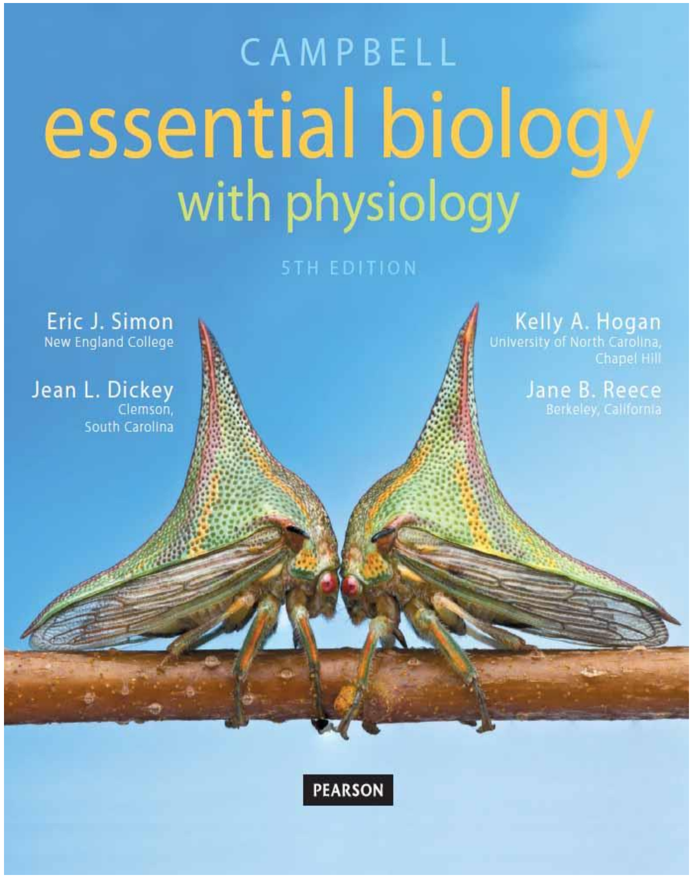
Essential Biology with Physiology

Fifth Edition



Chapter 8

Cellular Reproduction: Cells from Cells

Figure 8.0-1

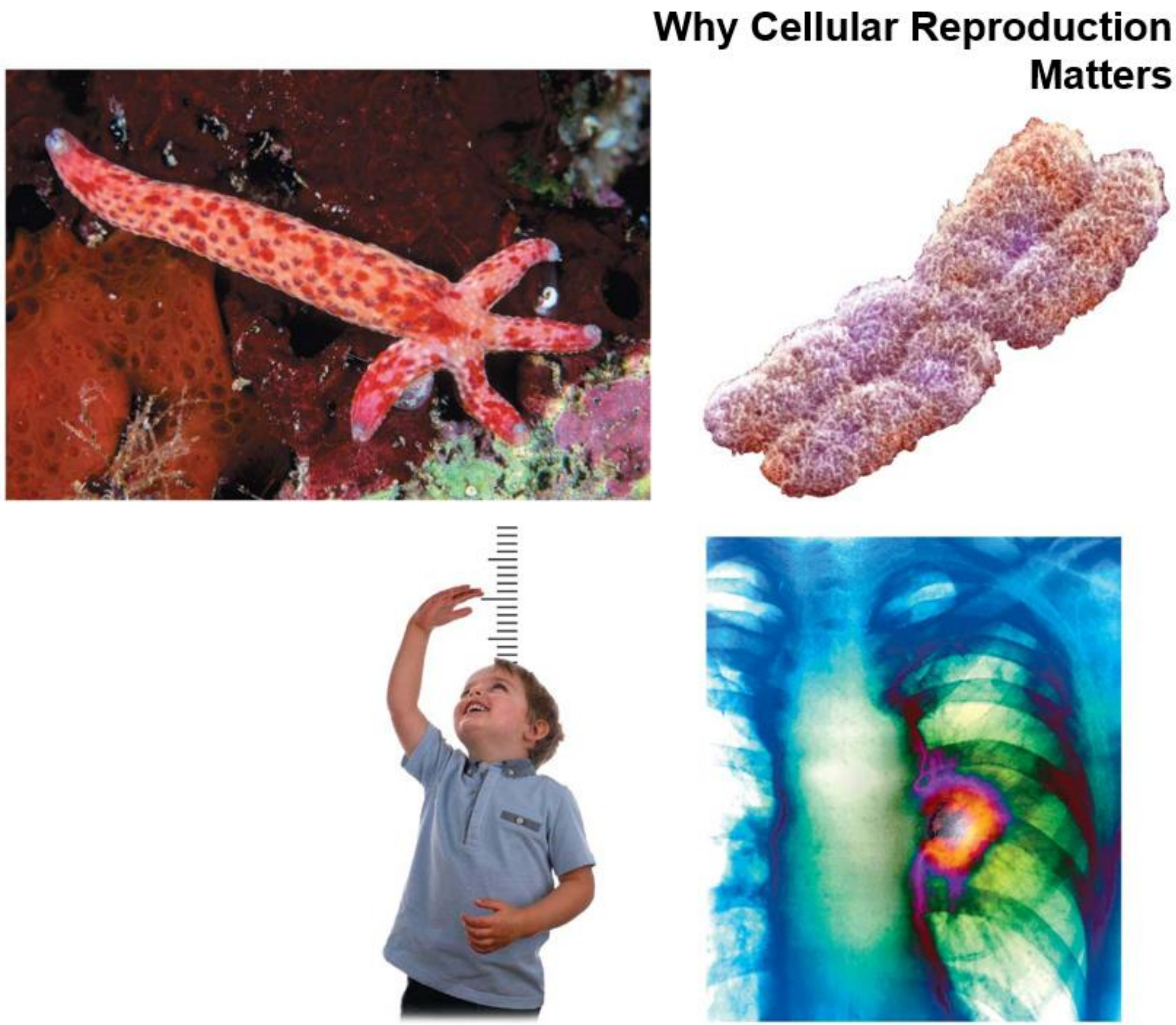


Figure 8.0-1a

Figure 8.0-1b

Figure 8.0-1c

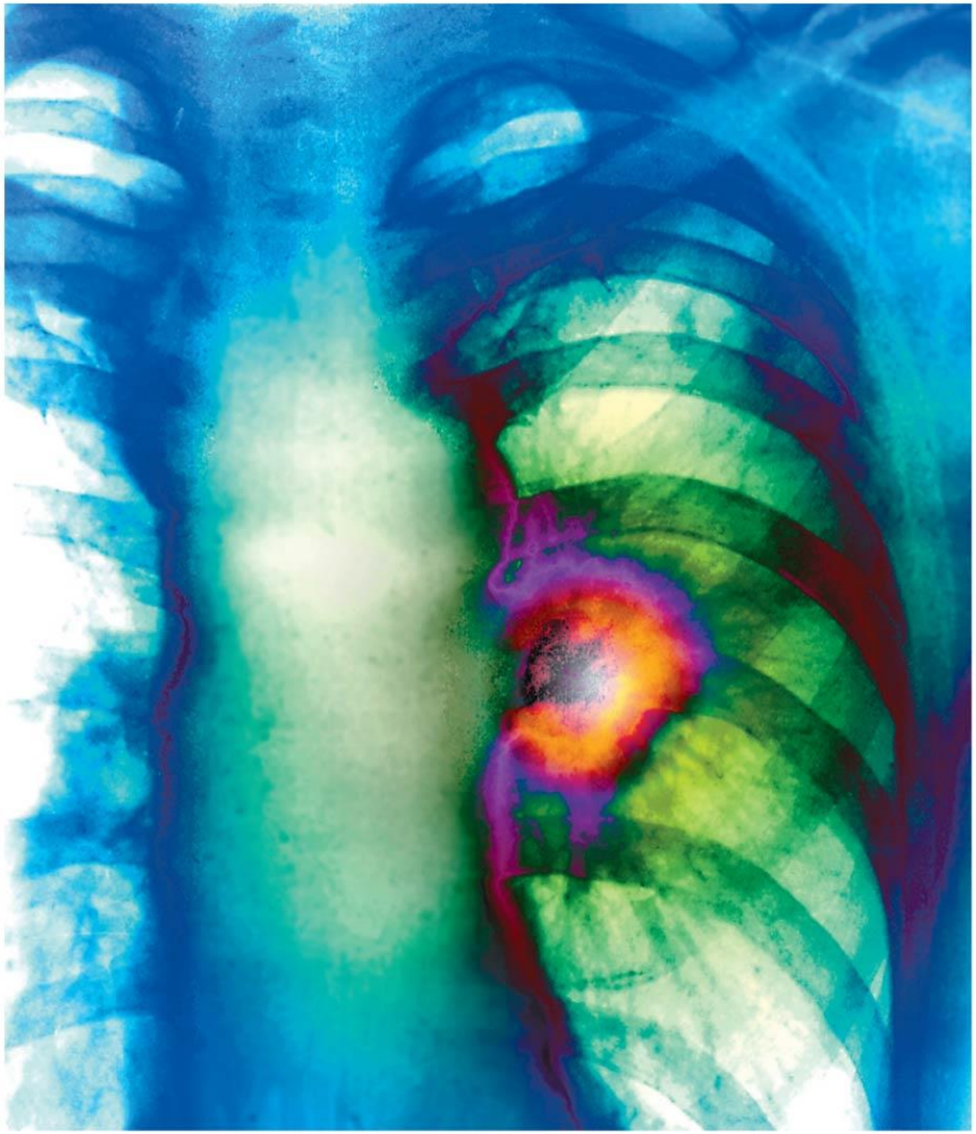
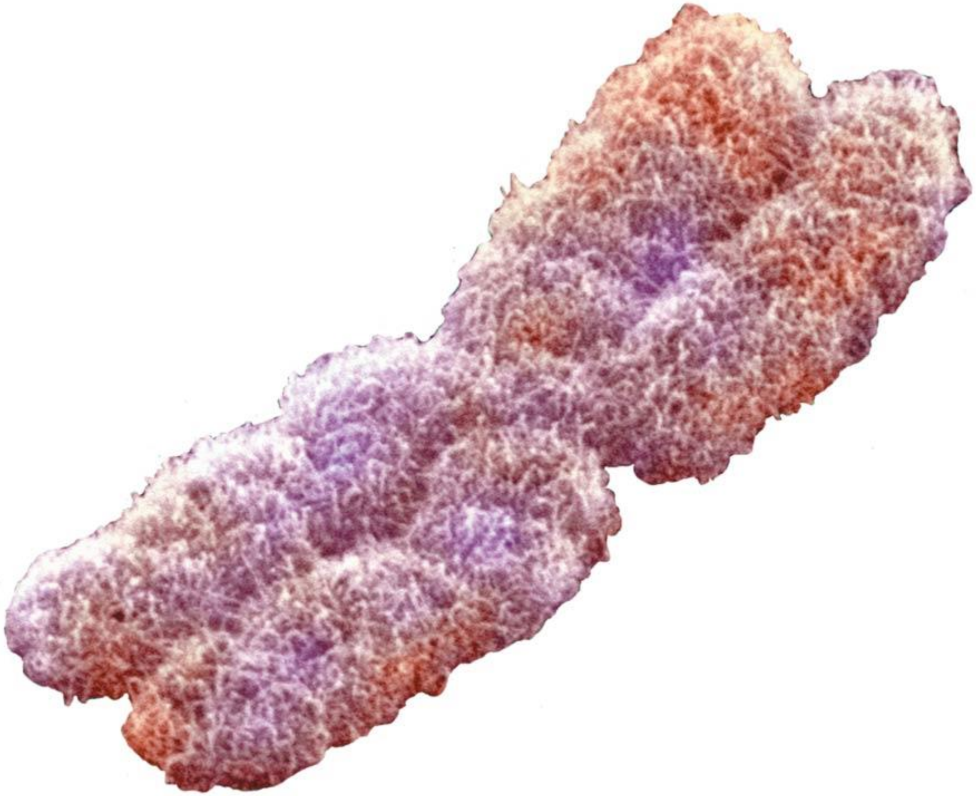


Figure 8.0-1d



Biology and Society: Virgin Birth of a Dragon

- Zookeepers at the Chester Zoo were surprised to discover that their Komodo dragon had laid eggs.
  - The female dragon had not been in the company of a male.
  - The eggs developed in a process called parthenogenesis, the production of offspring by a female without involvement of a male.
  - DNA analysis confirmed that Flora’s offspring derived their genes solely from her.

Figure 8.0 The Komodo Dragon

Chapter Thread: Life with and without Sex

Biology and Society: Virgin Birth of a Dragon (1 of 2)

- Parthenogenesis is rare among vertebrates (animals with backbones), although it has been documented in
  - sharks (including the hammerhead),
  - domesticated birds, and
  - now Komodo dragons.
- Soon, zoologists identified a second Komodo at a different zoo who had also borne young by parthenogenesis.

Biology and Society: Virgin Birth of a Dragon (2 of 2)

- The ability of organisms to procreate is the one characteristic that best distinguishes living things from nonliving matter.
  - All organisms—from bacteria to lizards to you—are the result of repeated cell divisions.
  - The perpetuation of life therefore depends on cell division, the production of new cells.

What Cell Reproduction Accomplishes (1 of 7)

- Reproduction
  - may result in the birth of new organisms but
  - more commonly involves the production of new cells.
- When a cell undergoes reproduction, or **cell division**, two “daughter” cells are produced that are genetically identical to
  - each other and
  - the “parent” cell.

What Cell Reproduction Accomplishes (2 of 7)

- Before a parent cell splits into two, it duplicates its **chromosomes**, the structures that contain most of the cell’s DNA.
- During cell division, each daughter cell receives one identical set of chromosomes from the lone, original parent cell.

What Cell Reproduction Accomplishes (3 of 7)

- Cell division plays several important roles in the lives of organisms. Cell division
  - replaces damaged or lost cells,
  - permits growth, and
  - allows for reproduction.

Video: Sea Urchin (Time Lapse)

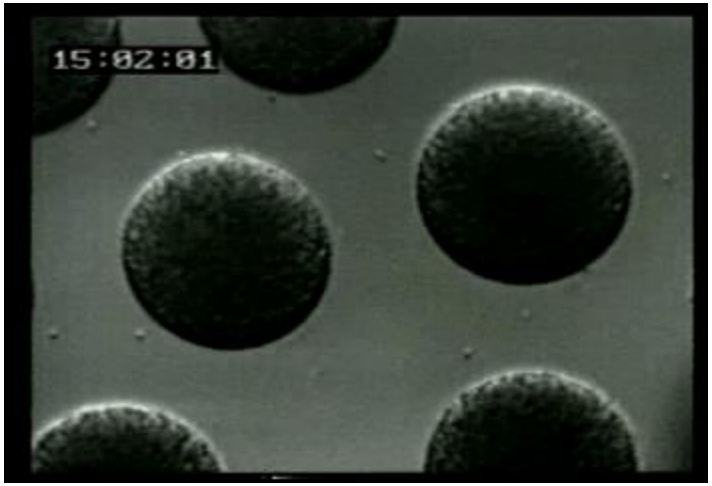


Figure 8.1 Three Functions of Cell Division by Mitosis (1 of 6)

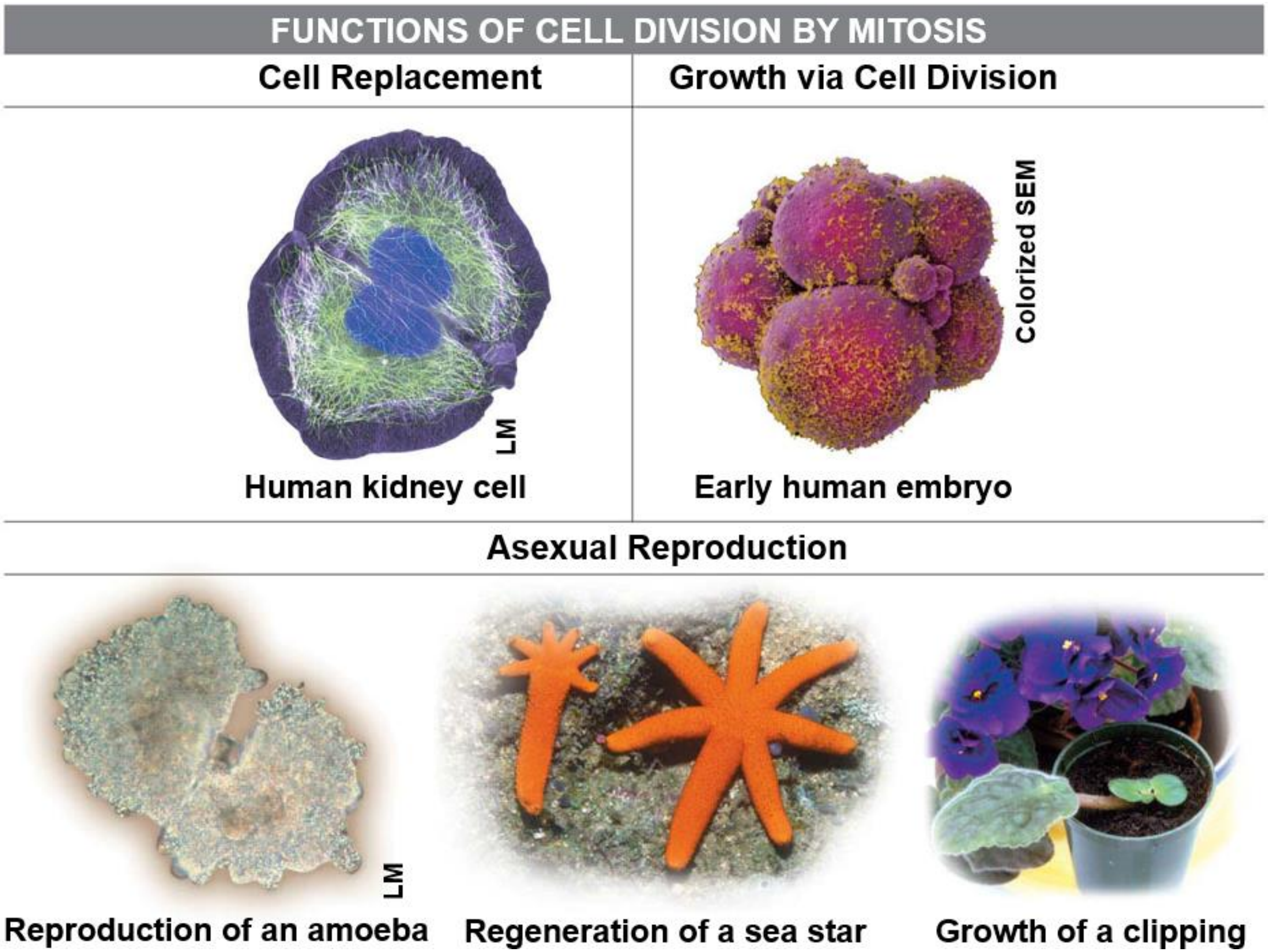
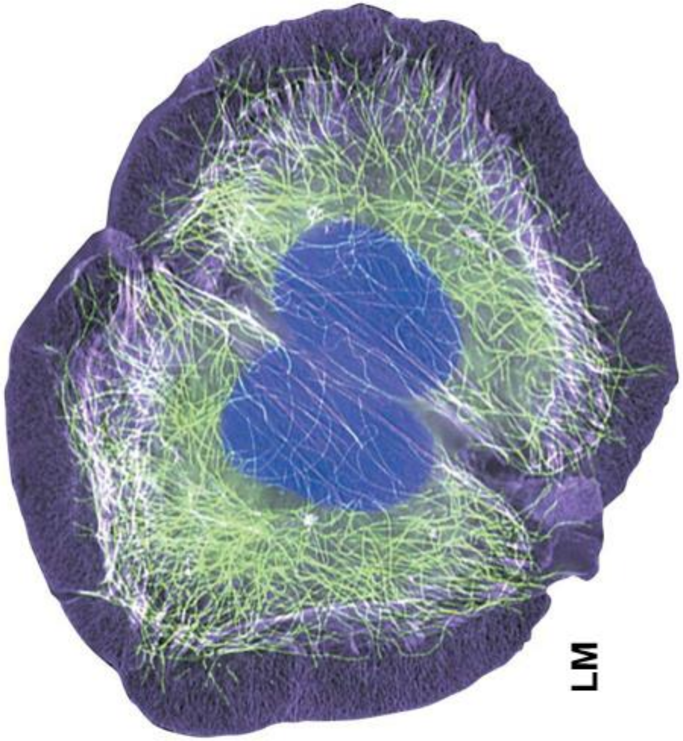


Figure 8.1 Three Functions of Cell Division by Mitosis (2 of 6)

Cell Replacement



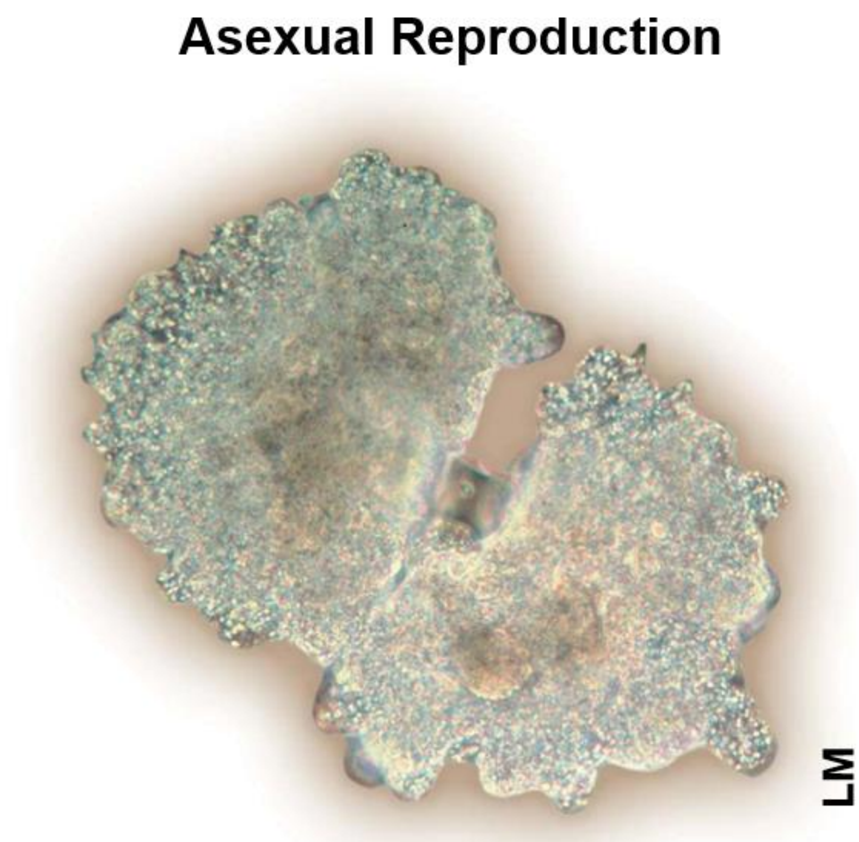
Human kidney cell

Figure 8.1 Three Functions of Cell Division by Mitosis (3 of 6)

Growth via Cell Division

Early human embryo

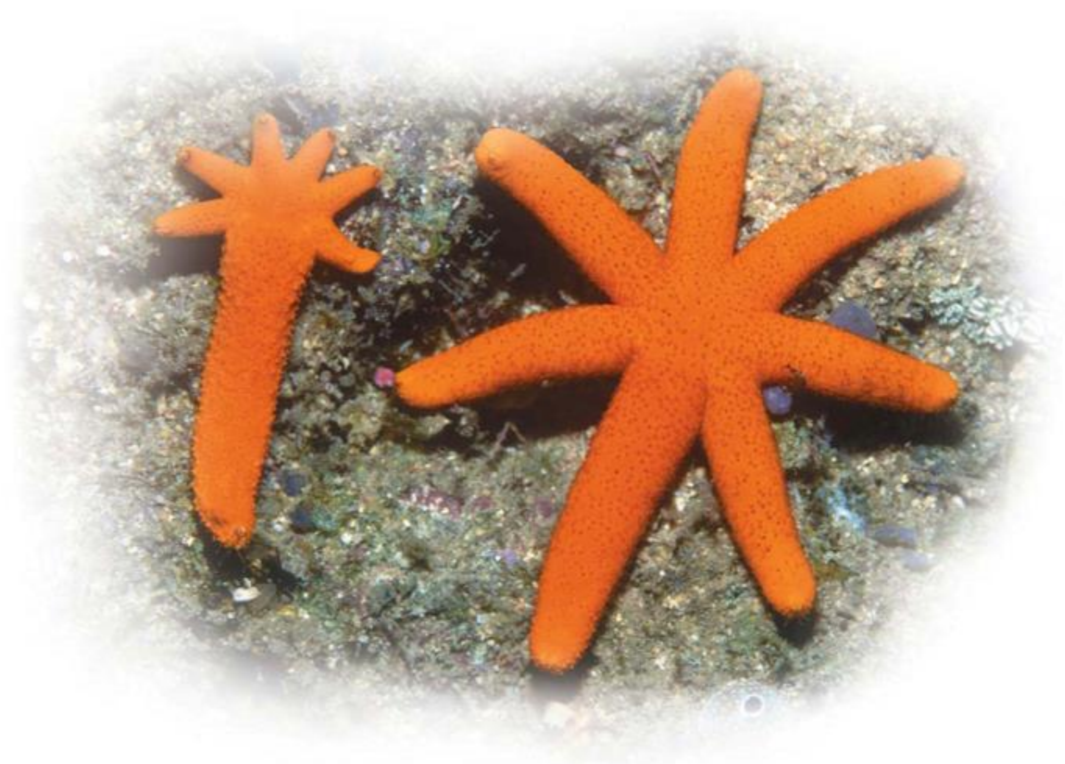
Figure 8.1 Three Functions of Cell Division by Mitosis (4 of 6)



Reproduction of an amoeba

Figure 8.1 Three Functions of Cell Division by Mitosis (5 of 6)

Asexual Reproduction



Regeneration of a sea star

Figure 8.1 Three Functions of Cell Division by Mitosis (6 of 6)

Asexual Reproduction

Growth of a clipping

Pearson

What Cell Reproduction Accomplishes (4 of 7)

- In **asexual reproduction**,
  - single-celled organisms reproduce by dividing in half and
  - there is no fertilization of an egg by a sperm.
- Many multicellular organisms can reproduce asexually as well. For example, some sea star species have the ability to grow new individuals from fragmented pieces.
- Growing a new plant from a clipping is another example of asexual reproduction.

What Cell Reproduction Accomplishes (5 of 7)

- In asexual reproduction, the lone parent and its offspring have identical genes.
- Mitosis is the type of cell division responsible for
  - asexual reproduction and
  - growth and maintenance of multicellular organisms.

What Cell Reproduction Accomplishes (6 of 7)

- **Sexual reproduction** requires fertilization of an egg by a sperm.
  - The production of **gametes**—egg and sperm—involves a special type of cell division called meiosis, which occurs only in reproductive organs.

What Cell Reproduction Accomplishes (7 of 7)

- In summary, two kinds of cell division are involved in the lives of sexually reproducing organisms:
  1. mitosis for growth and maintenance and
  2. meiosis for reproduction.

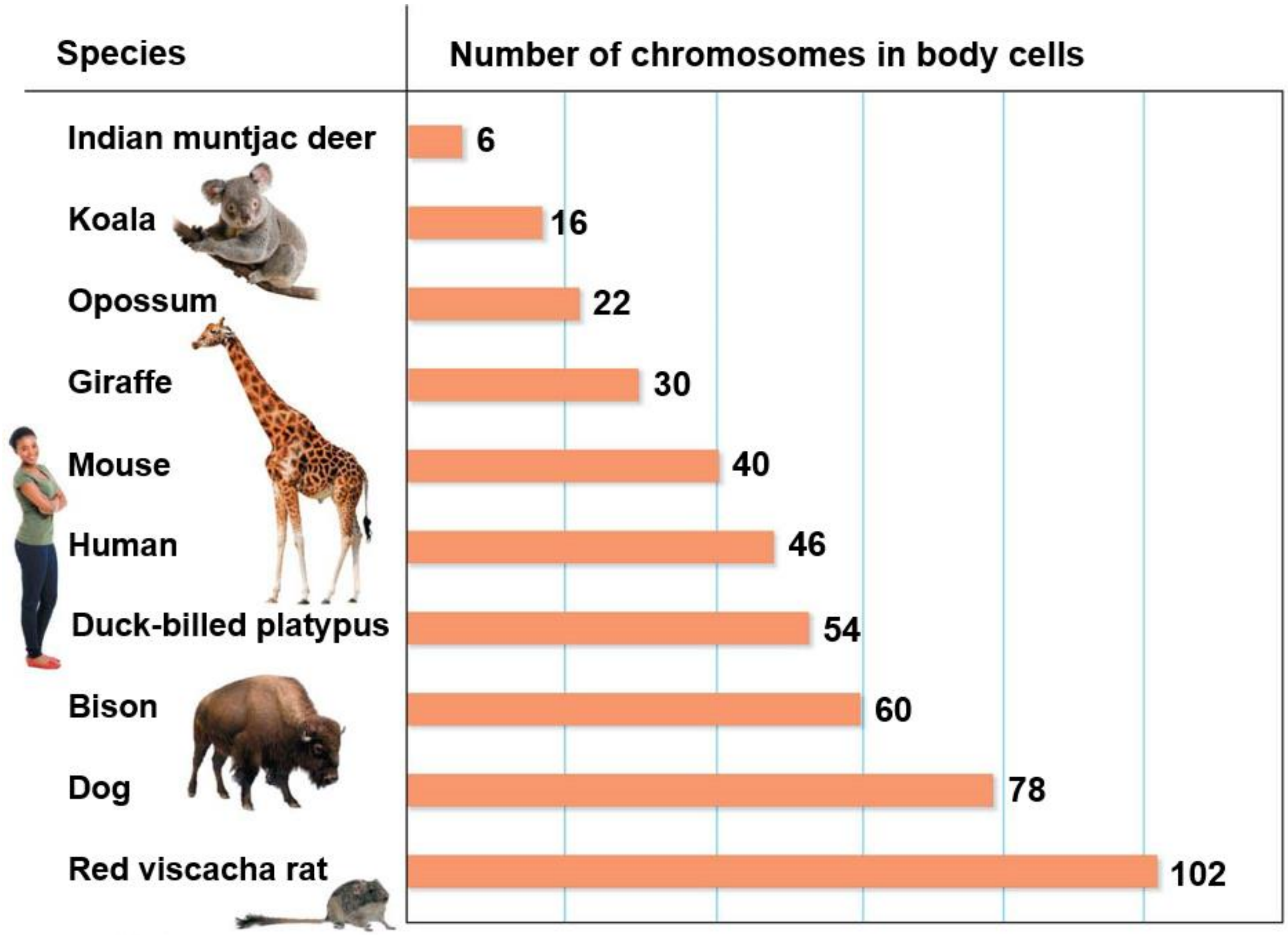
The Cell Cycle and Mitosis

- In a eukaryotic cell,
  - most genes are located on chromosomes in the cell nucleus and
  - a few genes are found in DNA in mitochondria and chloroplasts.

Eukaryotic Chromosomes

- Each eukaryotic chromosome contains one very long DNA molecule, typically bearing thousands of genes.
- The number of chromosomes in a eukaryotic cell depends on the species.

