

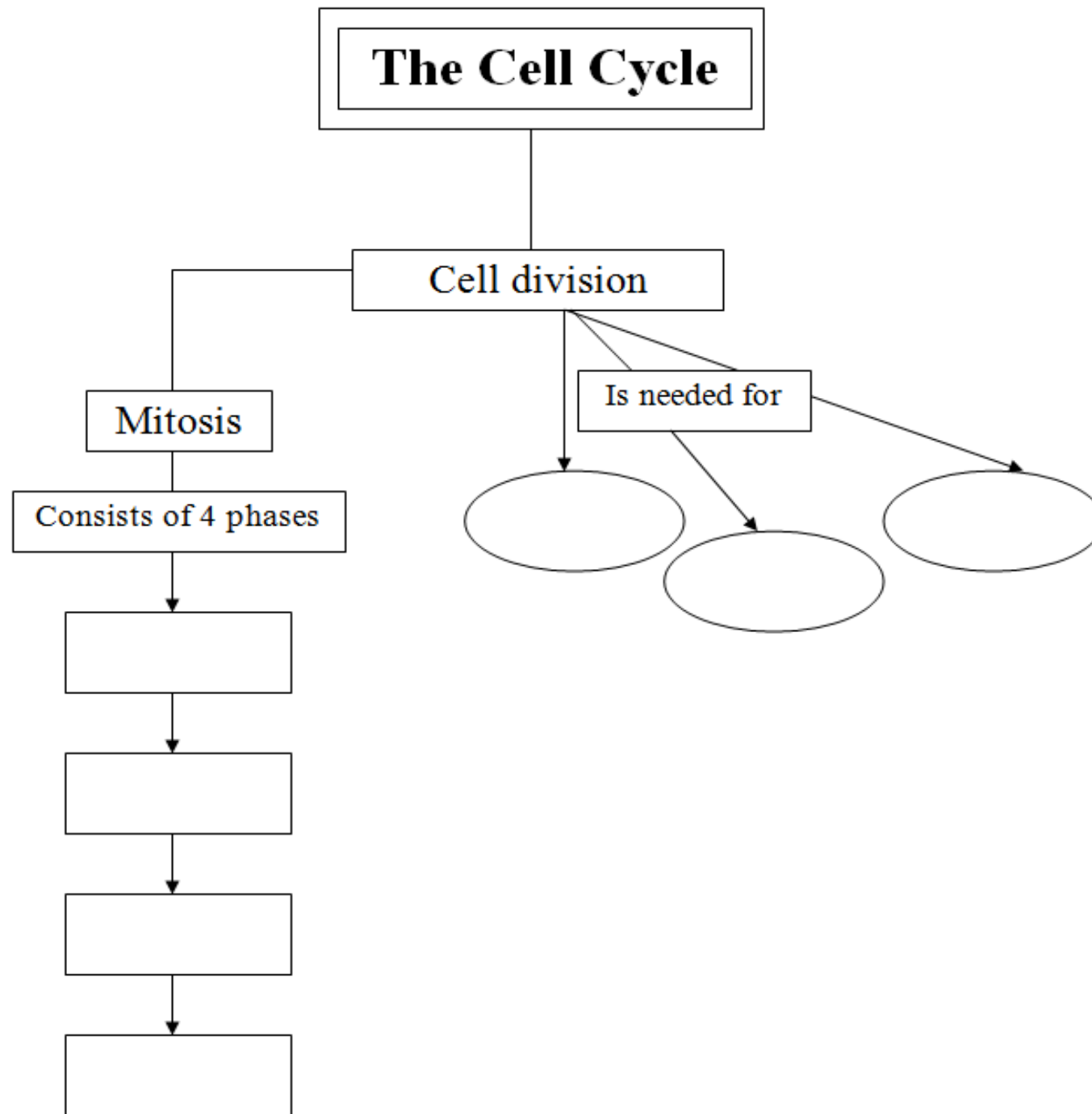
Lesson 1

Quiz (short)

