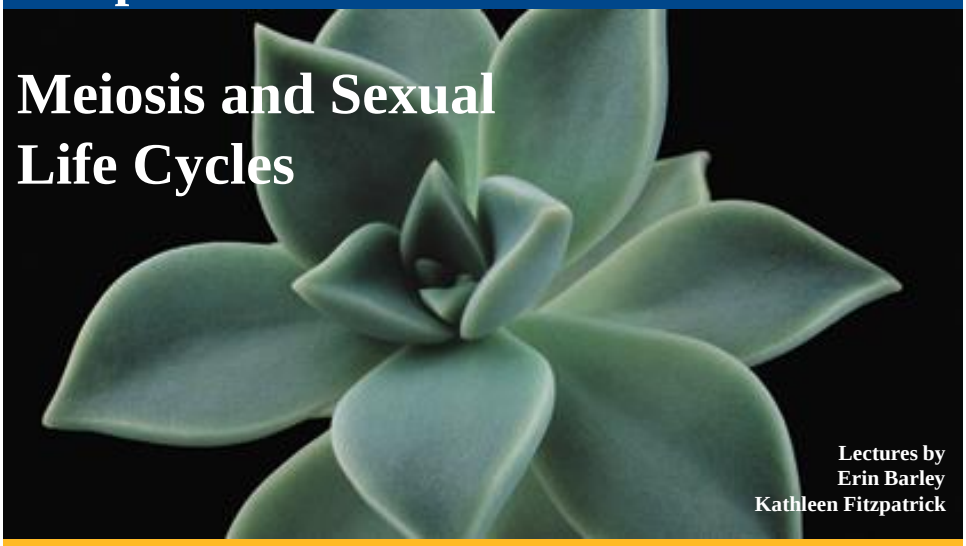
LECTURE PRESENTATIONS
For CAMPBELL BIOLOGY, NINTH EDITION
Jane B. Reece, Lisa A. Urry, Michael L. Cain, Steven A. Wasserman, Peter V. Minorsky, Robert B. Jackson

Chapter 13

Meiosis and Sexual Life Cycles

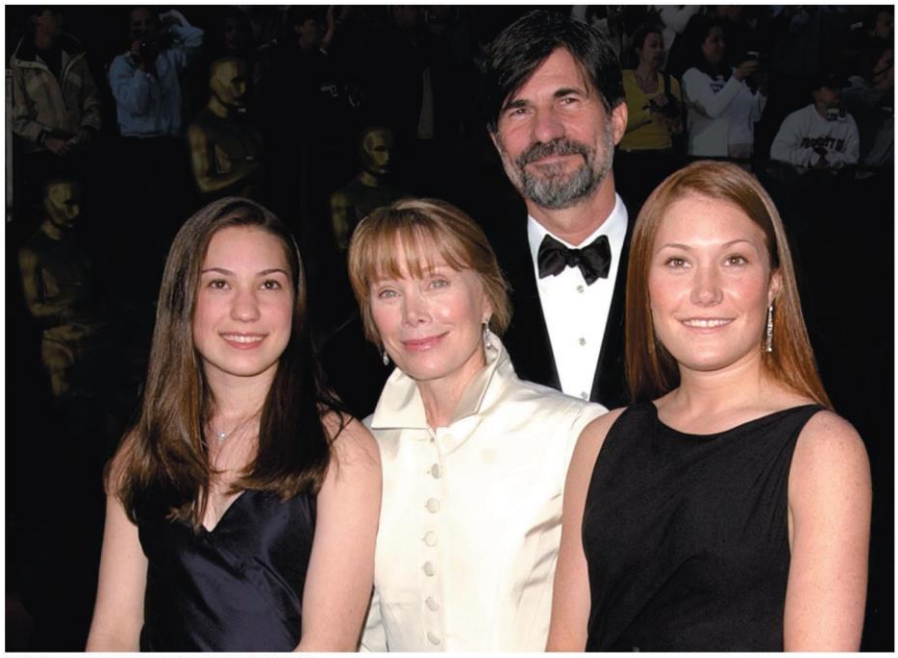


Lectures by
Erin Barley
Kathleen Fitzpatrick

Overview: Variations on a Theme

- Living organisms are distinguished by their ability to reproduce their own kind
- **Genetics** is the scientific study of heredity and variation
- **Heredity** is the transmission of traits from one generation to the next
- **Variation** is demonstrated by the differences in appearance that offspring show from parents and siblings