Figure 8.2 The Number of Chromosomes in the Cells of Selected Mammals



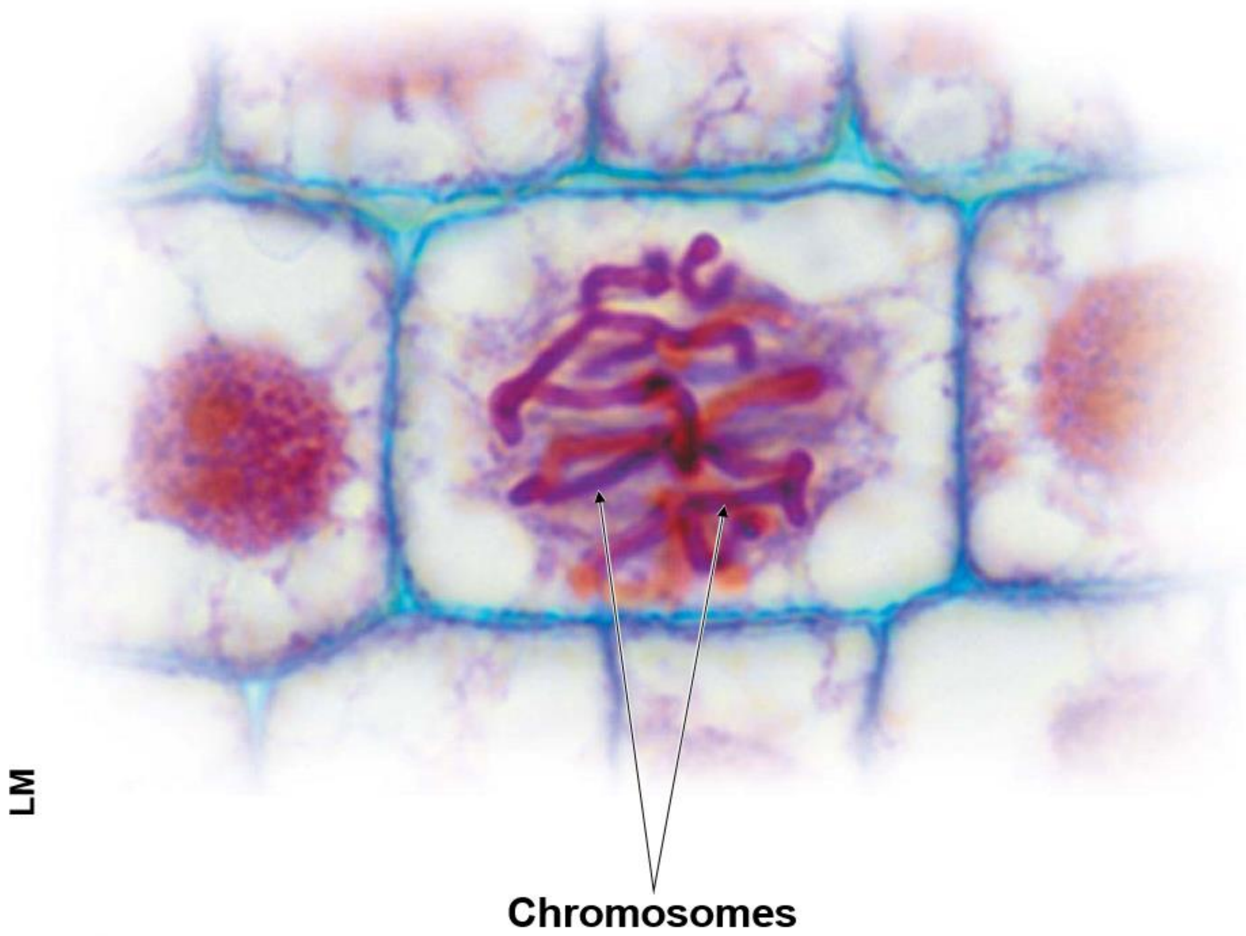
Eukaryotic Chromosomes (1 of 3)

- Chromosomes are made of **chromatin**, fibers composed of roughly equal amounts of DNA and protein molecules, which help
  - organize the chromatin and
  - control the activity of its genes.

Eukaryotic Chromosomes (2 of 3)

- Most of the time, the chromosomes exist as thin fibers that are much longer than the nucleus they are stored in.
  - If fully extended, the DNA in just one of your cells would be more than six feet long!
  - As a cell prepares to divide, its chromatin fibers coil up, forming compact chromosomes that can be viewed under a light microscope.
  - When a cell is not dividing, the chromosomes are too thin to be seen under a light microscope.

Figure 8.3 A Plant Cell Just Before Division, with Chromosomes Colored by Stains



Eukaryotic Chromosomes (3 of 3)

- The DNA in a cell is packed into an elaborate, multilevel system of coiling and folding.
- **Histones** are proteins used to package DNA in eukaryotes.
- **Nucleosomes** consist of DNA wound around histone molecules.

Animation: DNA Packing

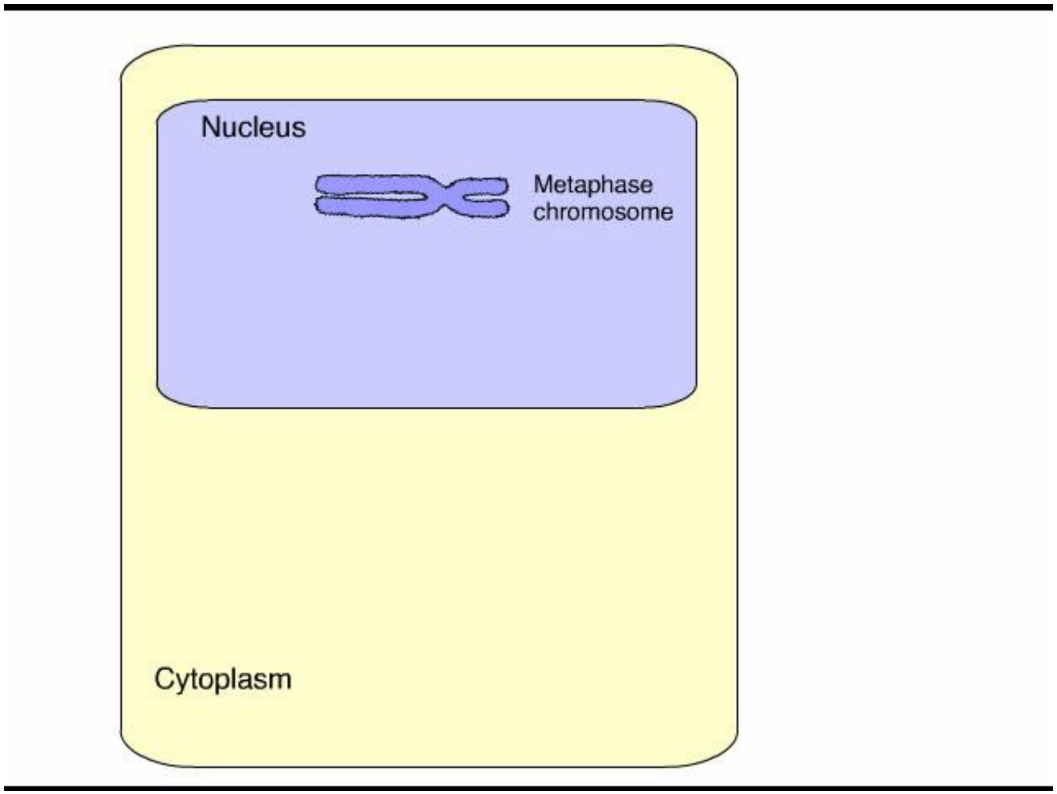


Figure 8.4 DNA Packing in a Eukaryotic Chromosome (1 of 5)

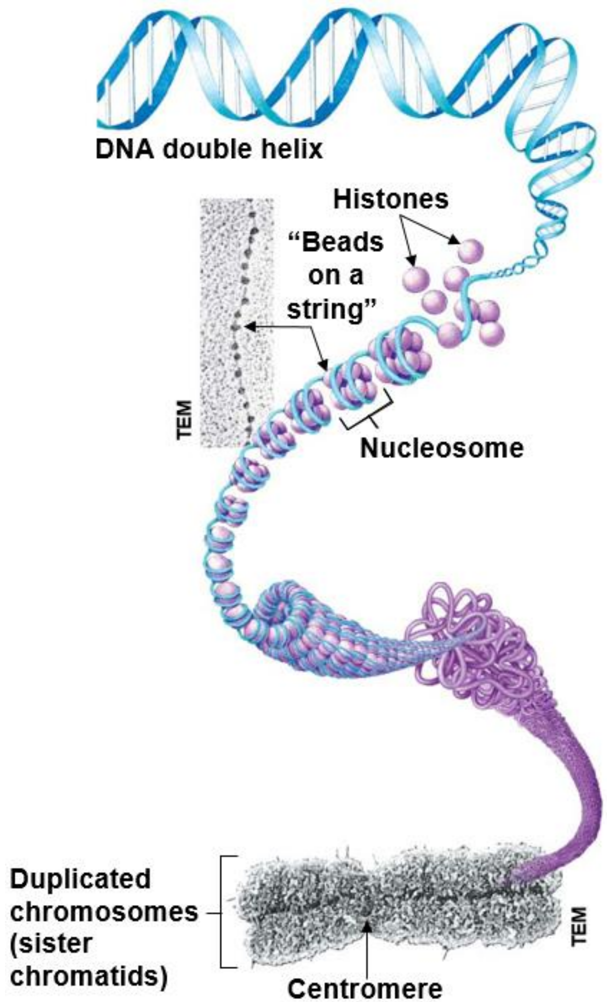


Figure 8.4 DNA Packing in a Eukaryotic Chromosome (2 of 5)

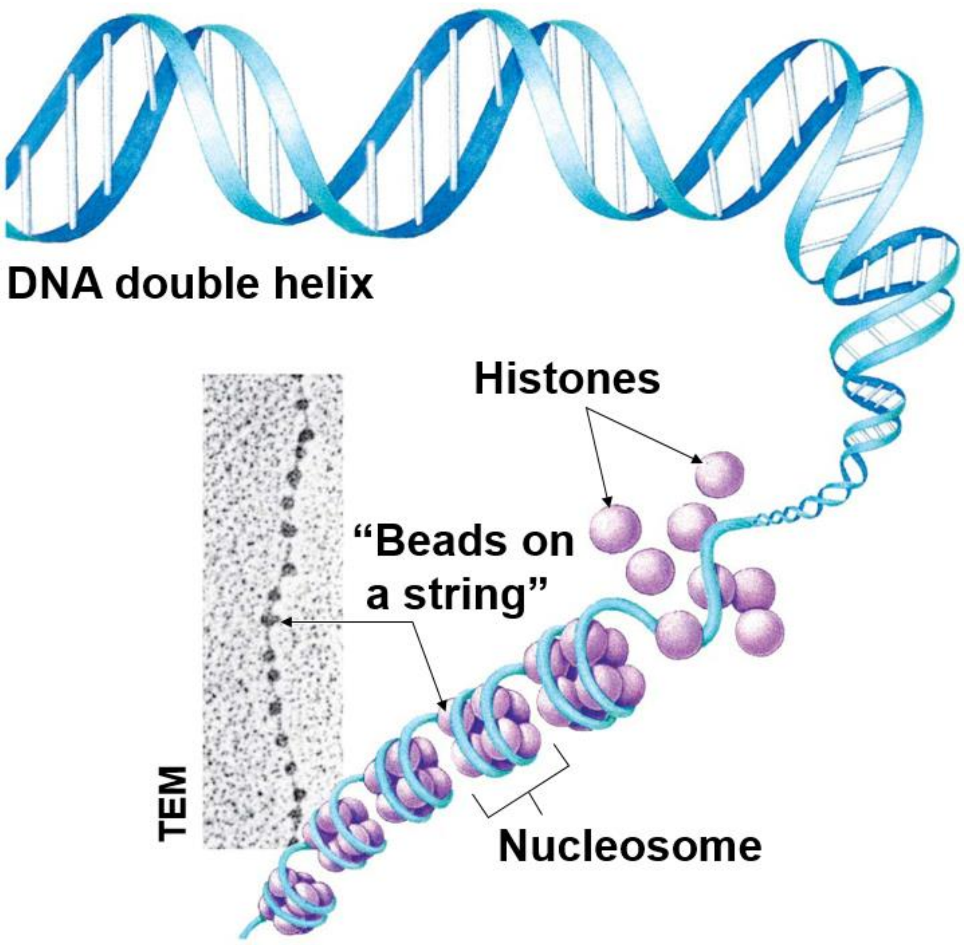


Figure 8.4 DNA Packing in a Eukaryotic Chromosome (3 of 5)

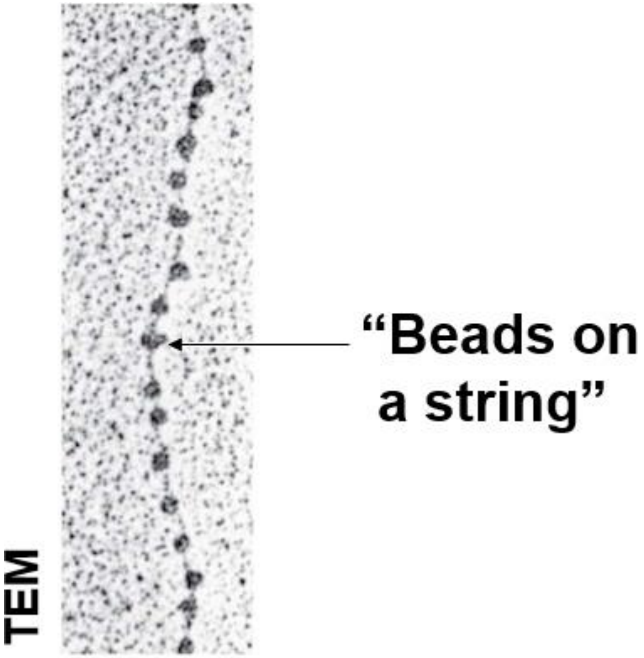


Figure 8.4 DNA Packing in a Eukaryotic Chromosome (4 of 5)

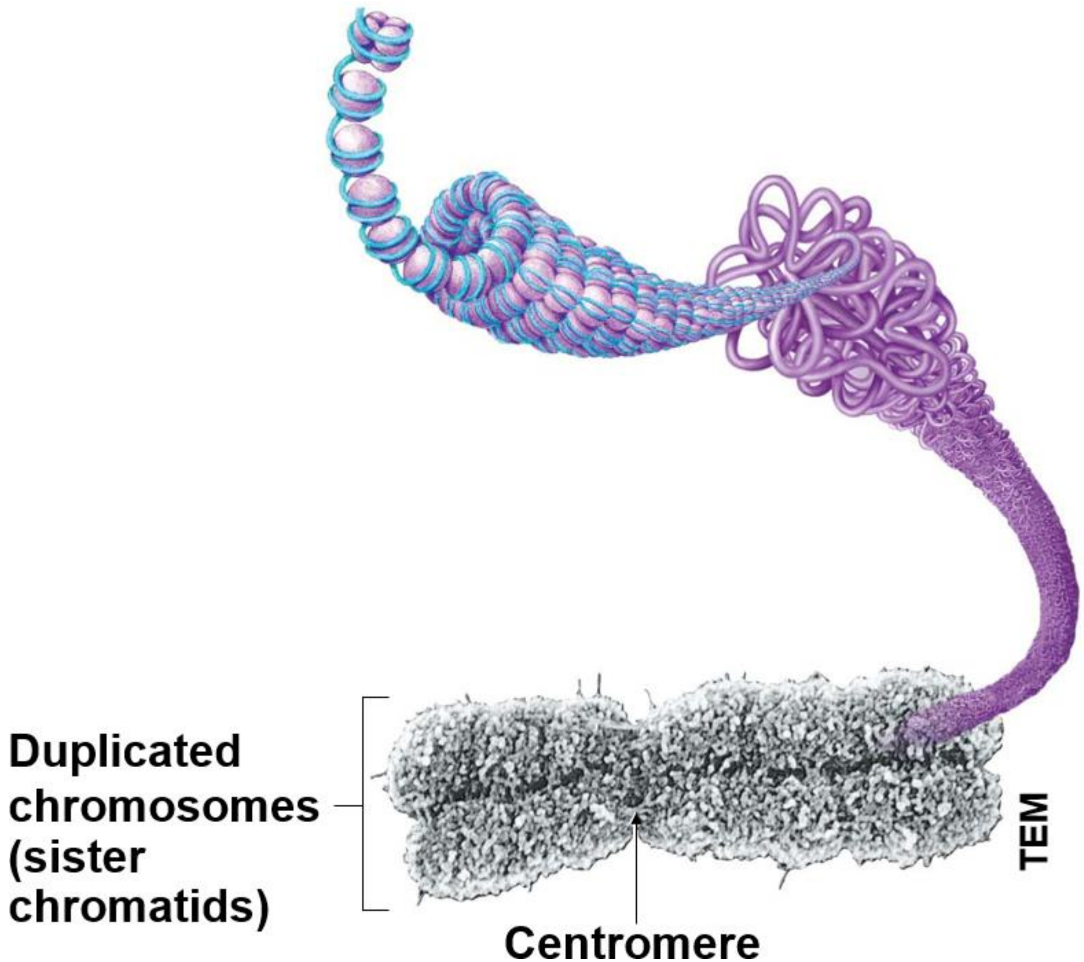
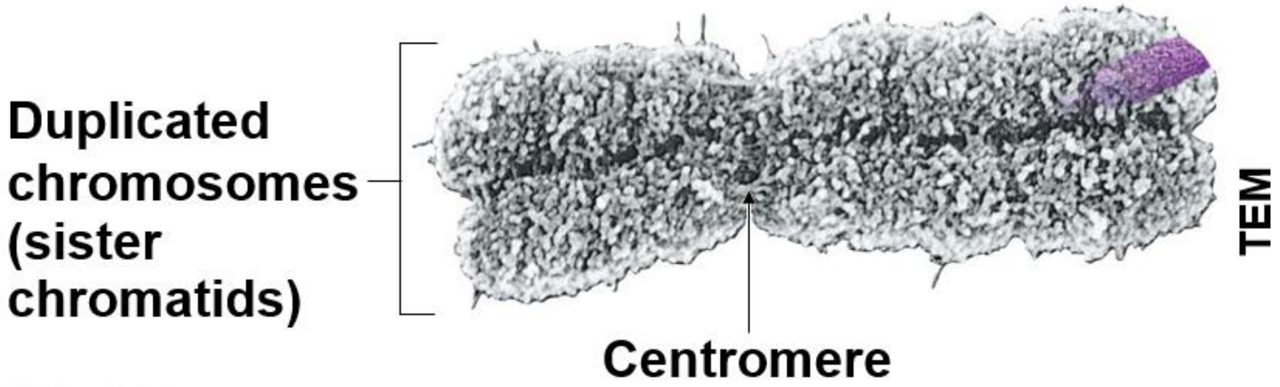


Figure 8.4 DNA Packing in a Eukaryotic Chromosome (5 of 5)



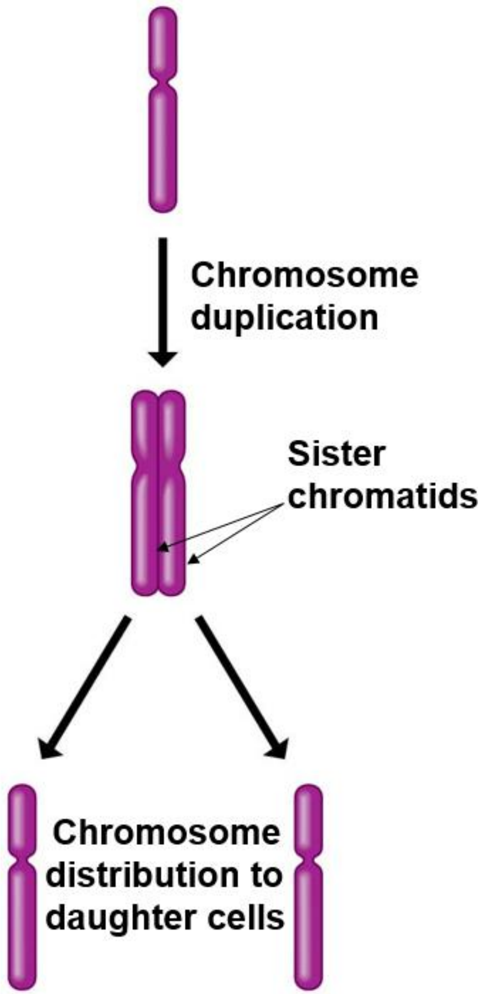
Information Flow: Duplicating Chromosomes (1 of 2)

- Before a cell begins the division process,
  - the DNA molecule of each chromosome is copied through the process of DNA replication and
  - new histone protein molecules attach as needed.
- The result is that each chromosome consists of two copies called **sister chromatids**, which contain identical genes.
- Two sister chromatids are joined together tightly at a narrow “waist” called the **centromere**.

Information Flow: Duplicating Chromosomes (2 of 2)

- When the cell divides, the sister chromatids of a duplicated chromosome separate from each other.
- Once separated from its sister, each chromatid
  - is considered a full-fledged chromosome and
  - is identical to the original chromosome.

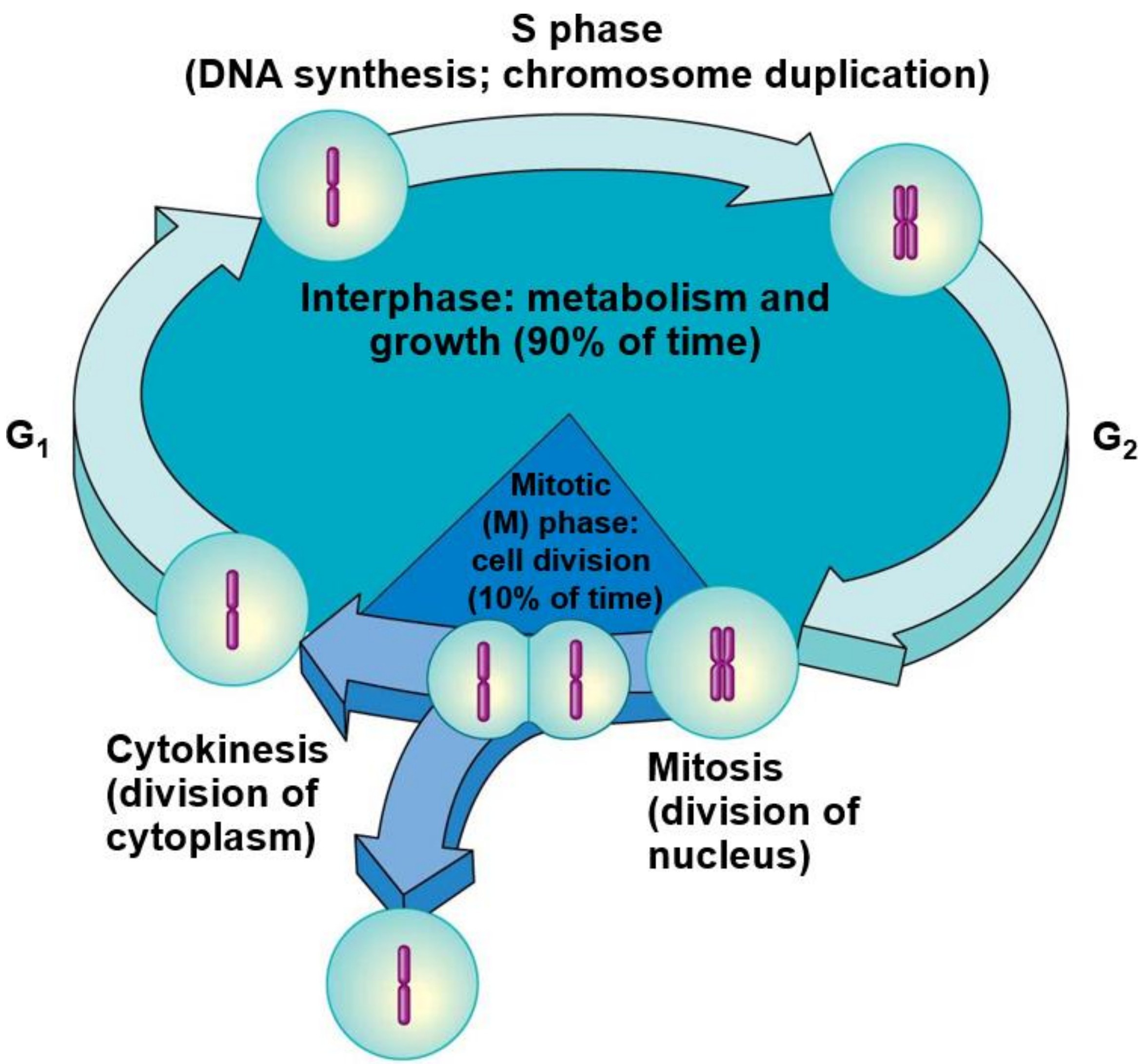
Figure 8.5 Duplication and Distribution of a Single Chromosome



The Cell Cycle (1 of 5)

- A **cell cycle** is the ordered sequence of events that extend from the time a cell is first formed from a dividing parent cell to its own division into two cells.
- Think of the cell cycle as the "lifetime" of a cell, from its "birth" to its own reproduction.

Figure 8.6 The Eukaryotic Cell Cycle



The Cell Cycle (2 of 5)

- Most of the cell cycle is spent in **interphase**, which lasts for at least 90% of the cell cycle.
- During interphase, a cell
  - performs its normal functions,
  - doubles everything in its cytoplasm, and
  - grows in size.

The Cell Cycle (3 of 5)

- From the standpoint of cell reproduction, the most important event of interphase is chromosome duplication, when the DNA in the nucleus is precisely doubled.
  - The period when this occurs is called the S phase (for DNA **synthesis**).

The Cell Cycle (4 of 5)

- The interphase periods before and after the S phase are called the G_1 and G_2 phases, respectively (G stands for **gap**).
  - During G_1, each chromosome is single, and the cell performs its normal functions.
  - During G_2 (after DNA duplication during the S phase), each chromosome in the cell consists of two identical sister chromatids, and the cell prepares to divide.

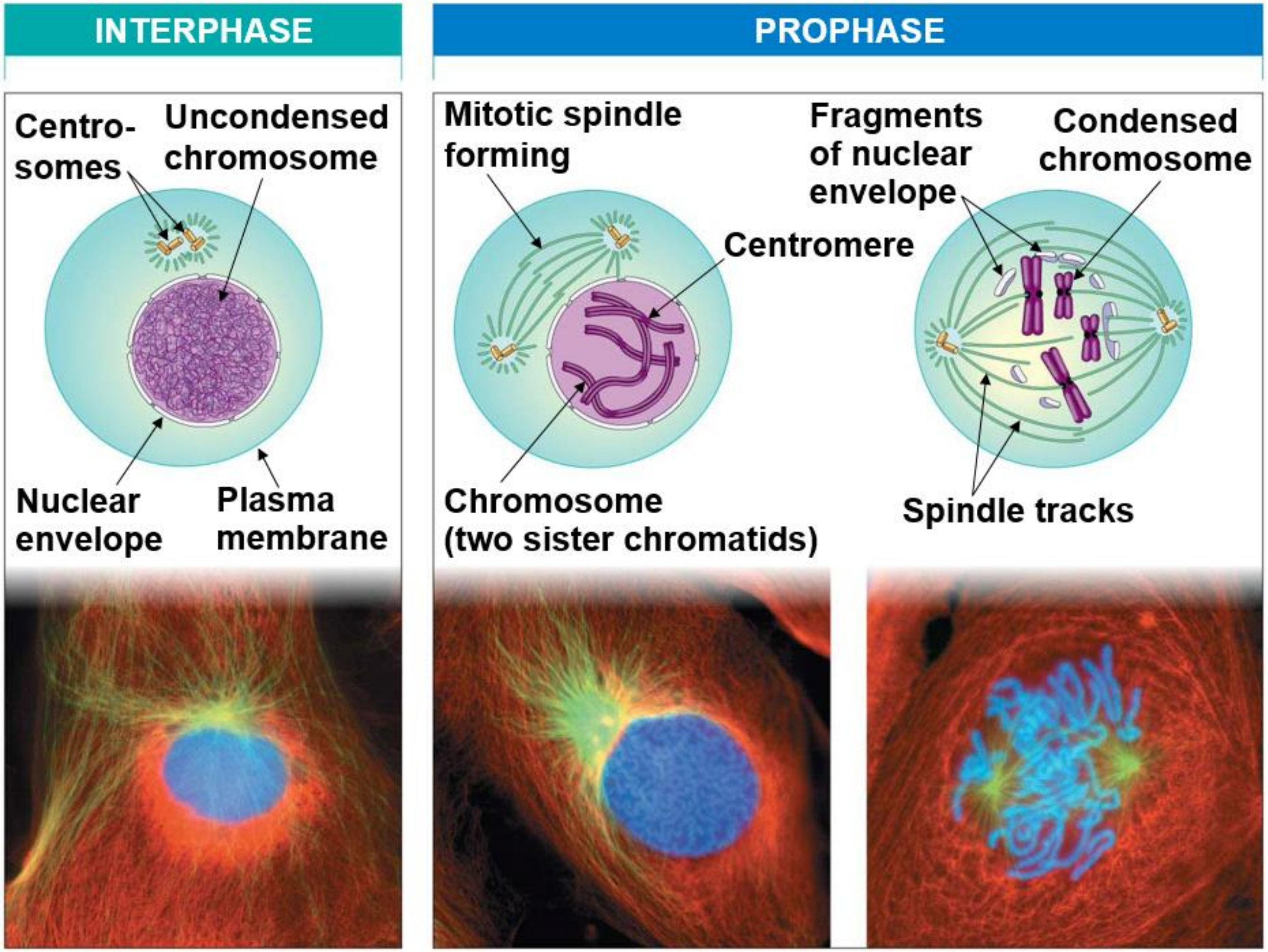
The Cell Cycle (5 of 5)

- The **mitotic (M) phase** includes two overlapping processes:
  1. **mitosis**, in which the nucleus and its contents divide evenly into two daughter nuclei, and
  2. **cytokinesis**, in which the cytoplasm (along with all the organelles) is divided in two.
- The combination of mitosis and cytokinesis produces two genetically identical daughter cells.

Mitosis and Cytokinesis

- **Figure 8.7** illustrates the cell cycle for an animal cell using drawings, descriptions, and photo micrographs.
  - The micrographs running along the bottom row of the page show dividing cells from a salamander, with chromosomes depicted in blue.
  - The drawings in the top row include details that are not visible in the micrographs.
  - The text within the figure describes the events occurring at each stage.

