

The Cellular Basis of Reproduction and Inheritance

In laboratories all over the world, biologists are studying cell division to try to understand why cells divide, what determines when they divide, what happens during cell division, and why some cells divide and others do not. The process of cell division is fundamental to inheritance, reproduction, growth, and development. Much of the inquiry into cell division is basic research; but this research has immense practical importance because understanding cell division will enable us to understand cancer, birth defects, heredity, and inherited diseases. This chapter explores the connections among cell division, reproduction, and inheritance.

Organizing Your Knowledge

Exercise 1 (Introduction - Module 8.3)

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

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"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.

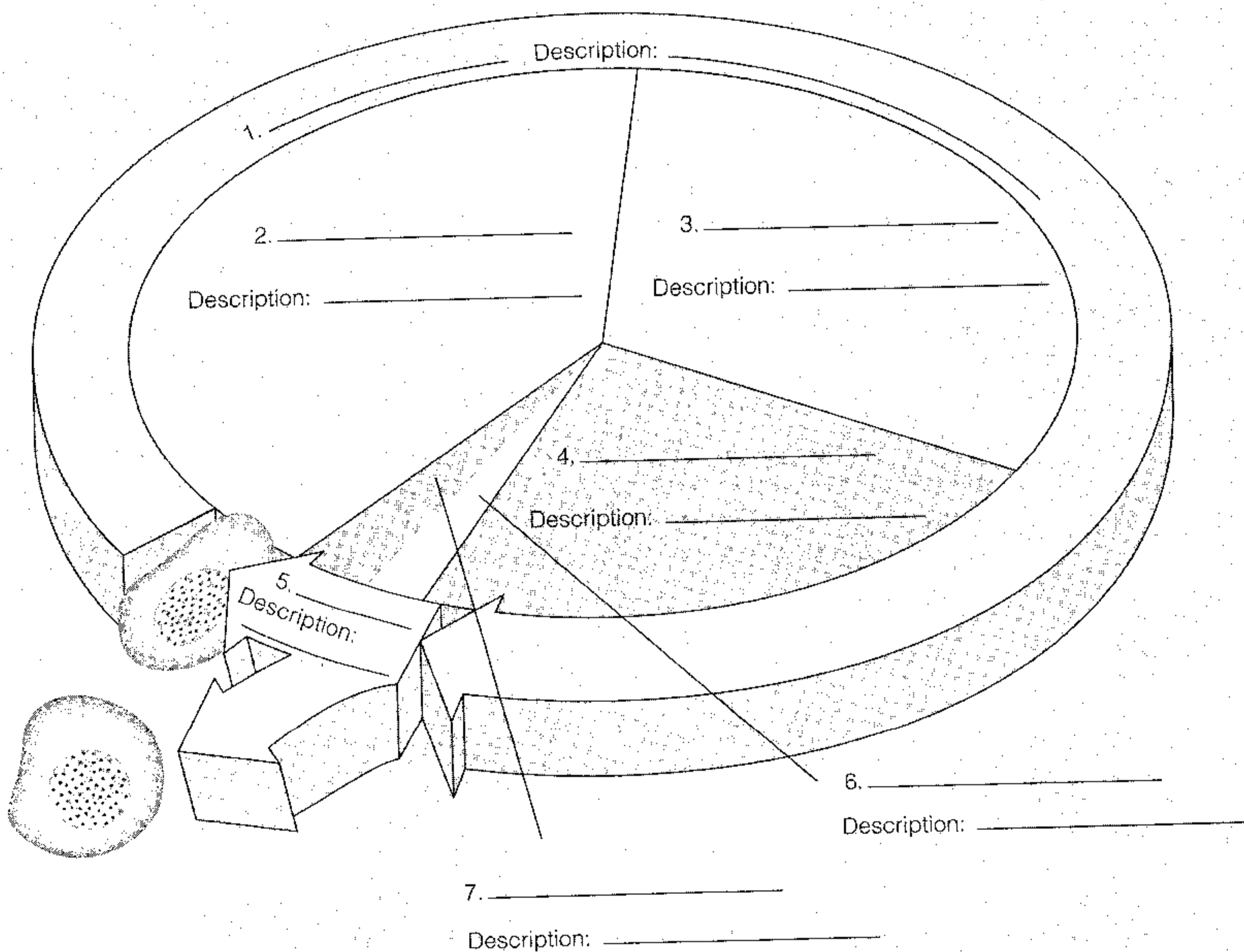
Prokaryotes also reproduce asexually, via a type of cell division called ⁸_____. Most genes in a prokaryote are carried on a single ⁹_____ DNA molecule, which is much ¹⁰_____ and ¹¹_____ in structure than the multiple chromosomes of eukaryotes. The prokaryote replicates its DNA and attaches the copies to different points on the plasma membrane. As new ¹²_____ grows between them, the chromosomes become separated. Finally, the plasma membrane and cell ¹³_____ grow inward, separating the chromosomes and dividing 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, and the ¹⁷_____ 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)

Web/CD Activity 8A The Cell Cycle

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, G₁, mitotic phase, cytokinesis, and G₂**. Then add a brief description of what is happening during that portion of the cycle. Choose from **DNA synthesis, cell growth, division of cytoplasm, activity between divisions, division of nucleus and chromosomes, activity between DNA synthesis and division, and mitosis plus cytokinesis**.