Cell cycle

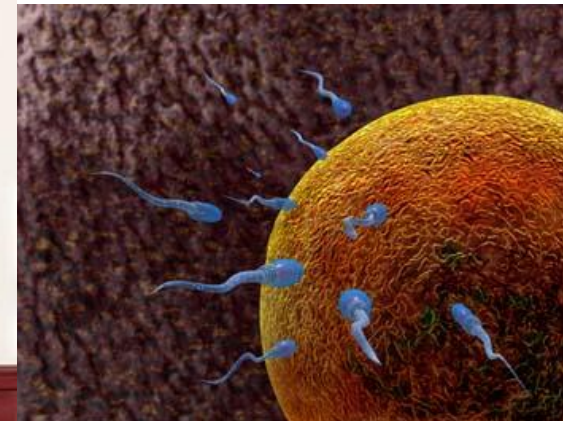
Chromosomes

Mitosis phases



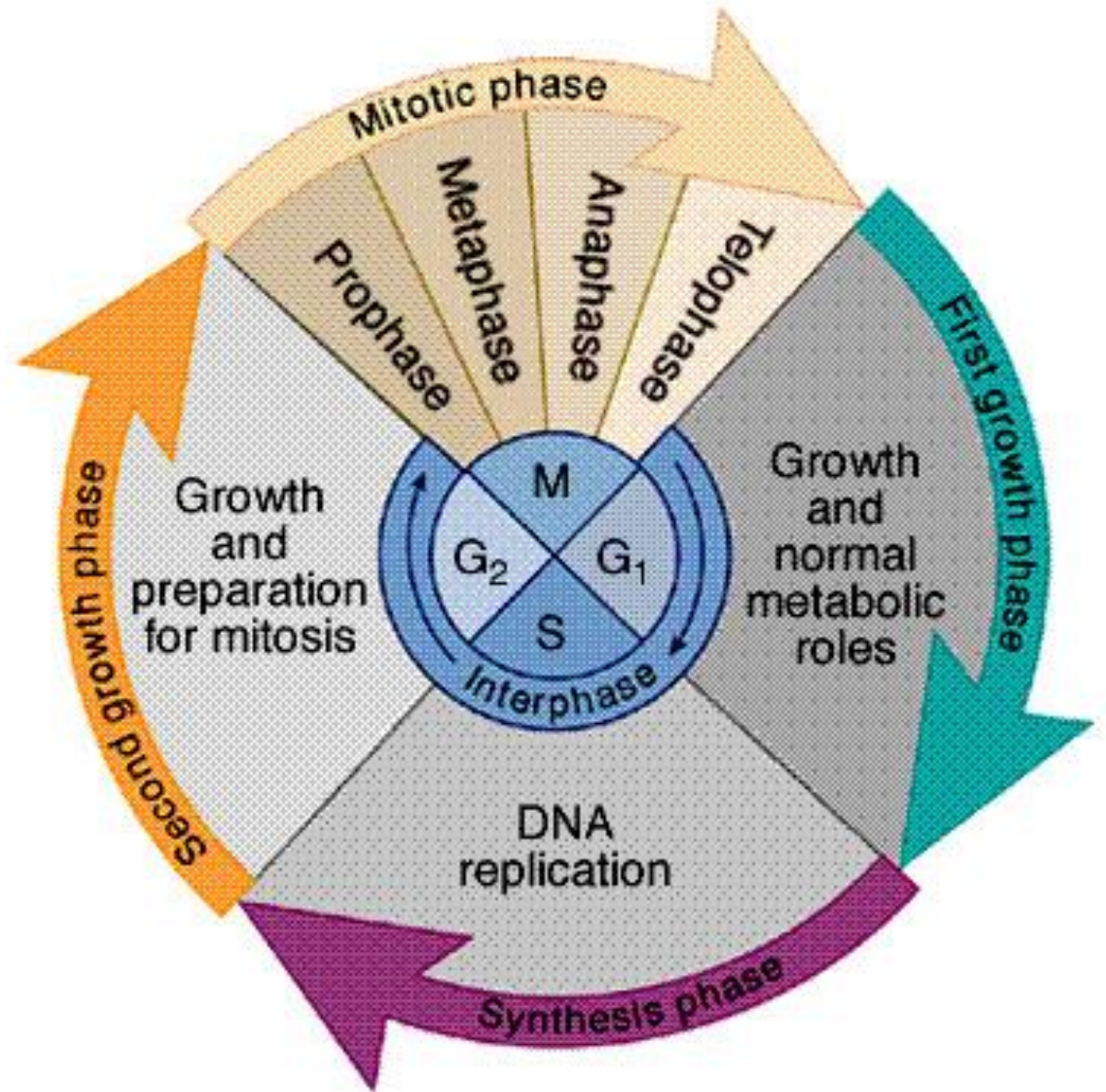
Cell division is needed for...

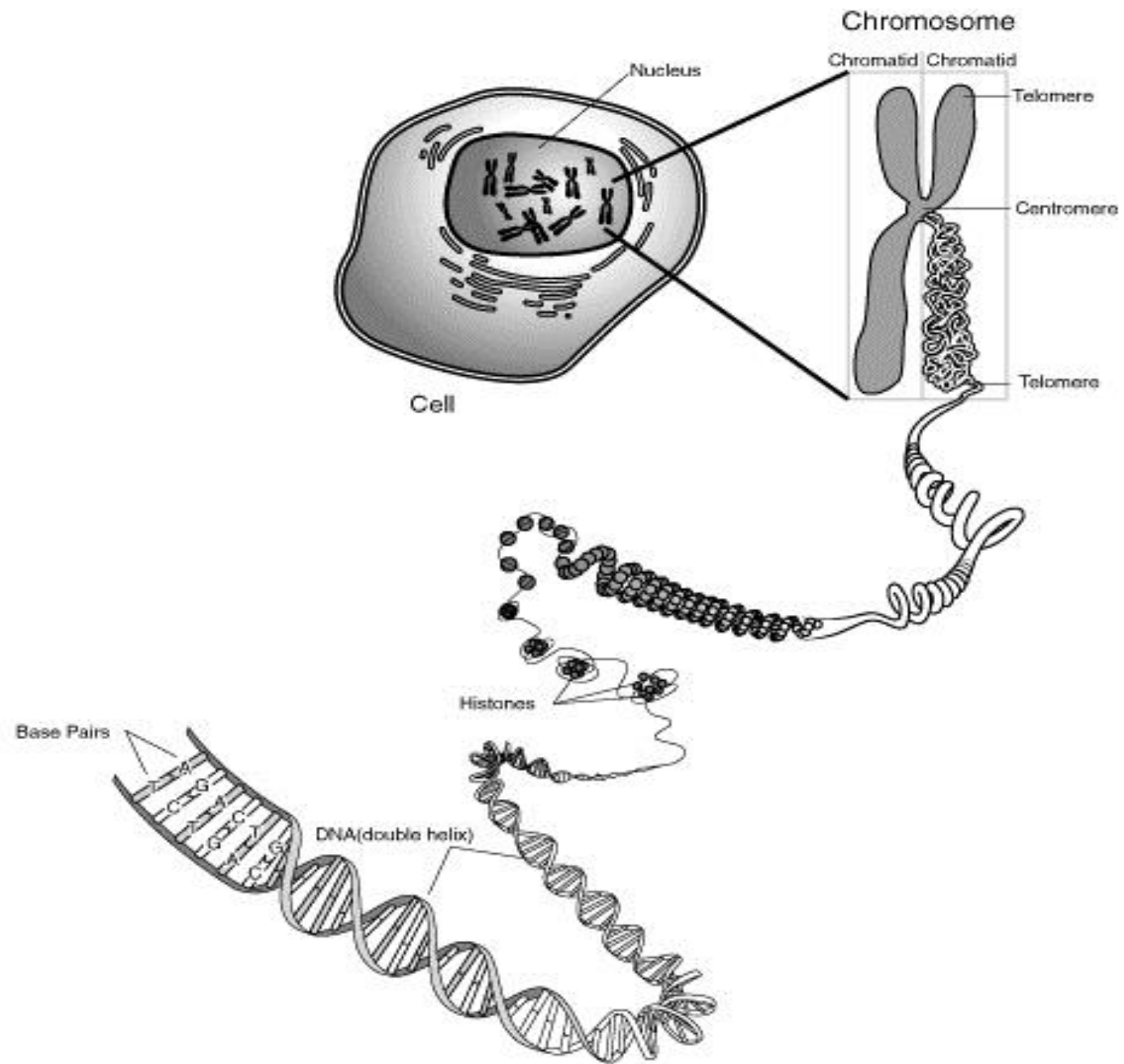
- Growth (Mitosis)
- Repair (Mitosis)
- Reproduction (Meiosis)



Mitosis consists of 4 phases (division of the nuclear DNA):