Figure 8.7 Cell Reproduction: A Dance of the Chromosomes (1 of 8)



Mitosis and Cytokinesis (1 of 8)

- Mitosis consists of four distinct phases:
  1. **Prophase**

Bioflix Animation: Mitosis

Video: Animal Mitosis

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Figure 8.7 Cell Reproduction: A Dance of the Chromosomes (2 of 8)

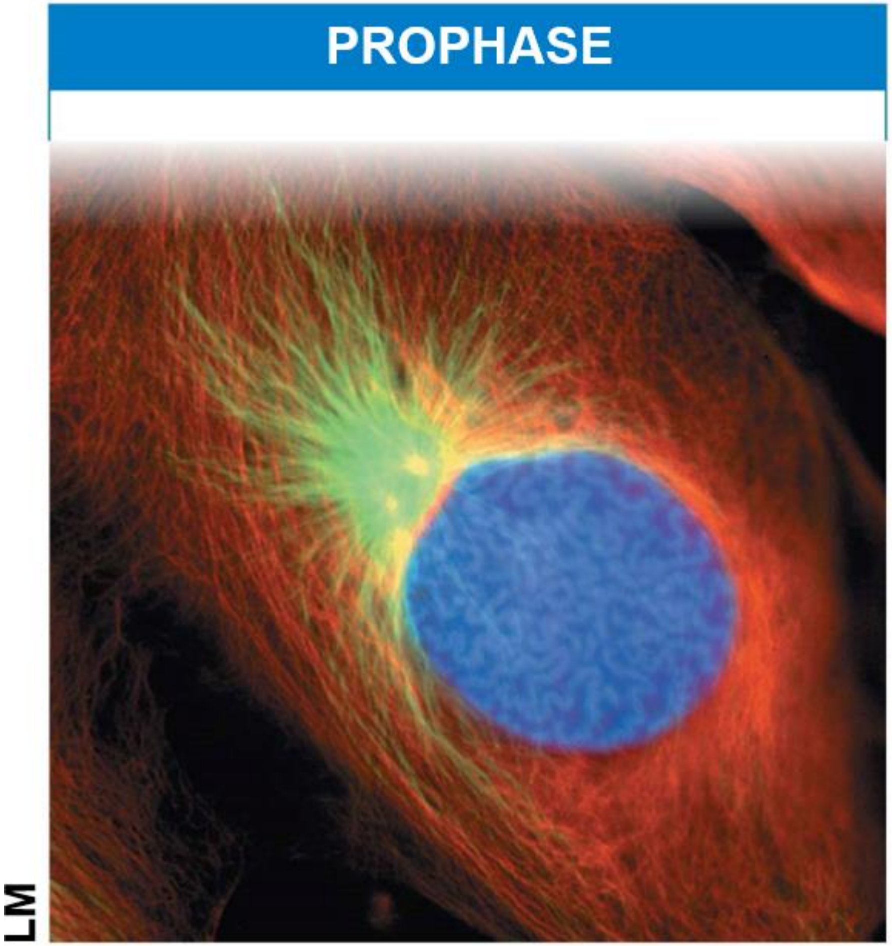
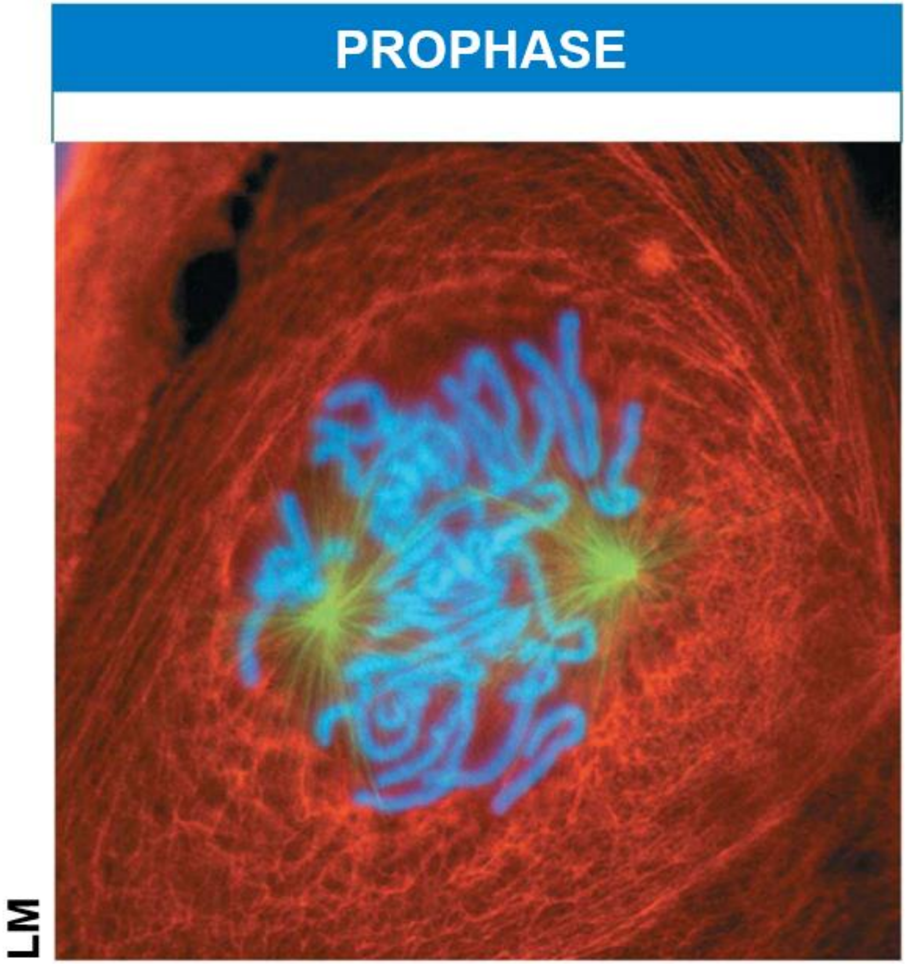


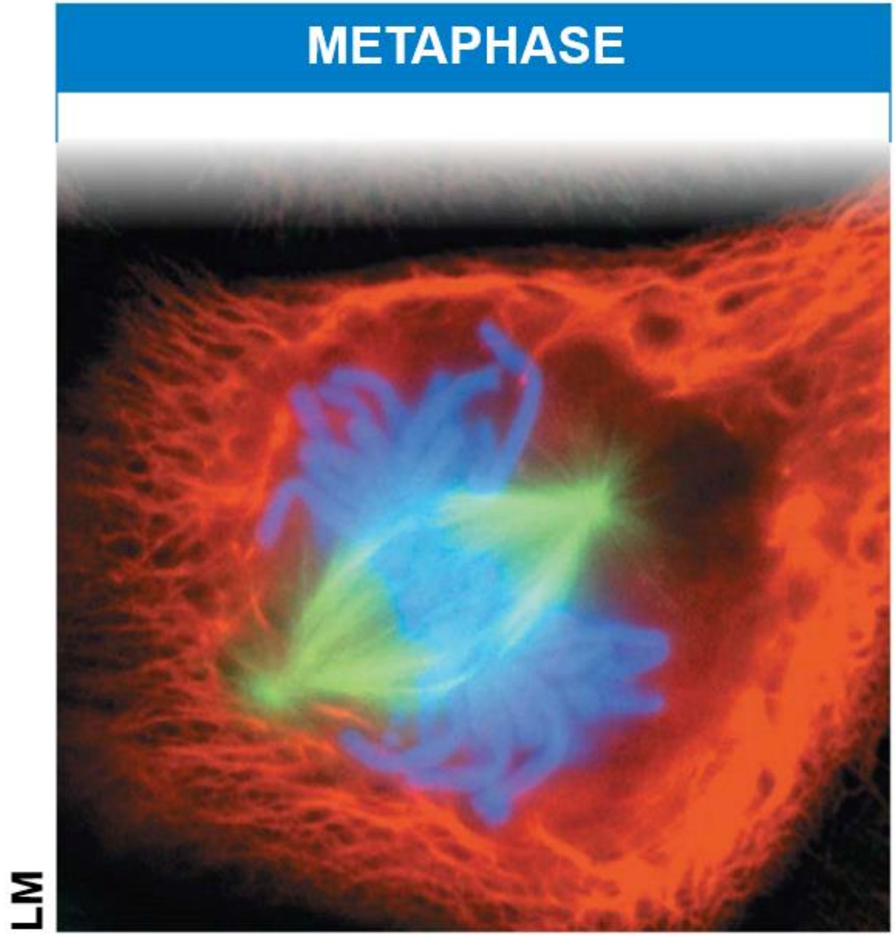
Figure 8.7 Cell Reproduction: A Dance of the Chromosomes (3 of 8)



Mitosis and Cytokinesis (2 of 8)

- Mitosis consists of four distinct phases:
  1. Prophase
  2. **Metaphase**

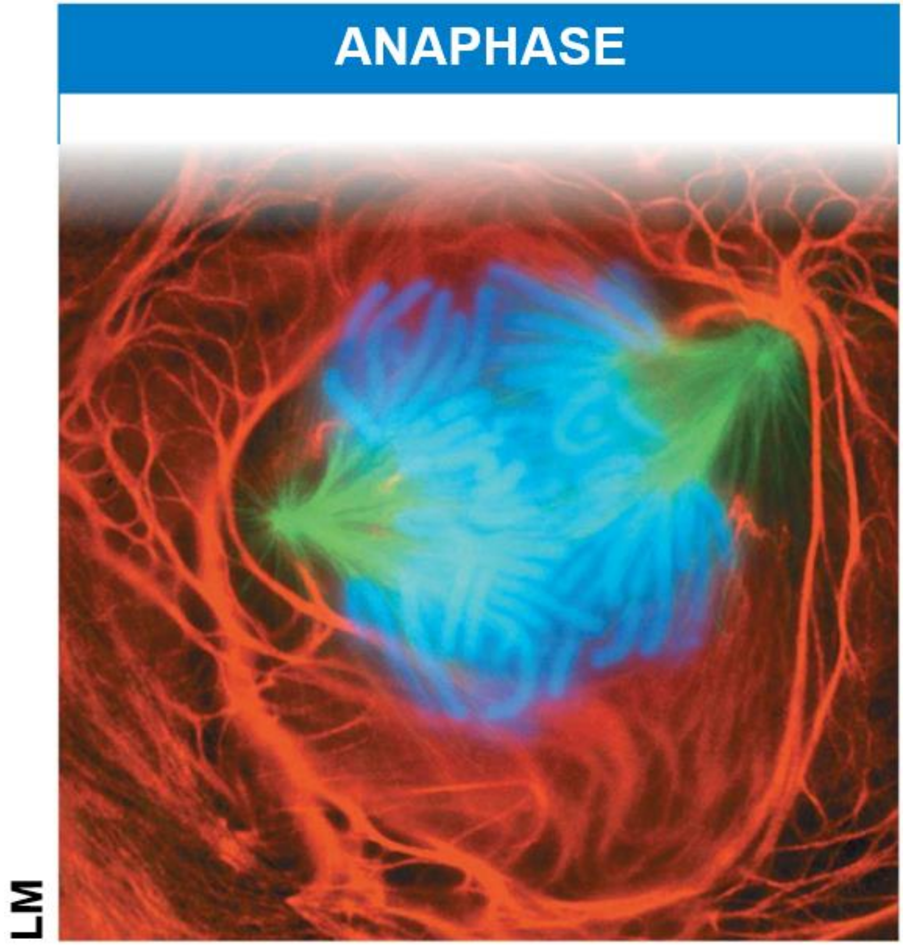
Figure 8.7 Cell Reproduction: A Dance of the Chromosomes (4 of 8)



Mitosis and Cytokinesis (3 of 8)

- Mitosis consists of four distinct phases:
  1. Prophase
  2. Metaphase
  3. **Anaphase**

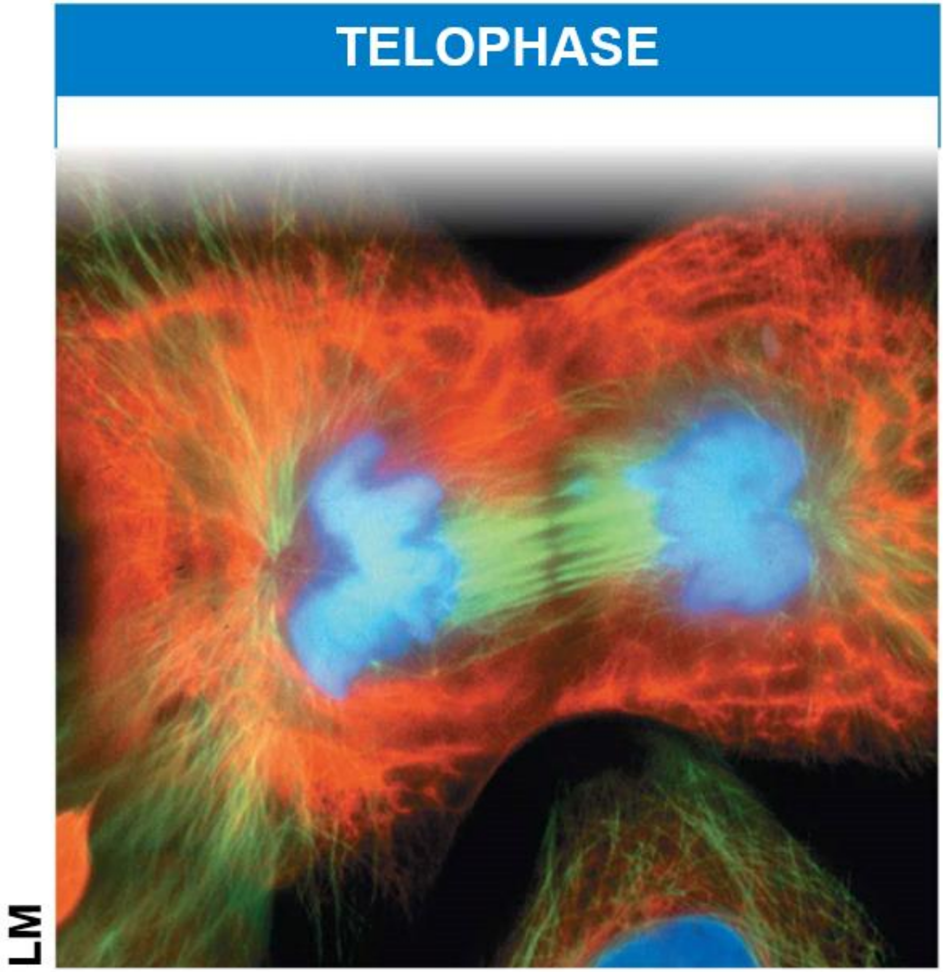
Figure 8.7 Cell Reproduction: A Dance of the Chromosomes (5 of 8)



Mitosis and Cytokinesis (4 of 8)

- Mitosis consists of four distinct phases:
  1. Prophase
  2. Metaphase
  3. Anaphase
  4. **Telophase**

Figure 8.7 Cell Reproduction: A Dance of the Chromosomes (6 of 8)



Mitosis and Cytokinesis (5 of 8)

- The chromosomes and their movements depend on the **mitotic spindle**, a football-shaped structure of microtubules that guides the separation of the two sets of daughter chromosomes.

Mitosis and Cytokinesis (6 of 8)

- Cytokinesis
  - usually begins during telophase,
  - divides the cytoplasm, and
  - is different in plant and animal cells.

Mitosis and Cytokinesis (7 of 8)

- In animal cells, cytokinesis
  - is known as **cleavage** and
  - begins with the appearance of a cleavage furrow, an indentation at the equator of the cell.

Animation: Cytokinesis

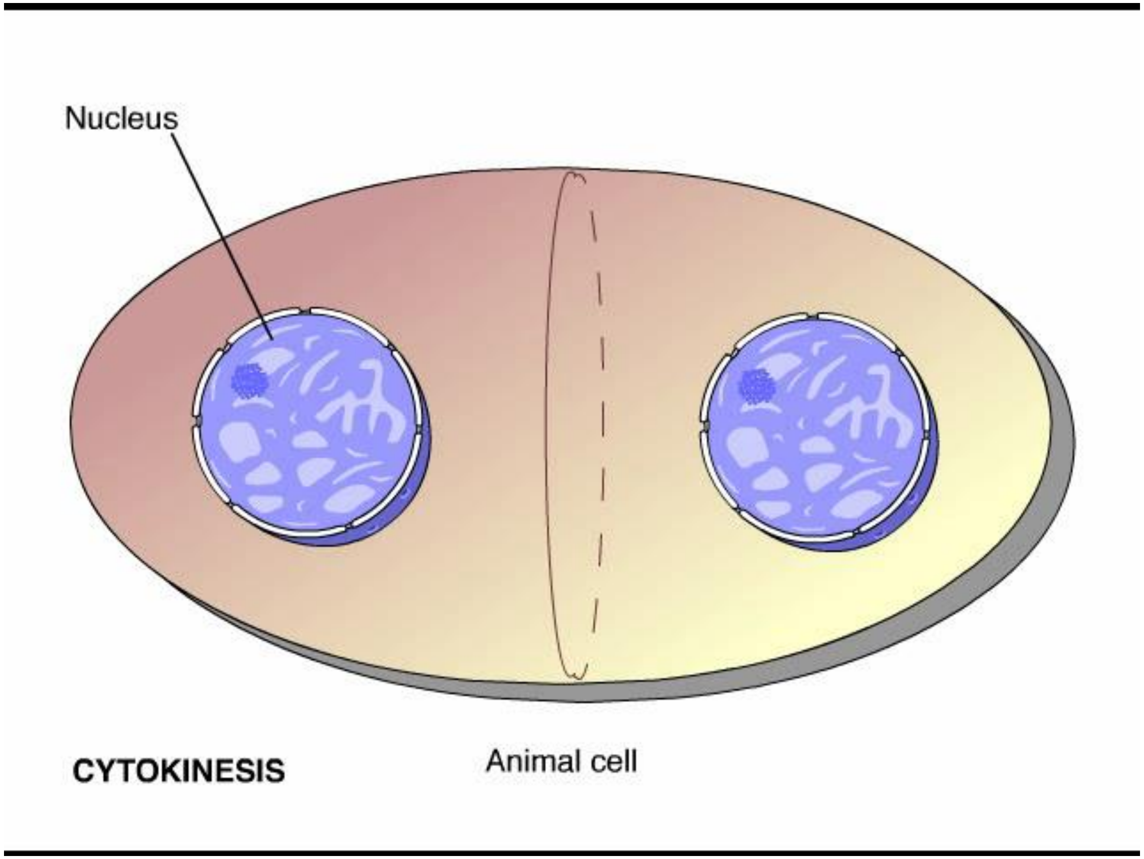
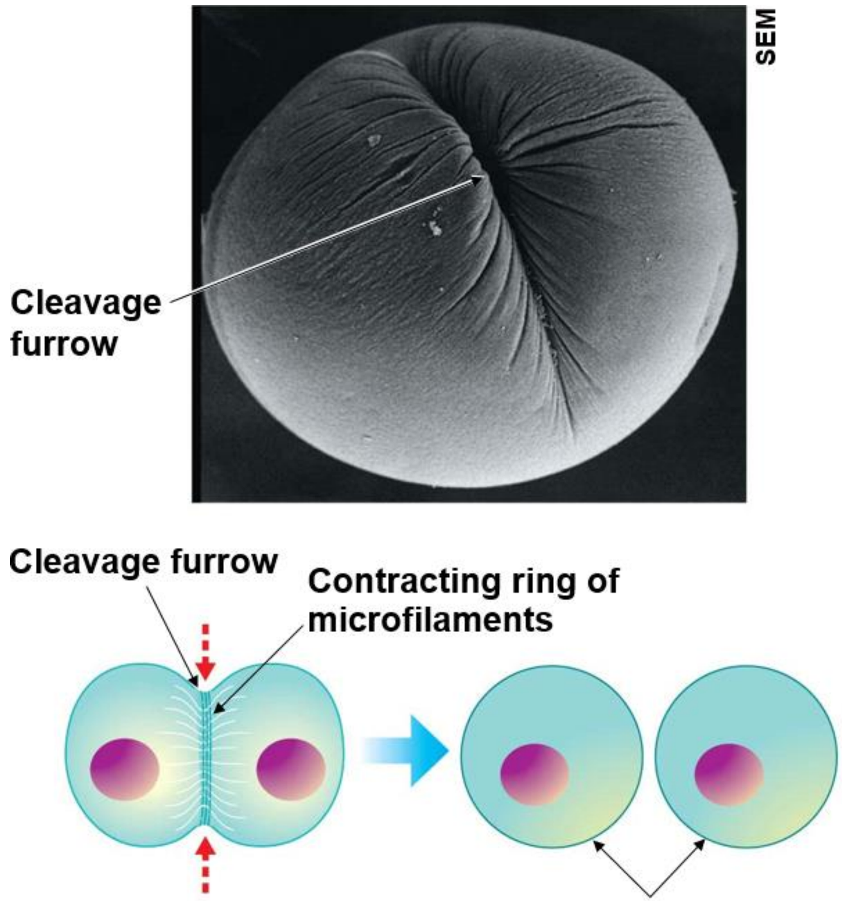
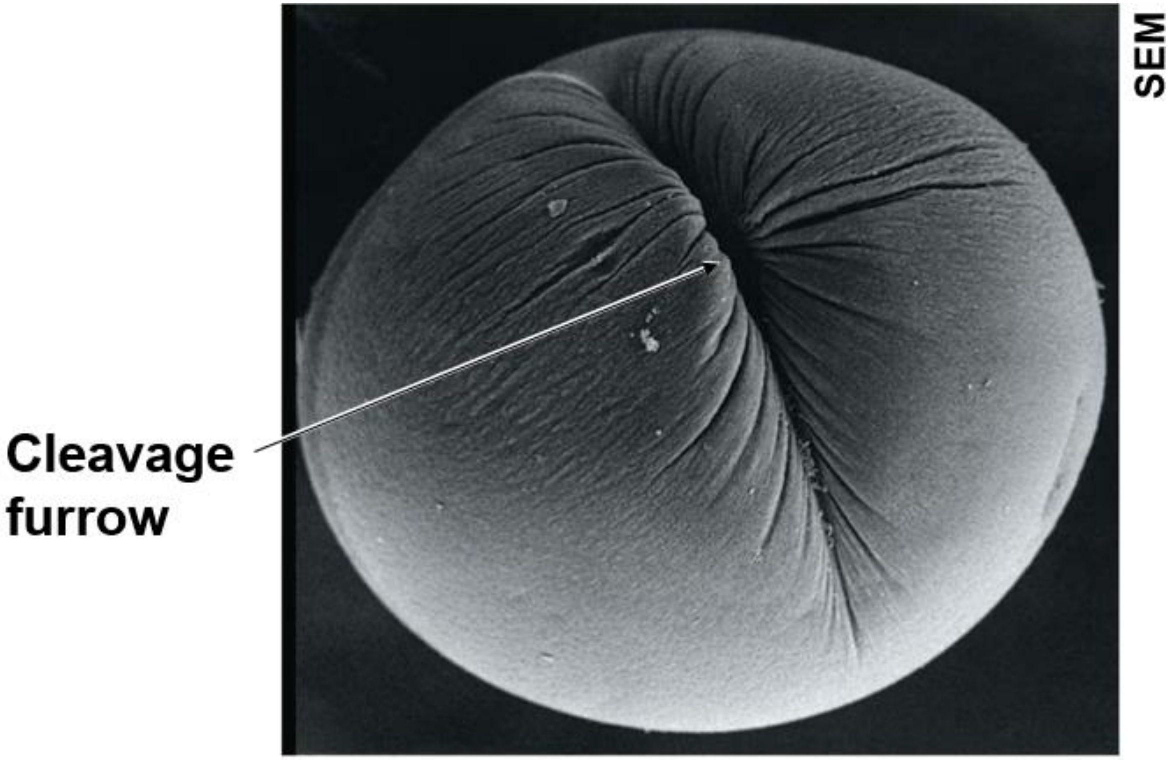


Figure 8.8 Cytokinesis in Animal and Plant Cells (1 of 4)



(a) Animal cell cytokinesis

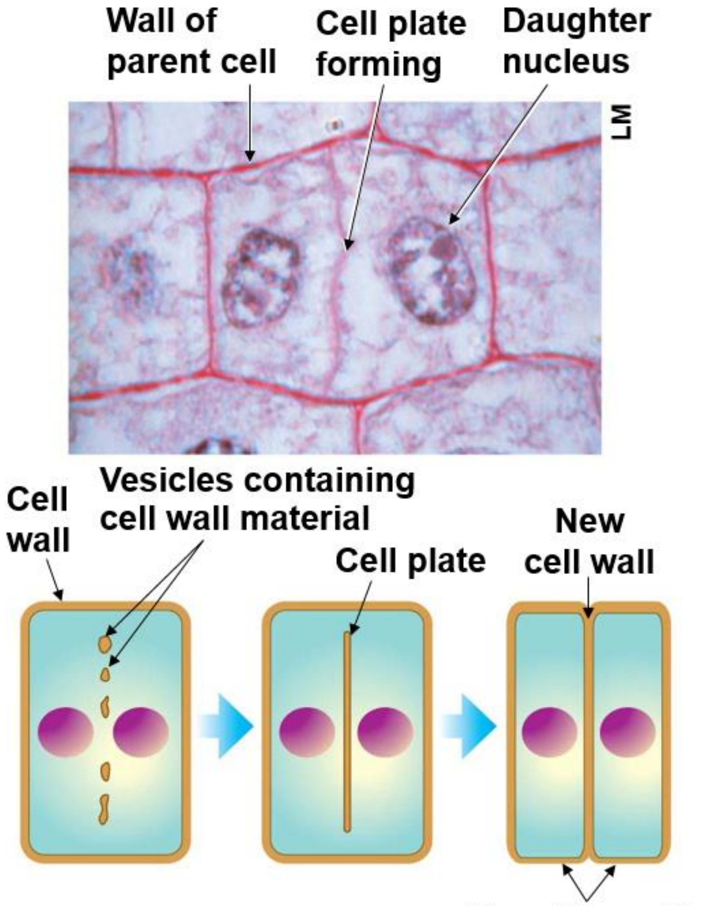
Figure 8.8 Cytokinesis in Animal and Plant Cells (2 of 4)



Mitosis and Cytokinesis (8 of 8)

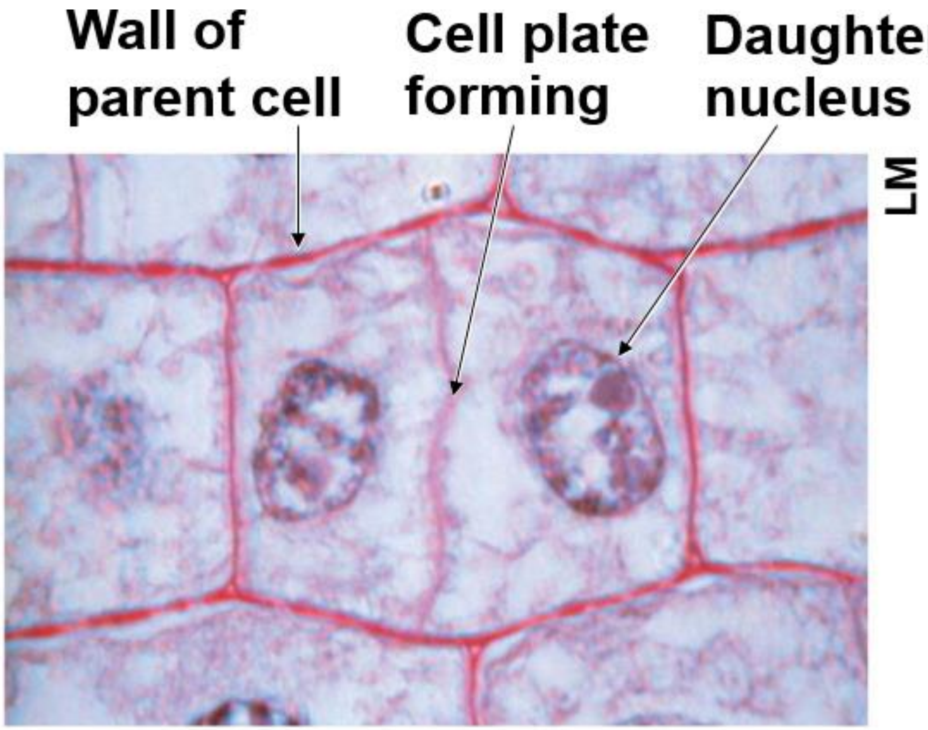
- In plant cells, cytokinesis begins when vesicles containing cell wall material collect at the middle of the cell and then fuse, forming a membranous disk called the **cell plate**.
  - The cell plate grows outward, accumulating more cell wall material as more vesicles join it.
  - Eventually, the membrane of the cell plate fuses with the plasma membrane, and the cell plate’s contents join the parental cell wall.

Figure 8.8 Cytokinesis in Animal and Plant Cells (3 of 4)



(b) Plant cell cytokinesis

Figure 8.8 Cytokinesis in Animal and Plant Cells (4 of 4)



Cancer Cells: Dividing Out of Control

- For a plant or animal to grow and maintain its tissues normally, it must be able to control the timing of cell division.
- The sequential events of the cell cycle are directed by a **cell cycle control system** that consists of specialized proteins within the cell. These proteins
  - integrate information from the environment and from other body cells and
  - send “stop” and “go-ahead” signals at certain key points during the cell cycle.

What Is Cancer? (1 of 3)

- Cancer is a disease of the cell cycle.
- Cancer cells
  - do not respond normally to the cell cycle control system,
  - divide excessively, and
  - may invade other tissues of the body.

What Is Cancer? (2 of 3)

- The abnormal behavior of cancer cells begins when
  - a single cell undergoes genetic changes (mutations) in one or more genes that encode for proteins in the cell cycle control system and
  - these changes cause the cell to grow abnormally.

What Is Cancer? (3 of 3)

- Cancer cells can form **tumors**, abnormally growing masses of body cells.
  - If the abnormal cells remain at the original site, the lump is called a **benign tumor**.
  - **Malignant tumors** can spread into neighboring tissues and other parts of the body, forming new tumors, and can interrupt organ function.
    - An individual with a malignant tumor is said to have **cancer**.
    - The spread of cancer cells beyond their original site is called **metastasis**.

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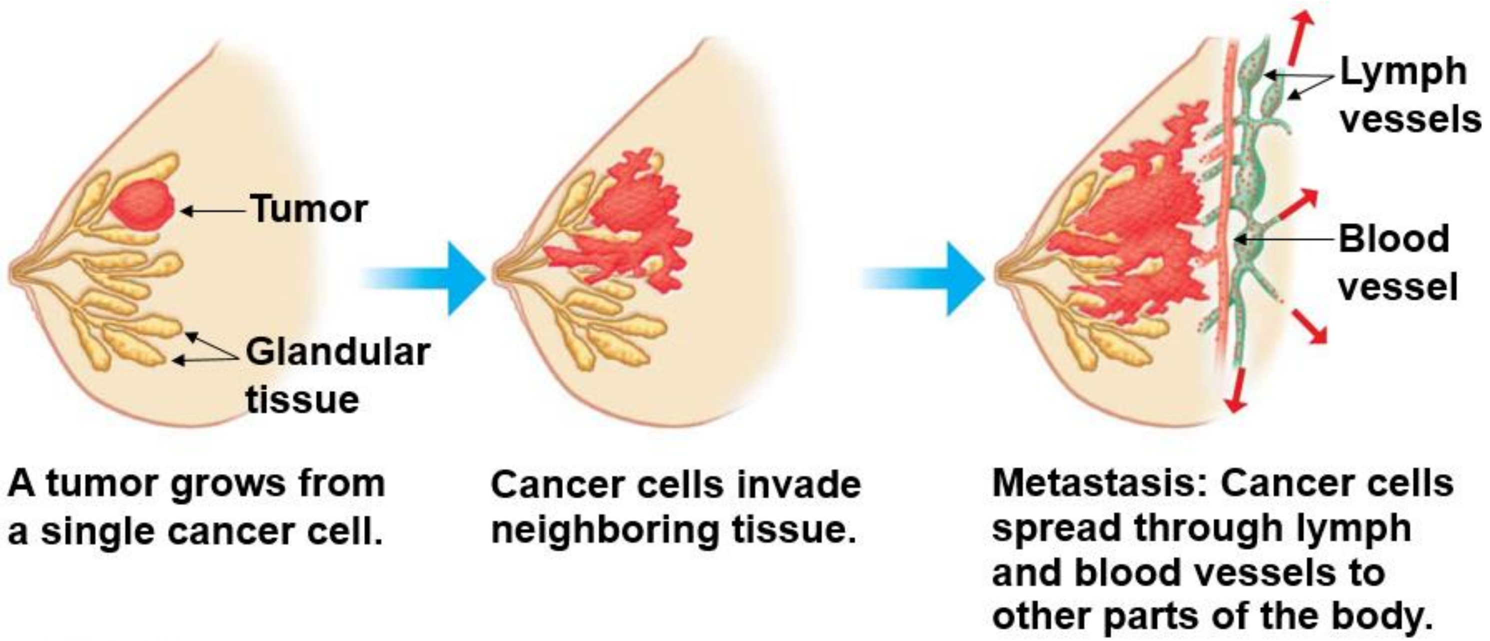
Figure 8.9 Growth and Metastasis of a Malignant Tumor of the Breast



Cancer Treatment

- There are three main types of cancer treatment.
  1. Surgery to remove a tumor is usually the first step.
  2. In **radiation therapy**, parts of the body that have cancerous tumors are exposed to concentrated beams of high-energy radiation, which often harm cancer cells more than normal cells. Radiation therapy is often effective against malignant tumors that have not yet spread.
  3. **Chemotherapy**, the use of drugs to disrupt cell division, is used to treat widespread or metastatic tumors.

Cancer Prevention and Survival

- Although cancer can strike anyone, there are certain lifestyle changes you can make to reduce your chances of developing cancer or increase your chances of surviving it. These include
  - not smoking,
  - exercising adequately,
  - avoiding exposure to the sun,
  - eating a high-fiber, low-fat diet,
  - performing self-exams, and
  - regularly visiting a doctor to identify tumors early.

Meiosis, the Basis of Sexual Reproduction

- Sexual reproduction
  - produces offspring that contain a unique combination of genes from the parents and
  - depends on the cellular processes of meiosis and fertilization.

