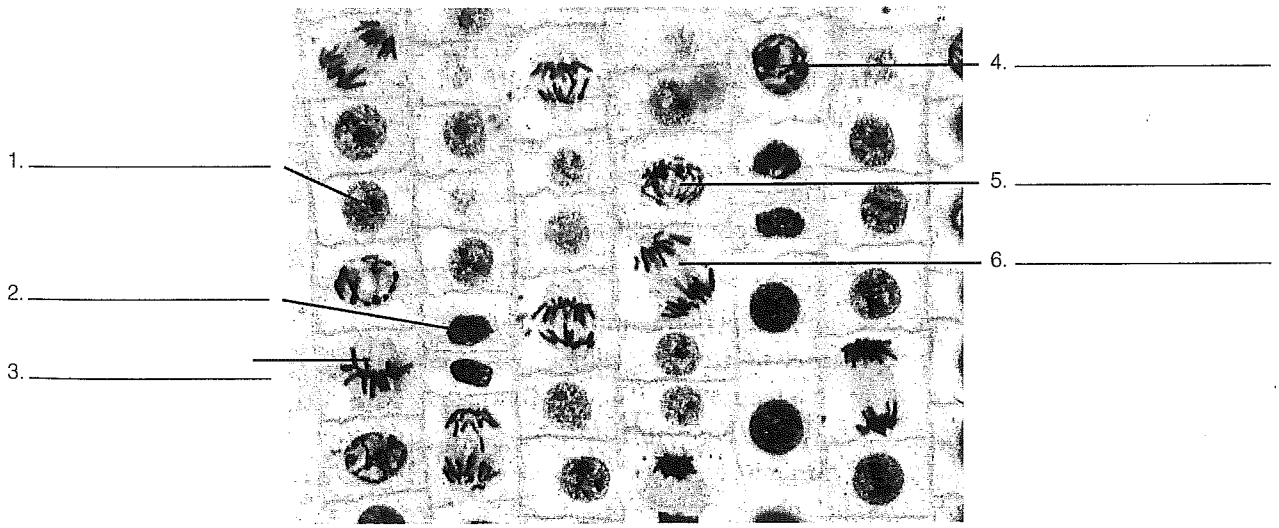
Exercise 4 (Module 8.6)

Summarize mitotic cell division. Briefly describe the appearance and activities of each of these cell parts during interphase and the five stages of mitosis. Include a simple sketch for each phase (just cell outlines and chromosomes).

	Interphase	*Prophase*	*Prometaphase*	*Metaphase*	*Anaphase*	*Telophase*
Nucleus and nuclear envelope						
Mitotic spindle						
Chromosomes						
Cell size and shape						
Sketch						

Exercise 5 (Module 8.6)

This is a photograph of cells in an onion root tip, an area of rapid cell division. In which stage of mitosis (or interphase) is each of the numbered cells?



Exercise 6 (Module 8.6)

Match each structure on the left with its correct role in mitosis in an animal cell on the right.

_____ 1. Metaphase plate
_____ 2. Kinetochores
_____ 3. Sister chromatids
_____ 4. Spindle microtubules
_____ 5. Centrosome
_____ 6. Motor proteins

A. Where spindle microtubules attach to chromosomes
B. Move chromosomes
C. Pulled apart by spindle microtubules
D. Material around centrioles from which mitotic spindle grows
E. "Walk" chromosomes along microtubules toward cell poles
F. Chromosomes come to rest here during metaphase

Exercise 7 (Module 8.7)

Read this module and then write a statement containing exactly 30 words (no more, no less!) comparing cytokinesis in plant and animal cells. (Writing *exactly* 30 words will help you to think about the processes and choose your words carefully. It's fun to try it.)

Exercise 8 (Modules 8.8–8.11)

Review the functions of cell division and the factors that control it by filling in the blanks below.