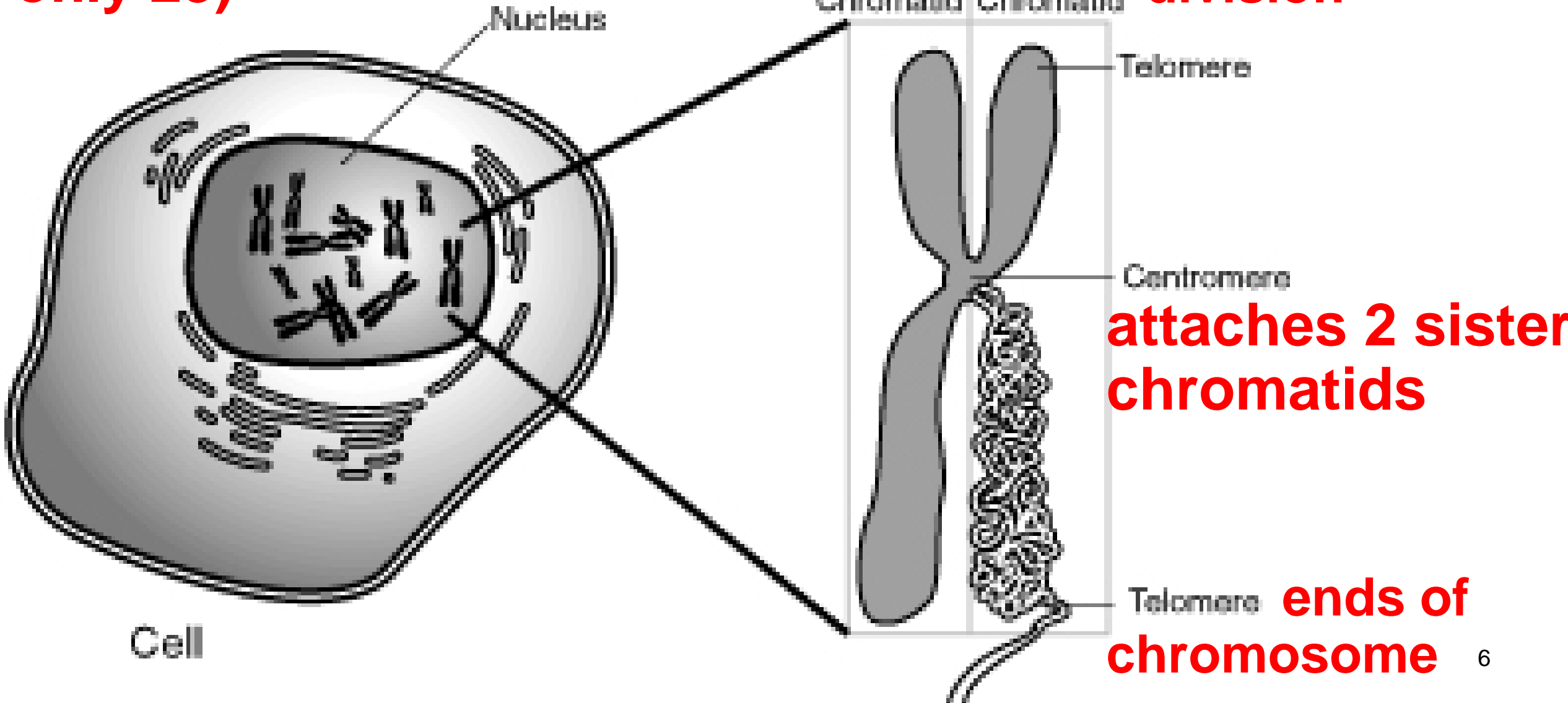
- Prophase
- Metaphase
- Anaphase
- Telophase