Figure 8.10 The Varied Products of Sexual Reproduction

Homologous Chromosomes (1 of 4)

- Different individuals of a single species have the same number and types of chromosomes.
- A human **somatic cell**
  - is a typical body cell and
  - has 46 chromosomes.

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Homologous Chromosomes (2 of 4)

- To produce a **karyotype**, a technician can
  - break open a human cell in metaphase of mitosis,
  - stain the chromosomes with dyes,
  - take a picture with the aid of a microscope, and
  - arrange the chromosomes in matching pairs by size.

Figure 8.11 Pairs of Homologous Chromosomes in a Human Male Karyotype (1 of 4)

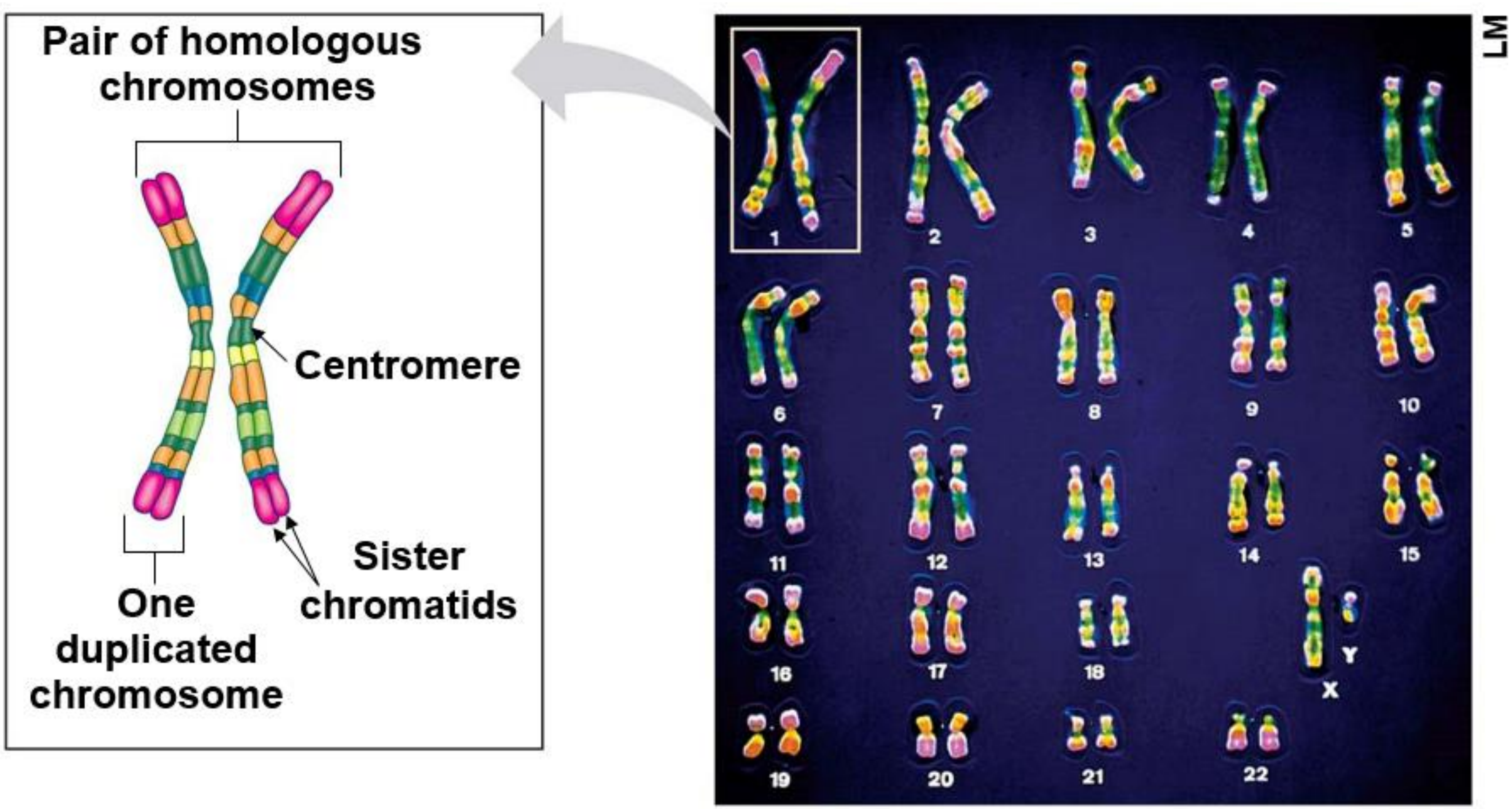
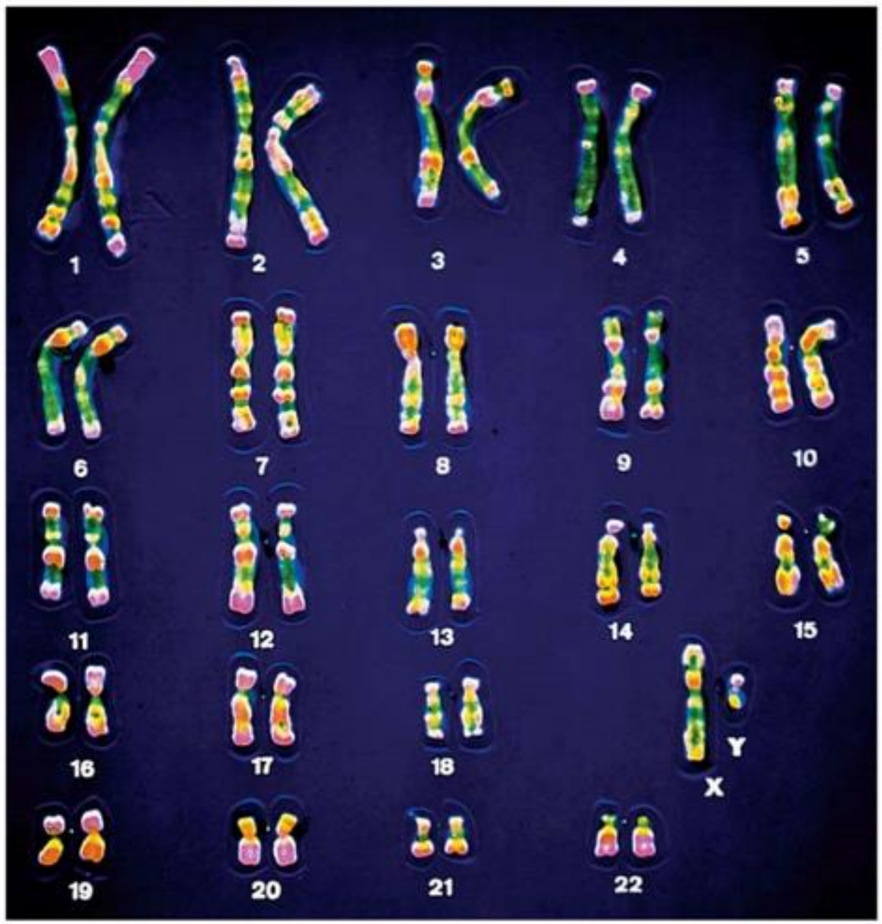


Figure 8.11 Pairs of Homologous Chromosomes in a Human Male Karyotype (2 of 4)



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Homologous Chromosomes (3 of 4)

- **Homologous chromosomes**
  - resemble each other in length and centromere position and
  - carry genes controlling the same inherited characteristics.

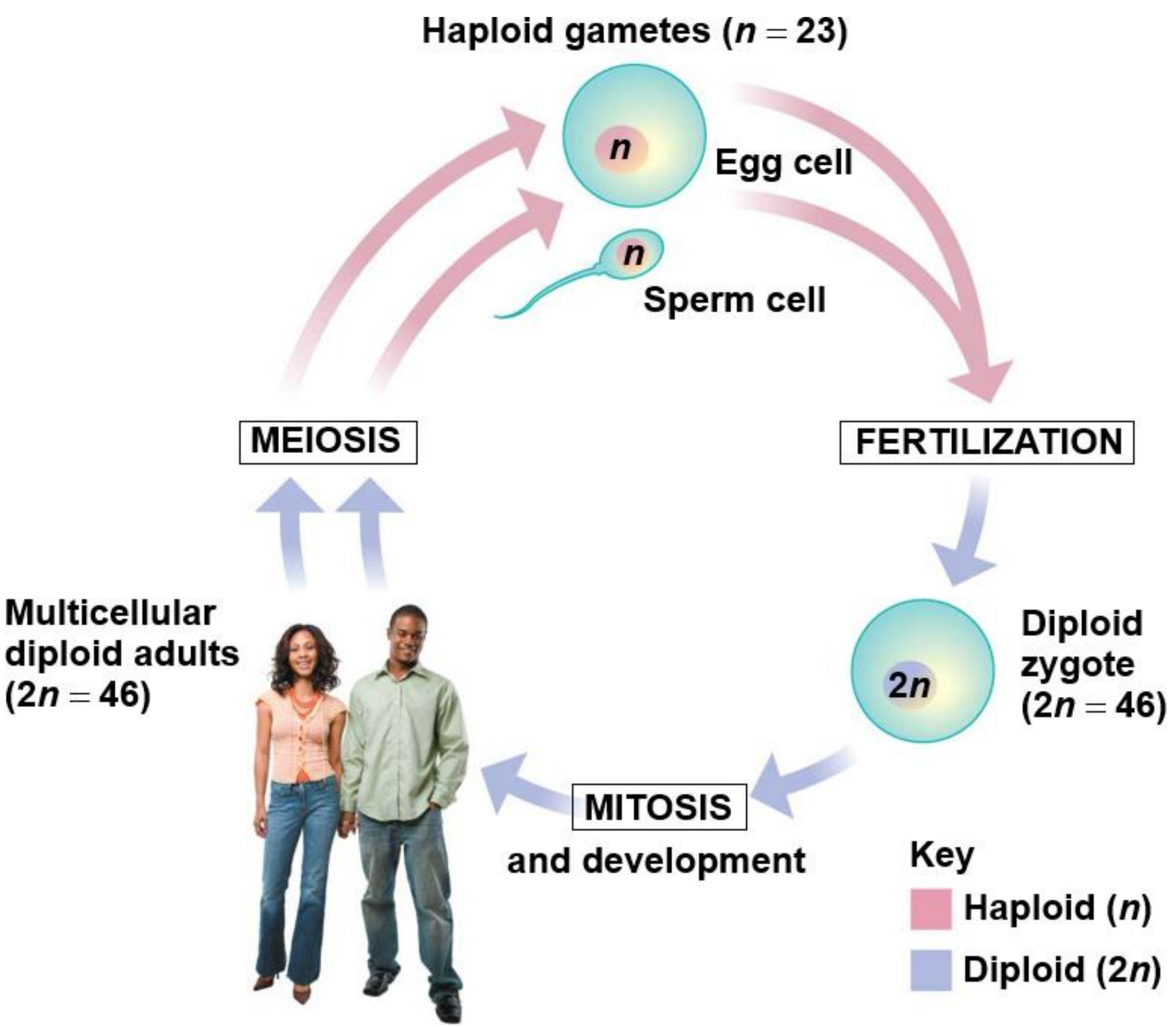
Homologous Chromosomes (4 of 4)

- Humans have 46 chromosomes:
  - 22 pairs of matching chromosomes, called **autosomes**, and
  - two different **sex chromosomes**, X and Y, which determine a person's sex (male or female).
- In mammals,
  - males have one X chromosome and one Y chromosome and
  - females have two X chromosomes.

Gametes and the Life Cycle of a Sexual Organism (1 of 4)

- The **life cycle** of a multicellular organism is the sequence of stages leading from the adults of one generation to the adults of the next.
- Having two sets of chromosomes, one inherited from each parent, is a key factor in the life cycle of humans and all other species that reproduce sexually.

Figure 8.12 The Human Life Cycle



Gametes and the Life Cycle of a Sexual Organism (2 of 4)

- Humans are said to be **diploid** organisms because all body cells contain pairs of homologous chromosomes.
  - A **haploid** cell has only one member of each pair of homologous chromosomes.

Gametes and the Life Cycle of a Sexual Organism (3 of 4)

- In the human life cycle, a haploid sperm cell from the father fuses with a haploid egg cell from the mother in a process called **fertilization**.
- The resulting fertilized egg, called a **zygote**, is diploid, with two sets of chromosomes, one set from each parent.

Gametes and the Life Cycle of a Sexual Organism (4 of 4)

- All sexual life cycles involve an alternation of diploid and haploid stages.
- Producing haploid gametes by meiosis keeps the chromosome number from doubling in every generation.

Figure 8.13 How Meiosis Halves Chromosome Number (1 of 3)

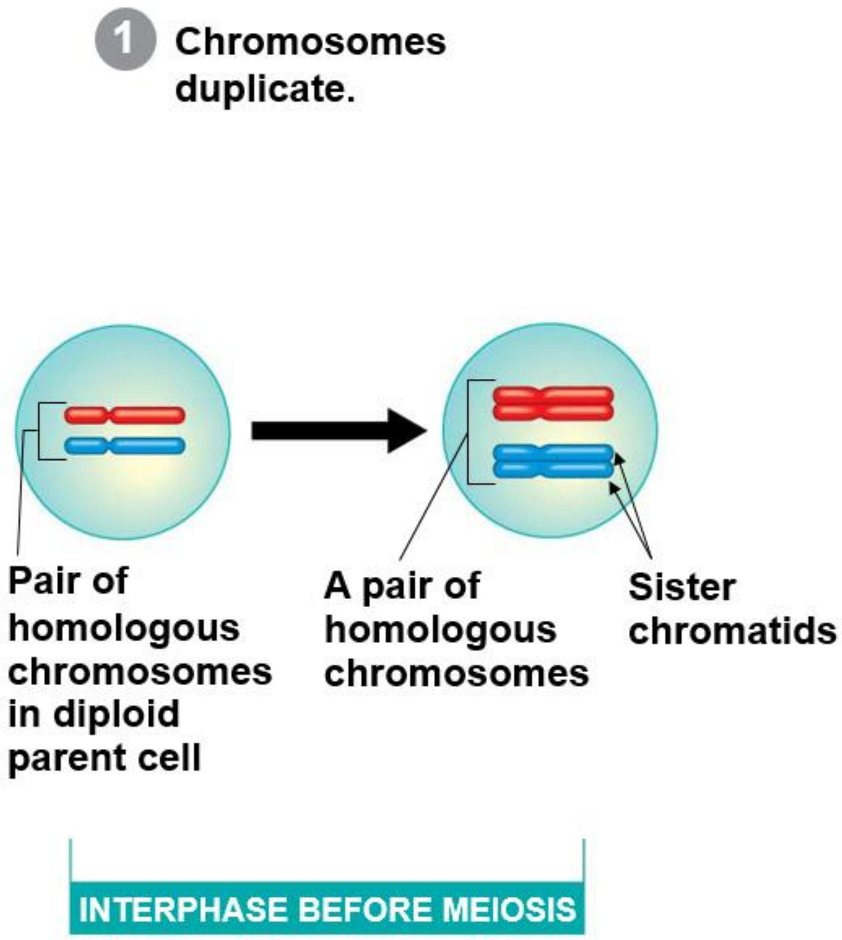


Figure 8.13 How Meiosis Halves Chromosome Number (2 of 3)

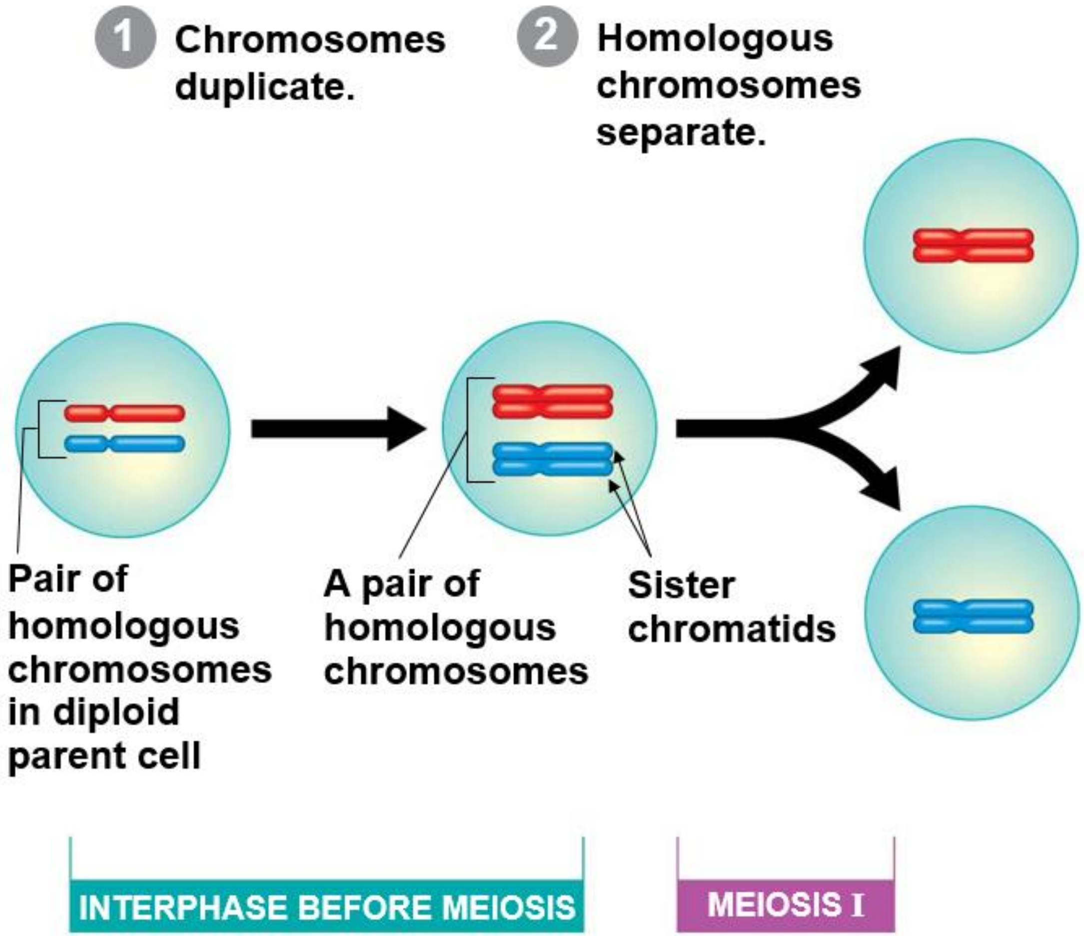
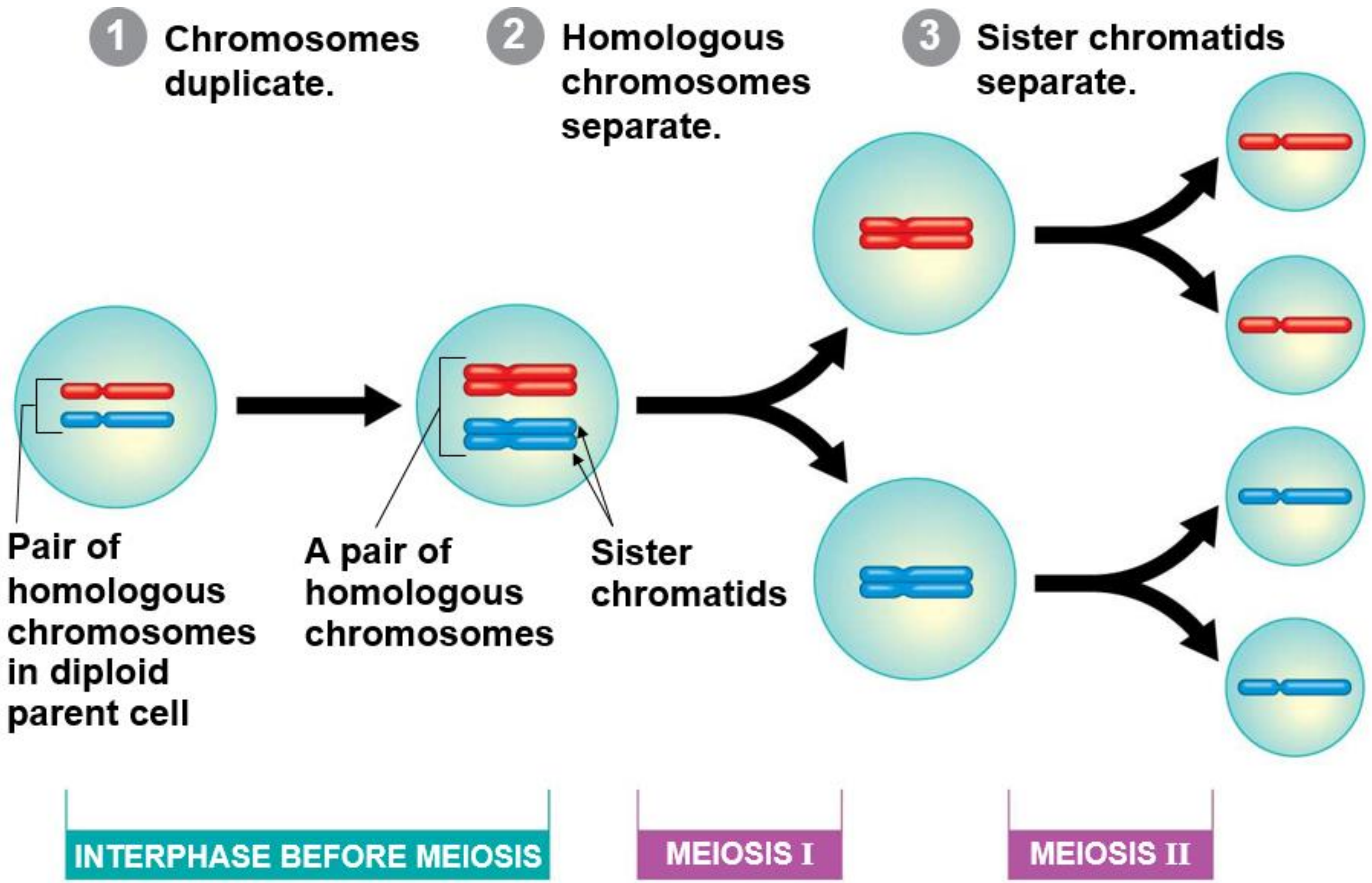


Figure 8.13 How Meiosis Halves Chromosome Number (3 of 3)



The Process of Meiosis (1 of 2)

- **Meiosis**, the process of cell division that produces haploid gametes in diploid organisms, resembles mitosis, but with two differences.
  1. The first difference is that the number of chromosomes during meiosis is cut in half.
     - In meiosis, a cell that has duplicated its chromosomes undergoes two consecutive divisions, called meiosis I and meiosis II.
     - Because one duplication of the chromosomes is followed by two divisions, each of the four daughter cells resulting from meiosis has a haploid set of chromosomes.

Bioflix Animation: Meiosis

The Process of Meiosis (2 of 2)

2. The second difference of meiosis compared with mitosis is an exchange of genetic material—pieces of chromosomes—between homologous chromosomes.
   – This exchange, called crossing over, occurs during the first prophase of meiosis.

Figure 8.14 The Stages of Meiosis (1 of 8)

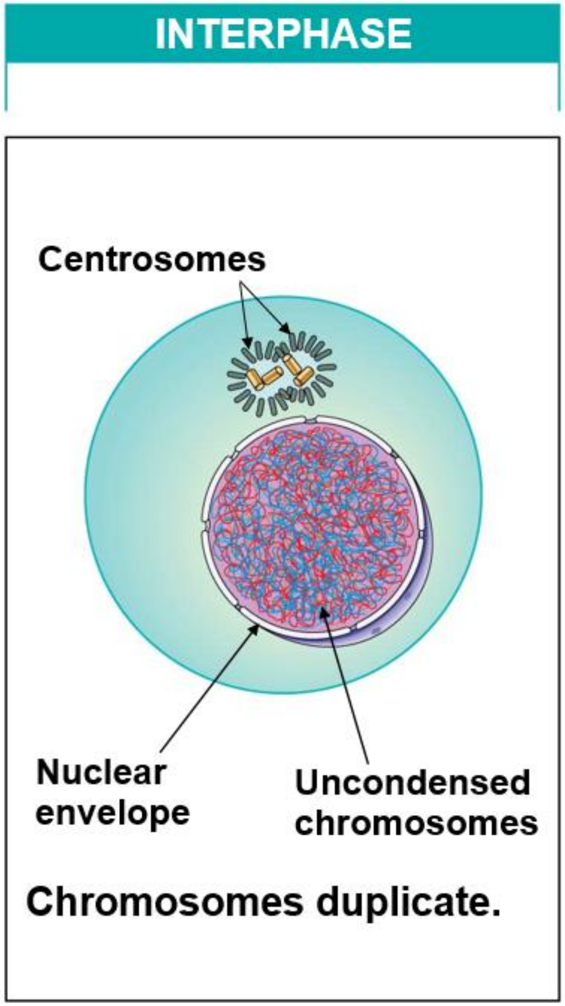


Figure 8.14 The Stages of Meiosis (2 of 8)

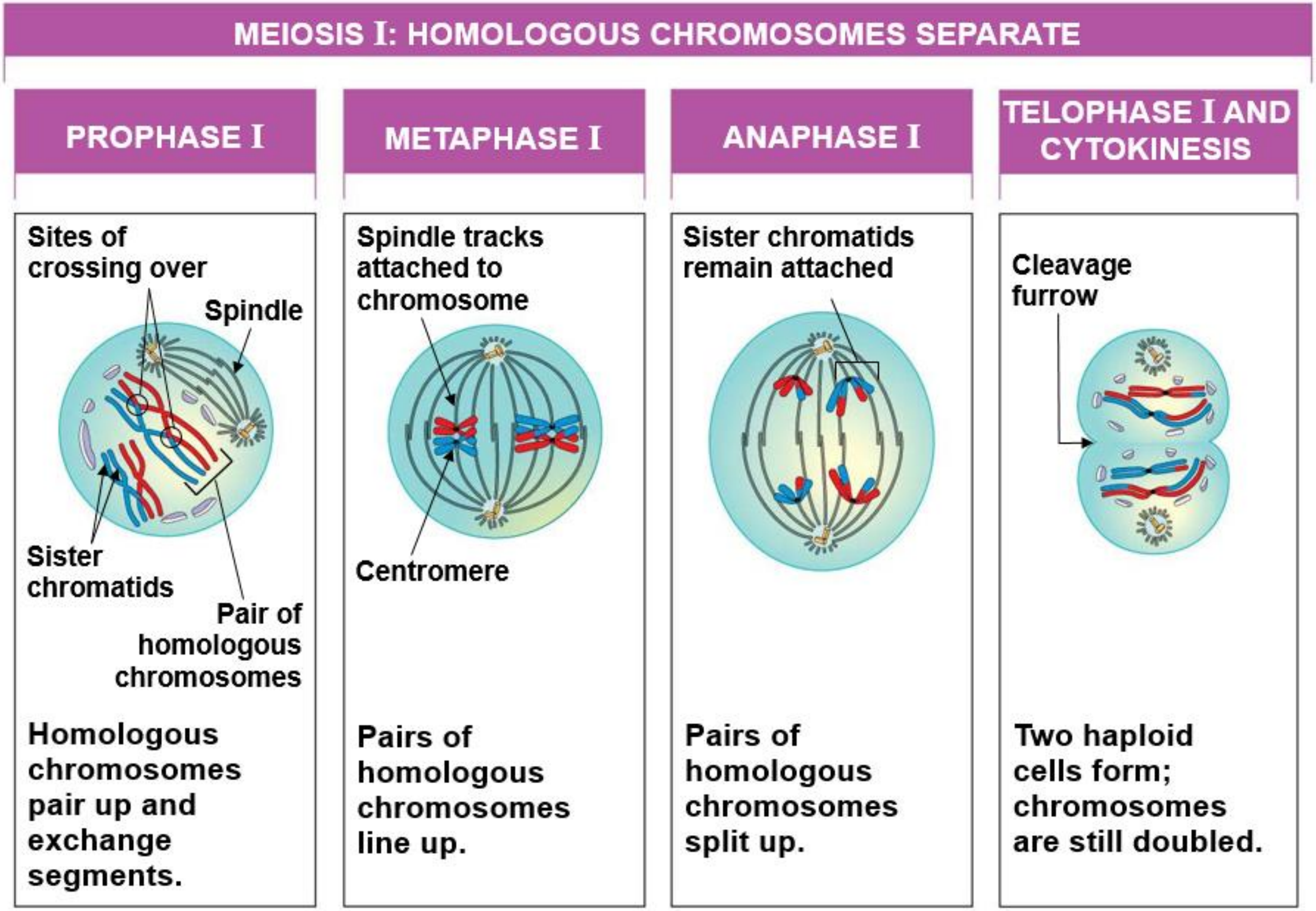


Figure 8.14 The Stages of Meiosis (3 of 8)

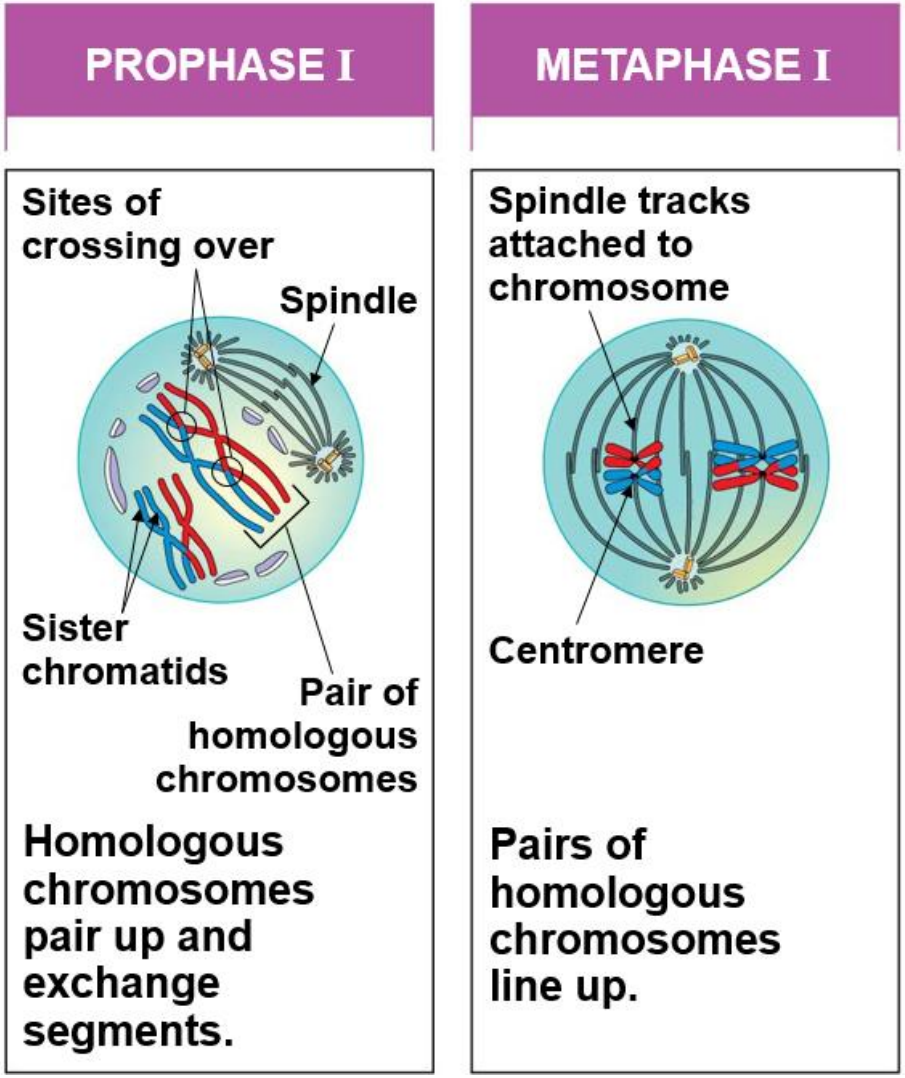


Figure 8.14 The Stages of Meiosis (4 of 8)