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Exercise 6 (Module 8.6)Web/CD Activity 8B *Mitosis and Cytokinesis Animation*

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Match the word or phrase on the right with the correct role in mitosis in an animal cell on the left.

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|--|-------|-------------------------|
| A. Where spindle microtubules attach to chromosomes | _____ | 1. Metaphase plate |
| B. Move chromosomes | _____ | 2. Kinetochores |
| C. Pulled apart by spindle microtubules | _____ | 3. Sister chromatids |
| D. Material around centrioles from which mitotic spindle grows | _____ | 4. Spindle microtubules |
| E. Chromosomes come to rest here during metaphase | _____ | 5. Centrosome |

Exercise 7 (Module 8.7)Web/CD Activity 8C *Mitosis and Cytokinesis Video*

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)Web/CD Activity 8D *Connection: Causes of Cancer*

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 ³ _____ and ⁴ _____ cells, cease to divide. Others, such as cells of the ⁵ _____, divide only if the organ is damaged. Some cells, such as those on the surface of the ⁶ _____ and the lining of the ⁷ _____, are constantly being abraded and lost. These cells are ⁸ _____ by cell division. In each of these cases, the new cells have exactly the same ⁹ _____ and ¹⁰ _____ of chromosomes as the parent cells, because of the way duplicated chromosomes divide in the process of ¹¹ _____.

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 ¹² _____. Cells growing in a laboratory dish will divide only when in contact with a solid ¹³ _____. In the body, this ¹⁴ _____ 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 ¹⁵ _____. Apparently, cells rely on proteins called ¹⁶ _____ for division, and will stop dividing when cells are crowded and these substances are depleted.

It appears that growth factors influence cell division by acting on the cell-cycle ¹⁷ _____ system, a set of proteins that triggers and coordinates events in the cell cycle. The system automatically ¹⁸ _____ cell division at several major checkpoints unless the "brakes" are overridden by go-ahead signals. There are checkpoints in the G₂ and M phases of the cell cycle, but the most important checkpoint for many cells is the ¹⁹ _____ checkpoint. If a cell receives a go-ahead signal, in the form of a growth factor, at the G₁ checkpoint, the cell will proceed into the ²⁰ _____ phase of the cell cycle, replicate its DNA, and eventually divide. (A growth factor probably acts on a cell by attaching to a ²¹ _____ 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—²² _____ cells, for example—are stopped at the G₁ checkpoint.

Sometimes cells escape these control mechanisms, divide uncontrollably, and invade other body tissues. These ²³ _____ 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 ²⁴ _____ signals. Cancer cells can go on dividing indefinitely (unlike normal cells, which can divide in culture for only about ²⁵ _____ generations). Cancer treatments, such as ²⁶ _____ and ²⁷ _____, slow cancer by interfering with ²⁸ _____. The anticancer drugs vinblastin and taxol prevent cell division by disrupting the ²⁹ _____ of the mitotic spindle.

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

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Exercise 11 (Module 8.15)

Compare mitosis and meiosis by completing this chart.

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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

