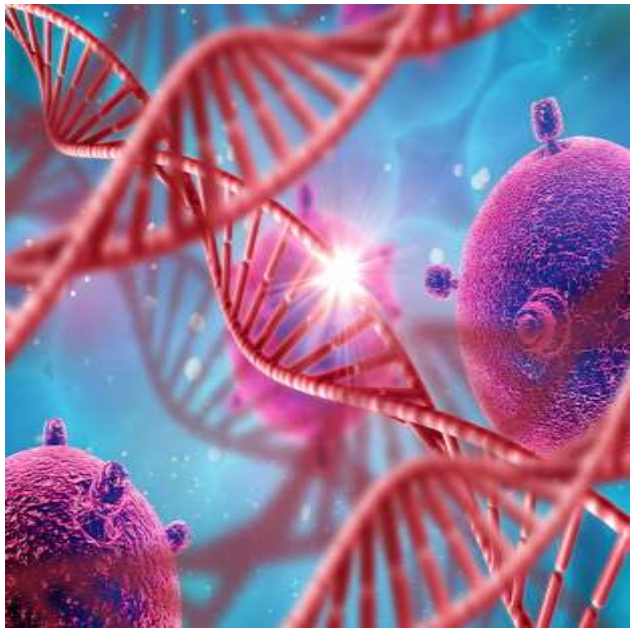
Lecture 16

General Biology & Cytology Course 2301130



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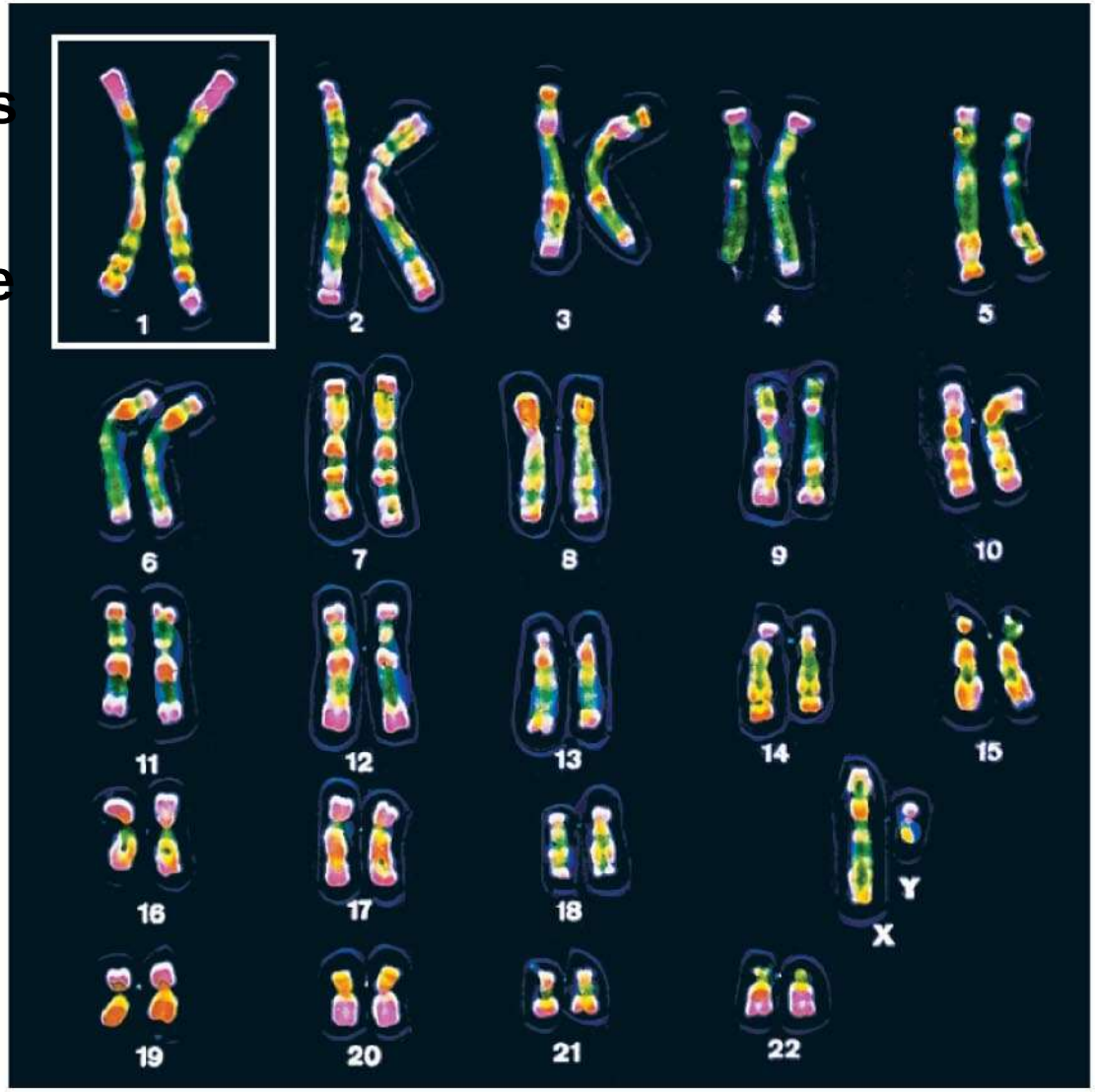
Meiosis and Sexual Life Cycles

***Themes*:**

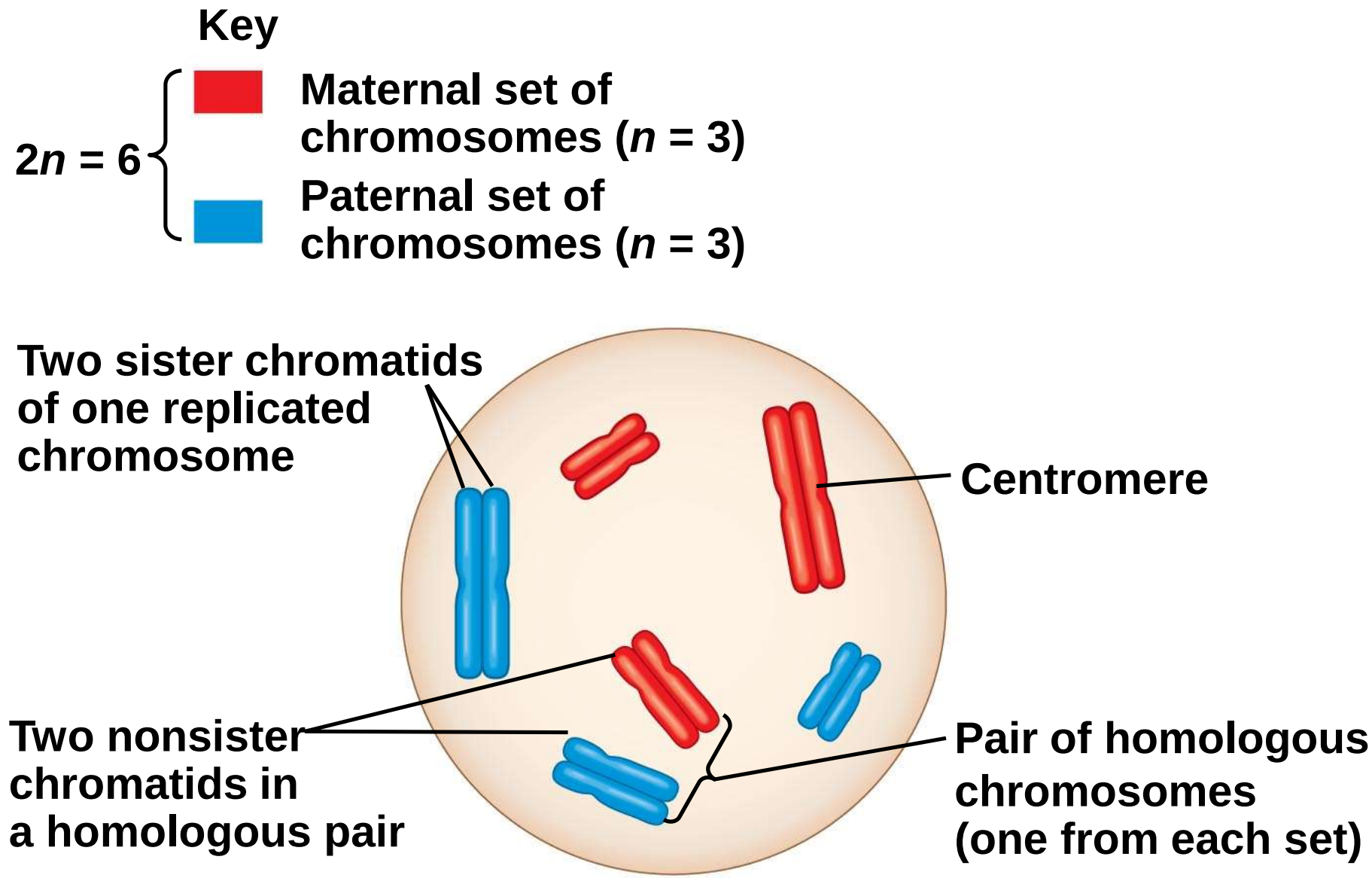
- **Genetics** is the scientific study of heredity and variation
- **Heredity** is the transmission of traits from one generation to the next
- **Variation** is demonstrated by the differences in appearance that offspring show from parents and siblings