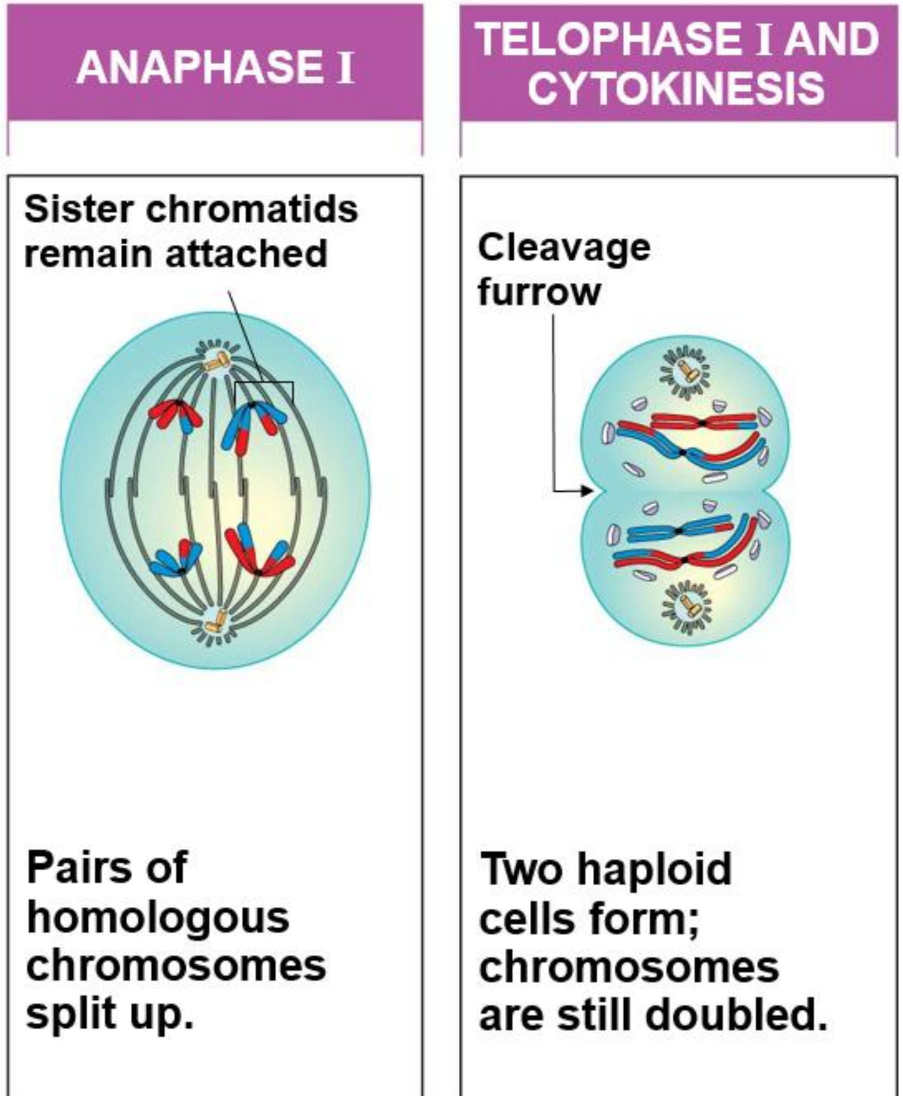


Figure 8.14 The Stages of Meiosis (5 of 8)

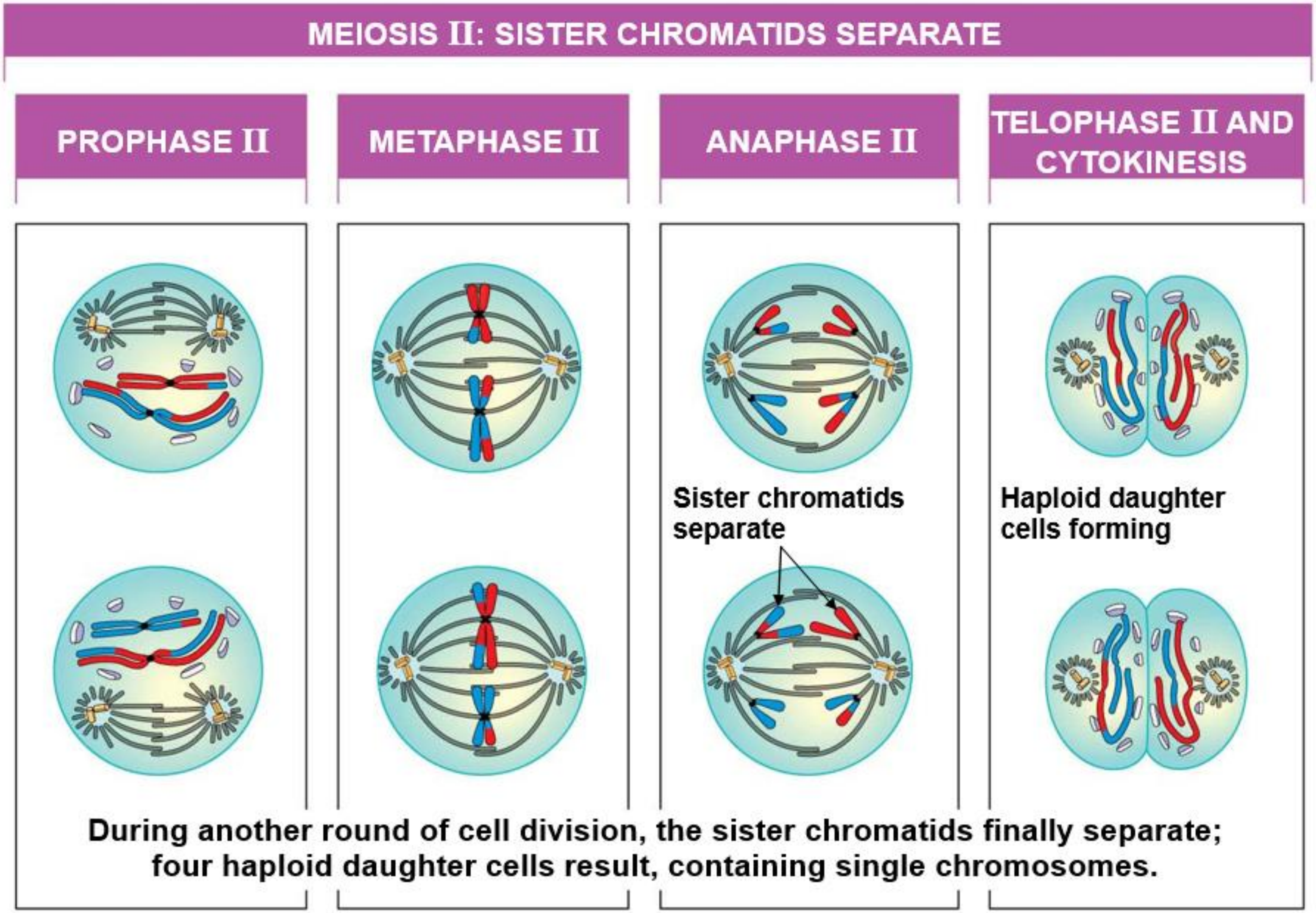


Figure 8.14 The Stages of Meiosis (6 of 8)

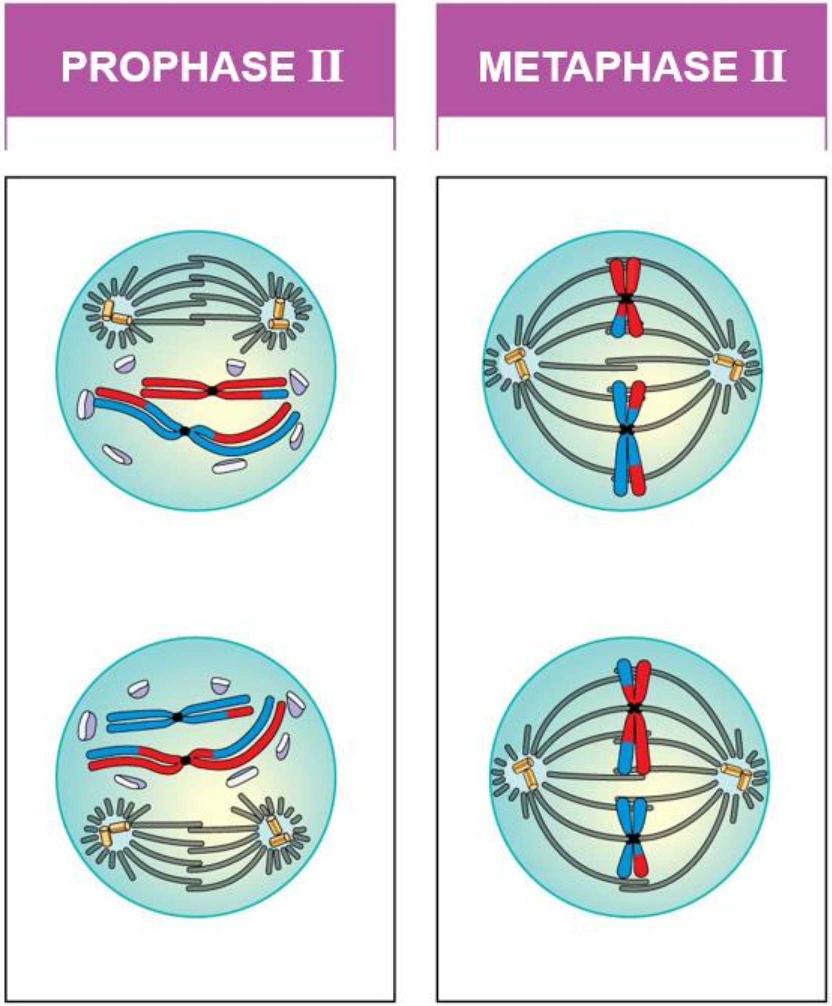


Figure 8.14 The Stages of Meiosis (7 of 8)

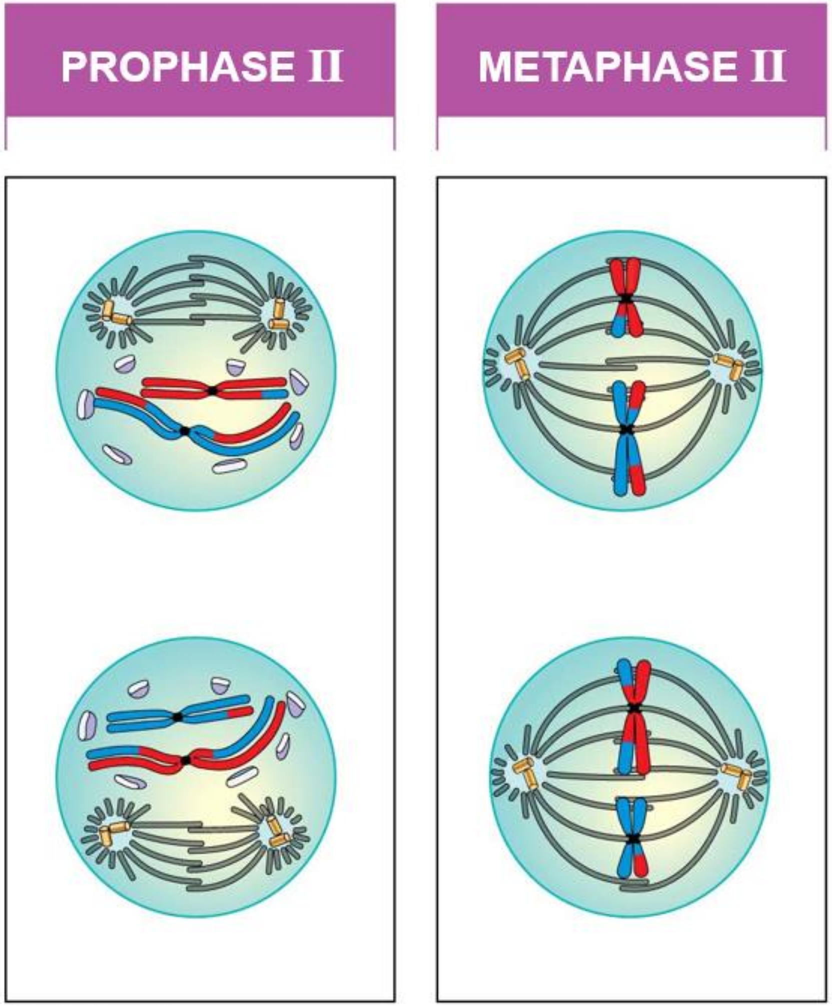
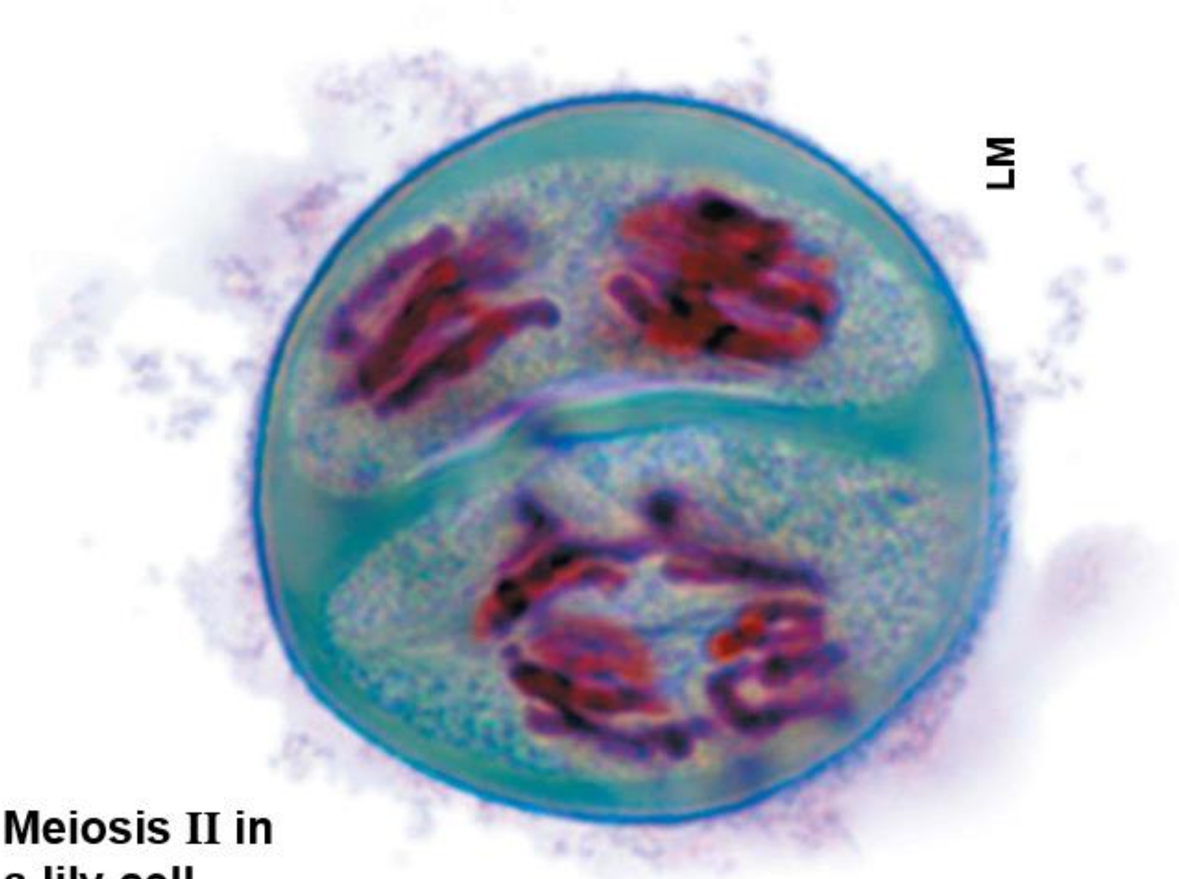


Figure 8.14 The Stages of Meiosis (8 of 8)



Meiosis II in
a lily cell

Review: Comparing Mitosis and Meiosis (1 of 2)

- For both mitosis and meiosis, the chromosomes duplicate only once, in the preceding interphase.
- The number of cell divisions varies:
  - Mitosis involves one division of the nucleus and cytoplasm (duplication, then division in half), producing two diploid cells.
  - Meiosis entails two nuclear and cytoplasmic divisions (duplication, division in half, then division in half again), yielding four haploid cells.

Review: Comparing Mitosis and Meiosis (2 of 2)

- All the events unique to meiosis occur during meiosis I.
- Meiosis II is virtually identical to mitosis in that it separates sister chromatids.
- But unlike mitosis, meiosis II yields daughter cells with a haploid set of chromosomes.

Figure 8.15 Comparing Mitosis and Meiosis (1 of 5)

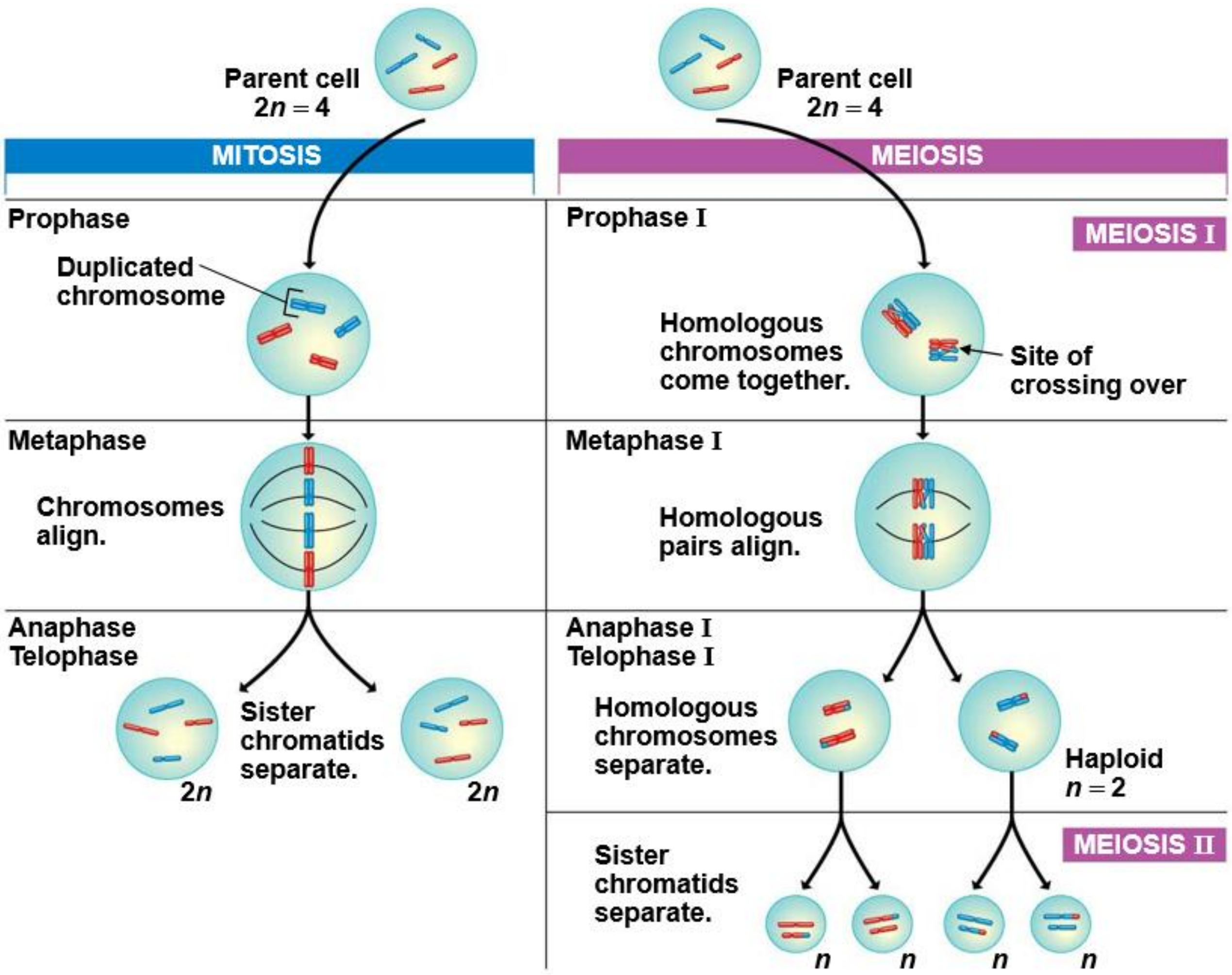


Figure 8.15 Comparing Mitosis and Meiosis (2 of 5)

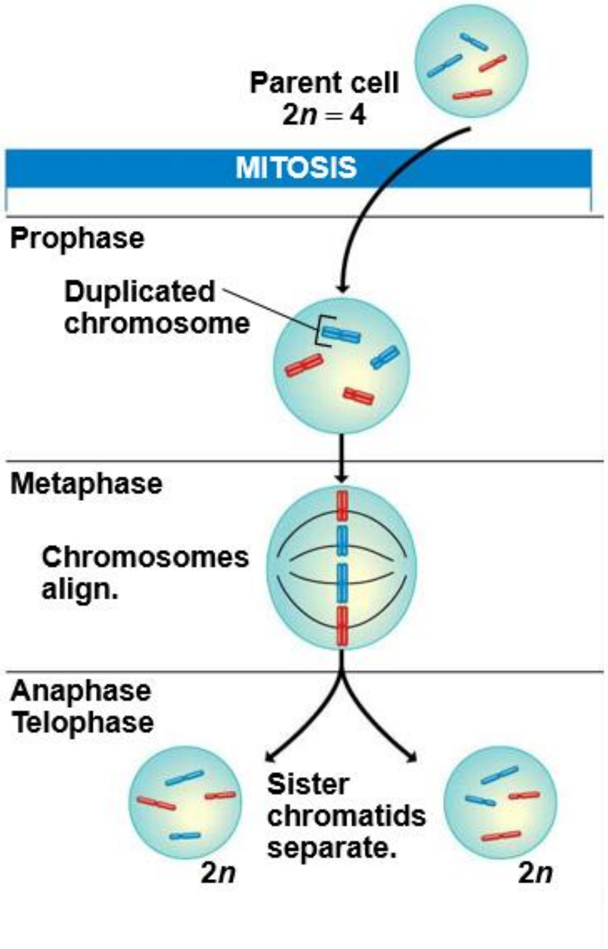
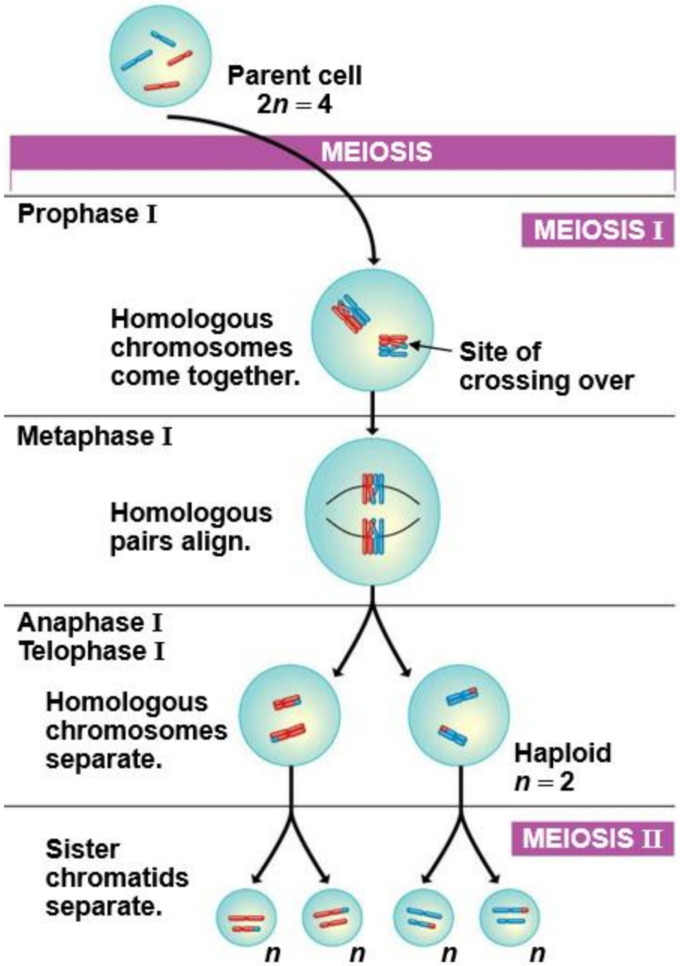


Figure 8.15 Comparing Mitosis and Meiosis (3 of 5)



The Origins of Genetic Variation

- Offspring of sexual reproduction are genetically different from their parents and one another.
- How does meiosis produce such genetic variation

Independent Assortment of Chromosomes (1 of 2)

- **Figure 8.16** illustrates one way in which meiosis contributes to genetic variety.
  - When aligned during metaphase I of meiosis, the side-by-side orientation of each homologous pair of chromosomes is a matter of chance.
  - For a species with more than two pairs of chromosomes, such as humans, every chromosome pair orients independently of all the others at metaphase I.

Figure 8.16 Results of Alternative Arrangements of Chromosomes at Metaphase of Meiosis I (1 of 6)

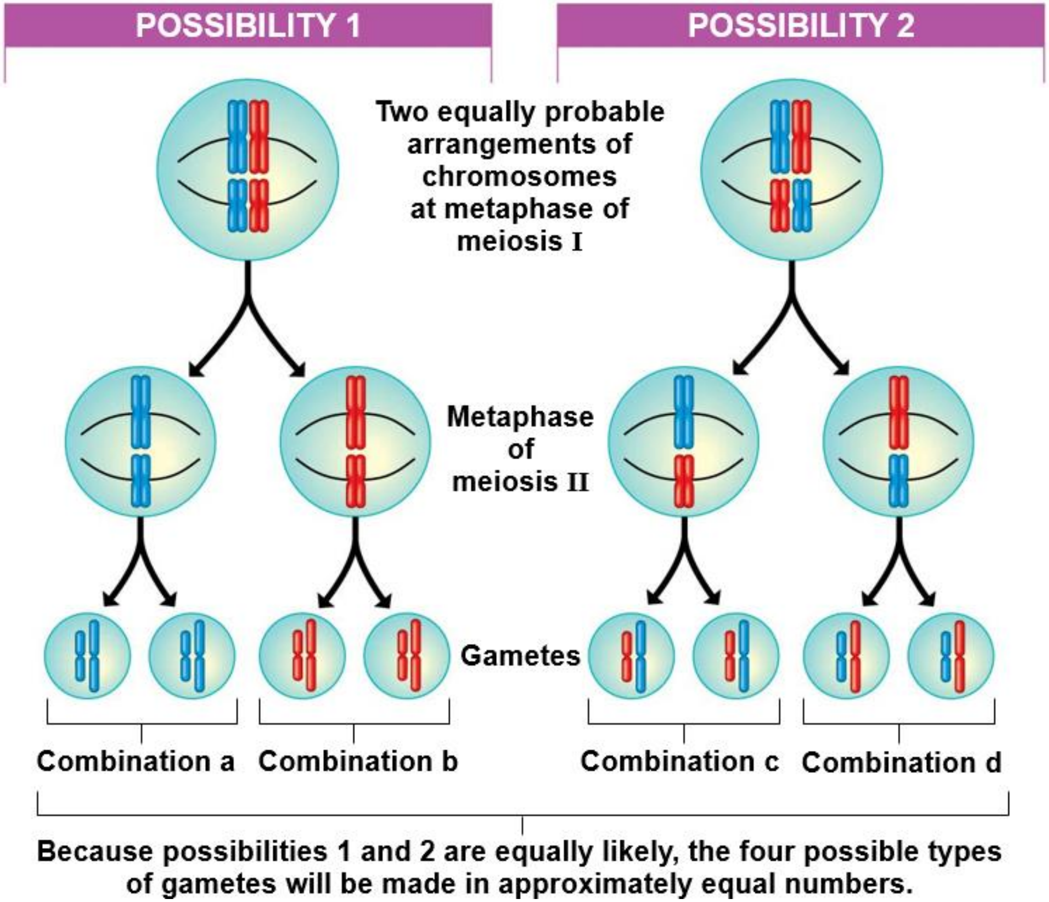


Figure 8.16 Results of Alternative Arrangements of Chromosomes at Metaphase of Meiosis I (2 of 6)

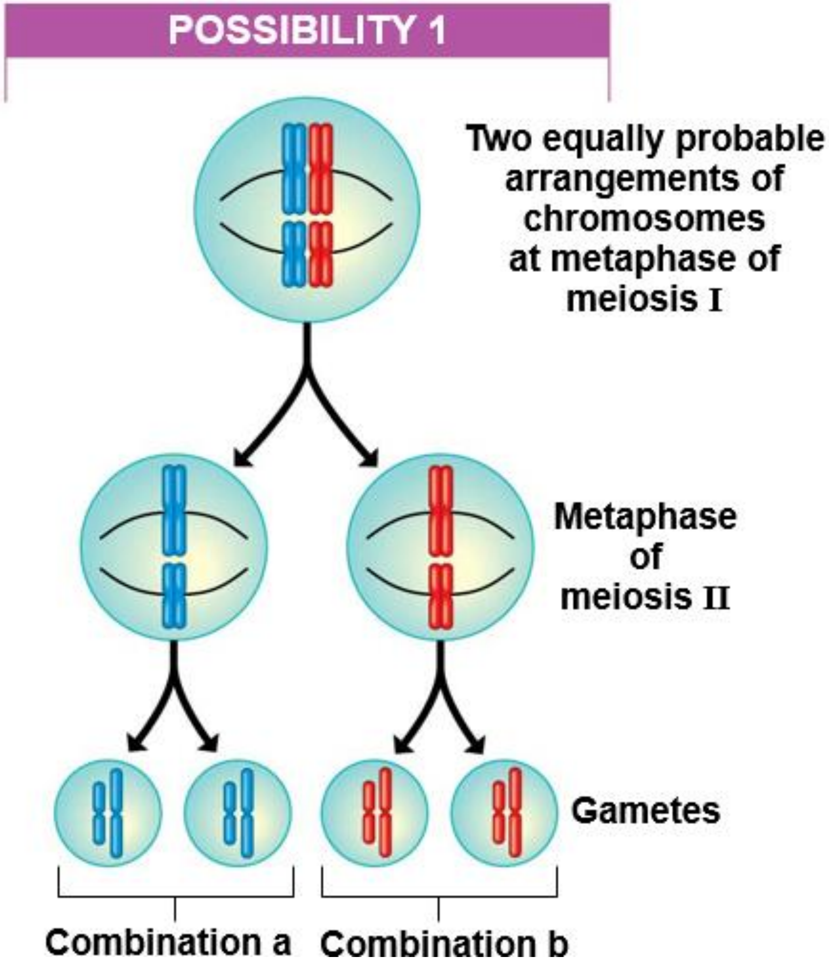
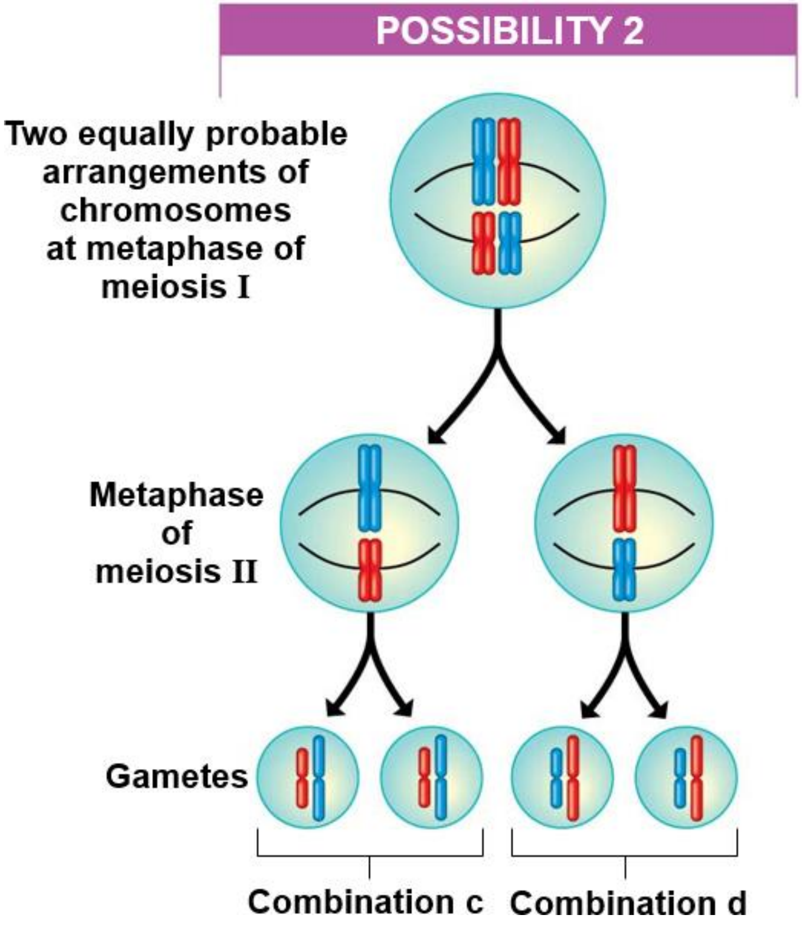


Figure 8.16 Results of Alternative Arrangements of Chromosomes at Metaphase of Meiosis I (3 of 6)



Independent Assortment of Chromosomes (2 of 2)

- For a human, $n = 23$, so there are 2^{23} or about 8A
- million, possible chromosome combinations that can appear in gametes.
- A single man and a single woman can produce zygotes with 64 trillion combinations of chromosomes!