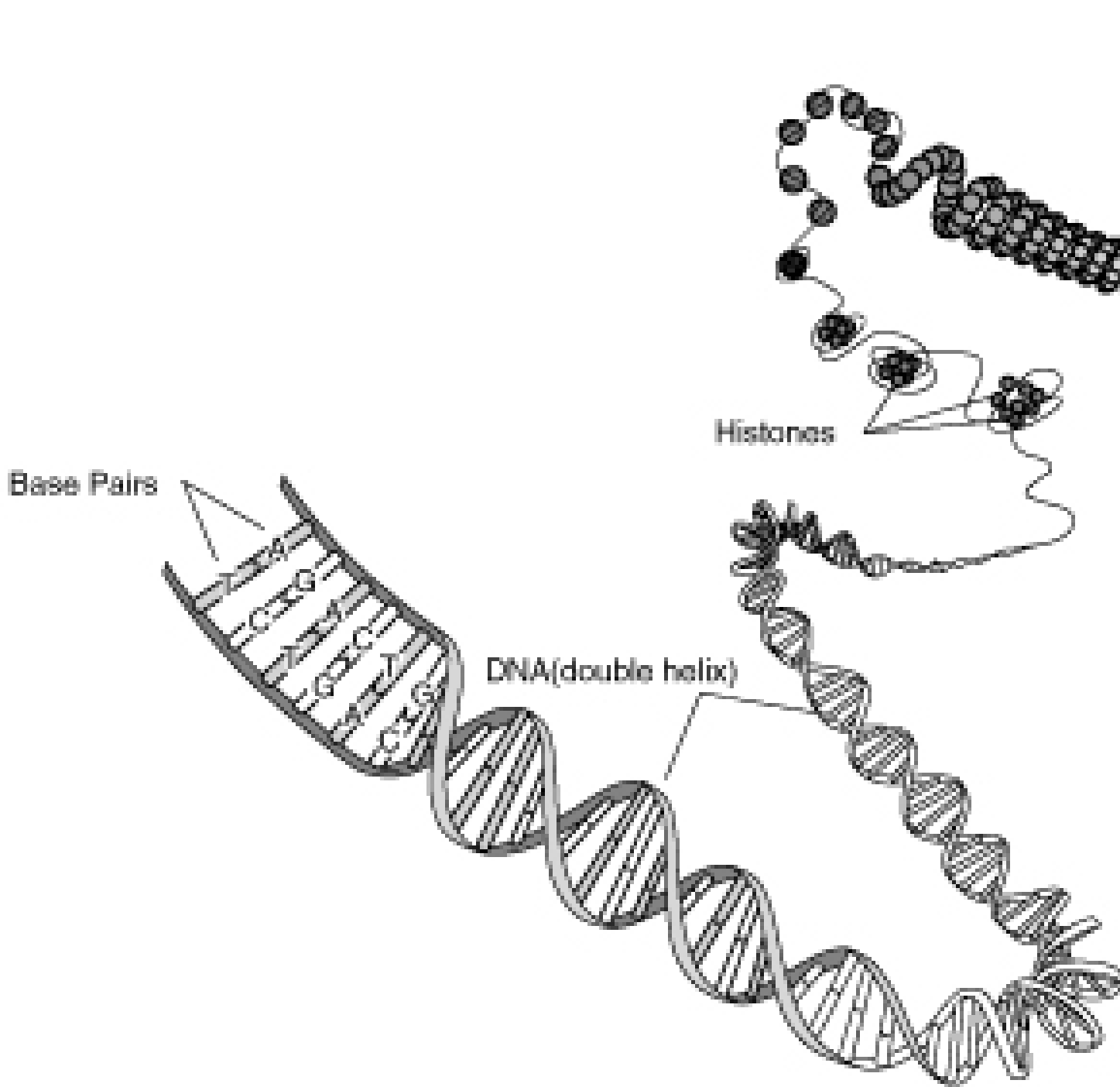




**A human cell nucleus contains
46 chromosomes (gametes
only 23)**

**double stranded
is ready for
division**

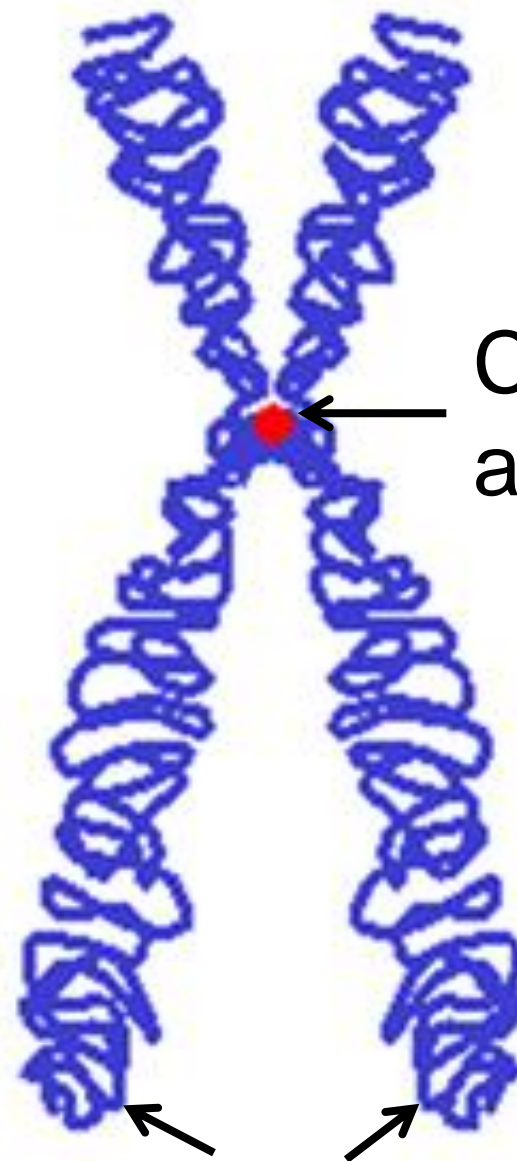




Chromosome

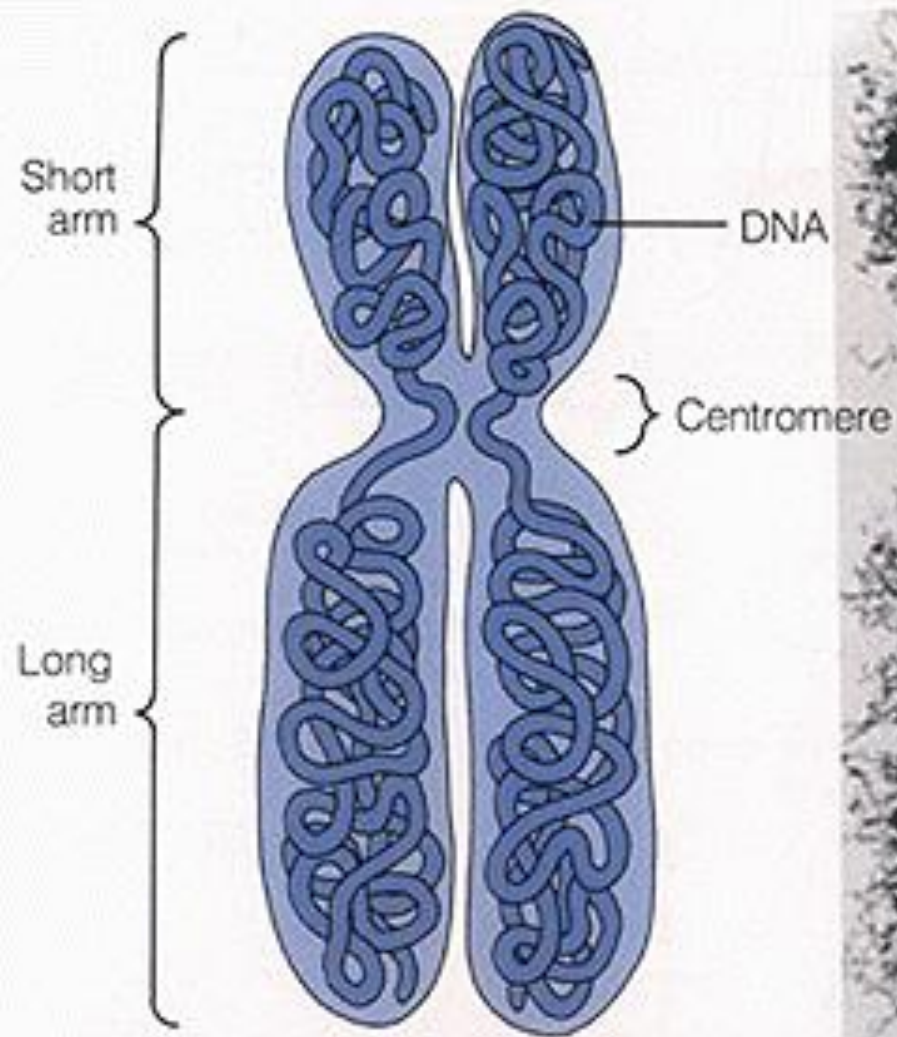
- long tightly coiled DNA molecule
- replicates before cell division

Chromosome Structure



Centromere
attaches 2 chromatids

Identical Sister Chromatids



(a)

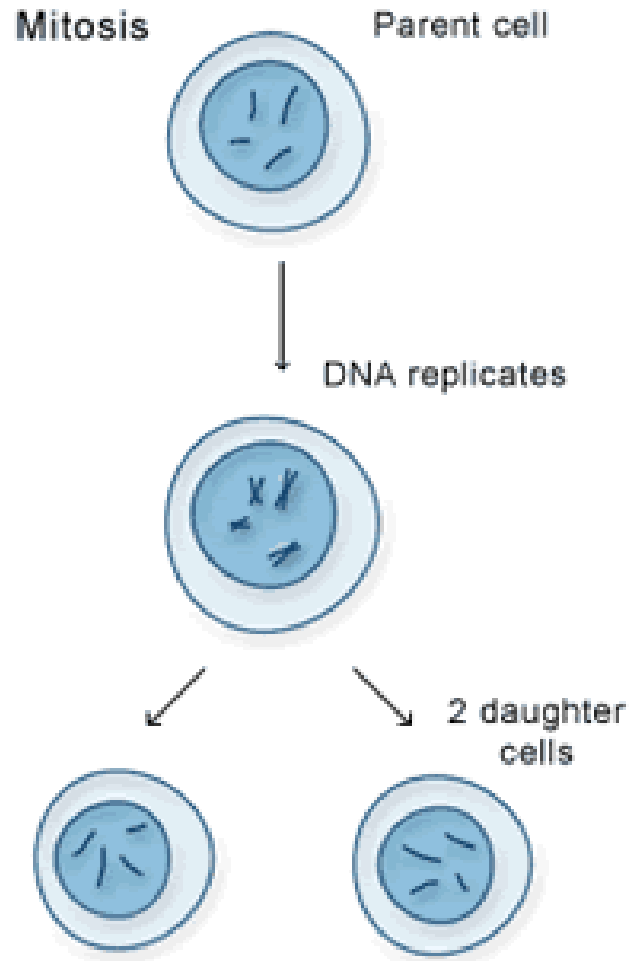
Two chromatids



(b)