- In a literal sense, children do not inherit particular physical traits from their parents
- It is genes that are actually inherited.
- **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
- Human **somatic cells** (any cell other than a gamete) have 23 pairs of chromosomes (**22 pairs of autosomes,1 pair of sex chromosomes**).
- The two chromosomes in each pair are called **homologous chromosomes**.
- Chromosomes in a homologous pair are the same length and carry genes controlling the same inherited characters

TECHNIQUE

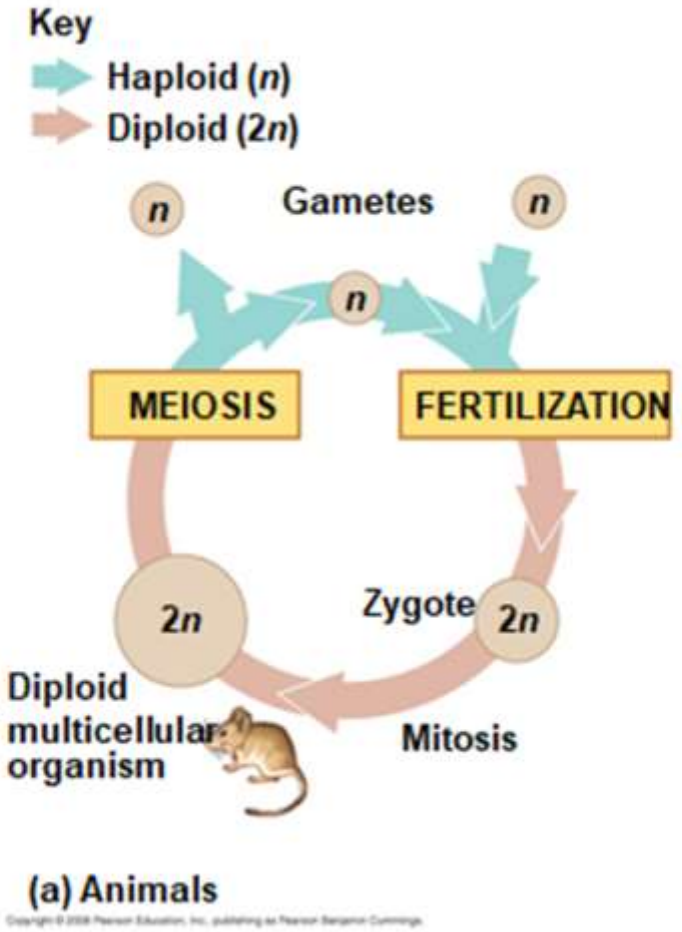


- The 46 chromosomes in a human somatic cell are **two sets of 23**: one from the mother and one from the father
- A **diploid cell** (2*n*) has two sets of chromosomes
- For humans, the diploid number is 46 (2*n* = 46)



- 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 consists of **22 autosomes** and a single sex chromosome
- In an unfertilized egg (ovum), the sex chromosome is X
- In a sperm cell, the sex chromosome may be either X or Y
- **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

- The process of producing a sperm or egg cell is called **gametogenesis**.
- For more specifically, the process of producing an **egg cell is** called **oogenesis** and the process of creating **sperm cells is called spermatogenesis**.



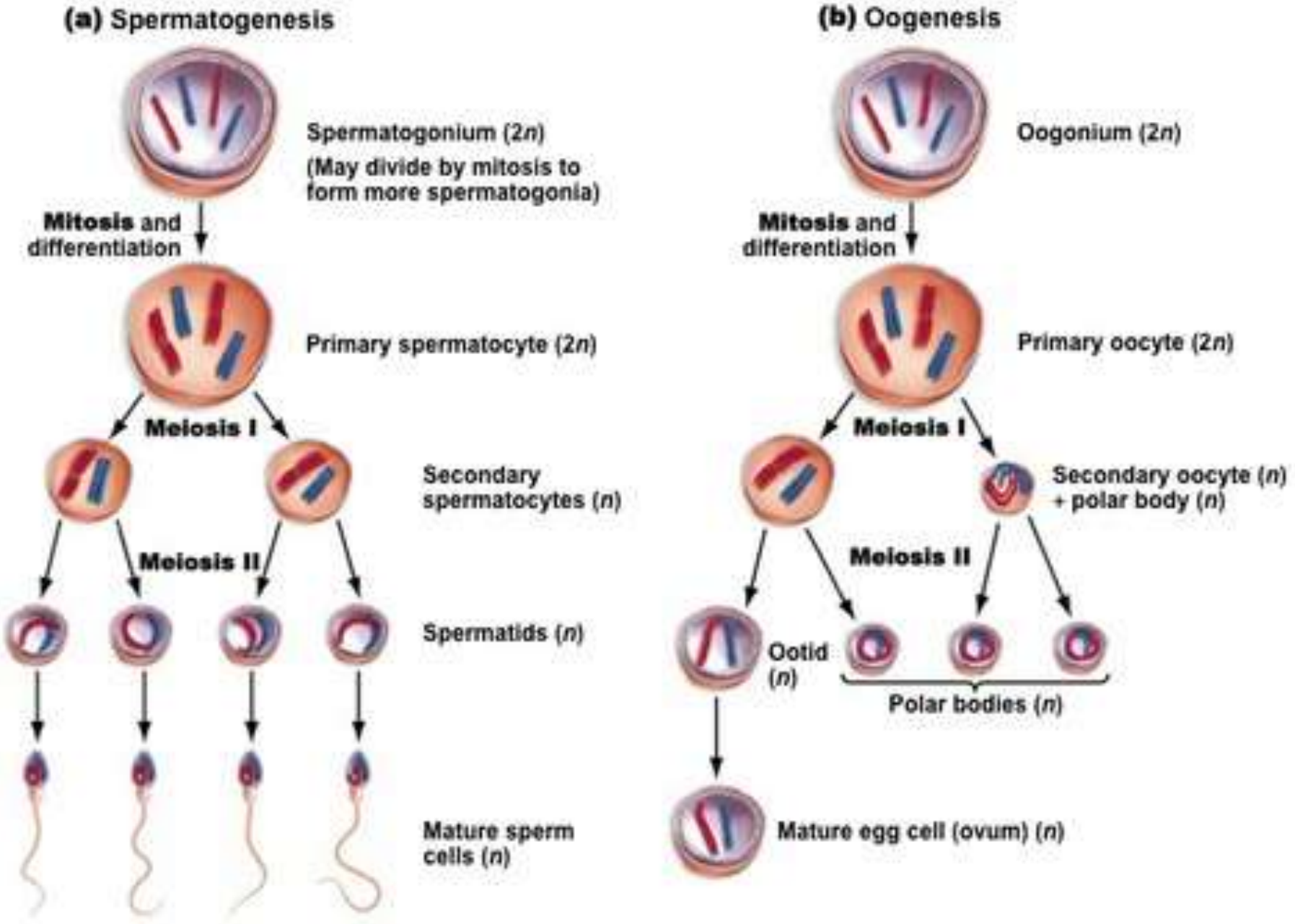
- **Meiosis**: it's a type of cell division occur in **germ cells** and formation the **gametes**.