Fig. 13-1



Concept 13.1: Offspring acquire genes from parents by inheriting chromosomes

- In a literal sense, children do not inherit particular physical traits from their parents
- It is genes that are actually inherited

Inheritance of Genes

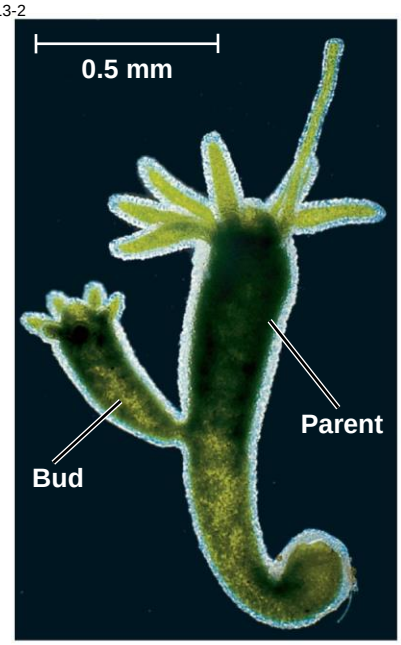
- **Genes** are the units of heredity, and are made up of segments of DNA
- Genes are passed to the next generation through reproductive cells called **gametes** (sperm and eggs)
- Each gene has a specific location called a **locus** on a certain chromosome
- One set of chromosomes is inherited from each parent

Comparison of Asexual and Sexual Reproduction

- In **asexual reproduction**, one parent produces genetically identical offspring by mitosis
- A **clone** is a group of genetically identical individuals from the same parent
- In **sexual reproduction**, two parents give rise to offspring that have unique combinations of genes inherited from the two parents

PLAY Video: Hydra Budding

Fig. 13-2



(a) Hydra

(b) Redwoods

Concept 13.2: Fertilization and meiosis alternate in sexual life cycles

- A **life cycle** is the generation-to-generation sequence of stages in the reproductive history of an organism

Sets of Chromosomes in Human Cells

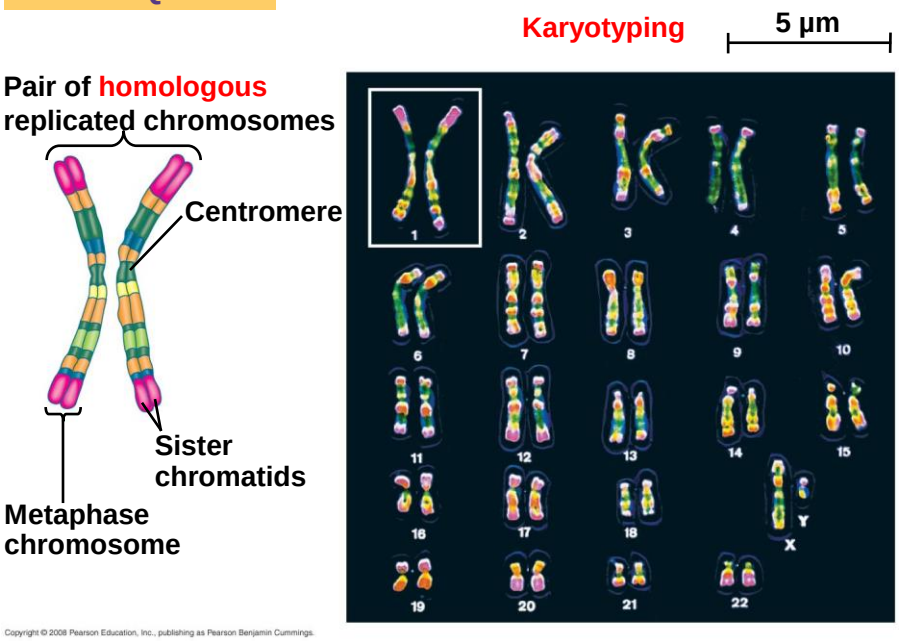
- Human **somatic cells** (any cell other than a gamete) have 23 pairs of chromosomes
- A **karyotype** is an ordered display of the pairs of chromosomes from a cell
- The two chromosomes in each pair are called **homologous chromosomes**, or homologs
- Chromosomes in a homologous pair are the same length and carry genes controlling the same inherited characters