Mitotic cell division has several important functions. Some animals rely on cell division for [1]_____ reproduction. *Hydra*, for example, produces buds that detach from the parent and take up life on their own. Cell division is also responsible for [2]_____, as seen in human embryos and plant roots. In an adult human, some cells, such as most nerve and muscle cells, cease to divide. Others, such as cells of the [3]_____, divide only if the organ is damaged. This process [4]_____ wounds. Some cells, such as those on the surface of the [5]_____ and the lining of the [6]_____, are constantly being abraded and lost. These cells are [7]_____ by cell division. In each of these cases, the new cells have exactly the same [8]_____ and [9]_____ of chromosomes as the parent cells because of the way duplicated chromosomes divide in the process of [10]_____.

Growth, cell replacement, and reproduction require control of the rate and timing of cell division. Much has been learned by studying cells grown in laboratory [11]_____. Cells growing in a laboratory dish will divide only when in contact with a solid [12]_____. In the body, this [13]_____dependence may keep normal cells from dividing if separated from their normal surroundings. Cells will multiply only until they touch one another, a phenomenon known as [14]_____. Apparently, cells rely on proteins called [15]_____ to tell them when to divide, and will stop when cells are crowded and these substances are depleted.

It appears that growth factors influence cell division by acting on the cell-cycle [16]_____ system, a set of molecules that triggers and coordinates events in the cell cycle. The system automatically [17]_____ cell division at several major checkpoints unless the "brakes" are overridden by go-ahead signals. There are checkpoints in the G_2 and M phases of the cell cycle, but the most important checkpoint for many cells is the [18]_____ checkpoint. If a cell receives a go-ahead signal in the form of a growth factor at the G_1 checkpoint, the cell will proceed into the [19]_____ phase of the cell cycle, replicate its DNA, and eventually divide. A growth factor probably acts on a cell by attaching to a [20]_____ protein in the cell membrane. This protein in turn generates a signal that acts on the cell cycle control system within the cell. In the absence of a go-ahead signal, a cell will cease dividing. Many of our cells that can no longer divide—[21]_____ cells, for example—are stopped at the G_1 checkpoint.

Sometimes cells escape these control mechanisms, divide uncontrollably, and invade other body tissues. These [22]_____ cells can kill the organism. In cell culture, they can grow without being attached to a solid surface, are unaffected by density-dependent inhibition, and are less affected than normal cells by growth factors and [23]_____ signals. Cancer cells can go on dividing indefinitely (unlike normal cells, which can divide in culture for only [24]_____ generations). A mass of cancer cells is called a [25]_____. If the cells of a tumor remain at the original site, the tumor is called a [26]_____ tumor; if the cells spread, it is a [27]_____ tumor. The spread of cancer cells is called [28]_____. Carcinomas are cancers that arise in body coverings, such as the skin. [29]_____ arise in support tissues, such as muscle or bone. [30]_____ are cancers of blood-forming tissues.

Cancer treatments, such as [31]_____ and [32]_____, slow cancer by interfering with [33]_____. The anticancer drugs vinblastin and taxol prevent cell division by disrupting the mitotic [34]_____.

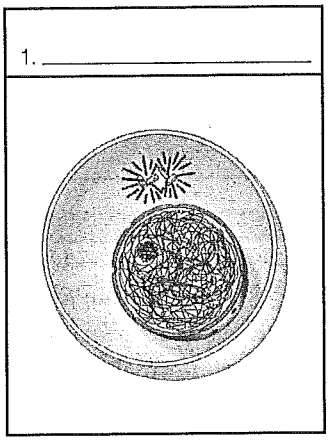
Exercise 9 (Modules 8.12–8.13)