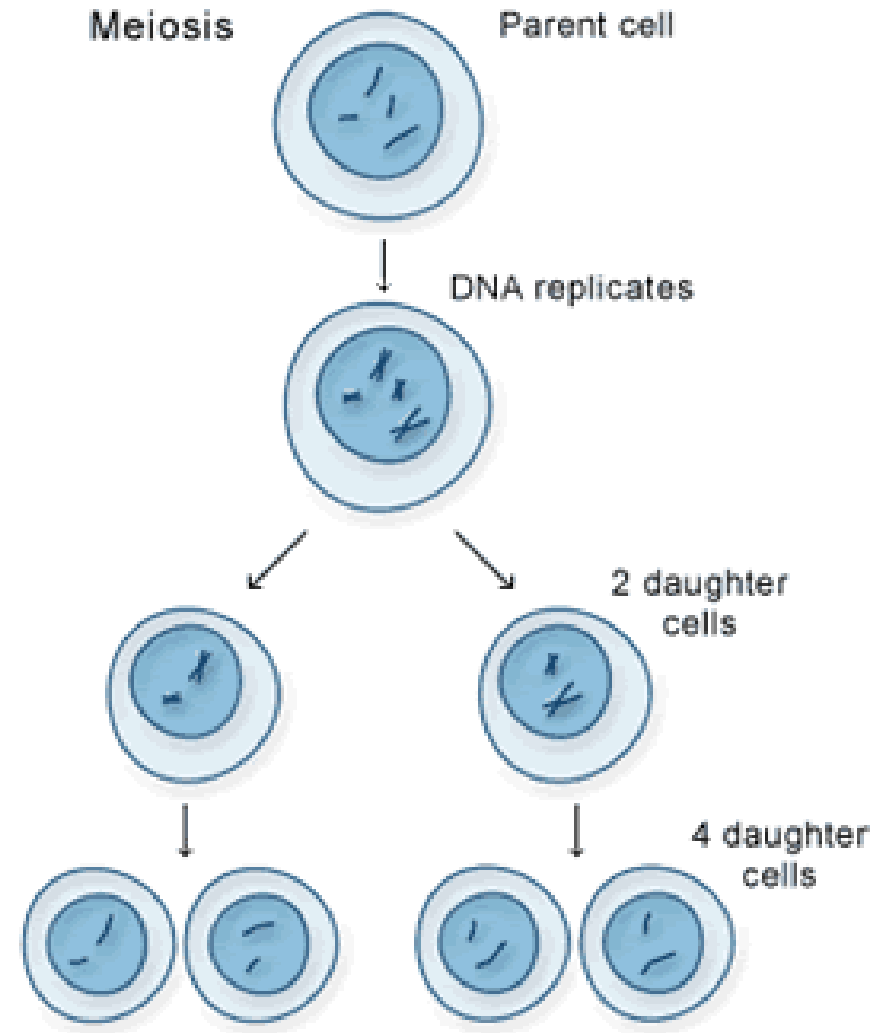
Cells can divide in two different ways...