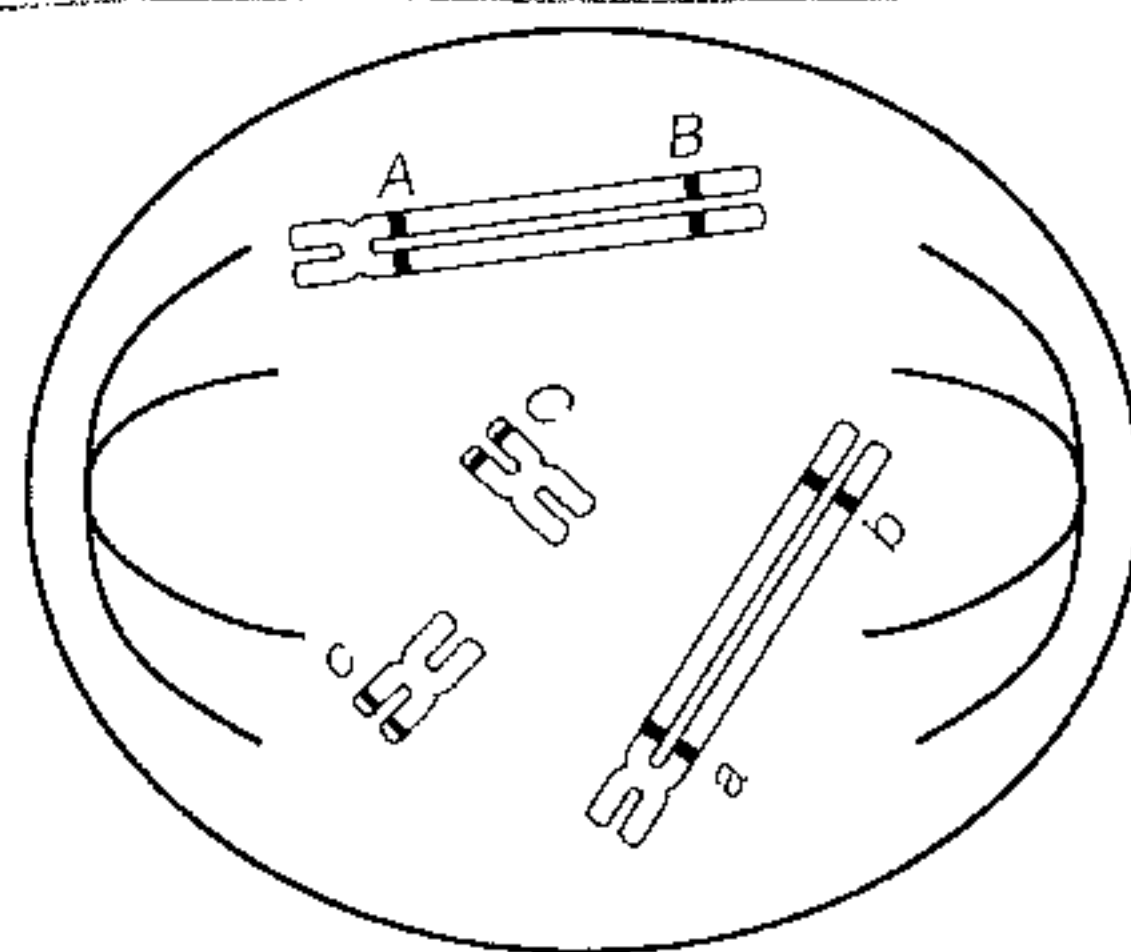
Exercise 12 (Modules 8.16 - 8.18)

Web/CD Activity 8G *Origins of Genetic Variation*

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These modules discuss how 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.