Fig. 13-3a

APPLICATION

Fig. 13-3b

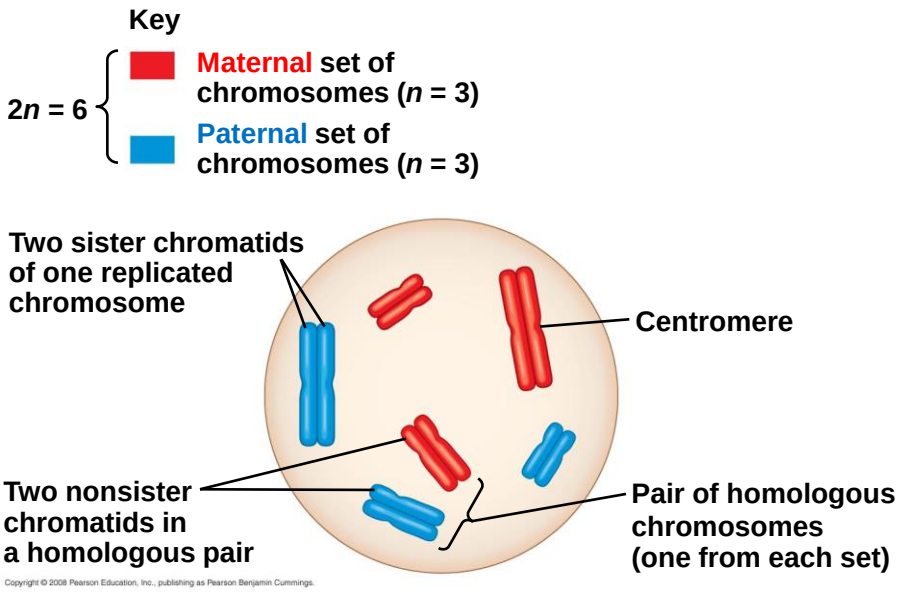
TECHNIQUE



- The **sex chromosomes** are called X and Y
- Human **females** have a homologous pair of X chromosomes (**XX**)
- Human **males** have one X and one Y chromosome (**XY**)
- The **22 pairs** of chromosomes that do not determine sex are called **autosomes**

- Each pair of homologous chromosomes includes one chromosome from each parent
- The 46 chromosomes in a human somatic cell are two sets of 23: one from the mother and one from the father
- A **diploid cell** (2*n*) has two sets of chromosomes
- For humans, the diploid number is 46 (2*n* = 46)

Fig. 13-4



- A **gamete** (sperm or egg) contains a single set of chromosomes, and is **haploid** (*n*)
- For humans, the haploid number is 23 (*n* = 23)
- Each set of 23 chromosomes consists of 22 autosomes and a single sex chromosome

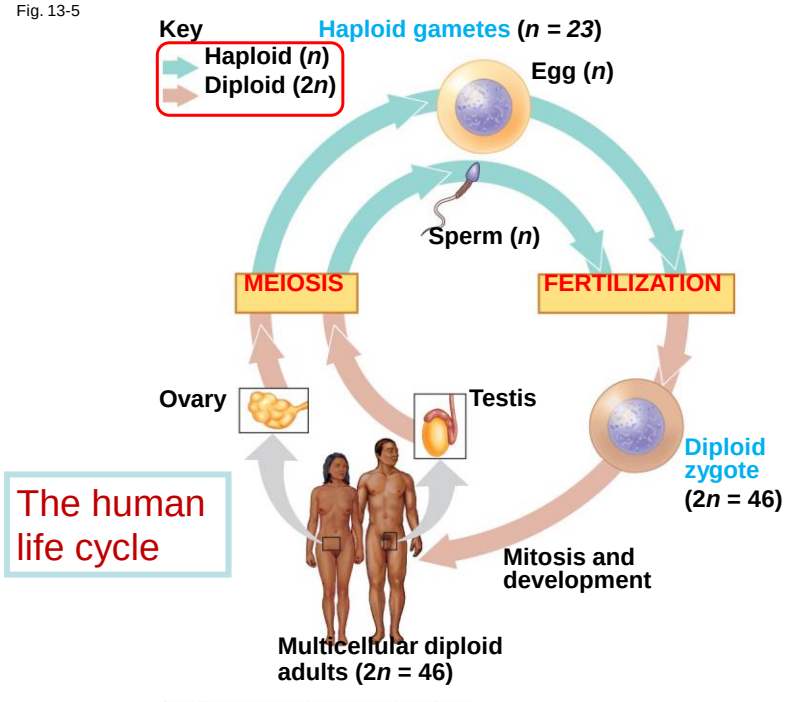
- Other examples:
- Drosophila melanogaster: 2n-8, 1n=4
- Dogs: 2n=78, 1n=39