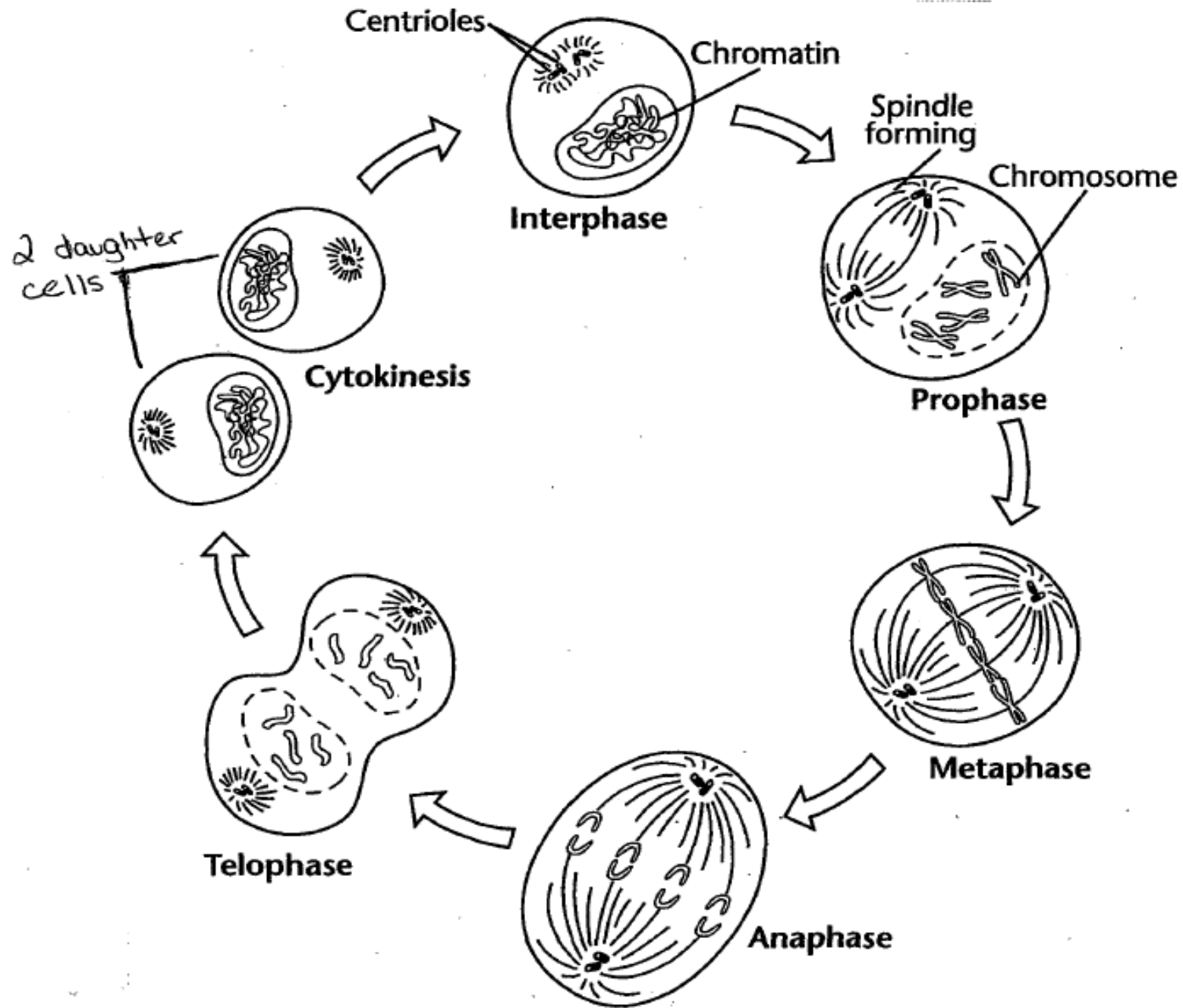
MITOSIS

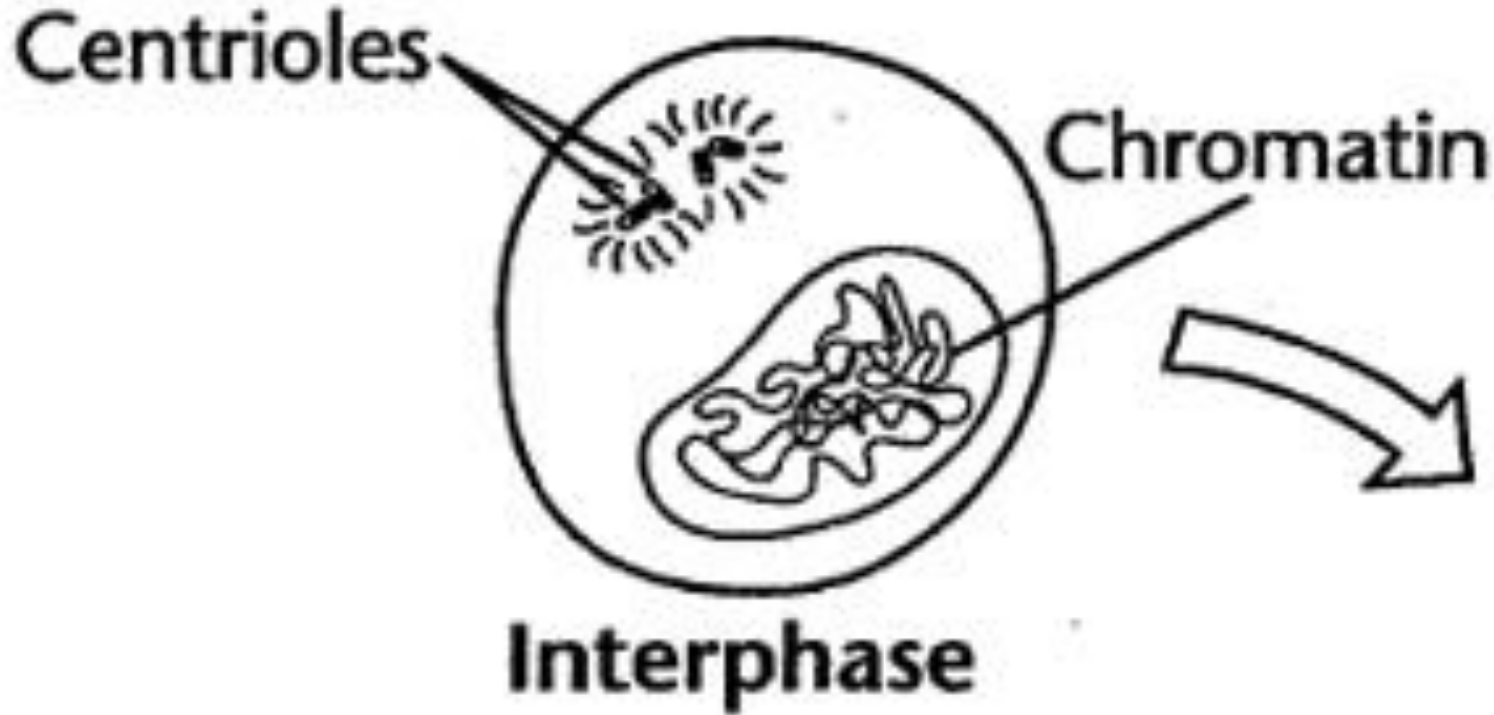


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MEIOSIS



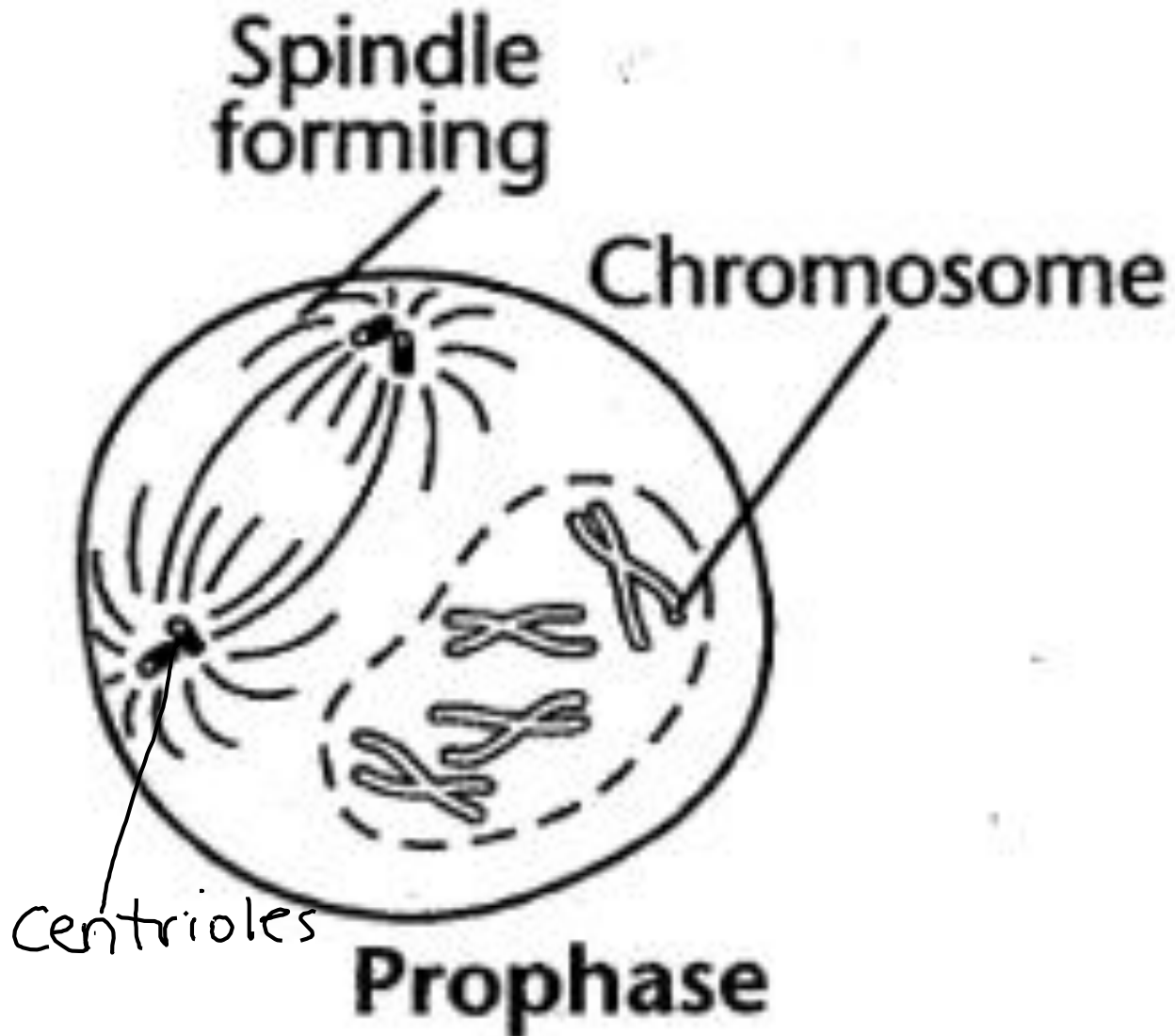




G1, S, G2 phases
NOT part of mitosis

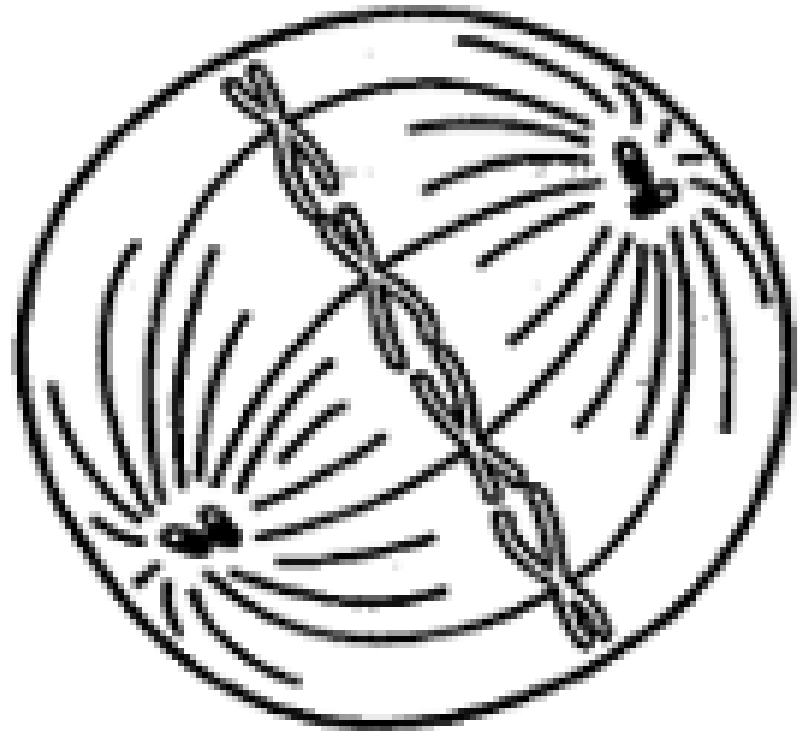
INTERPHASE

- growth
- normal cell functions
- chromosomes replicate to prepare for cell division (are spread out in nucleus as chromatin)



PROPHASE

- spindle fibers form
- centrioles begin to migrate / move to opposite poles (ends)
- nuclear membrane & nucleolus break down (degenerate)
- chromosomes condense / coil (become visible)