Yes, do this
- Rosalind

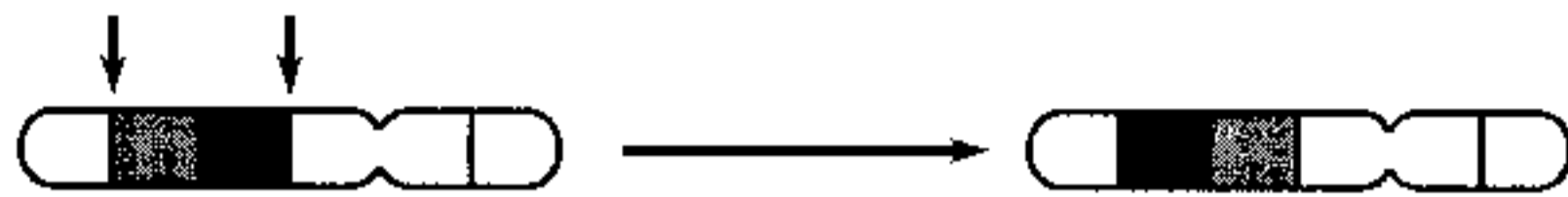
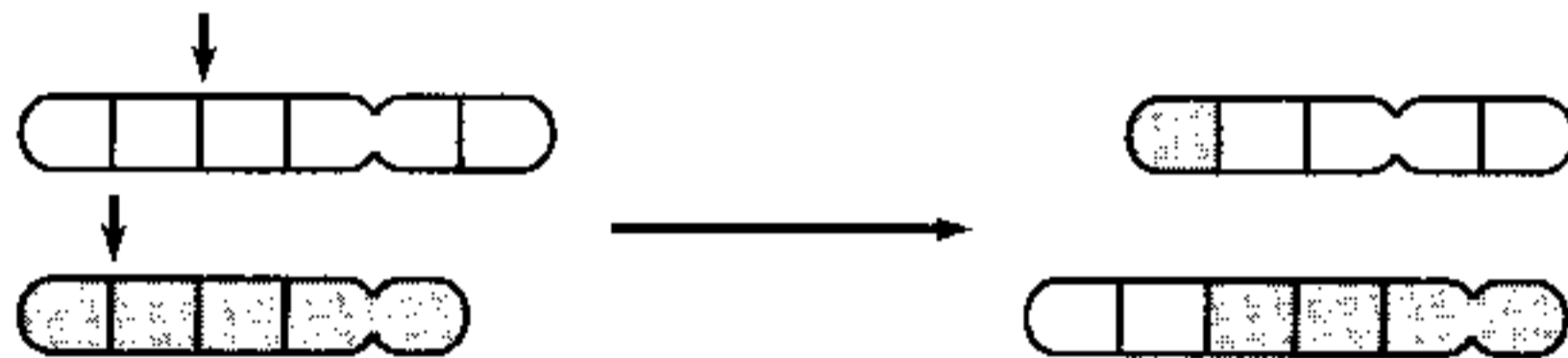
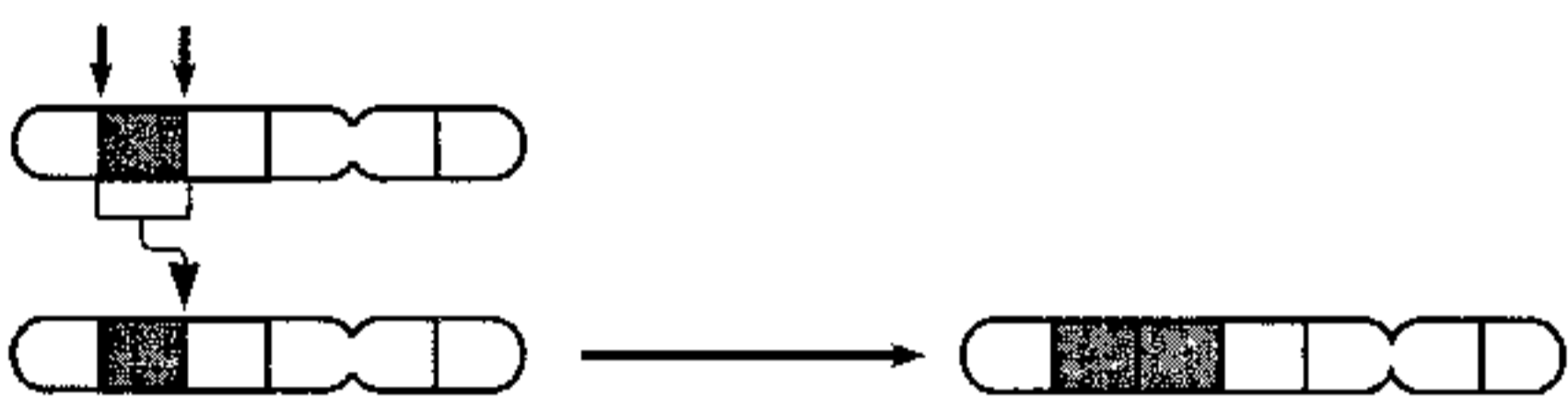
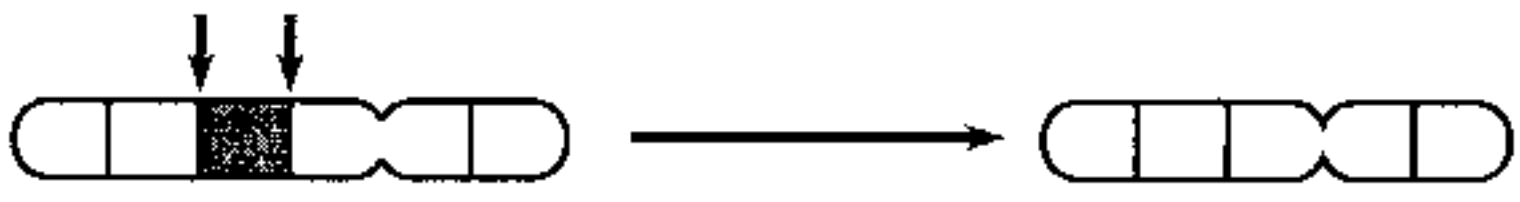


- Show how two different orientations of the chromosomes during metaphase I of meiosis could lead to the four different combinations of genes in gametes (assuming crossing over does not occur). (You don't need to show meiosis step by step—just the outcome.)
- Show how crossing over could recombine genes on the larger pair of chromosomes, producing different gametes.
- 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 8.23)

Chromosomes sometimes break, their parts can become scrambled, and abnormalities can result. Match each of the diagrams of chromosome alterations with its name and a description of its effects.

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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