Behavior of Chromosome Sets in the Human Life Cycle

- **Fertilization** *is the union of gametes (the sperm and the egg)*
- The fertilized egg is called a **zygote** and has one set of chromosomes from each parent
- The zygote produces somatic cells by mitosis and develops into an adult

- At sexual maturity, the ovaries and testes produce haploid gametes
- Gametes are the only types of human cells produced by **meiosis**, rather than mitosis
- Meiosis results in one set of chromosomes in each gamete

Fig. 13-5



The human life cycle

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

- Like mitosis, meiosis is preceded by the replication of chromosomes
- Meiosis takes place in **two sets of cell divisions**, called **meiosis I** and **meiosis II**
- The two cell divisions result in four daughter cells, rather than the two daughter cells in mitosis
- Each daughter cell has only half as many chromosomes as the parent cell

The Stages of Meiosis

- In the first cell division (meiosis I), homologous chromosomes separate
- Meiosis I results in two haploid daughter cells with replicated chromosomes; it is called the reductional division
- In the second cell division (meiosis II), sister chromatids separate
- Meiosis II results in four haploid daughter cells with unreplicated chromosomes; it is called the equational division

Fig. 13-7-1

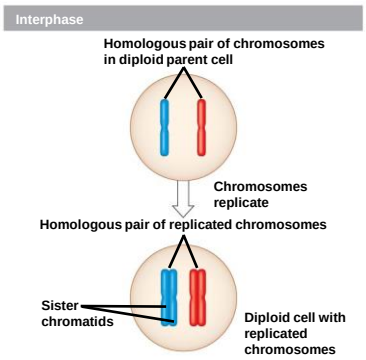


Fig. 13-7-2

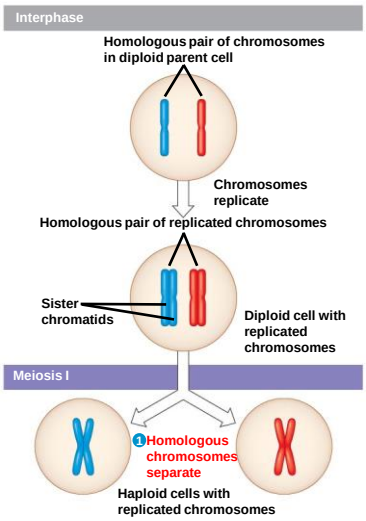


Fig. 13-7-3

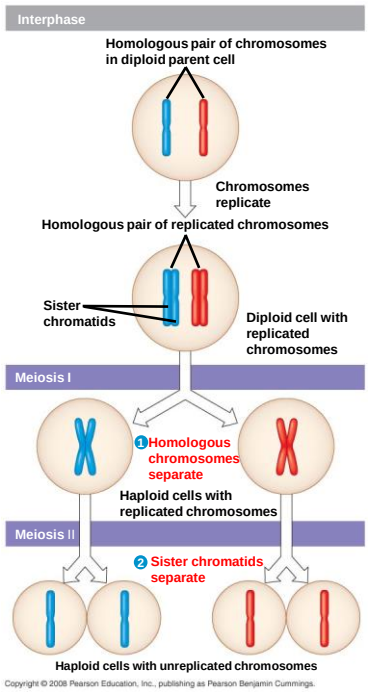
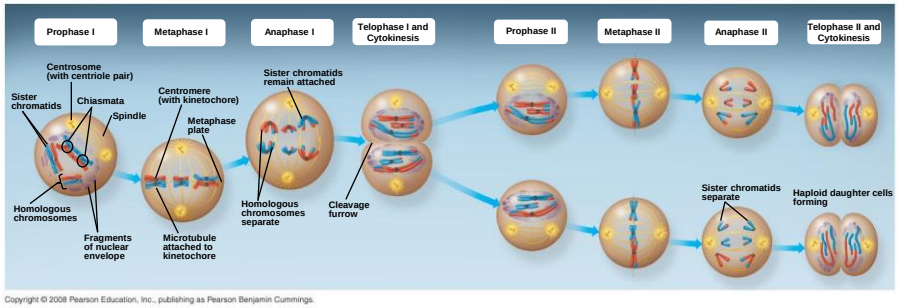
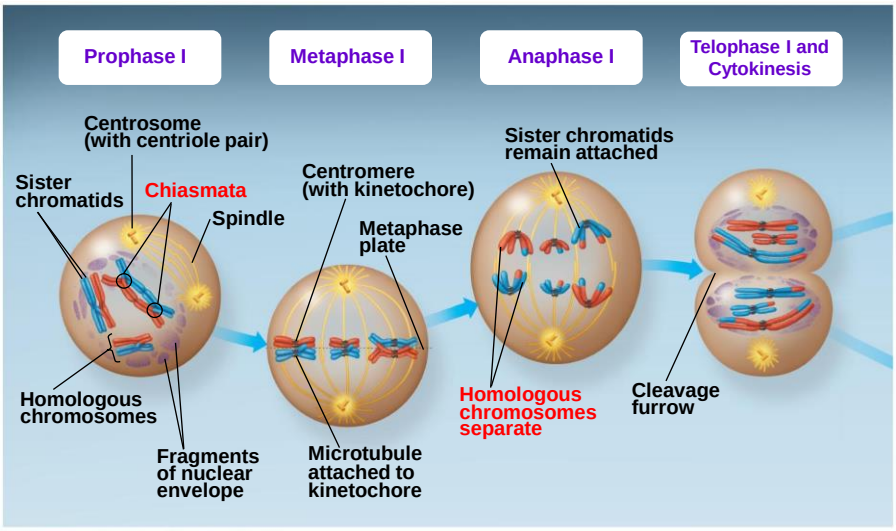