- Since cell division occurs twice during meiosis, ***with an intervening short interphase without an S phase.***

- One starting cell can produce four gametes (eggs or sperm) with 23 chromosomes.

- In each round of division, cells go through four stages: **prophase, metaphase, anaphase**, and **telophase**.

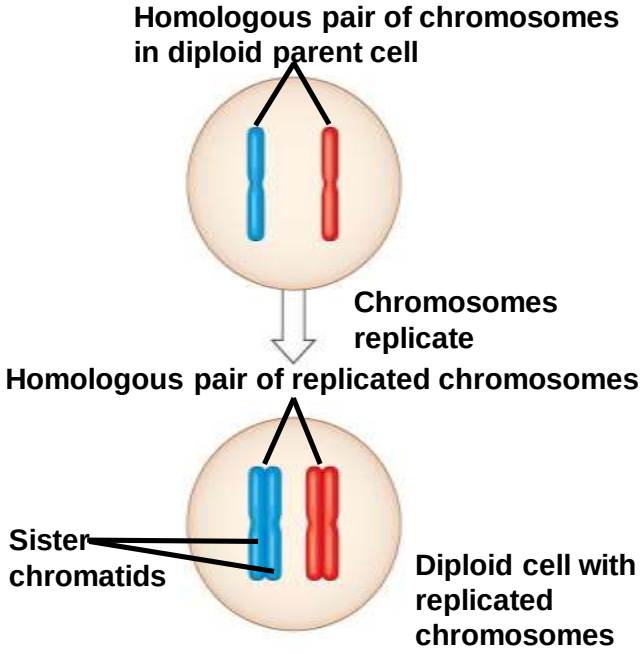
Figure 50.4

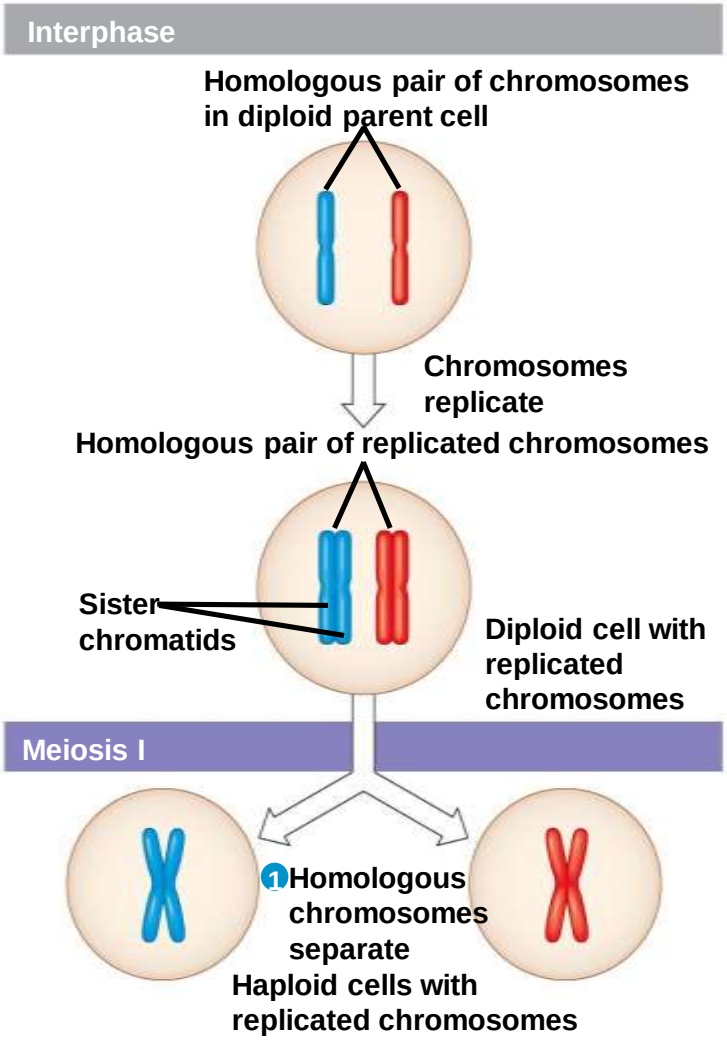


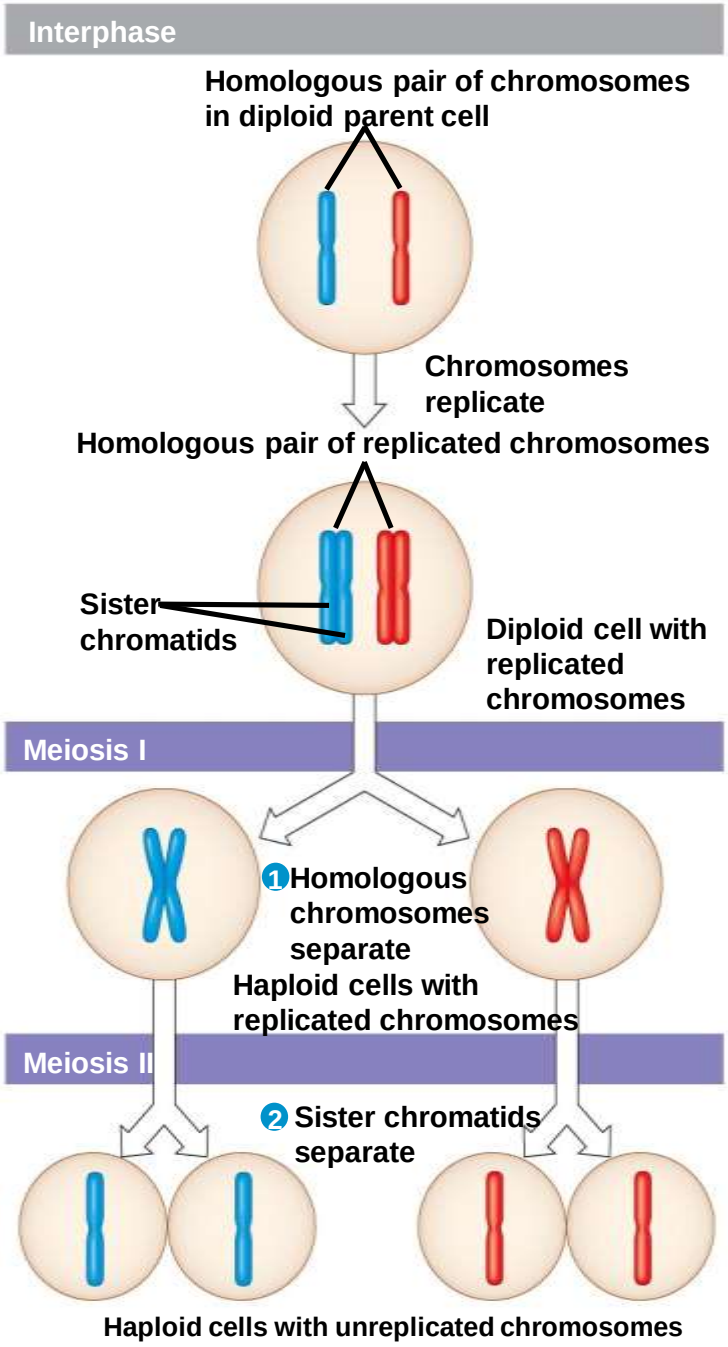
The Stages of Meiosis

- In meiosis, however, the cell has a more complex task. It still needs to separate sister chromatids (the two halves of a duplicated chromosome), as in mitosis.