Animation: Genetic Variation

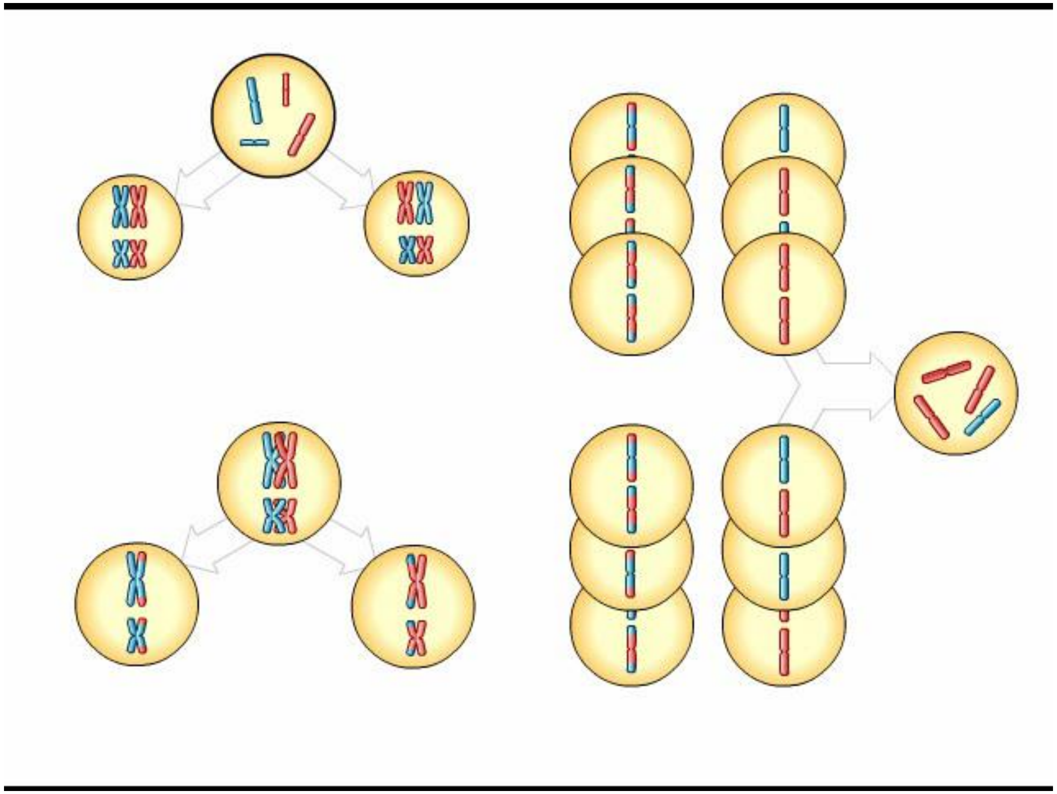
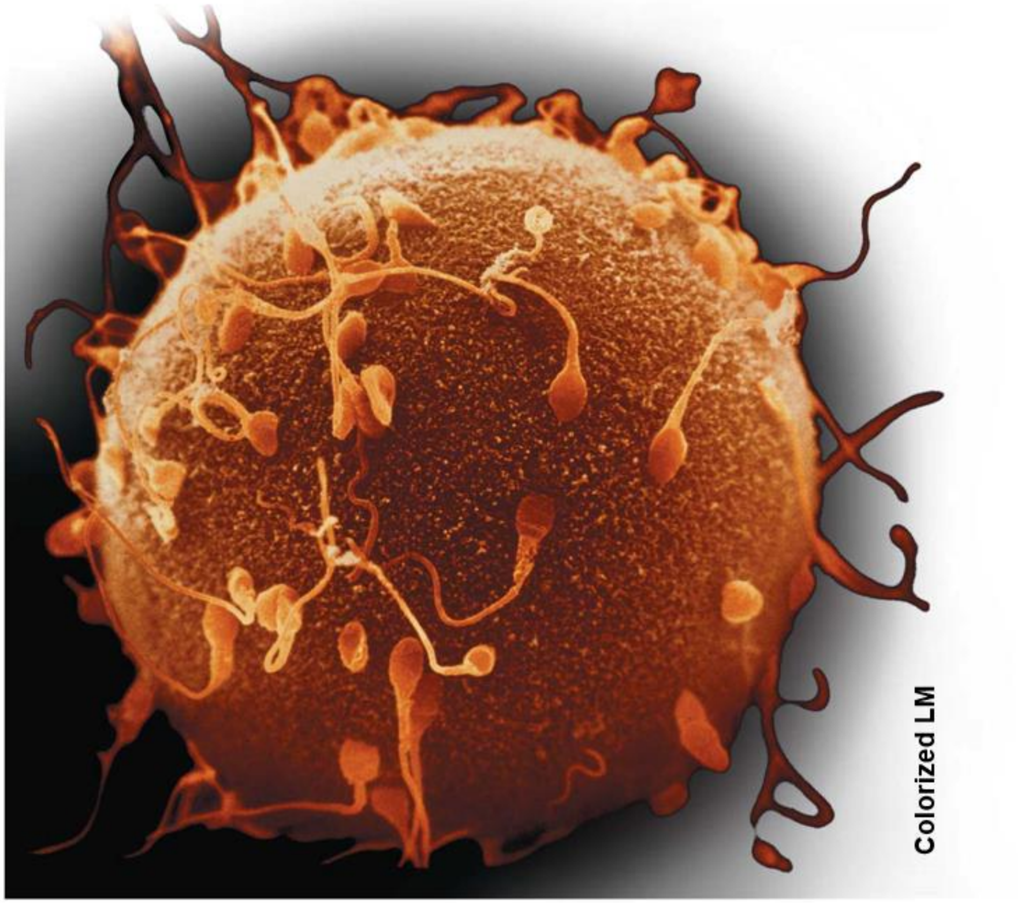


Figure 8.17 The Process of Fertilization: A Close-up View



Crossing Over

- **Crossing over** is the exchange of corresponding segments between nonsister chromatids of homologous chromosomes, which occurs during prophase I of meiosis.
- With crossing over, gametes arise with chromosomes that are partly from the mother and partly from the father.

Animation: Crossing Over

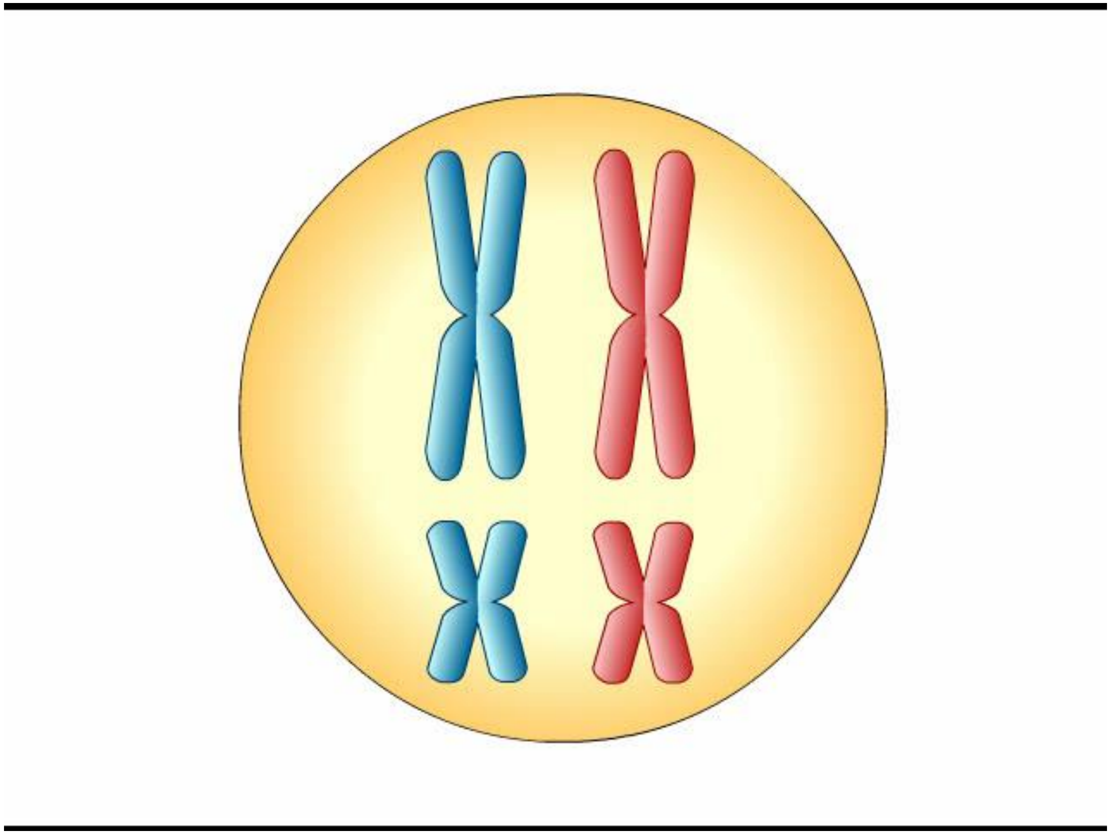


Figure 8.18 The Results of Crossing Over During Meiosis for a Single Pair of Homologous Chromosomes (1 of 3)

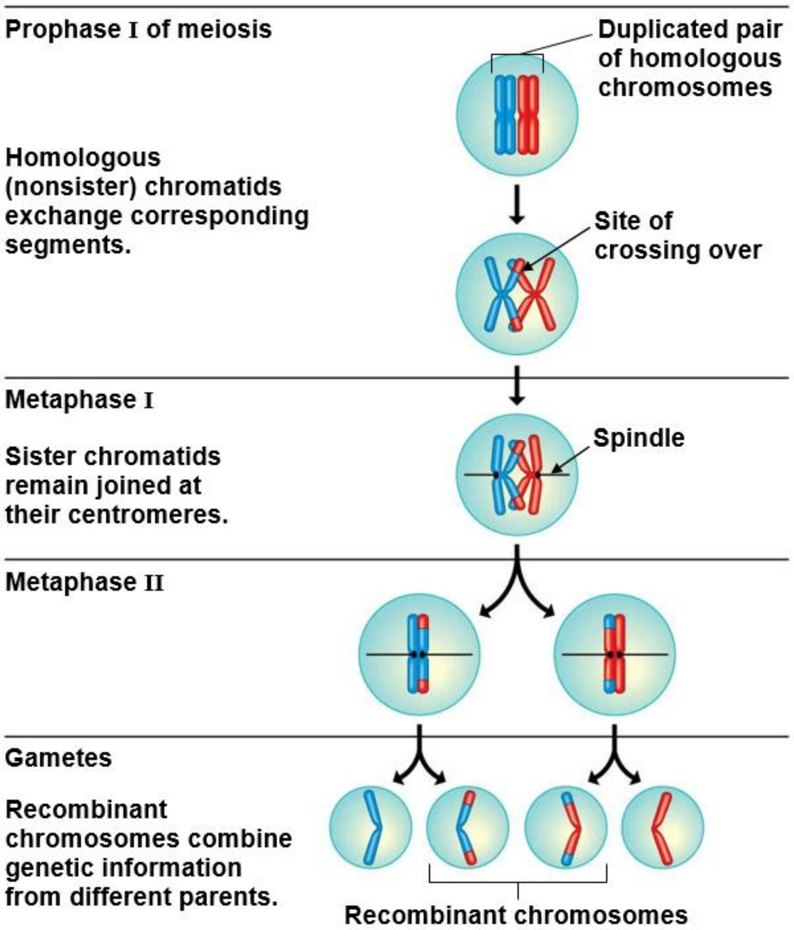


Figure 8.18 The Results of Crossing Over During Meiosis for a Single Pair of Homologous Chromosomes (2 of 3)

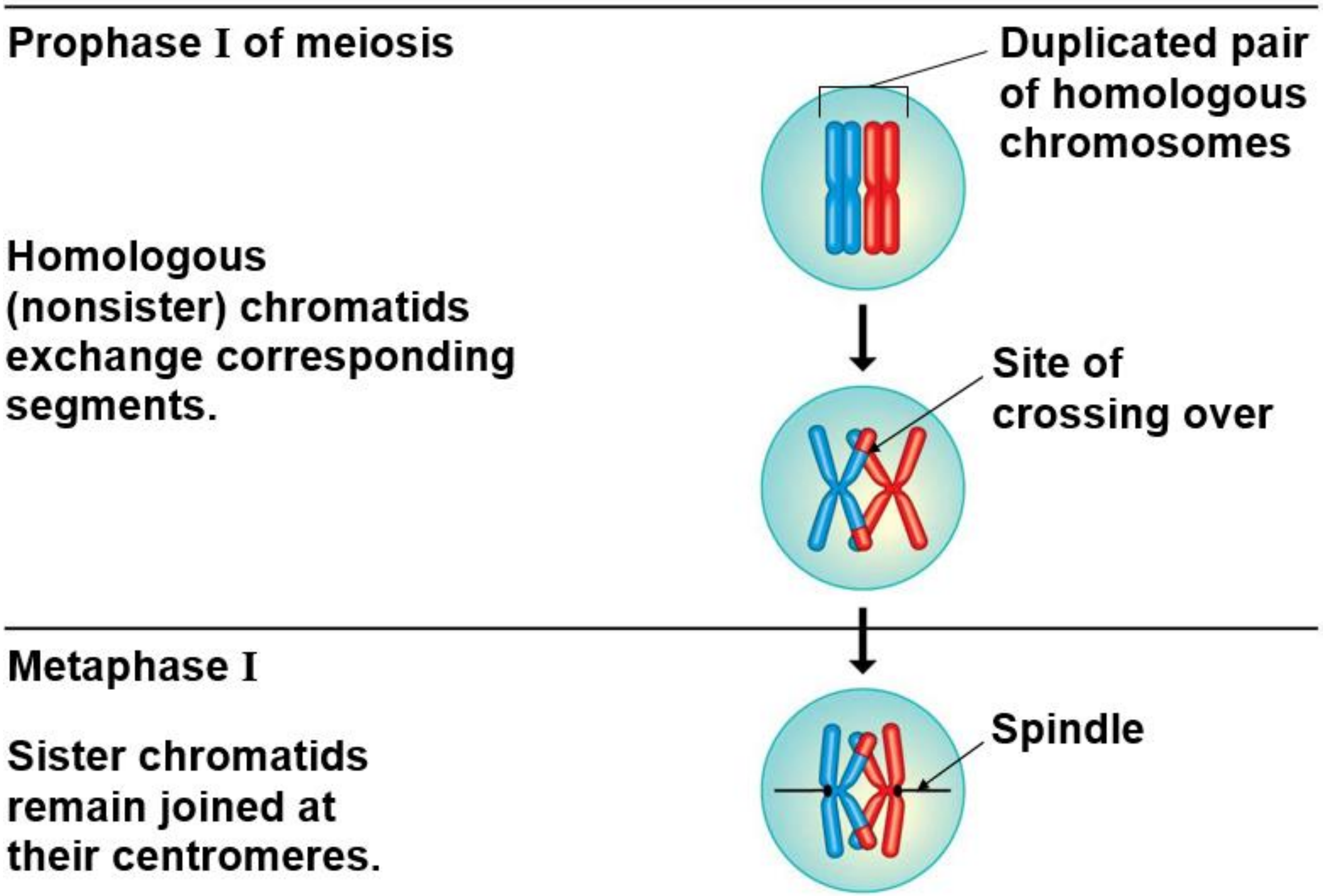
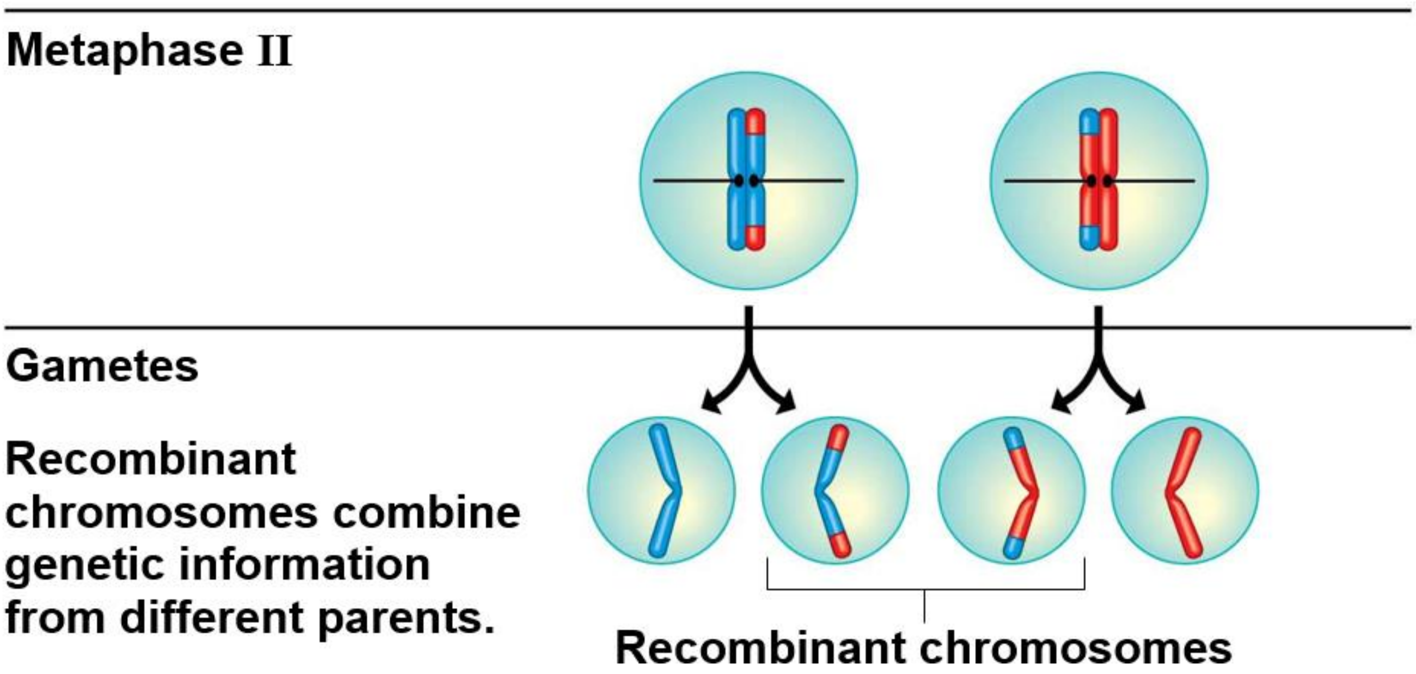


Figure 8.18 The Results of Crossing Over During Meiosis for a Single Pair of Homologous Chromosomes (3 of 3)



The Process of Science: Do All Animals Have Sex? (1 of 3)

- Although some animal species can reproduce asexually, very few animals reproduce **only** asexually.
- **Observation**: No one had ever found bdelloid rotifer males or evidence of sexual reproduction.
- **Question**: Does this entire class of animals reproduce solely by asexual means?

Figure 8.19 A Bdelloid Rotifer

The Process of Science: Do All Animals Have Sex? (2 of 3)

- **Hypothesis**: Bdelloid rotifers have thrived for millions of years without sexually reproducing.
- **Prediction**: Bdelloid rotifers would display much more variation in their pairs of homologous genes than most organisms.
- **Experiment**: Researchers compared the sequences of a particular gene in bdelloid and non-bdelloid rotifers.

The Process of Science: Do All Animals Have Sex? (3 of 3)

- **Results**:
  - Among non-bdelloid rotifers that reproduce sexually, the two homologous versions of the gene were nearly identical, differing by only 0.5% on average.
  - In contrast, the two versions of the same gene in bdelloid rotifers differed by 3.5–54%.
  - These data provided strong evidence that bdelloid rotifers have evolved for millions of years without any sexual reproduction.

Pearson

When Meiosis Goes Awry

- What happens when there is an error in the process of meiosis?
- Such a mistake can result in genetic abnormalities that range from mild to severe to fatal.

How Accidents during Meiosis Can Alter Chromosome Number

- In **nondisjunction**, the members of a chromosome pair fail to separate at anaphase, producing gametes with abnormal numbers of chromosomes.
- Nondisjunction can occur during meiosis I or II.

Figure 8.20 Two Types of Nondisjunction (1 of 6)

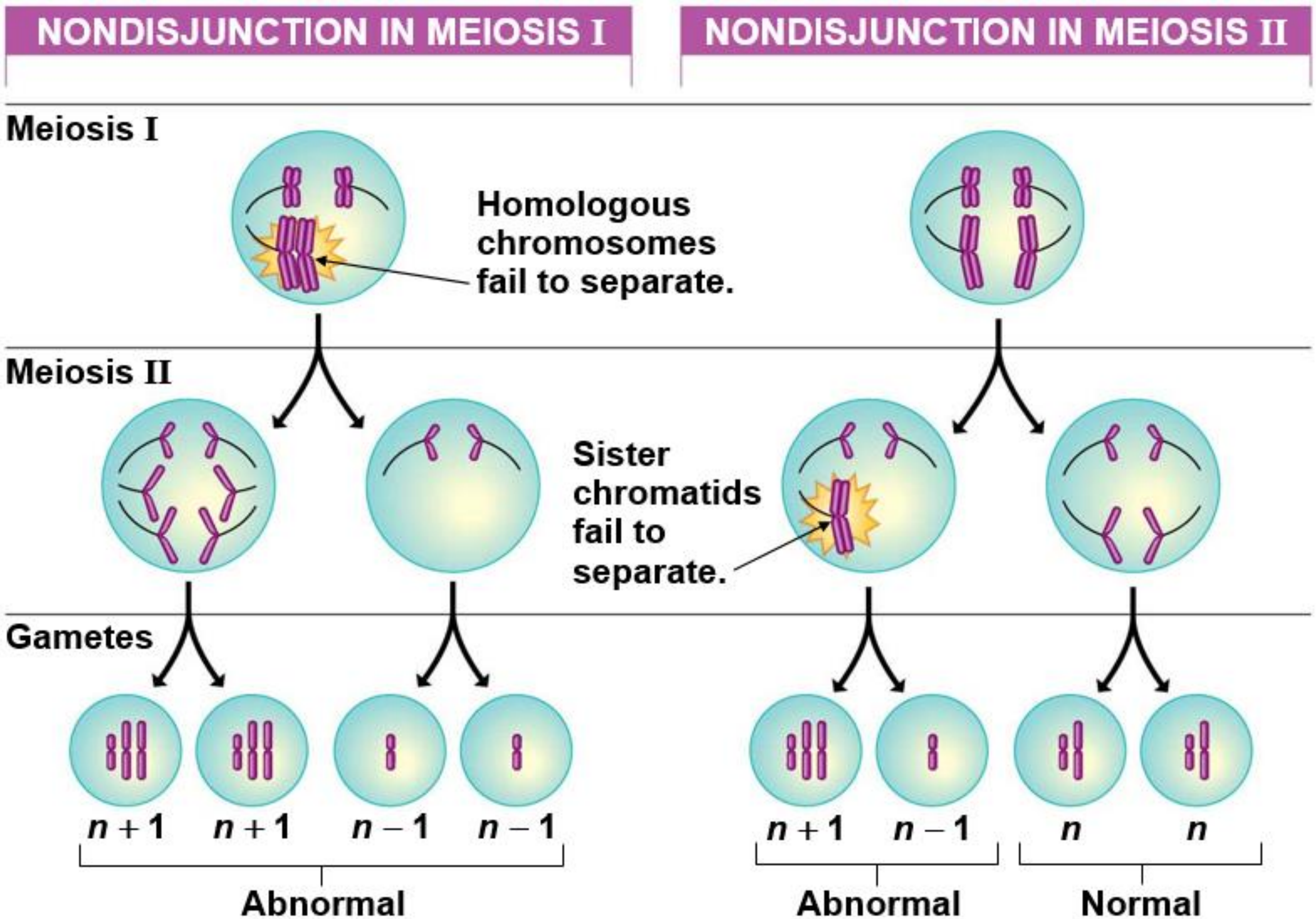


Figure 8.20 Two Types of Nondisjunction (2 of 6)

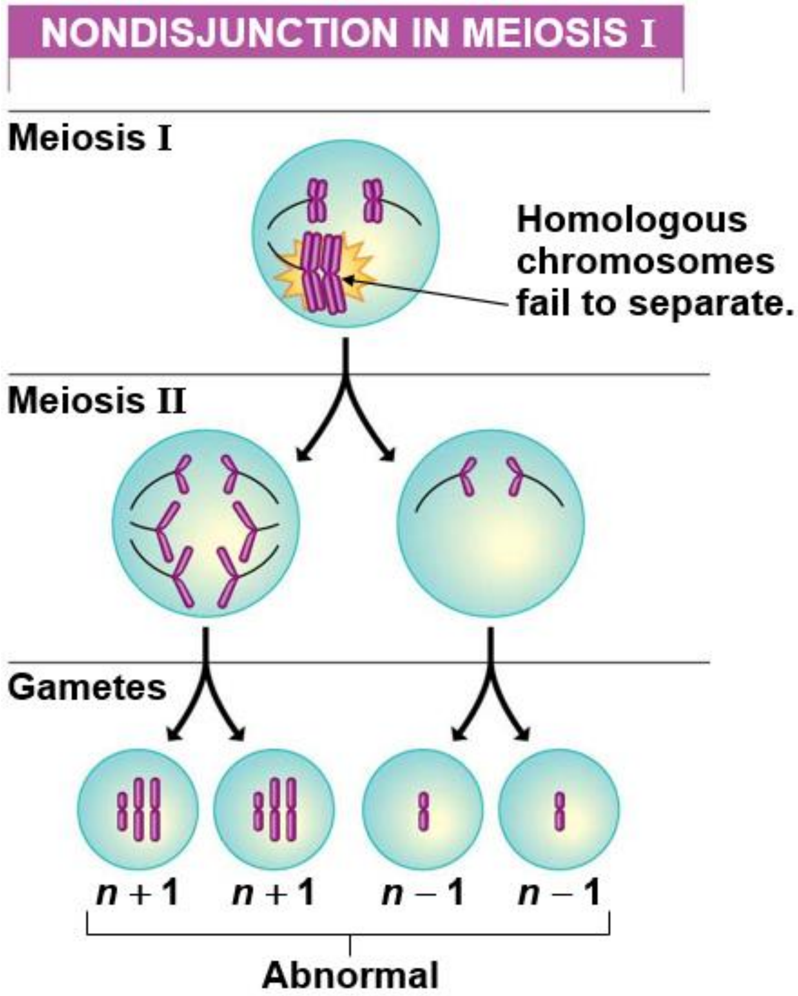
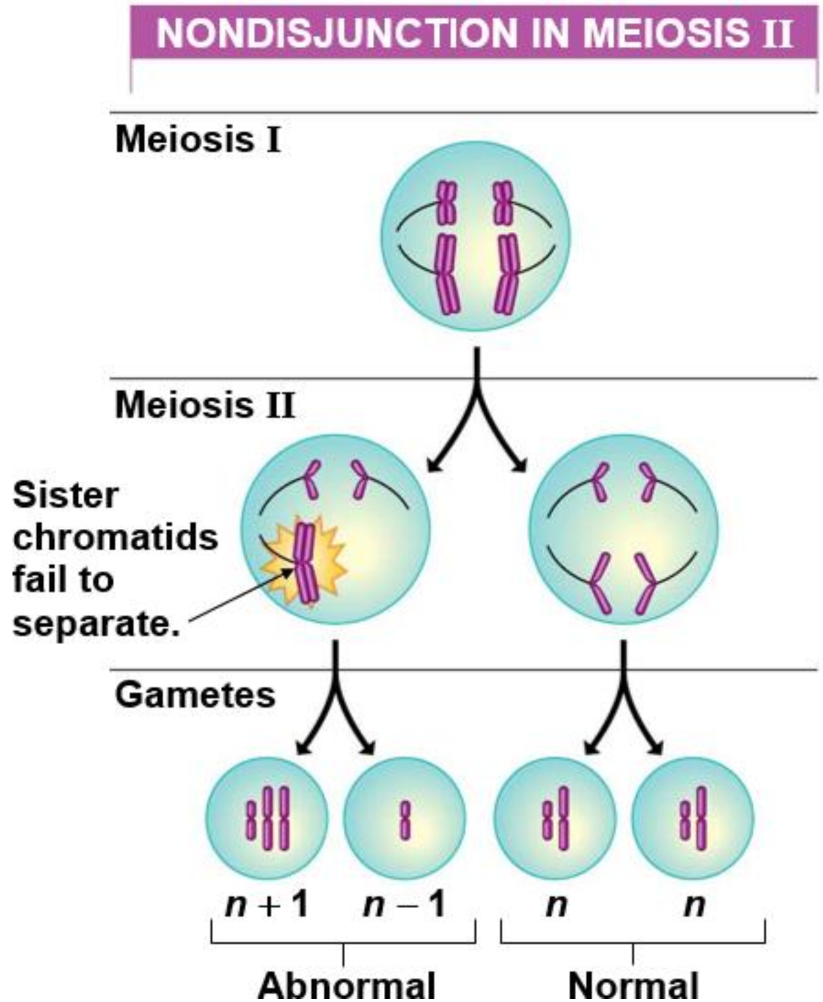


Figure 8.20 Two Types of Nondisjunction (3 of 6)



Pearson

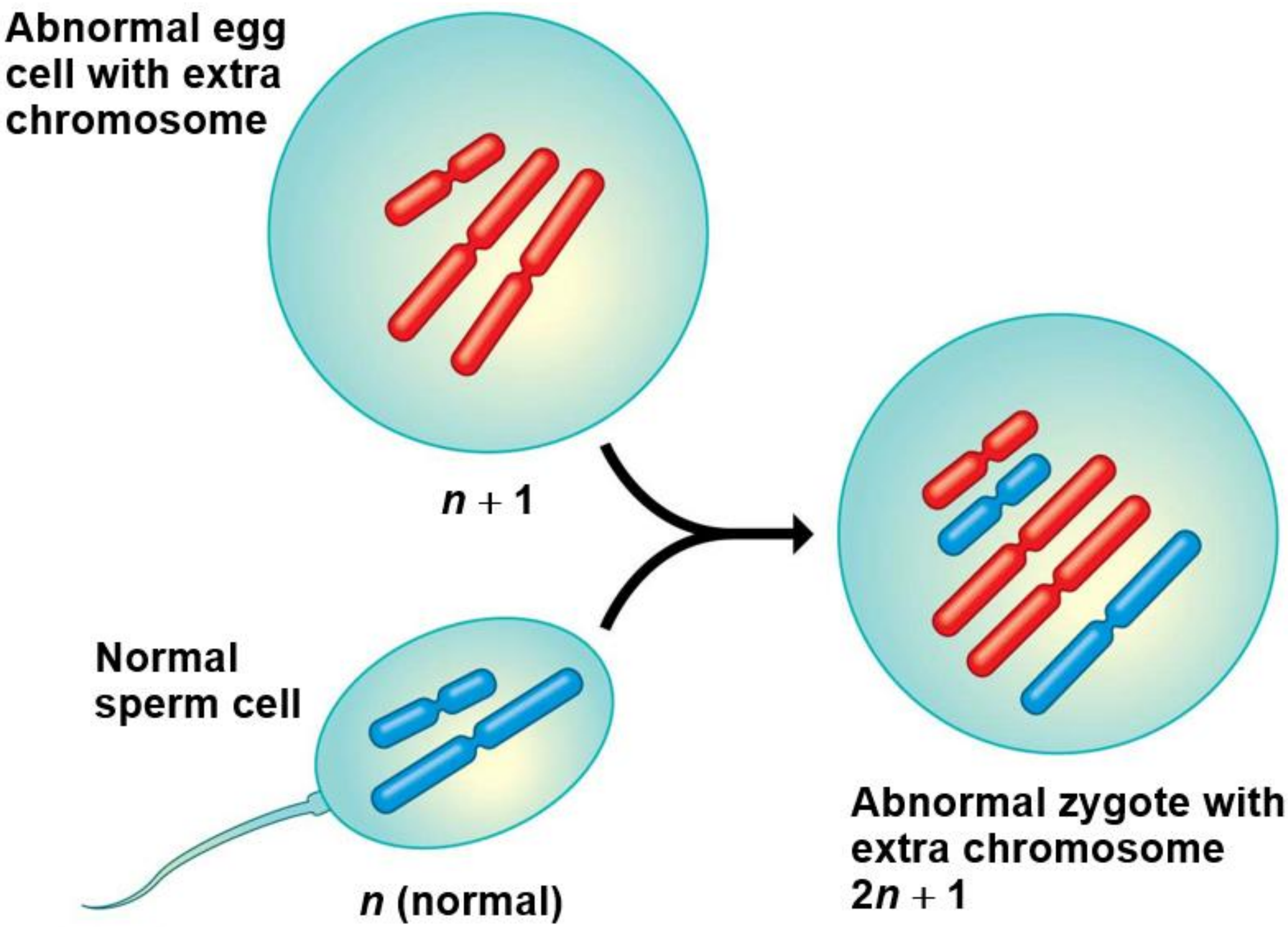
How Accidents during Meiosis Can Alter Chromosome Number (1 of 2)

- **Figure 8.21** shows what can happen when an abnormal gamete produced by nondisjunction unites with a normal gamete during fertilization.
  - When a normal sperm fertilizes an egg cell with an extra chromosome, the result is a zygote with a total of $2n + 1$ chromosomes.