Fig. 13-8



- Division in meiosis I occurs in four phases:
  - **Prophase I**
  - **Metaphase I**
  - **Anaphase I**
  - **Telophase I and cytokinesis**

Fig. 13-8a



Prophase I

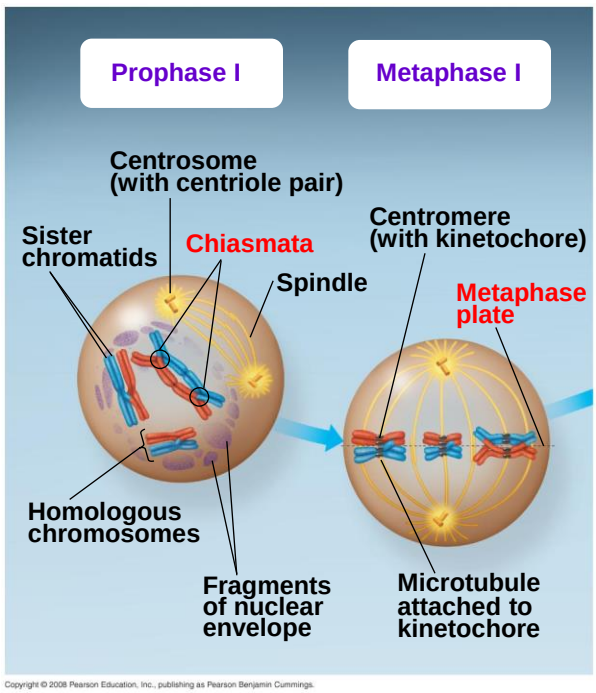
- Prophase I typically occupies more than 90% of the time required for meiosis
- Chromosomes begin to condense
- In **synapsis**, homologous chromosomes loosely pair up, aligned gene by gene

- In **crossing over**, nonsister chromatids exchange DNA segments
- Each pair of chromosomes forms a **tetrad**, a group of **four chromatids**
- Each tetrad usually has one or more **chiasmata**, *X-shaped regions where crossing over occurred*

Metaphase I

- In metaphase I, tetrads line up at the metaphase plate, with one chromosome facing each pole
- Microtubules from one pole are attached to the kinetochore of one chromosome of each tetrad
- Microtubules from the other pole are attached to the kinetochore of the other chromosome