- But it must also separate homologous chromosomes, the similar but nonidentical chromosome pairs an organism receives from its two parents
- 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.

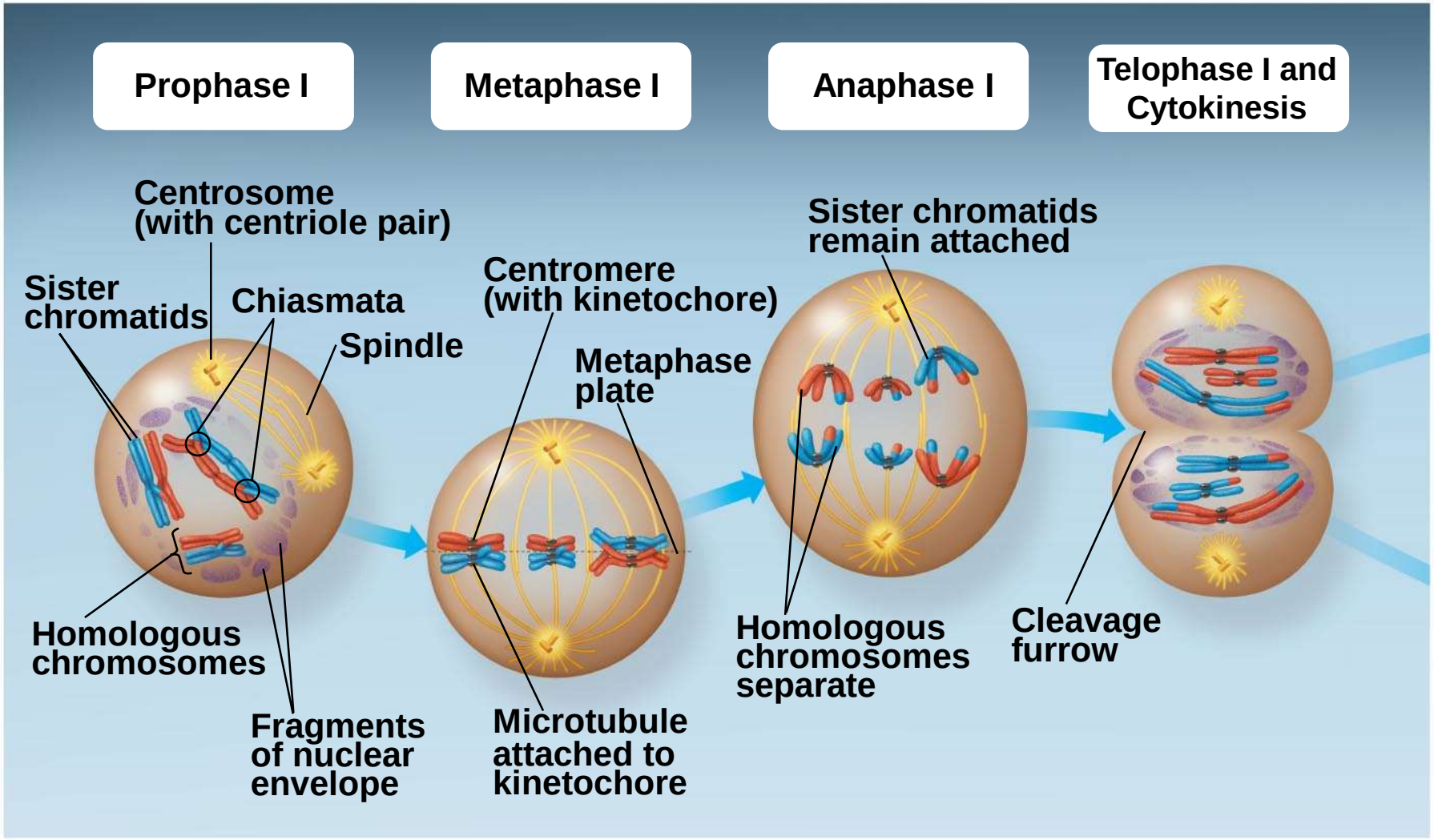
Interphase







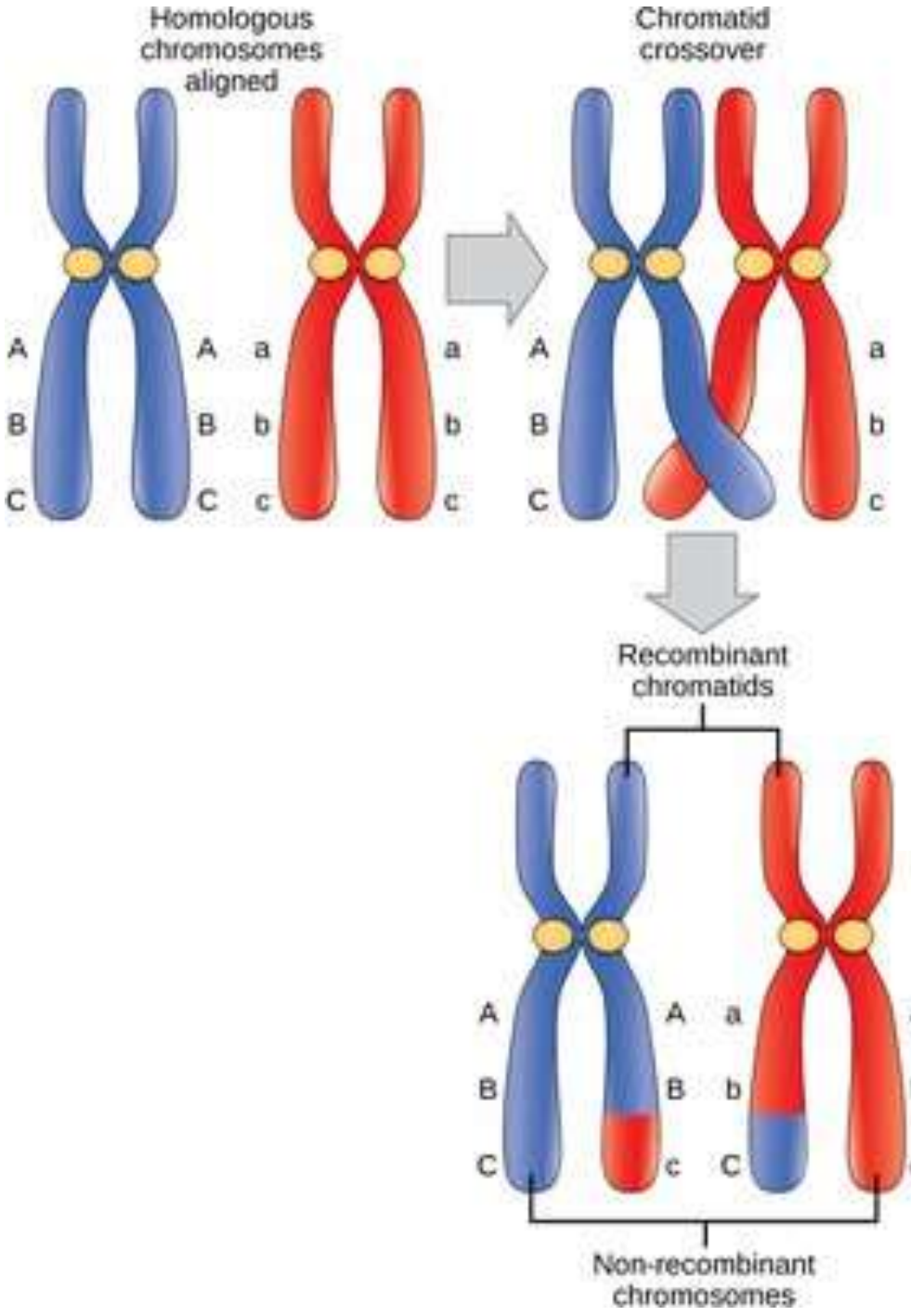
- **Meiosis I** is preceded by interphase with (*S phase*), in which chromosomes are replicated to form sister chromatids. (46 s-chromosomes ⟶ 46d-chromosomes)
- The sister chromatids are genetically identical and joined at the centromere.
- The single centrosome replicates, forming two centrosomes
- Division in meiosis I occurs in four phases:
  - Prophase I
  - Metaphase I
  - Anaphase I
  - Telophase I and cytokinesis