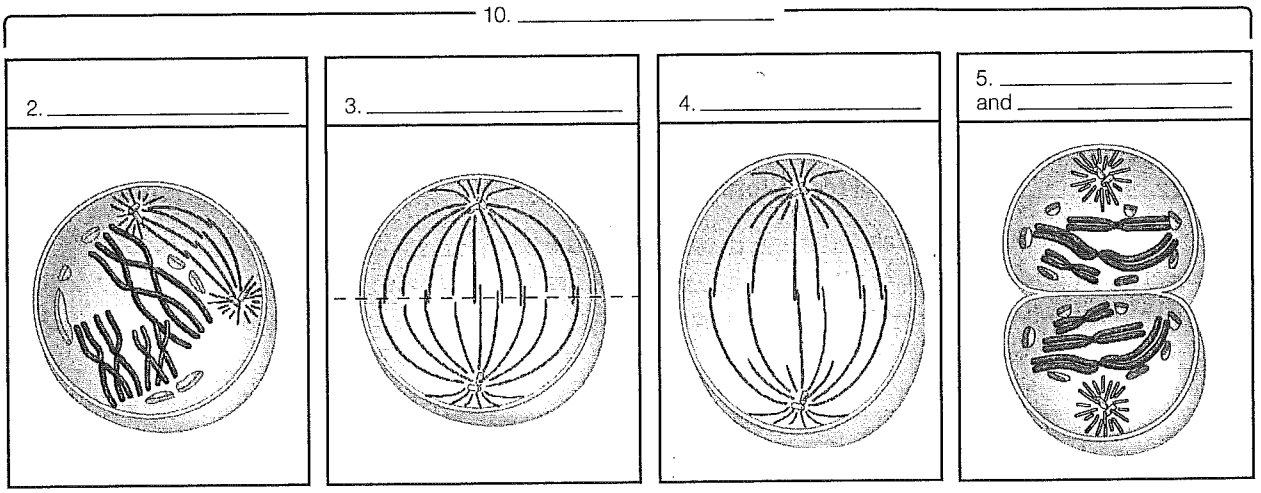
Describe the relationship between the terms or items in each of the following pairs.

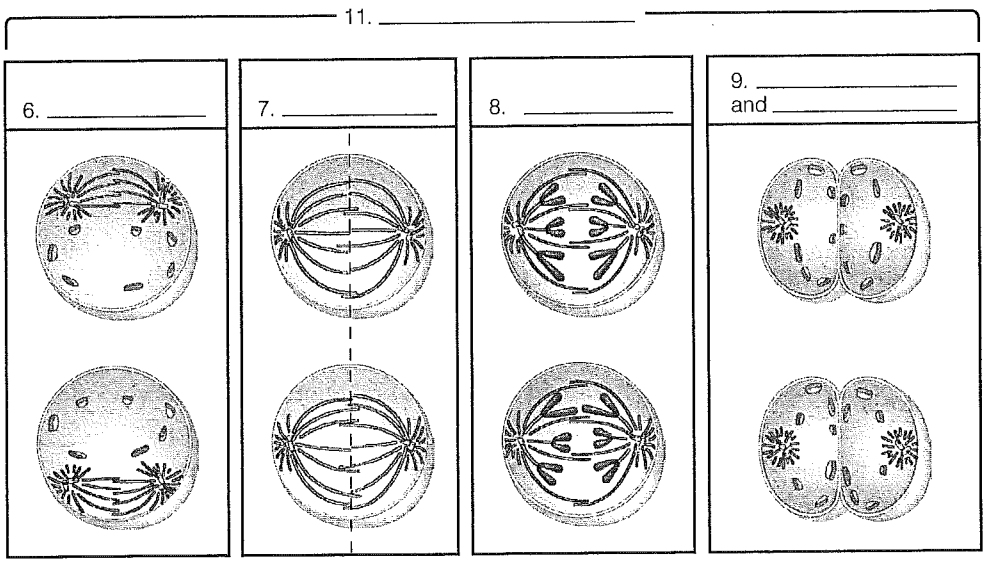
1. Sex chromosomes and autosomes
2. The two chromosomes of a homologous pair
3. The two sister chromatids of a single chromosome
4. A diploid cell and a haploid cell
5. A somatic cell and a gamete
6. An egg and a zygote
7. Fertilization and meiosis
8. Mitosis and meiosis
9. X and Y chromosomes
10. Gene and locus

Exercise 10 (Module 8.14)

Review meiosis by drawing in the chromosomes to complete this sequence of diagrams. Some have been done for you. Label **meiosis I, meiosis II,** the **phases** of meiosis I and II, a pair of **homologous chromosomes,** two **sister chromatids,** and an example of **crossing over.** To make you think carefully about meiosis, the diploid number of chromosomes is 6 in this example. (It is 4 in Module 8.14.)