Fig. 13-8b



Anaphase I

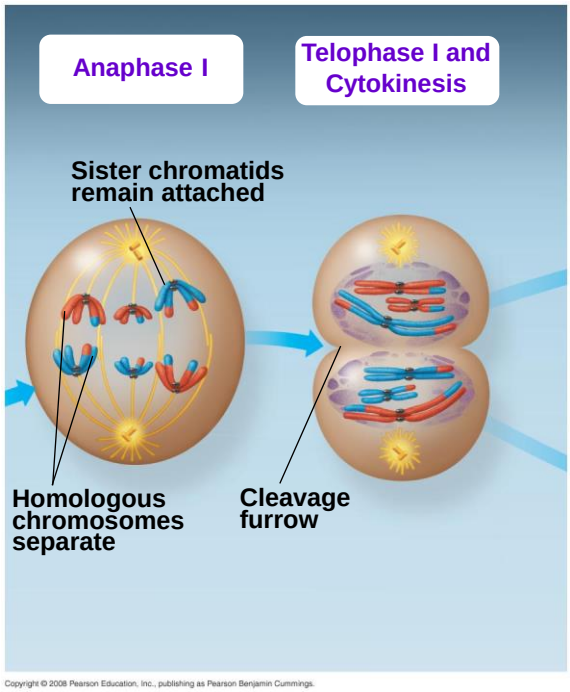
- In anaphase I, **pairs of homologous chromosomes separate**
- One chromosome moves toward each pole, guided by the spindle apparatus
- Sister chromatids remain attached at the centromere and move as one unit toward the pole

Telophase I and Cytokinesis

- In the beginning of telophase I, each half of the cell has a haploid set of chromosomes; each chromosome still consists of two sister chromatids
- **Cytokinesis** usually occurs simultaneously, forming **two haploid daughter cells**

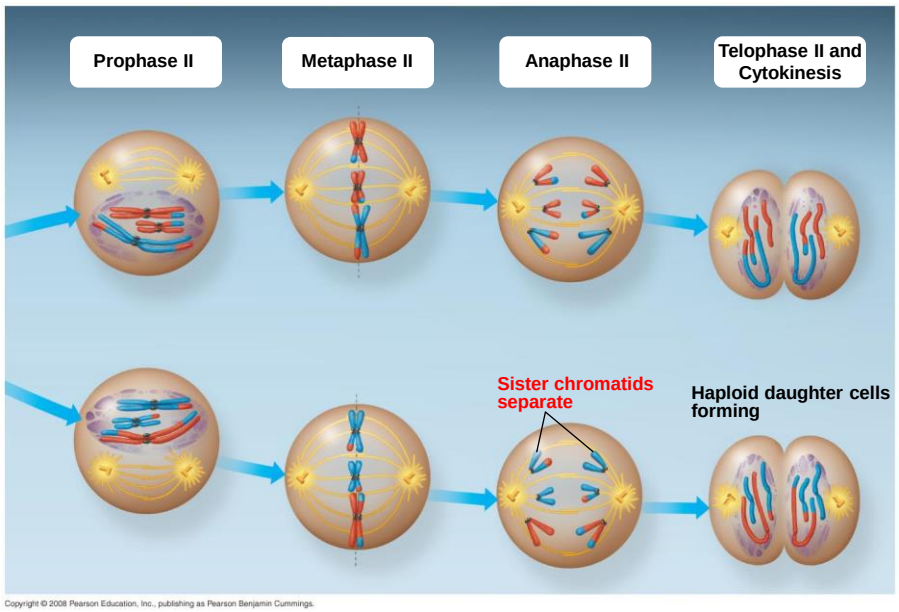
- In animal cells, a cleavage furrow forms; in plant cells, a cell plate forms
- *No chromosome replication occurs between the end of meiosis I and the beginning of meiosis II* because the chromosomes are already replicated

Fig. 13-8c



- **Division in meiosis II** also occurs in four phases:
  - **Prophase II**
  - **Metaphase II**
  - **Anaphase II**
  - **Telophase II and cytokinesis**
- Meiosis II is **very similar to mitosis**

Fig. 13-8d



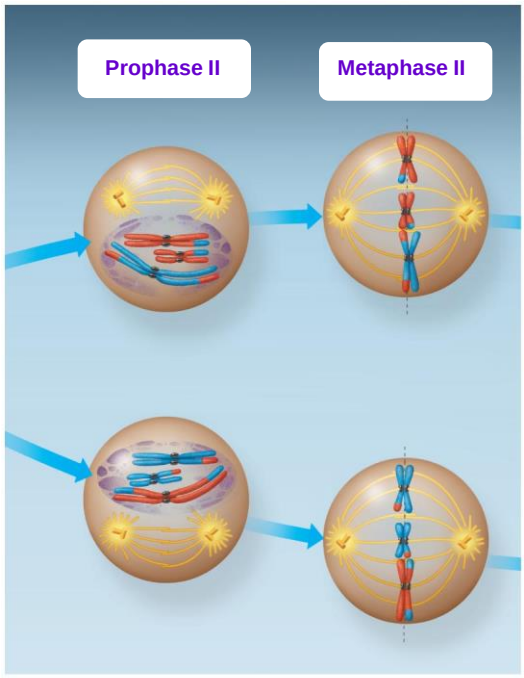
Prophase II

- In prophase II, a spindle apparatus forms
- In late prophase II, chromosomes (each still composed of two chromatids) move toward the metaphase plate