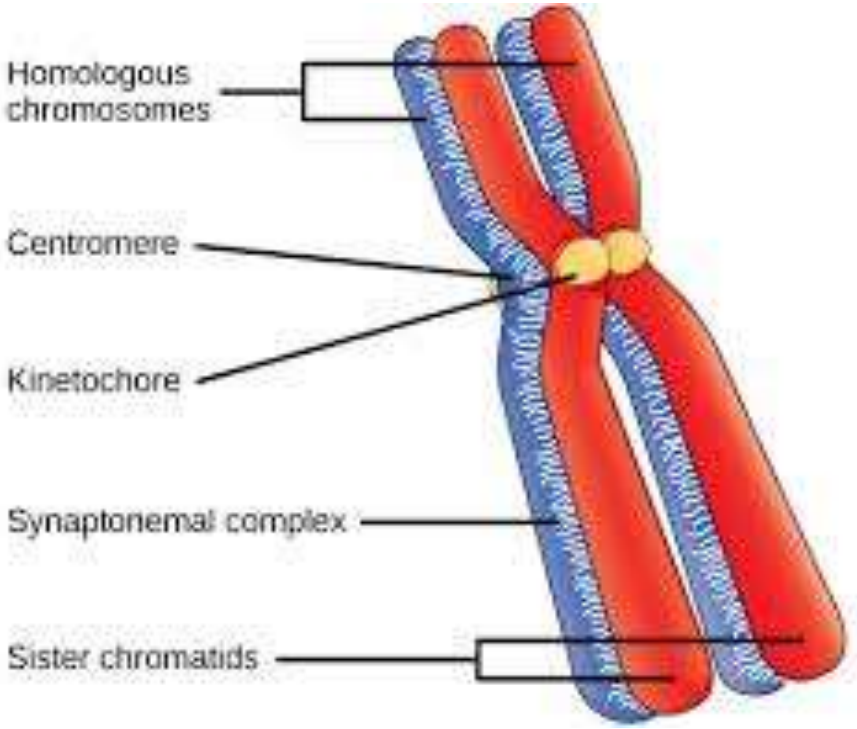


Prophase I

- Prophase I typically occupies more than 90% of the time required for meiosis

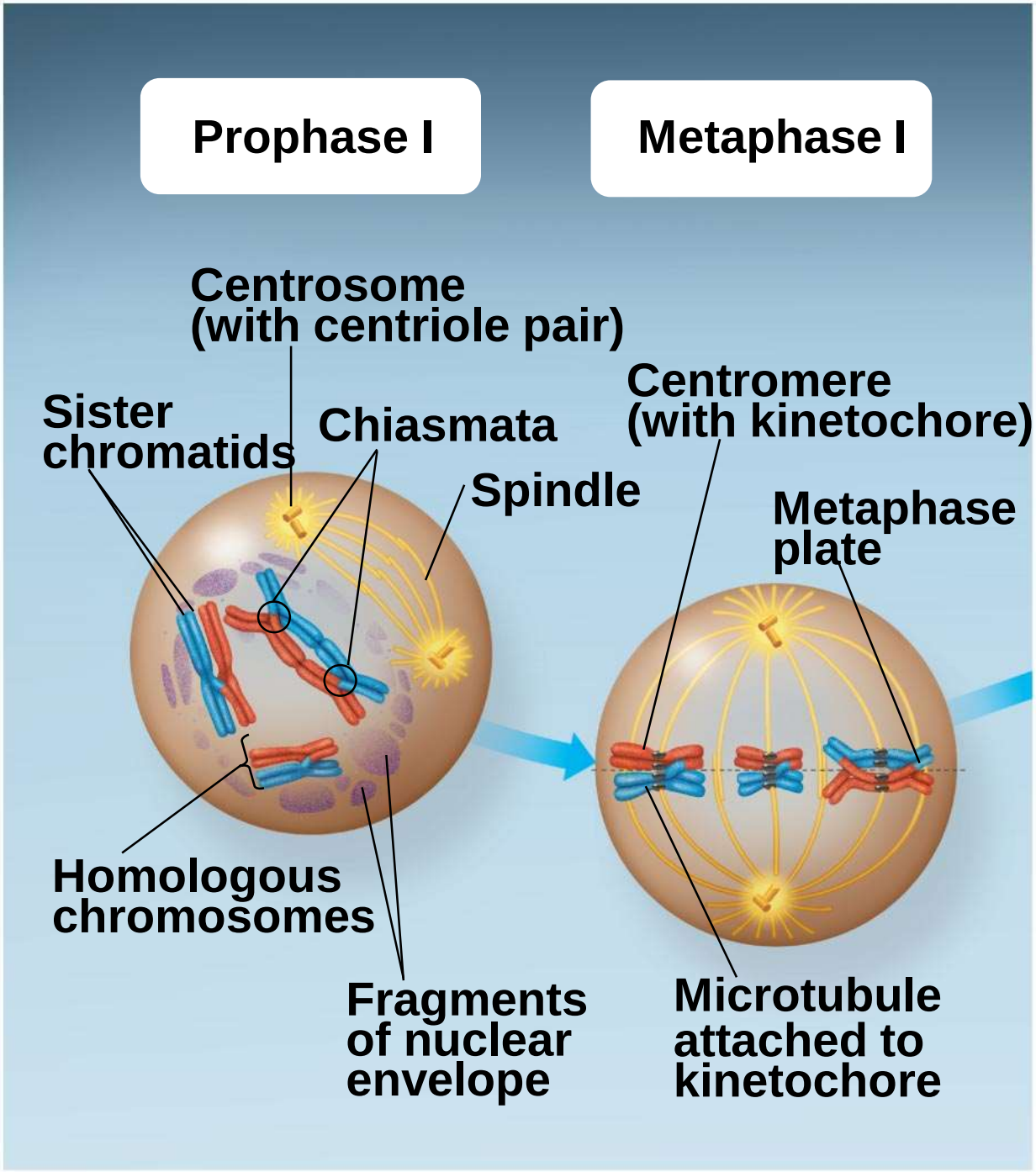
1. Chromosomes begin to condense
2. Pairing of the homologous chromosomes and forming a tetrad, a group of four chromatids and make connection (**synapsis)**, by protein called **synaptonemal complex**
3. C**rossing-over** occurs bet the chromatids of the homologous chromosomes at site called **chiasmata** and nonsister chromatids exchange DNA segments.
4. Nucleolus and nuclear envelope disappear and mitotic spindle is formed.