How Accident during Meiosis Can Alter Chromosome Number (2 of 2)

- Because mitosis duplicates the chromosomes as they are, the abnormality will be passed to all embryonic cells.
- If the organism survives, it will have an abnormal karyotype and probably a syndrome of disorders caused by the abnormal number of genes.

Figure 8.21 Fertilization After Nondisjunction in the Mother



Down Syndrome: An Extra Chromosome 21 (1 of 3)

- In a condition called **trisomy 21**, there are three number 21 chromosomes, making 47 chromosomes in total.
- A person with trisomy 21 has a condition called **Down syndrome**, which
  - affects about 1 out of every 700 children,
  - is the most common chromosome number abnormality, and
  - is the most common serious birth defect in the United States.

Figure 8.11 Pairs of Homologous Chromosomes in a Human Male Karyotype (3 of 4)

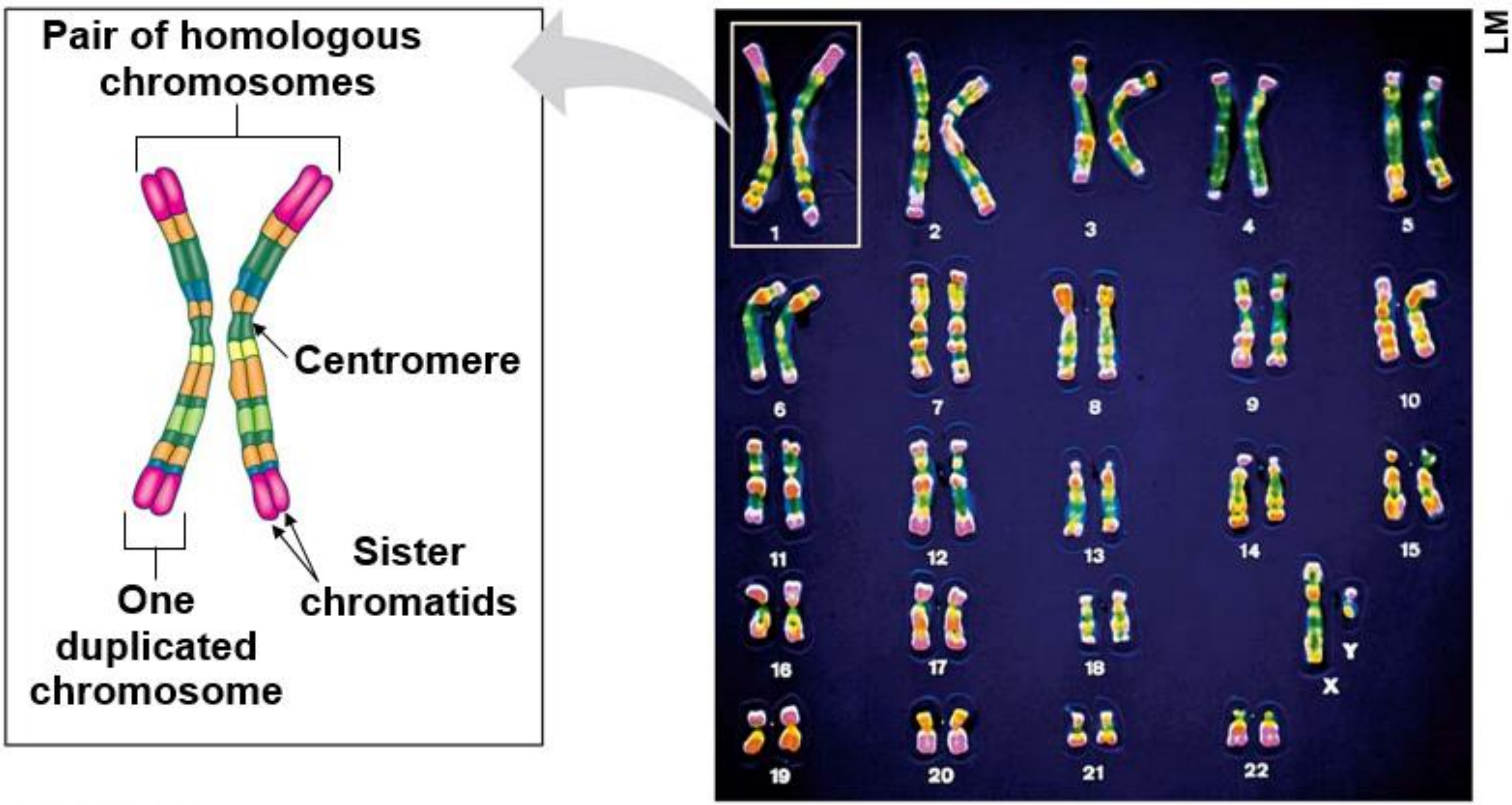


Figure 8.11 Pairs of Homologous Chromosomes in a Human Male Karyotype (4 of 4)

Figure 8.22 Trisomy 21 and Down Syndrome (1 of 3)

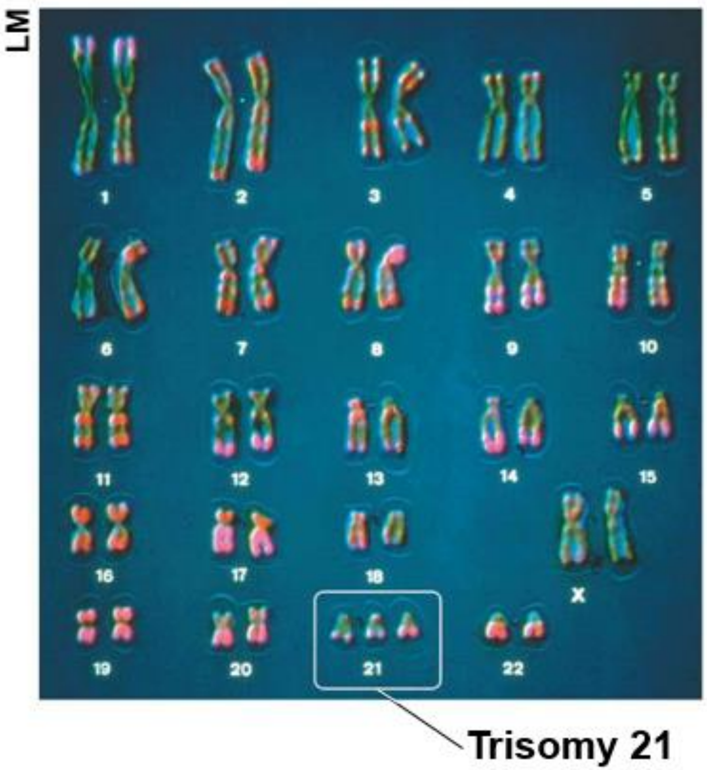


Figure 8.22 Trisomy 21 and Down Syndrome (2 of 3)

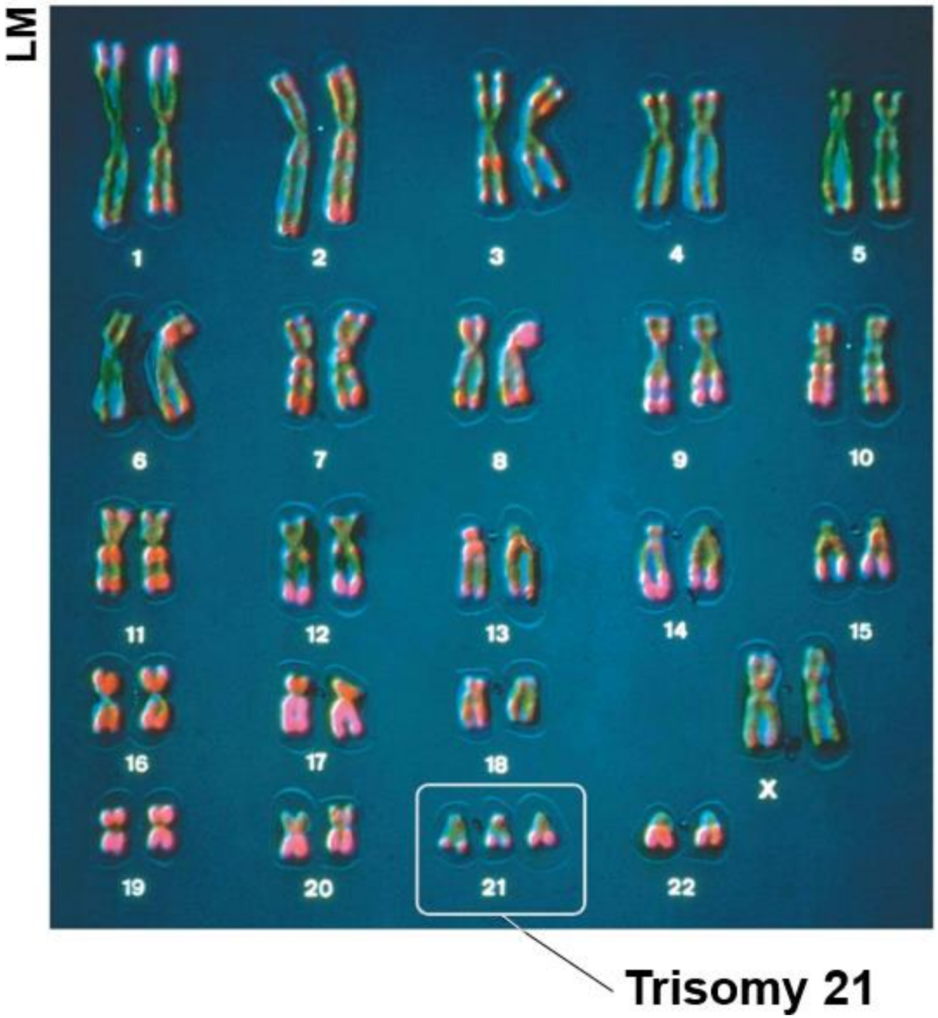


Figure 8.22 Trisomy 21 and Down Syndrome (3 of 3)

Pearson

Down Syndrome: An Extra Chromosome 21 (2 of 3)

- People with Down syndrome
  - have characteristic facial features,
  - usually have a life span shorter than normal, and
  - exhibit varying degrees of developmental delays.
- However, some individuals may live to middle age or beyond, and many are socially adept and can function well within society.

Down Syndrome: An Extra Chromosome 21 (3 of 3)

- Although we don't know why, the risk of Down syndrome increases with the age of the mother.
- The fetuses of pregnant women age 35 and older are therefore candidates for chromosomal prenatal screenings.

Abnormal Numbers of Sex Chromosomes

- Nondisjunction in meiosis can lead to abnormal numbers of sex chromosomes, X and Y.
- Unusual numbers of sex chromosomes seem to upset the genetic balance less than unusual numbers of autosomes.
- **Table 8.1** lists the most common human sex chromosome abnormalities.

Table 8.1 Abnormalities of Sex Chromosome Number in Humans

Table 8.1 Abnormalities of Sex Chromosome Number in Humans

Sex Chromosomes	**Syndrome**	**Origins of Nondisjunction**	**Frequency in Population**
XXY	Klinefelter syndrome (male)	Meiosis in egg or sperm formation	$\frac{1}{2,000}$
XYY	None (normal male)	Meiosis in sperm formation	$\frac{1}{2,000}$
XXX	None (normal female)	Meiosis in egg or sperm formation	$\frac{1}{1,000}$
XO	Turner syndrome (female)	Meiosis in egg or sperm formation	$\frac{1}{5,000}$

Evolution Connection: The Advantages of Sex (1 of 2)

- Many species can reproduce both sexually and asexually.
- Asexual reproduction
  - eliminates the need to expend energy forming gametes and copulating with a partner and
  - confers an evolutionary advantage when organisms are
    - sparsely distributed or
    - superbly suited to a stable environment.

Figure 8.23 Sexual and Asexual Reproduction

Evolution Connection: The Advantages of Sex (2 of 2)

- Sexual reproduction may convey an evolutionary advantage by
  - producing offspring of varied genetic makeup or
  - reducing the incidence of harmful genes more rapidly.

Figure 8.7 Cell Reproduction: A Dance of the Chromosomes (7 of 8)

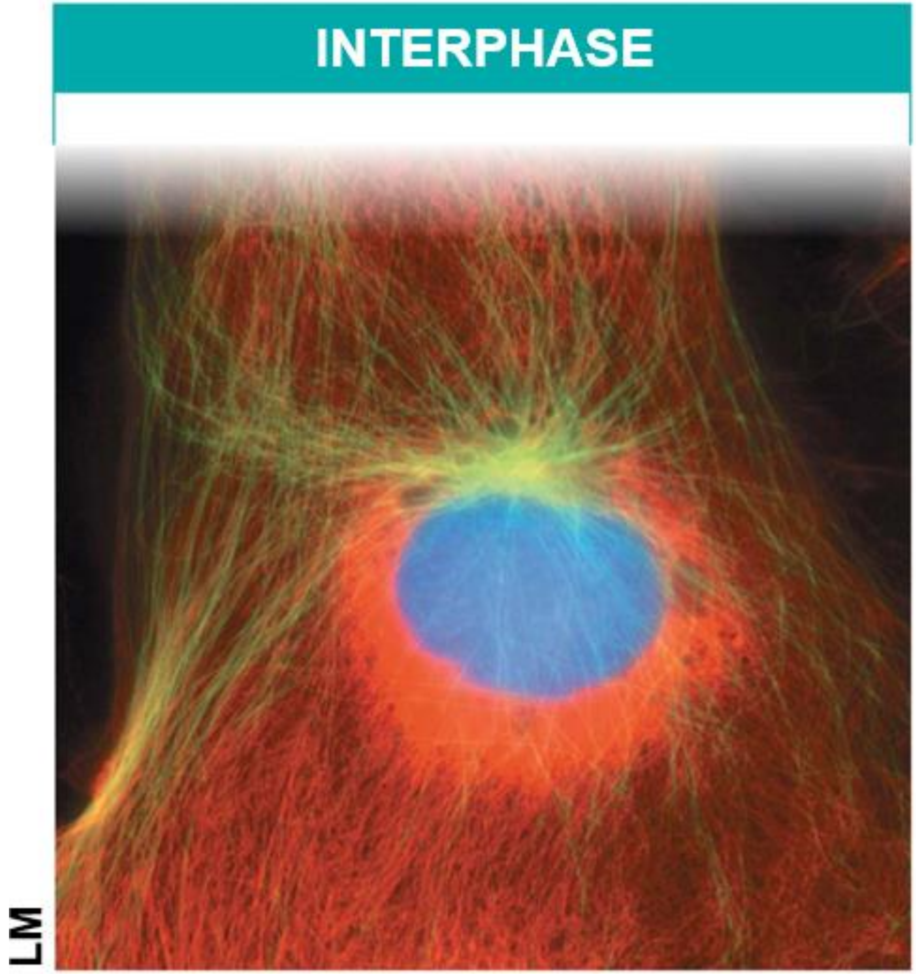


Figure 8.7 Cell Reproduction: A Dance of the Chromosomes (8 of 8)

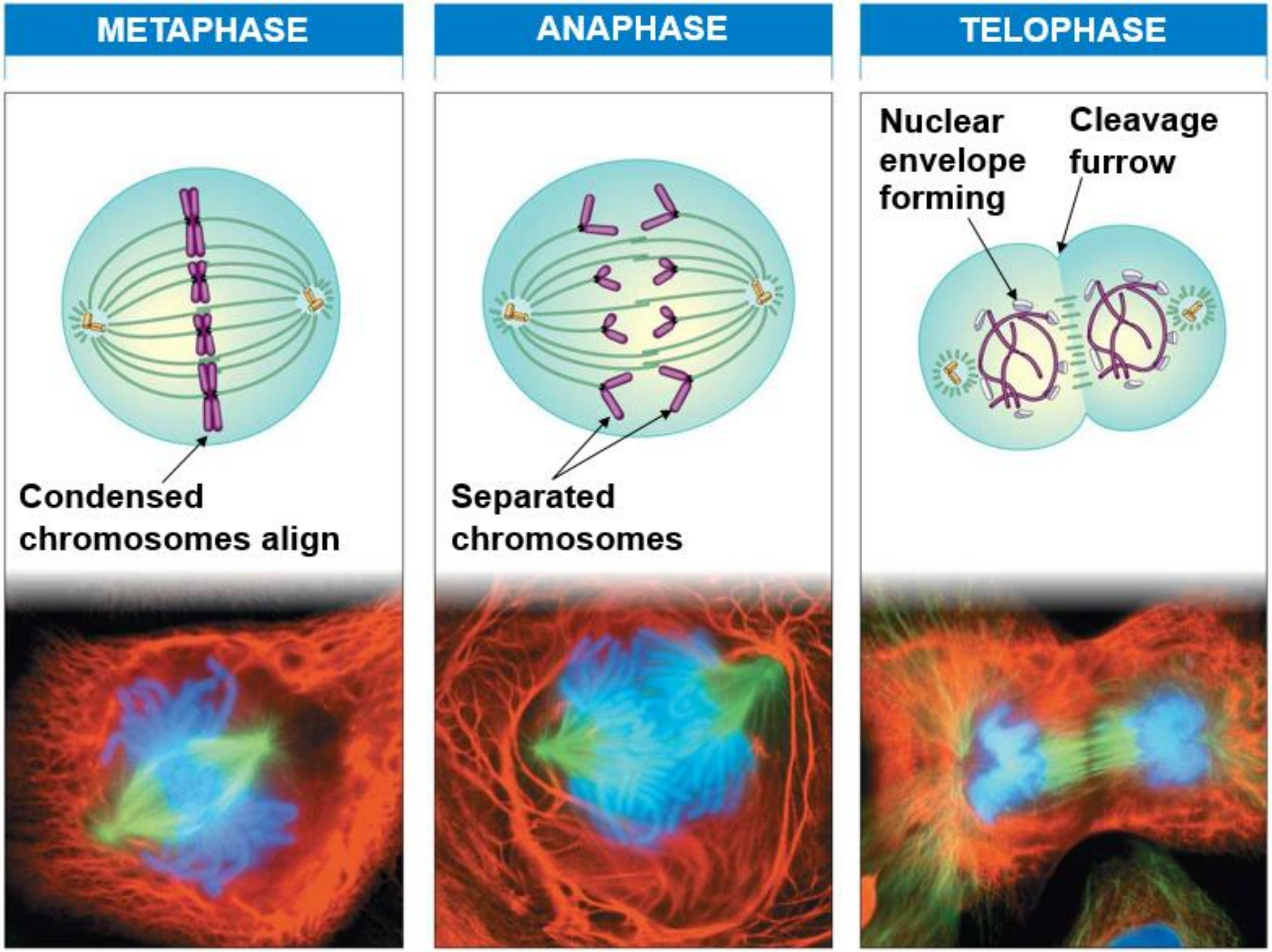


Figure 8.15 Comparing Mitosis and Meiosis (4 of 5)

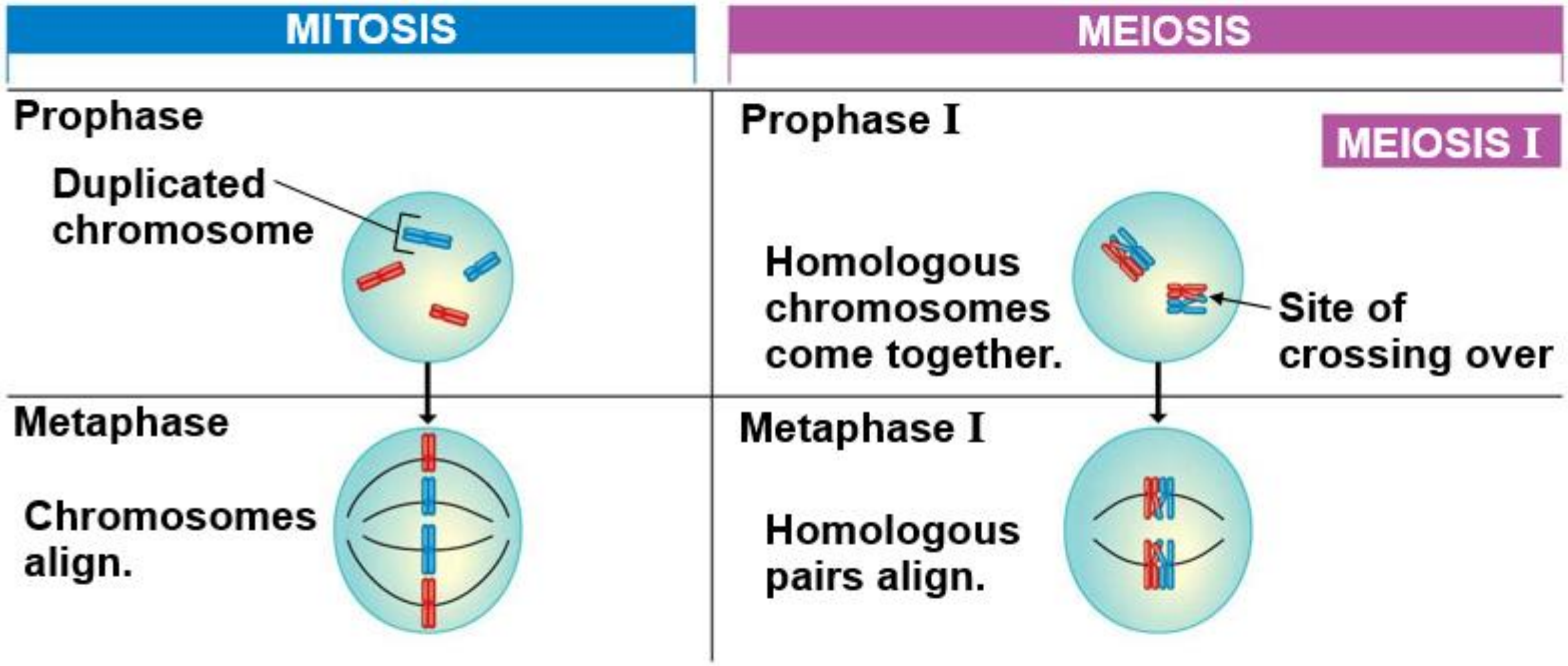


Figure 8.15 Comparing Mitosis and Meiosis (5 of 5)

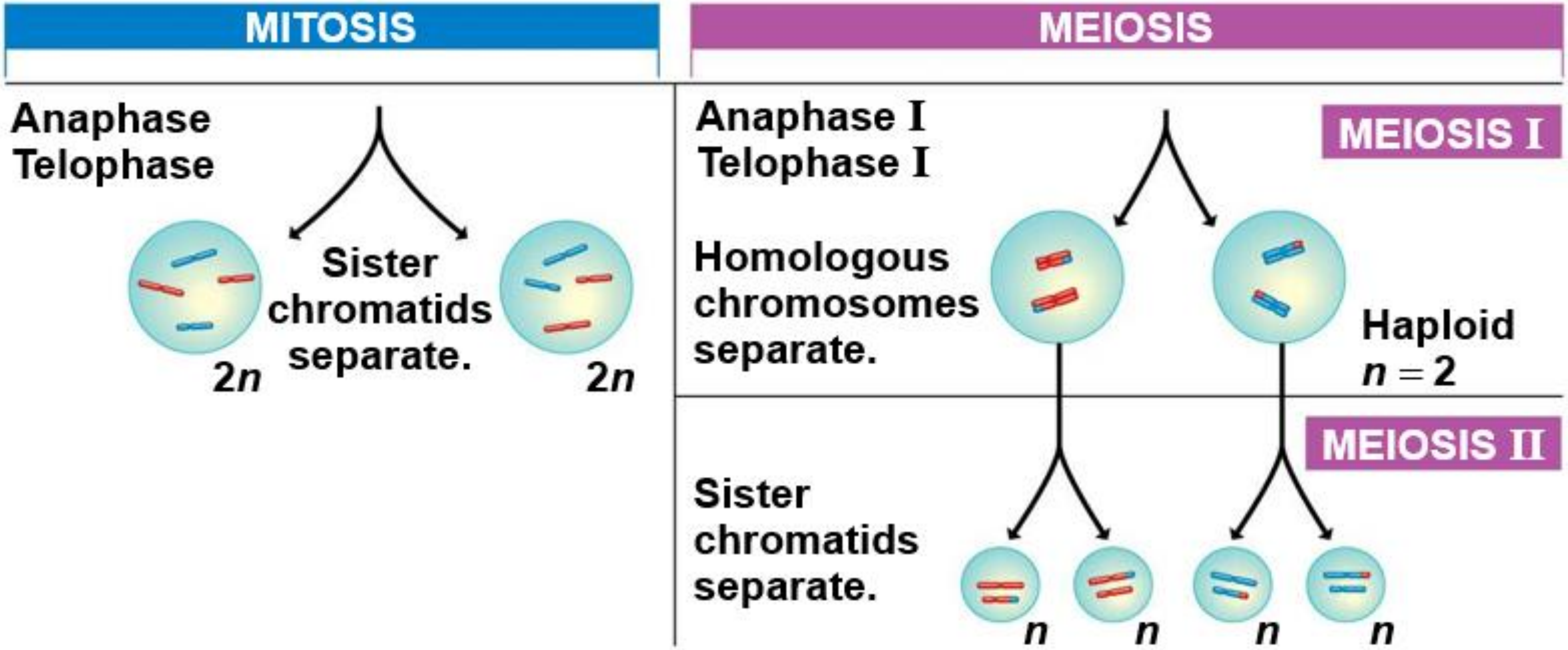


Figure 8.16 Results of Alternative Arrangements of Chromosomes at Metaphase of Meiosis I (4 of 6)

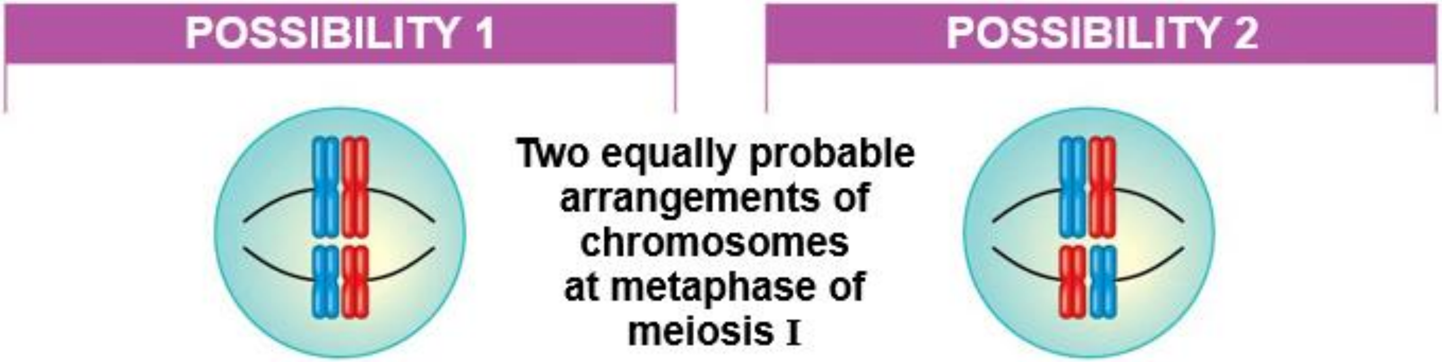


Figure 8.16 Results of Alternative Arrangements of Chromosomes at Metaphase of Meiosis I (5 of 6)

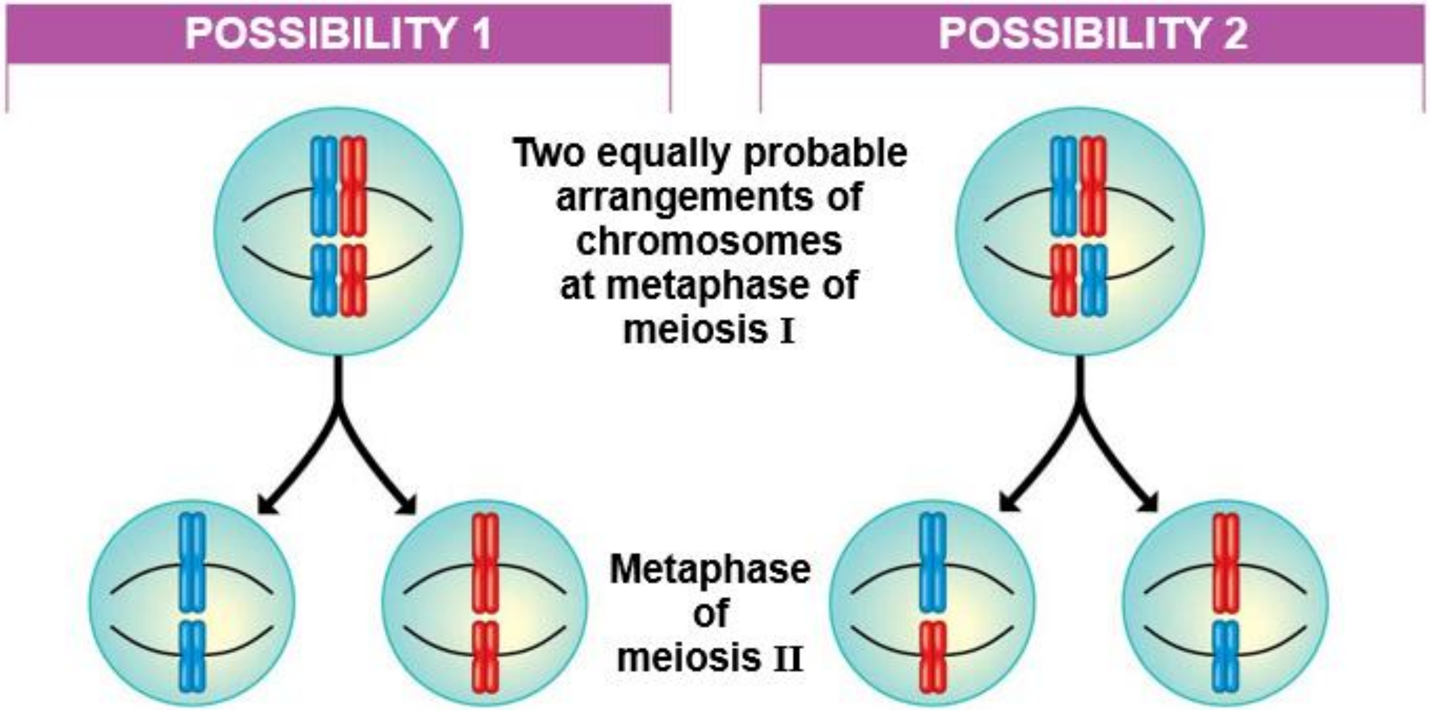


Figure 8.16 Results of Alternative Arrangements of Chromosomes at Metaphase of Meiosis I (6 of 6)