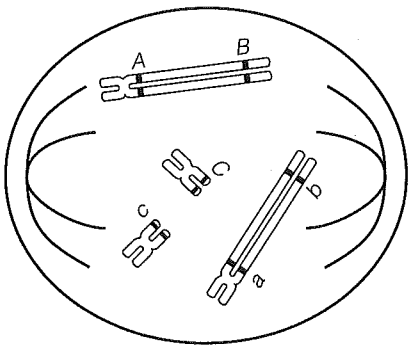
Exercise 11 (Module 8.15)

Compare mitosis and meiosis by completing this chart.

Mitosis	*Meiosis*
1.	Produces haploid daughter cells unlike parent cell
Involves one cell division	2.
Produces two daughter cells	3.
4.	Homologous chromosomes pair and then separate
Individual chromosomes line up at metaphase plate	5.
No crossing over occurs	6.
7.	Needed for sexual reproduction

Exercise 12 (Modules 8.16–8.18)

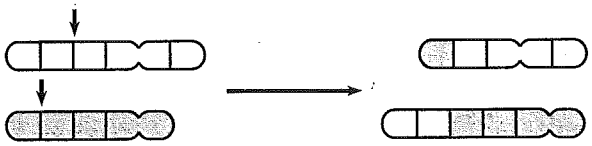
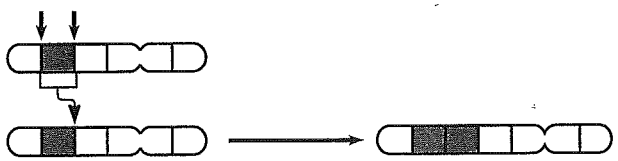
These modules discuss how independent orientation of chromosomes, random fertilization, and crossing over can lead to varied offspring. The diagram below shows the two homologous pairs of chromosomes in a cell with a diploid number of 4. Three different genes are also shown. On separate paper, complete the sketches described in questions 1 through 3.



1. Show how two different orientations of the chromosomes during metaphase I of meiosis could lead to four different combinations of genes in gametes (assuming crossing over does not occur). (You don't need to show meiosis step by step—just the outcome.)
2. Show how crossing over could recombine genes on the larger pair of chromosomes, producing different gametes.
3. How many different combinations of genes in gametes are possible if these two processes happen simultaneously? Try to sketch all of them.

Exercise 14 (Module 8.24)

Chromosomes sometimes break, their parts can become scrambled, and abnormalities can result. Match each of the diagrams of chromosome alterations with its name (A-D) and a description of its effects (W-Z).

	Diagram	*Name*	*Effects*
1.		_____	_____
2.		_____	_____
3.		_____	_____
4.		_____	_____

Names:
A. Deletion
B. Duplication
C. Inversion
D. Translocation

Effects:
W. May cause chronic myelogenous leukemia in somatic cells
X. Least likely to have serious effects, because genes are still present in normal numbers
Y. Likely to have the most serious effects, as in *cri du chat* syndrome
Z. A chromosome fragment breaks off and joins a homologous chromosome

Test Your Knowledge

Multiple Choice

1. There are a number of differences between binary fission of a bacterium and human cell division. Which of the following is *not* one of them?
   a. A bacterium has only one chromosome.
   b. Human cells undergo mitosis and cytokinesis.
   c. Bacteria are smaller and simpler than human cells.
   d. Bacteria have to duplicate their DNA before dividing; human cells do not.
   e. Human chromosomes are larger and more complex.