Homologous chromosomes aligned
Chromatid crossover
A
B
C
a
b
c
Recombinant chromatids
Non-recombinant chromosomes


Homologous chromosomes
Centromere
Kinetochore
Synaptonemal complex
Sister chromatids

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



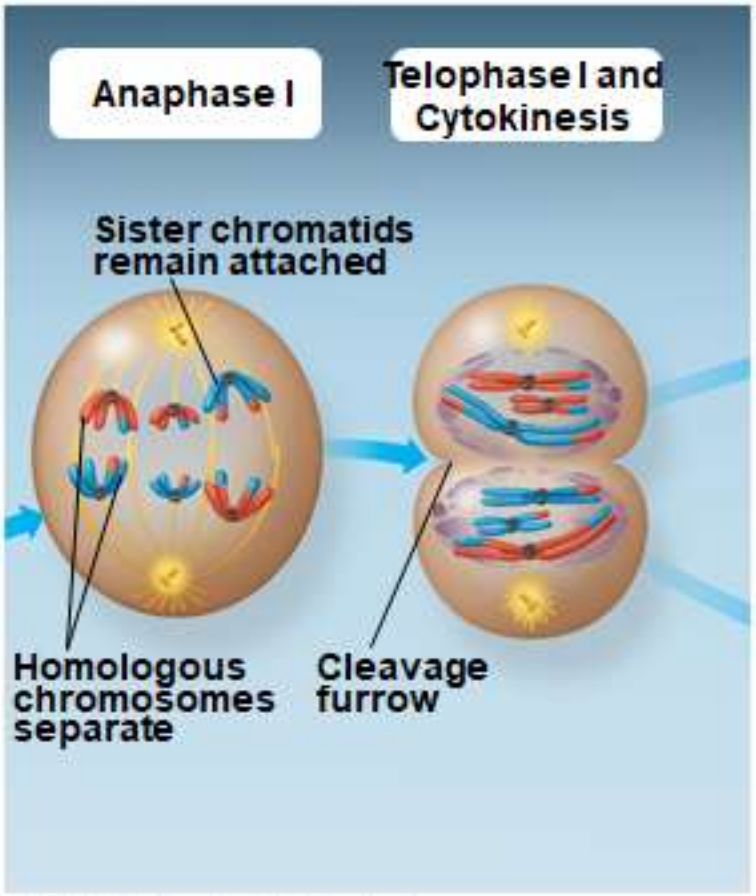
Anaphase I

- 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 (**don’t divide**) and move as one unit toward the pole

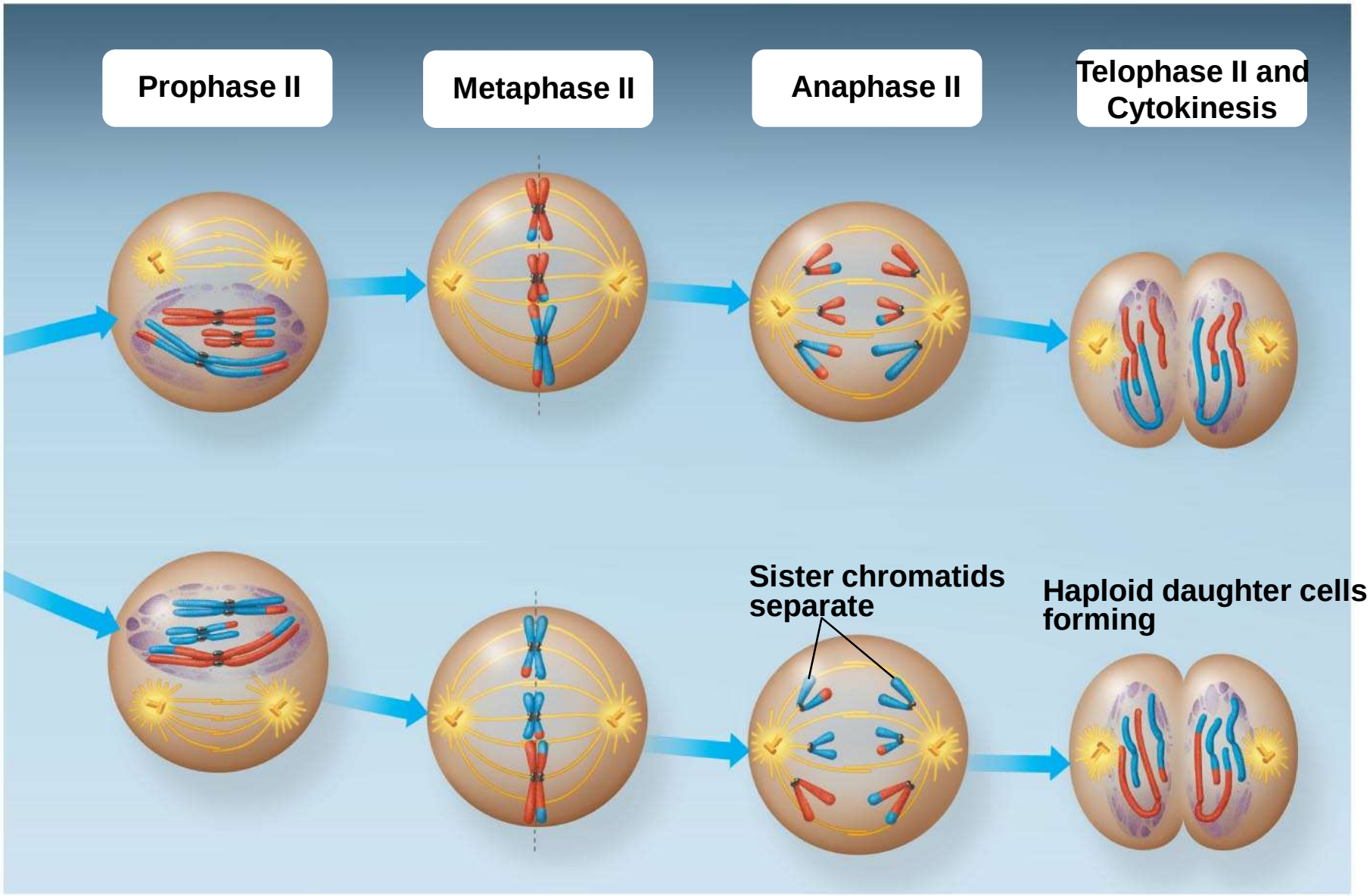
Telophase I and Cytokinesis

- 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
- No chromosome replication occurs between the end of <u>meiosis I and the beginning of meiosis II</u> because the chromosomes are already replicated