Metaphase II

- In metaphase II, the sister chromatids are arranged at the metaphase plate
- Because of crossing over in meiosis I, the two sister chromatids of each chromosome are no longer genetically identical
- The kinetochores of sister chromatids attach to microtubules extending from opposite poles

Fig. 13-8e



Anaphase II

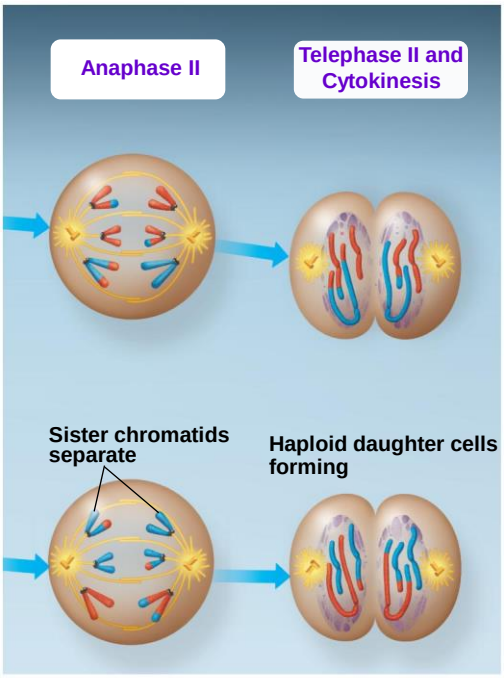
- In anaphase II, **the sister chromatids separate**
- The sister chromatids of each chromosome now move as two newly individual chromosomes toward opposite poles

Telophase II and Cytokinesis

- In telophase II, the chromosomes arrive at opposite poles
- Nuclei form, and the chromosomes begin decondensing

- Cytokinesis separates the cytoplasm
- At the end of meiosis, there are four daughter cells, each with a haploid set of unreplicated chromosomes
- Each daughter cell is genetically distinct from the others and from the parent cell

Fig. 13-8f



A Comparison of Mitosis and Meiosis

- Mitosis conserves the number of chromosome sets, producing cells that are genetically identical to the parent cell
- Meiosis reduces the number of chromosomes sets from two (diploid) to one (haploid), producing cells that differ genetically from each other and from the parent cell
- The mechanism for separating sister chromatids is virtually identical in meiosis II and mitosis