2. You would be unlikely to see which of the following human cells dividing?
   a. muscle cell
   b. skin cell
   c. cancer cell
   d. cell from an embryo
   e. intestinal lining cell

3. Which of the following correctly matches a phase of the cell cycle with its description?
   a. M—replication of DNA
   b. S—immediately precedes cell division
   c. G_2—cell division
   d. G_1—immediately follows cell division
   e. All of the above are correctly matched.

4. Which of the following is *not* true of human somatic cells?
   a. They arise by mitotic cell division.
   b. They are haploid.
   c. They are body cells other than eggs and sperm.
   d. They are larger and more complex than bacterial cells.
   e. They contain 46 chromosomes.

5. In telophase of mitosis, the mitotic spindle breaks down and nuclear envelopes form. This is essentially the opposite of what happens in
   a. prophase.
   b. interphase.
   c. metaphase.
   d. S phase.
   e. anaphase.

6. Sister chromatids
   a. cross over during prophase I of meiosis.
   b. separate during the first meiotic division.
   c. are produced during S phase between cell divisions.
   d. cross over during prophase II of meiosis.
   e. are also called homologous chromosomes.

7. Which of the following is *not* a function of mitotic cell division in animals?
   a. asexual reproduction
   b. growth
   c. repair of damaged organs
   d. production of gametes
   e. cell replacement

8. Meiosis
   a. is responsible for body growth and repair.
   b. halves the number of chromosomes in cells.
   c. is the process by which the body produces diploid cells.
   d. follows mitosis and splits the cytoplasm in two.
   e. is important in asexual reproduction.

9. Crossing over is
   a. important in genetic recombination.
   b. what makes a cell become cancerous.
   c. a key process that occurs during mitosis.
   d. an important mechanism of chromosome repair.
   e. what prevents cells from multiplying indefinitely in cell culture.

10. Human _____ are diploid, and human _____ are haploid.
    a. sex chromosomes . . . autosomes
    b. autosomes . . . sex chromosomes
    c. somatic cells . . . gametes
    d. gametes . . . somatic cells
    e. chromosomes . . . chromatids

11. Which of the following does *not* lead to genetic variability?
    a. random fertilization
    b. crossing over during meiosis
    c. division of chromosomes during anaphase of mitosis
    d. orientation of chromosomes during metaphase I of meiosis
    e. mutation

12. Most cells will divide if they receive the proper signal at a checkpoint in the ____ phase of the cell cycle.
    a. M
    b. G_1
    c. S
    d. G_2
    e. cytokinesis

13. Geneticists suspect that the extra chromosome seen in Down syndrome usually comes from the egg, rather than the sperm, because
    a. eggs are produced so rapidly that there is more chance for error.
    b. Down syndrome is due to a dominant gene in women, a recessive gene in men.
    c. most women inherit Down syndrome from their mothers.
    d. eggs are produced in much larger numbers than sperm.
    e. meiosis takes much longer in the ovary, increasing the likelihood of error.

14. Which of the following chromosomal alterations would you expect to have the most drastic consequences?
    a. inversion
    b. duplication
    c. translocation
    d. deletion
    e. a and b are equally the most serious

15. Disorders involving unusual numbers of sex chromosomes show that "maleness" is caused by the
    a. presence of an X chromosome.
    b. presence of a Y chromosome.
    c. absence of an X chromosome.
    d. absence of a Y chromosome.
    e. absence of an X chromosome and presence of a Y chromosome.

Essay

1. Explain why, strictly speaking, the phrase "like begets like" applies only to asexual reproduction.

2. Briefly describe mitosis and cytokinesis and state their functions.

3. Describe how cancer cells differ from normal body cells.

4. Compare mitosis and meiosis. What are their functions? Which produces haploid cells? Diploid cells? What kinds of cells undergo mitosis and meiosis? What kinds of cells are produced by each? How many cells are produced?

5. How might the genes on the sister chromatids of a certain chromosome compare with each other and with the genes on the sister chromatids of the homologous chromosome?

6. Describe three aspects of sexual reproduction that lead to the production of varied offspring.

7. Explain how an error in meiosis can cause a baby to be born with an extra or missing chromosome.

8. About one in 700 babies born in the United States possesses an extra chromosome 21, resulting in Down syndrome. Why are few individuals seen who have extra copies of other chromosomes?