- 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

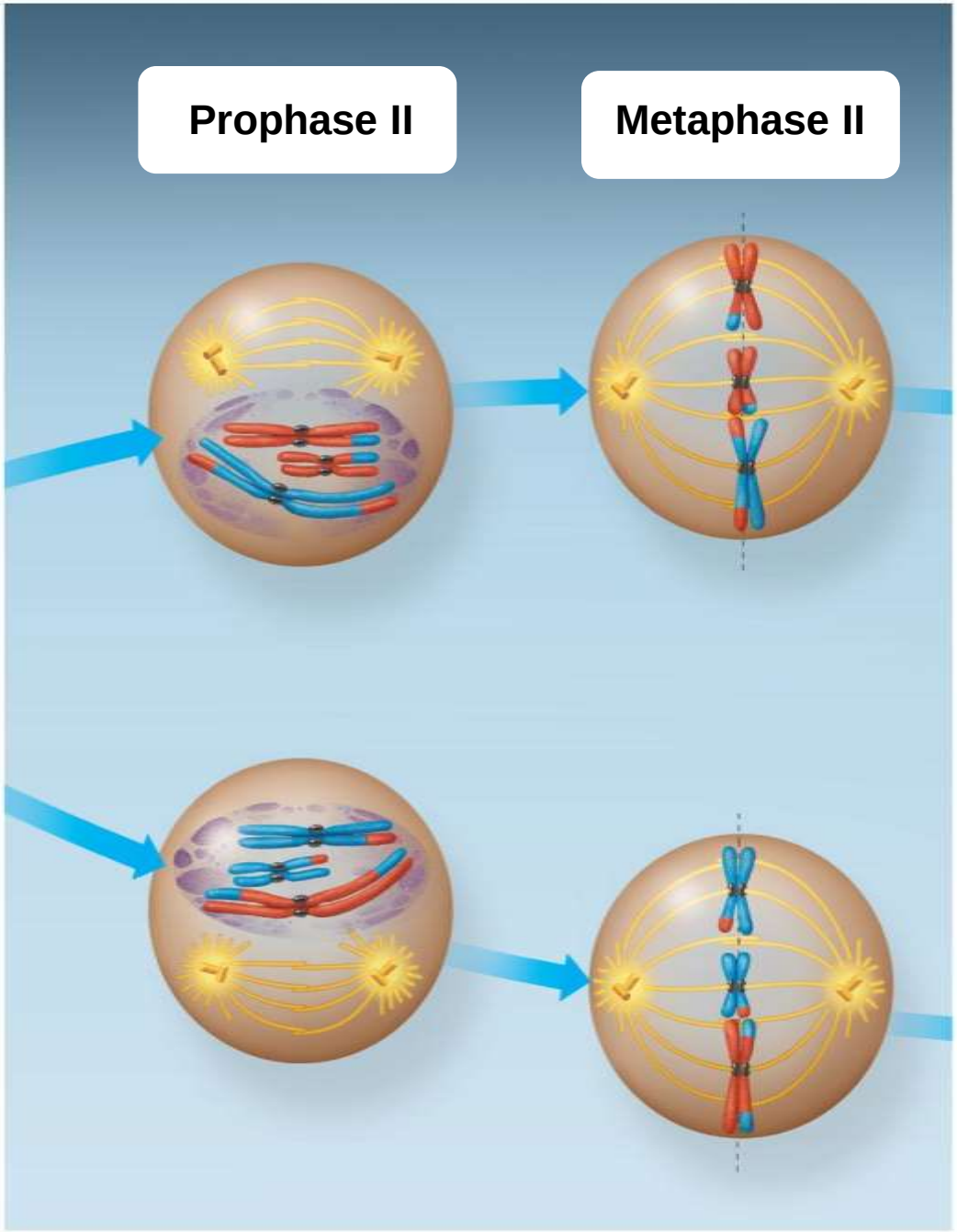


Prophase II

- 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



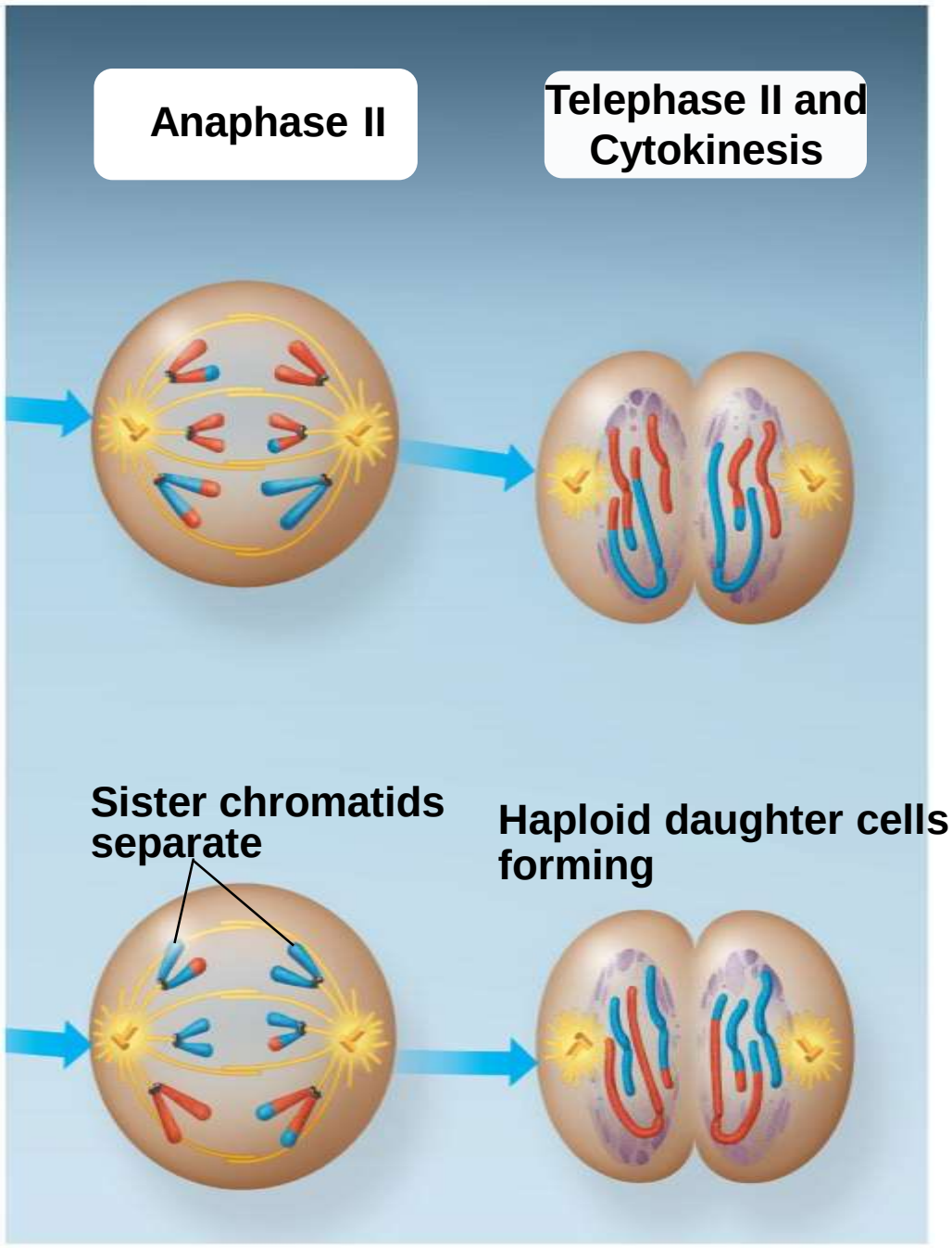
Anaphase II

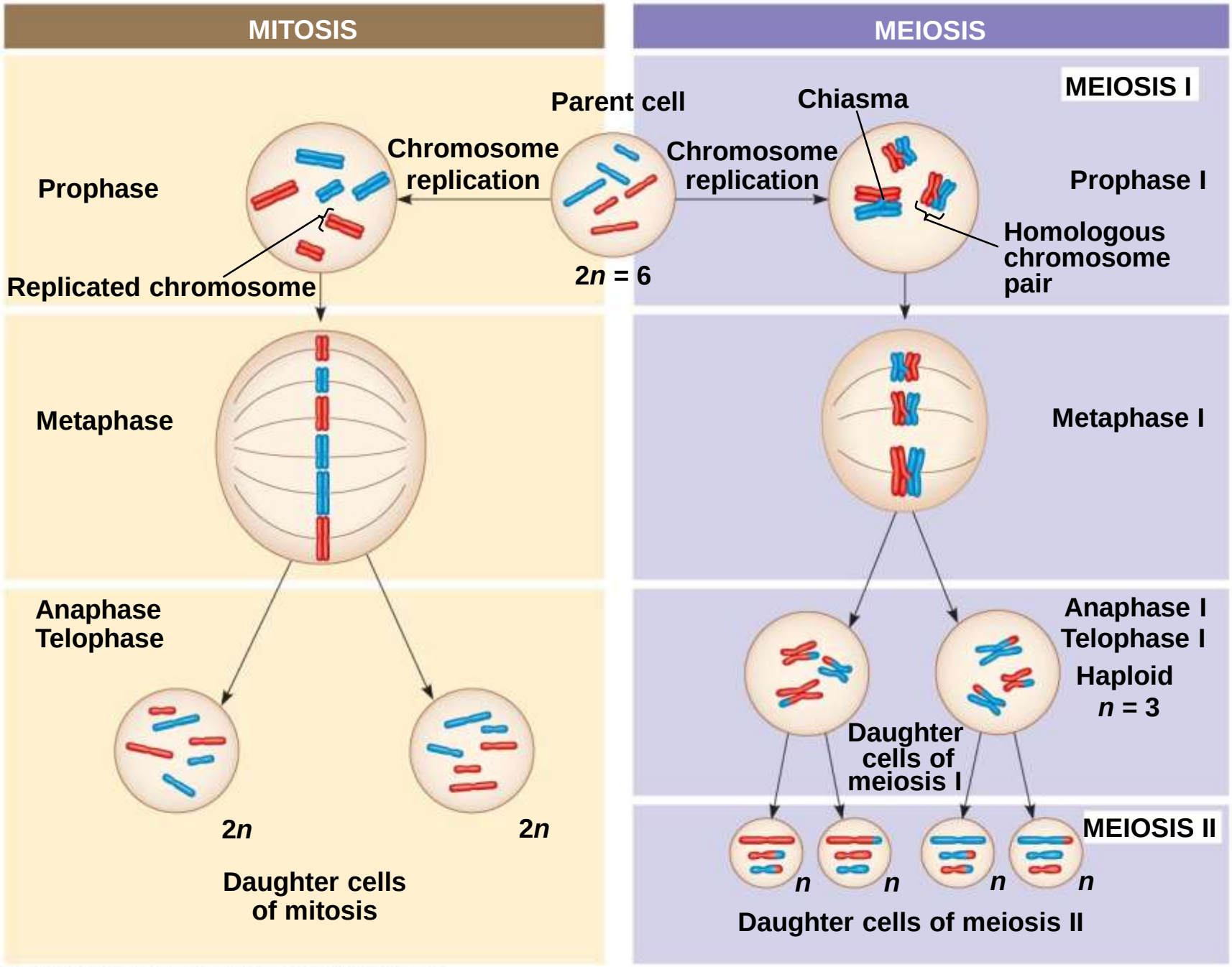
- In anaphase II, the sister chromatids separate
- The sister chromatids of each chromosome now move as two newly individual chromosomes toward opposite poles

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





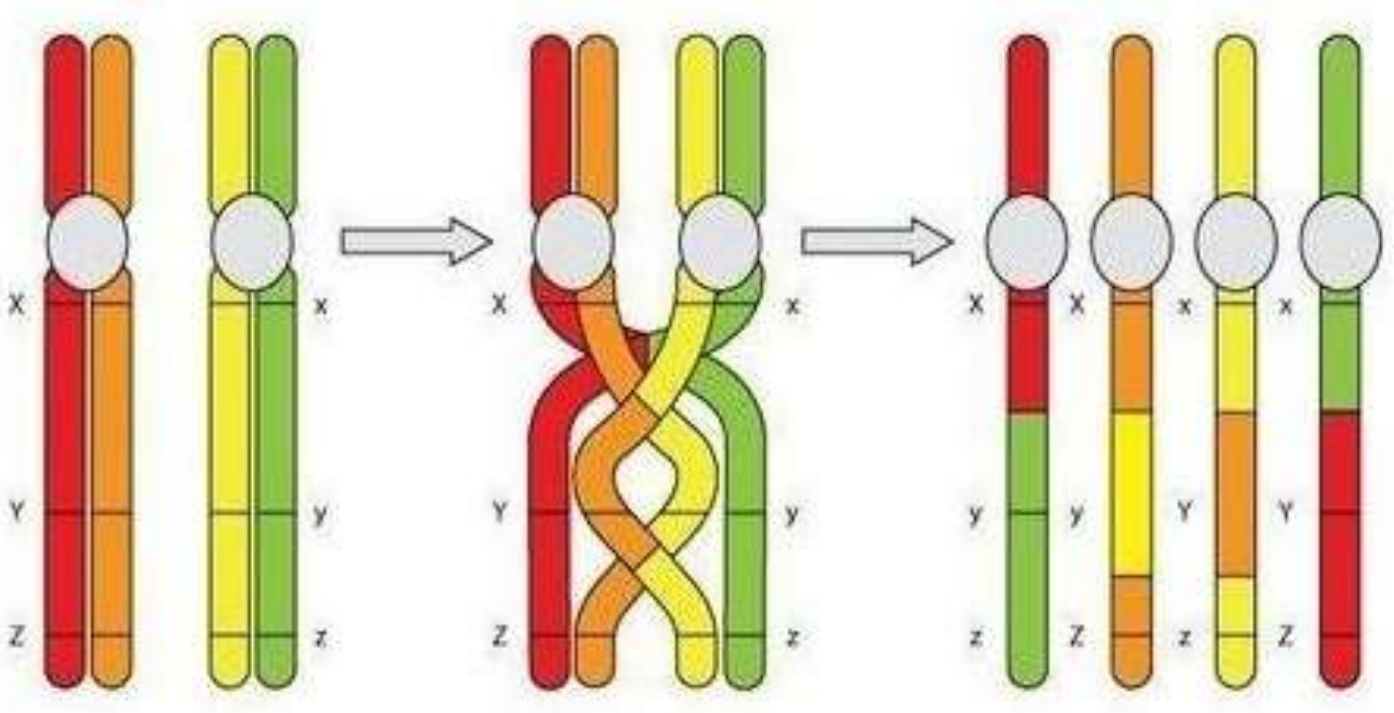
SUMMARY		
Property	**Mitosis**	**Meiosis**
DNA replication	Occurs during interphase before mitosis begins	Occurs during interphase before meiosis I begins
Number of divisions	One, including prophase, metaphase, anaphase, and telophase	Two, each including prophase, metaphase, anaphase, and telophase
Synapsis 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

Genetic variation in meiosis

1. **During Prophase I**: Crossing over
Between homologous chromosomes, result
in exchanging genetic materials.

2. **During Metaphase I**: Independent assortment
of homologous chromosomes(segregation of alleles in different gametes independently of each others) due to random distribution of parents chromosomes
at the equator

Crossing over



Independent assortment