Fig. 13-9

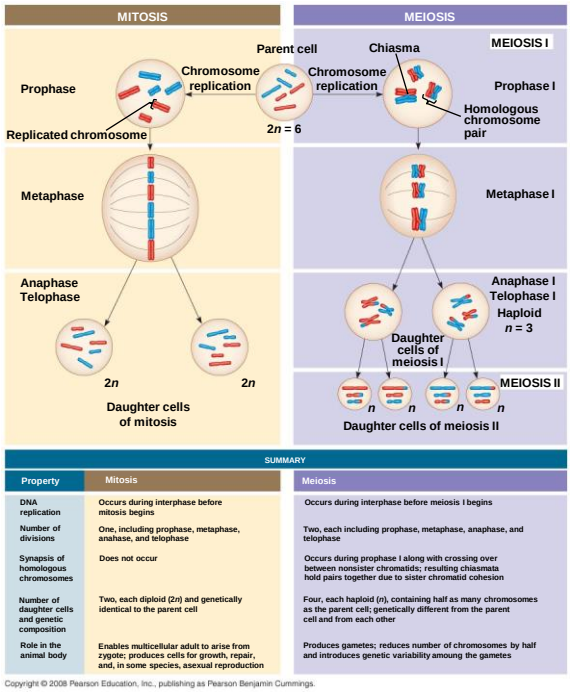


Fig. 13-9a

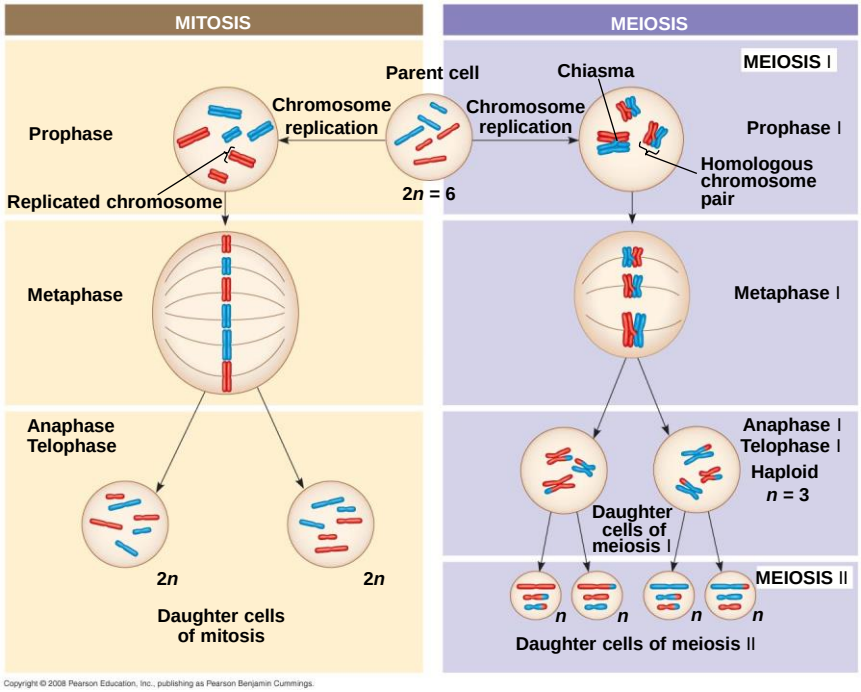
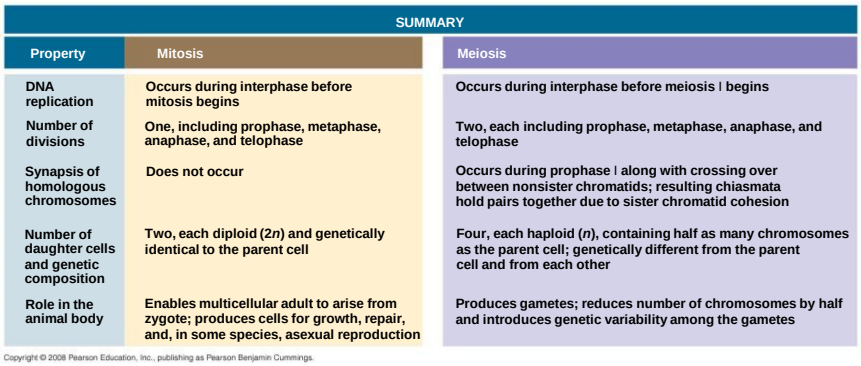


Fig. 13-9b



SUMMARY

Property	Mitosis	Meiosis
DNA replication	Occurs during interphase before mitosis begins	Occurs during interphase before meiosis I begins
Number of divisions	One, including prophase, metaphase, anaphase, and telophase	Two, each including prophase, metaphase, anaphase, and telophase
Synapsis of homologous chromosomes	Does not occur	Occurs during prophase I along with crossing over between nonsister chromatids; resulting chiasmata hold pairs together due to sister chromatid cohesion
Number of daughter cells and genetic composition	Two, each diploid (2*n*) and genetically identical to the parent cell	Four, each haploid (*n*), containing half as many chromosomes as the parent cell; genetically different from the parent cell and from each other
Role in the animal body	Enables multicellular adult to arise from zygote; produces cells for growth, repair, and, in some species, asexual reproduction	Produces gametes; reduces number of chromosomes by half and introduces genetic variability among the gametes

- Three events are unique to meiosis, and all three occur in meiosis I:
  - **Synapsis** and **crossing over** in prophase I: Homologous chromosomes physically connect and exchange genetic information
  - At the metaphase plate, there are **paired homologous chromosomes (tetrads),** instead of individual replicated chromosomes
  - At **anaphase I**, it is **homologous chromosomes**, instead of sister chromatids, that separate

- Sister chromatid cohesion allows sister chromatids of a single chromosome to stay together through meiosis I
- Protein complexes **called cohesins** are responsible for this cohesion