Apply the Concepts

Multiple Choice

1. In certain fungi and algae, cells undergo mitosis repeatedly without subsequently undergoing cytokinesis. What would result from this?
    a. a decrease in chromosome number
    b. inability to duplicate DNA
    c. division of the organism into many cells, most lacking nuclei
    d. large cells containing many nuclei
    e. a rapid rate of sexual reproduction

2. A human bone marrow cell, in prophase of mitosis, contains 46 chromosomes. How many chromatids does it contain altogether?
    a. 46
    b. 92
    c. 23
    d. 23 or 46, depending on when during prophase you look
    e. 46 or 92, depending on when during prophase you look

3. Which of the following is the most significant difference between mitosis and meiosis?
    a. Chromosomes are duplicated before mitosis.
    b. Meiosis is not followed by cytokinesis.
    c. Homologous pairs of chromosomes are split up in meiosis.
    d. A spindle formed of microtubules moves the chromosomes in mitosis.
    e. Crossing over occurs in mitosis.

4. If there are 22 chromosomes in the nucleus of a toad skin cell, a toad egg would contain ____ chromosomes.
   a. 22
   b. 44
   c. 11
   d. 33
   e. 88

5. Which of the following carry the same genetic information?
   a. sister chromatids
   b. X and Y chromosomes
   c. all autosomes
   d. homologous chromosomes
   e. all haploid cells

6. A cell biologist carefully measured the quantity of DNA in grasshopper cells growing in cell culture. Cells examined during the G_2 phase of the cell cycle contained 200 units of DNA. What would be the amount of DNA in one of the grasshopper daughter cells seen in telophase of mitosis?
   a. 50 units
   b. 100 units
   c. between 50 and 100 units
   d. 200 units
   e. 400 units

7. What would be the quantity of DNA in one of the grasshopper cells (question 6) produced by telophase II of meiosis?
   a. 50 units
   b. 100 units
   c. between 50 and 100 units
   d. 200 units
   e. 400 units

8. The two chromosomes of a homologous pair
   a. carry identical genetic information at corresponding locations.
   b. carry information for the same characteristics at different locations.
   c. carry identical genetic information at different locations.
   d. carry information for the same characteristics at corresponding locations.
   e. Any of the above is possible.

9. A picture of a dividing pigeon cell taken through a microscope shows that the cell contains seven chromosomes, each consisting of two chromatids. This picture must have been taken during
   a. metaphase of mitosis.
   b. prophase I of meiosis.
   c. telophase II of meiosis.
   d. prophase II of meiosis.
   e. telophase of mitosis.

10. A culture of mouse cells is treated with a chemical that interferes with the activity of microfilaments. Which of the following will probably be affected the most?
    a. mitosis
    b. chromosome duplication
    c. pairing of homologous chromosomes
    d. cytokinesis
    e. joining of sister chromatids at the centromere

11. A zoologist examined an intestine cell from a crayfish and counted 200 chromosomes, each consisting of two chromatids, at prophase I of mitosis. What would he expect to see in each of the four cells at telophase II of meiosis if he looked in the crayfish ovary?
    a. 50 chromosomes, each consisting of two chromatids
    b. 50 chromosomes, each consisting of one chromatid
    c. 100 chromosomes, each consisting of two chromatids
    d. 100 chromosomes, each consisting of one chromatid
    e. 200 chromosomes, each consisting of one chromatid

12. One chromosome of a homologous pair carries the genes *J* and *K*. The other chromosome of the pair carries the genes *j* and *k* at corresponding loci. Crossing over results in exchange of chromosome segments and production of gametes with new combinations of genes. A "recombinant"-type gamete resulting from this crossover might contain
    a. genes *J* and *K*.
    b. genes *j* and *K*.
    c. genes *J* and *j*.
    d. genes *j* and *k*.
    e. genes *K* and *k*.