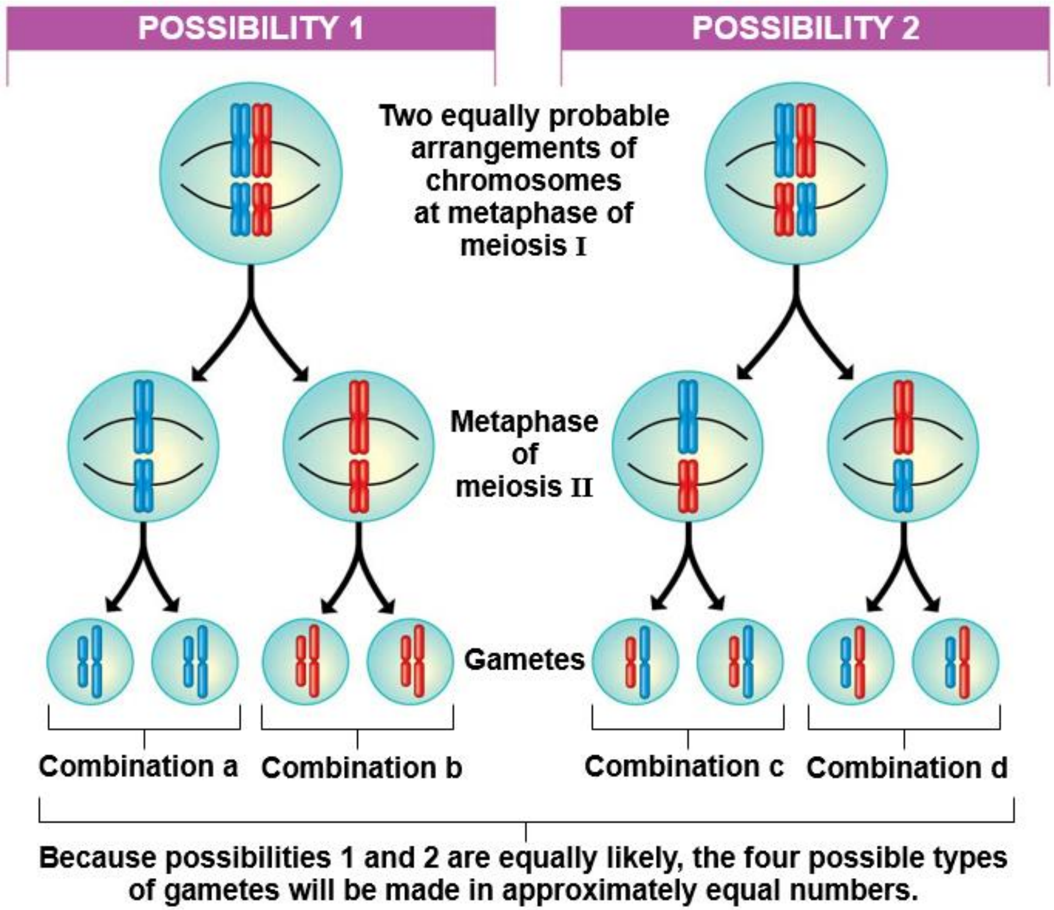


Figure 8.20 Two Types of Nondisjunction (4 of 6)

Figure 8.20 Two Types of Nondisjunction (5 of 6)

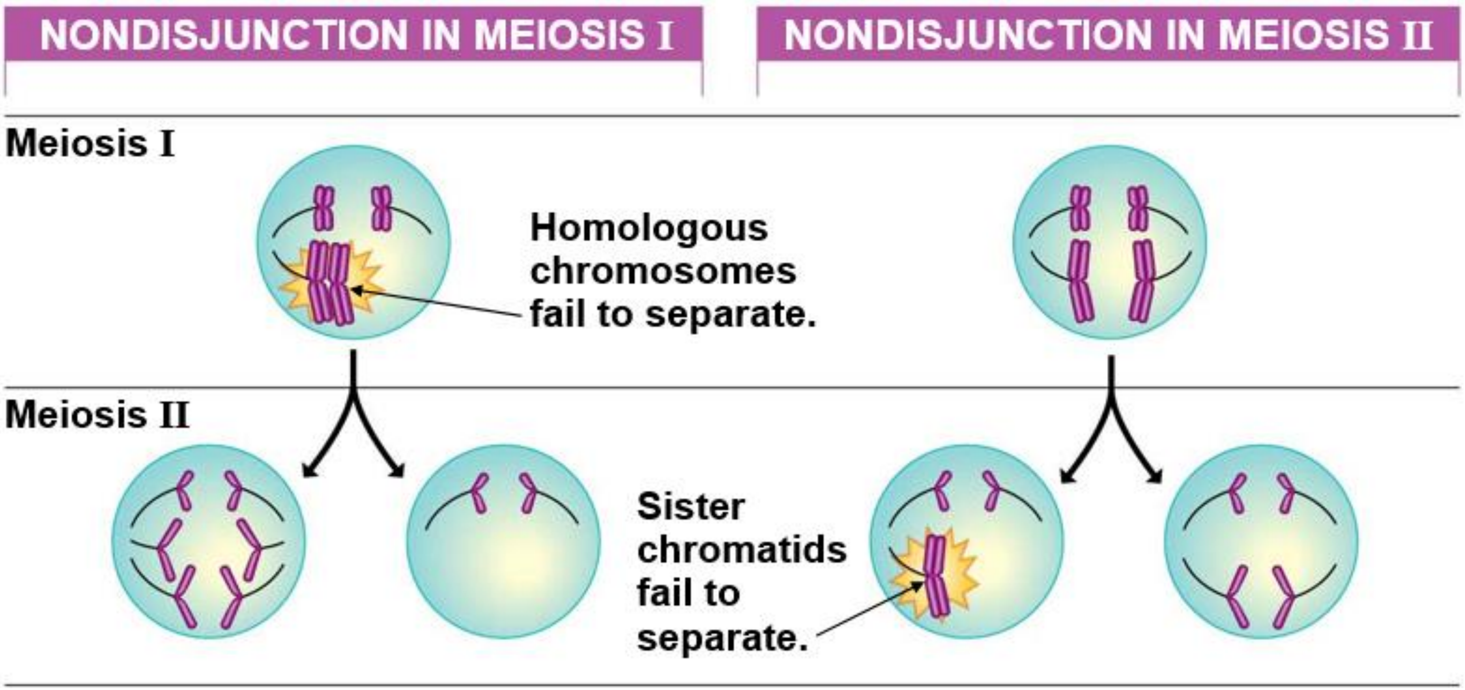


Figure 8.20 Two Types of Nondisjunction (6 of 6)

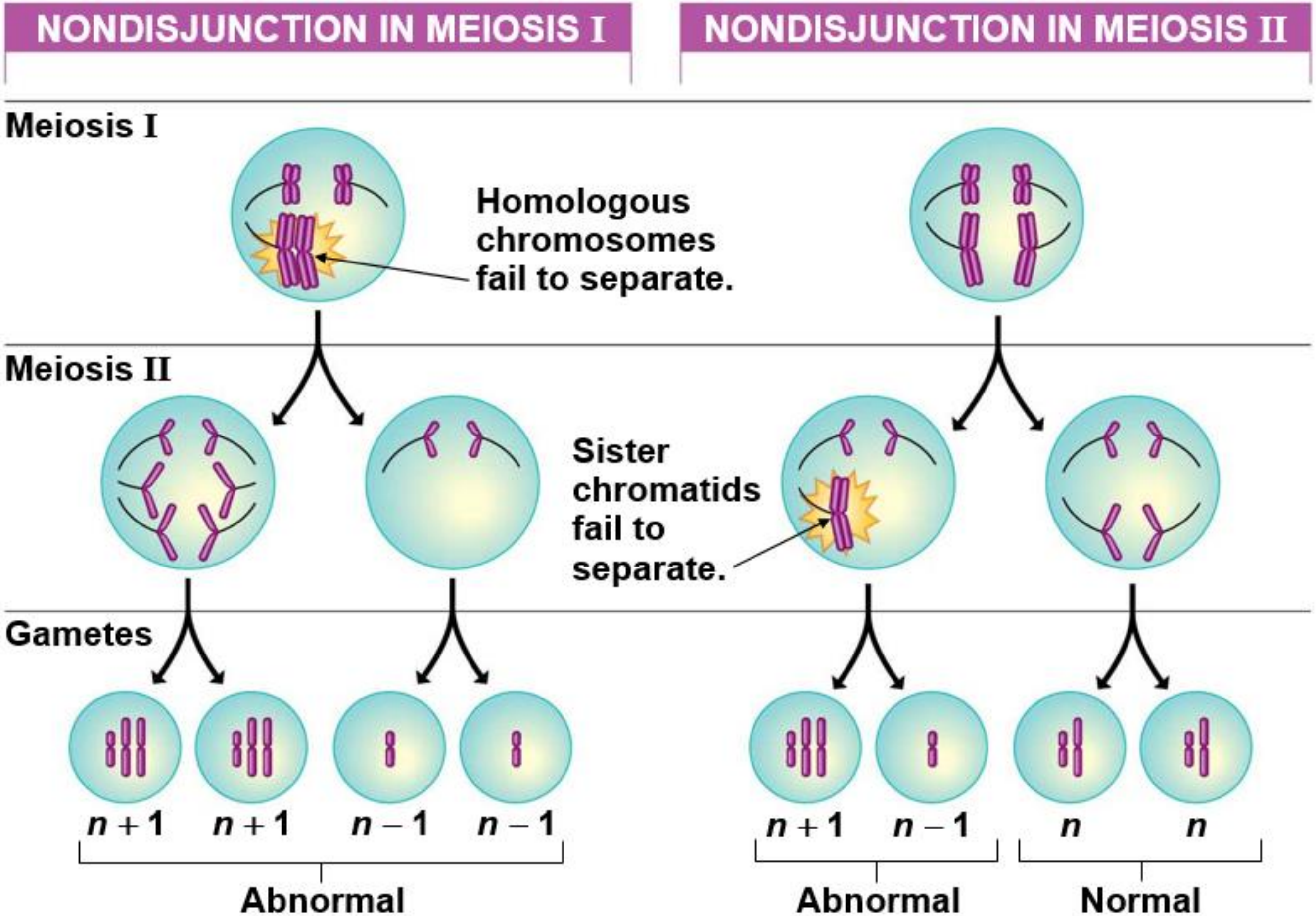


Figure 8.UN01

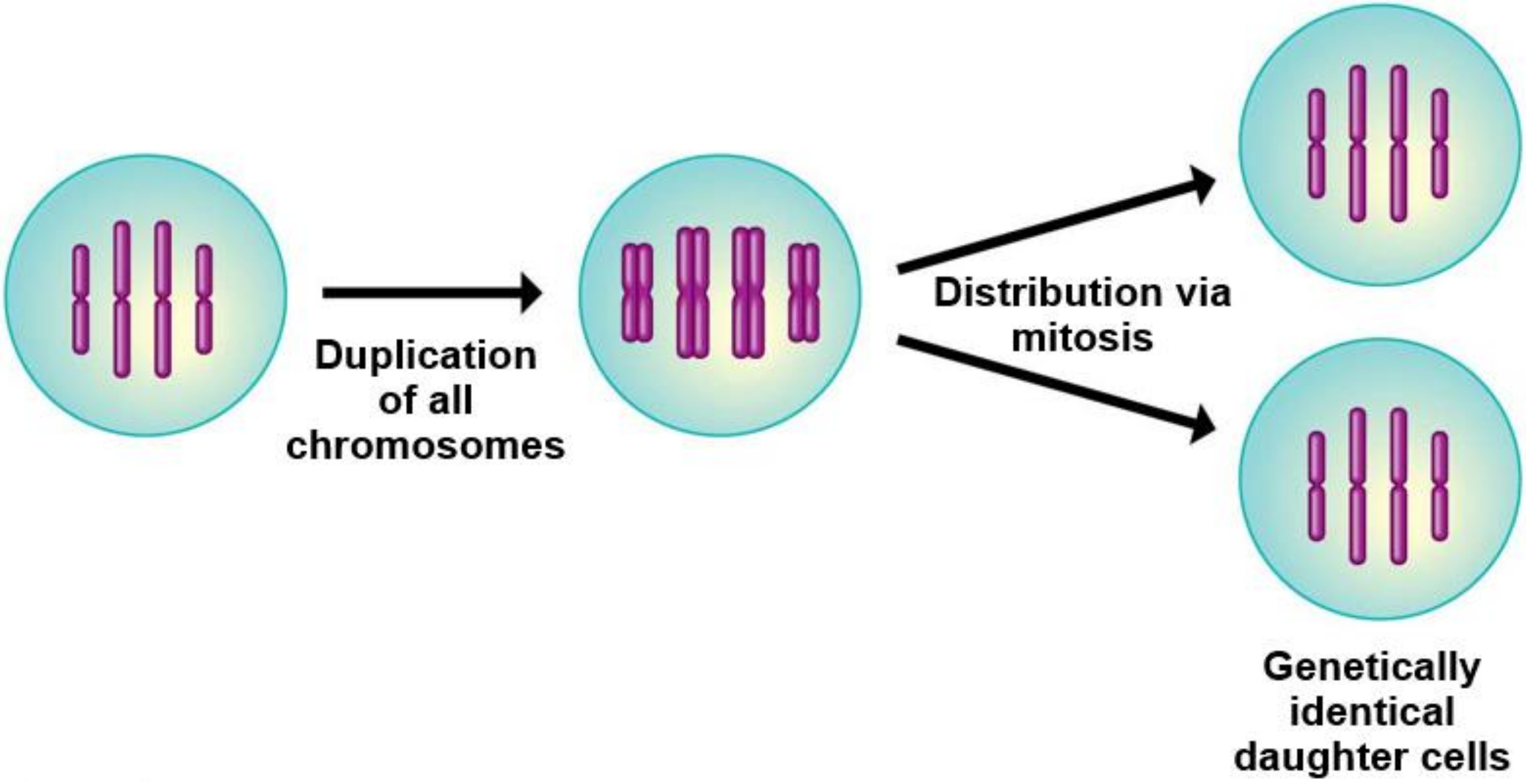


Figure 8.UN02

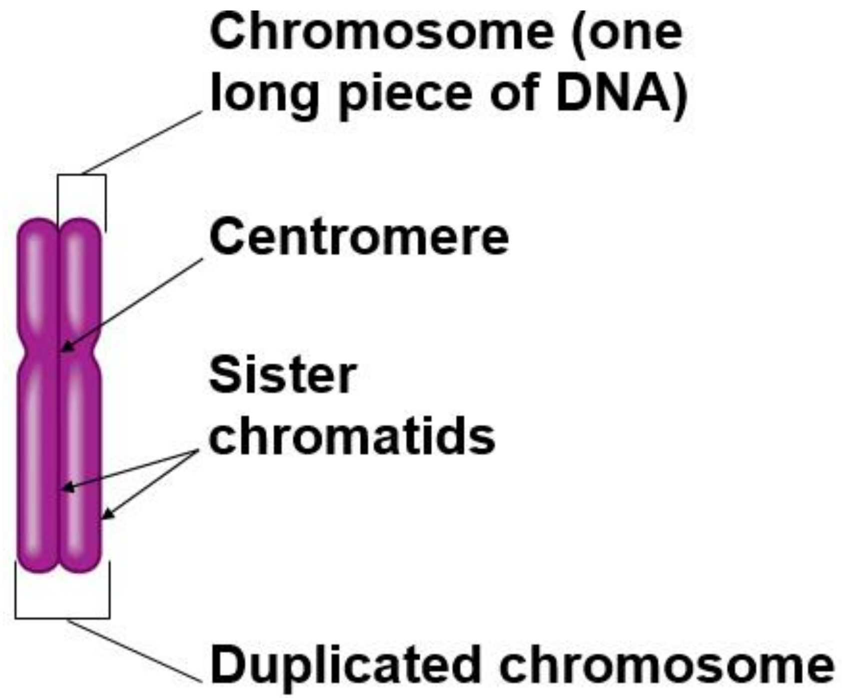


Figure 8.UN03

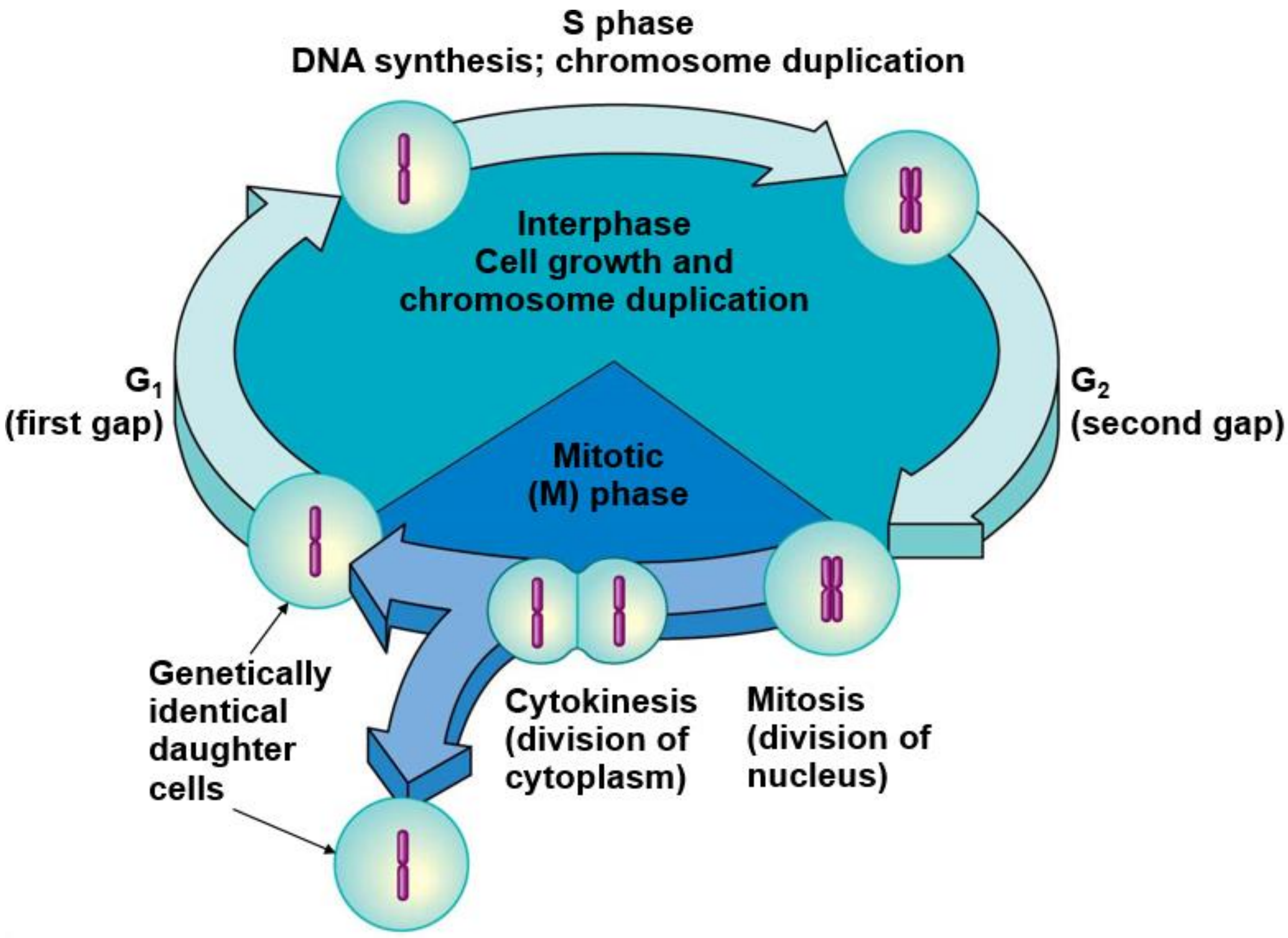


Figure 8.UN04

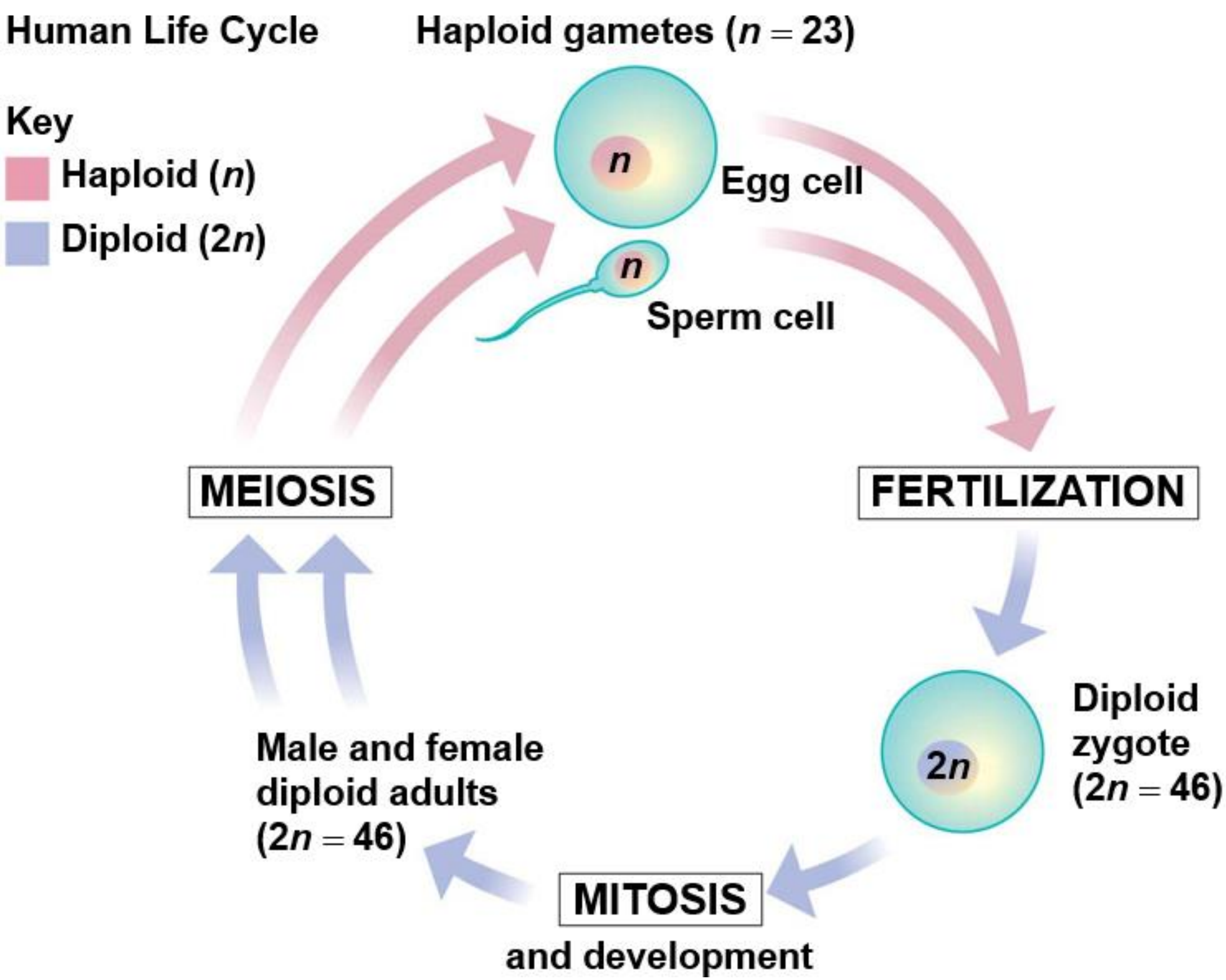


Figure 8.UN05

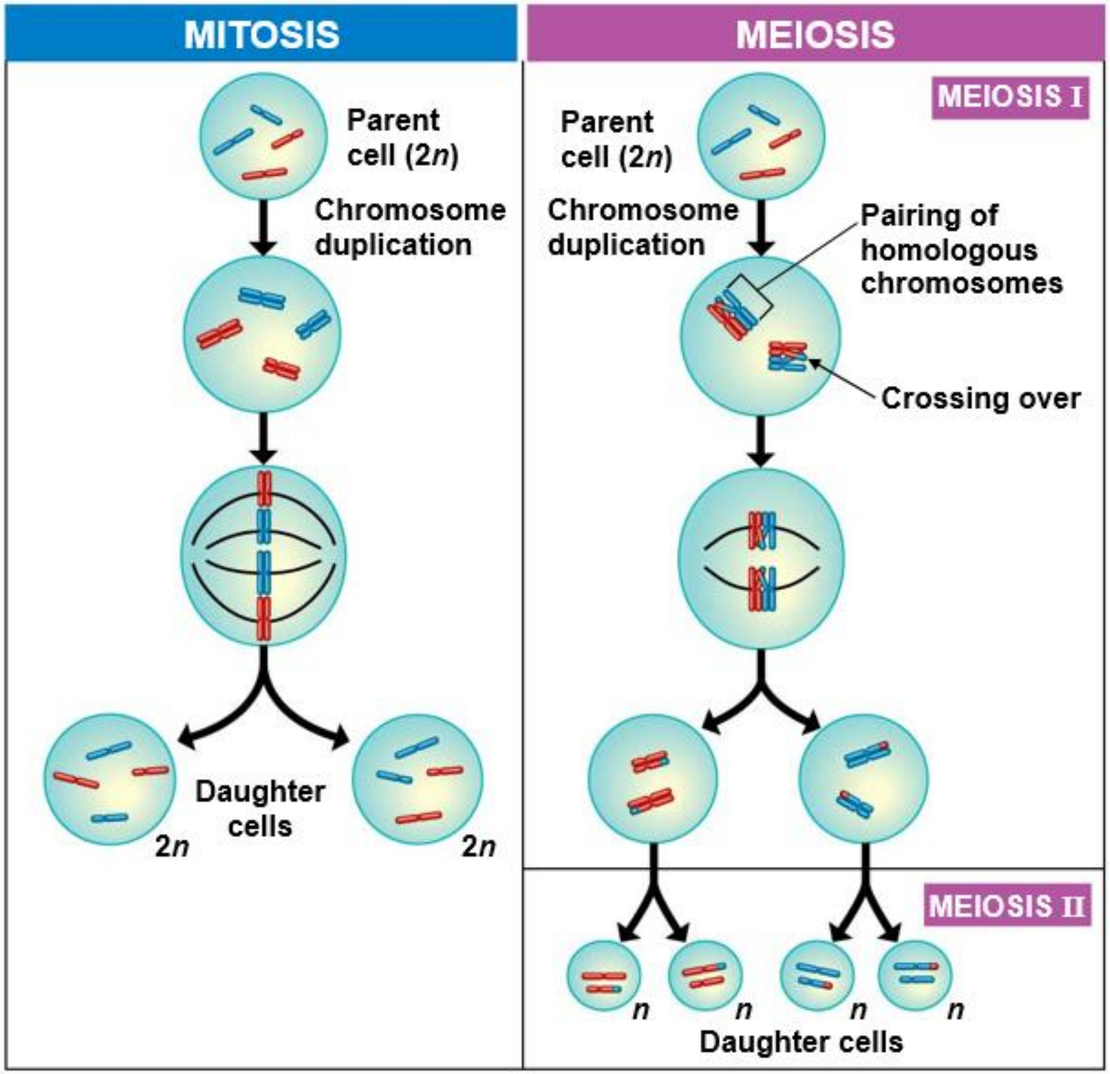


Figure 8.UN06

	Mitosis	Meiosis
a. Number of chromosomal duplications		
b. Number of cell divisions		
c. Number of daughter cells produced		
d. Number of chromosomes in daughter cells		
e. How chromosomes line up during metaphase		
f. Genetic relationship of daughter cells to parent cells		
g. Functions performed in the human body		

Figure 8.UN07

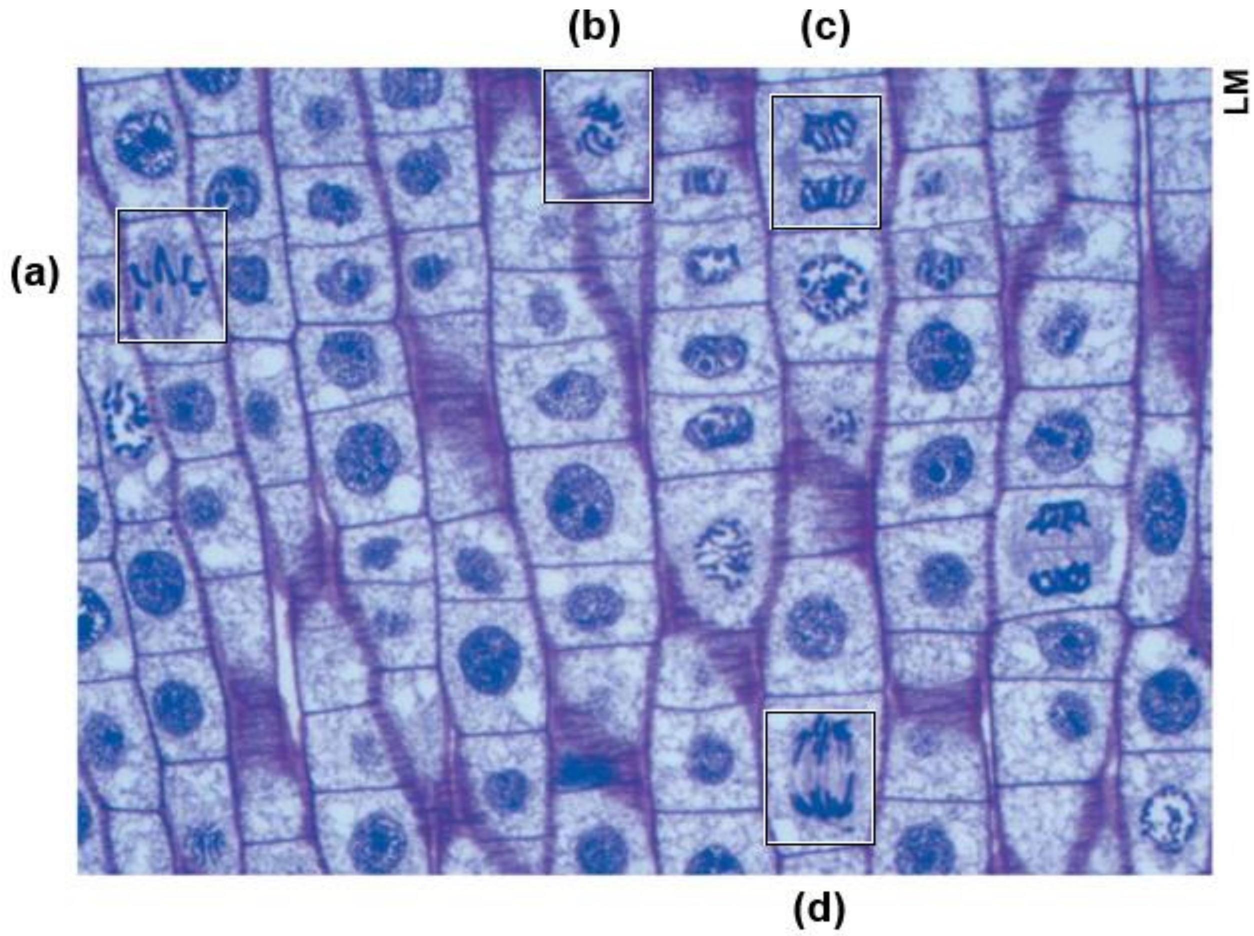


Figure 8.UN08