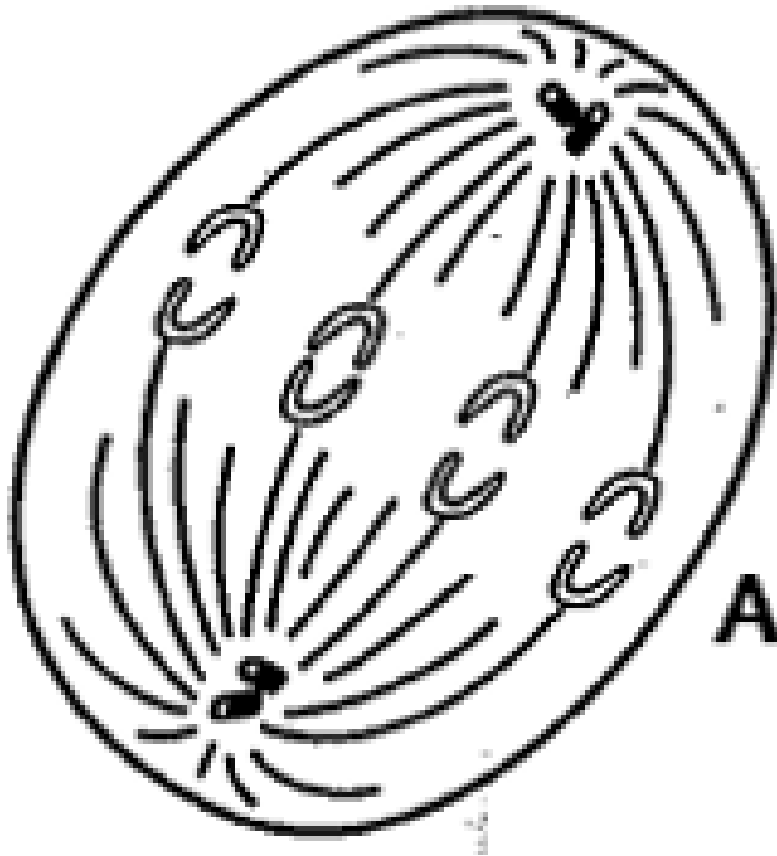
Metaphase

METAPHASE

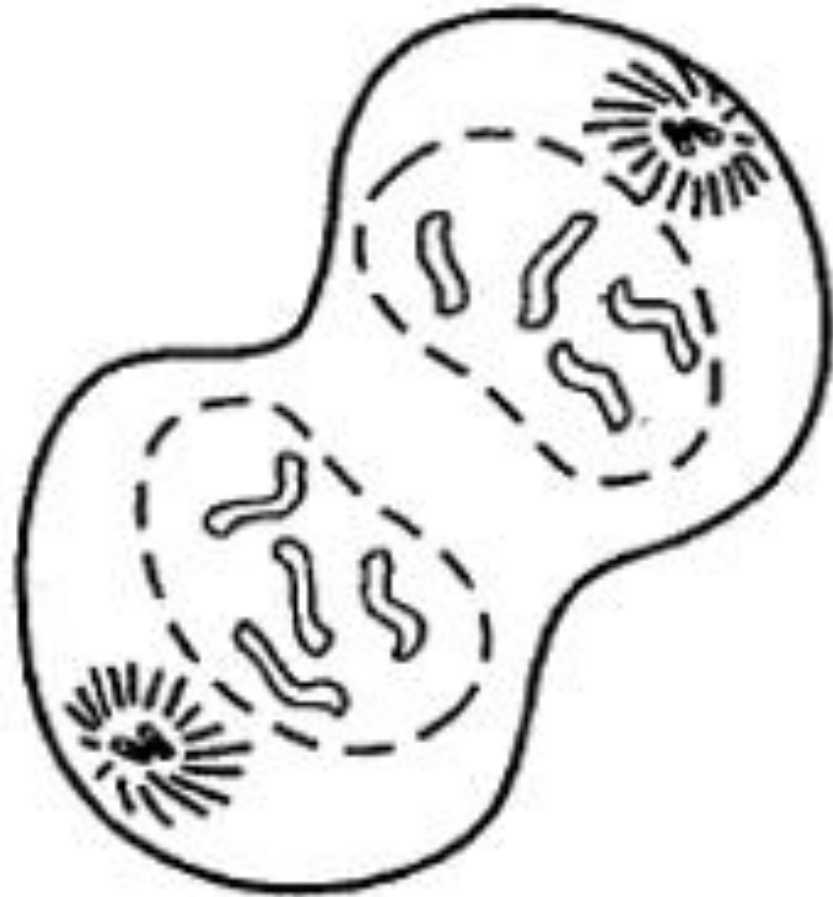
- spindle fibers **attach** at each centromere
- Alignment of chromosomes on **equatorial plane** (middle)

ANAPHASE

- chromatids are pulled apart by spindle fibers (Disjunction)
- 1 from each pair moves to opposite poles



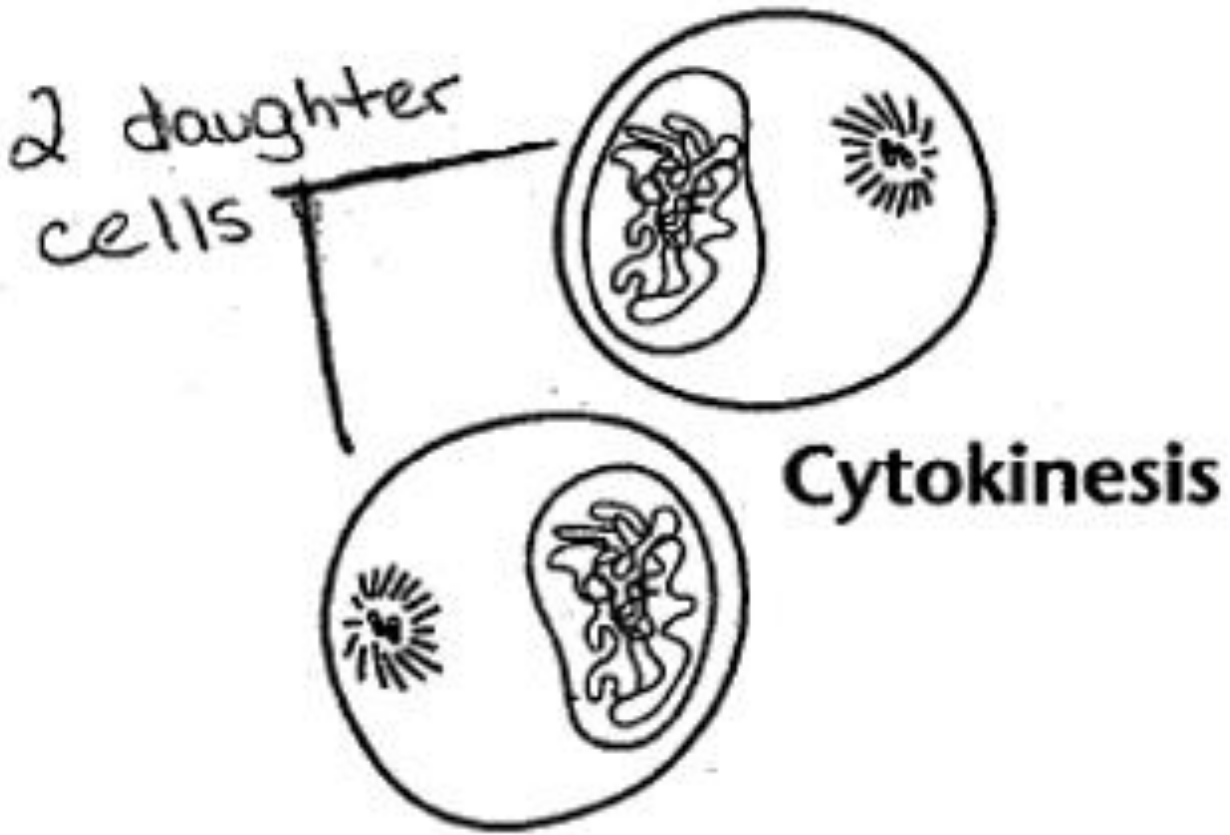
Anaphase



Telophase

TELOPHASE

- nuclear membranes reform
- 2 separate but identical nuclei
- each has a full set of single stranded chromosomes
- Mitosis is complete

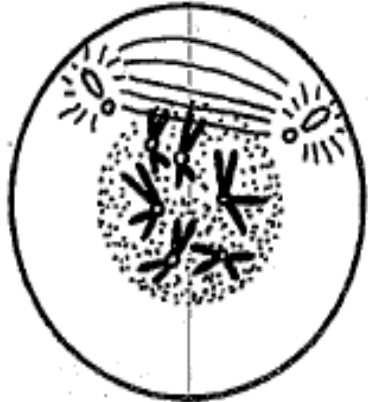


CYTOKINESIS

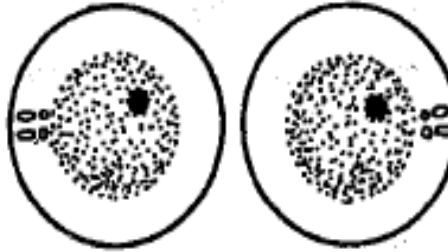
- Division of cytoplasm and other organelles
- Forms 2 identical daughter cells

Mitosis in Animal Cells

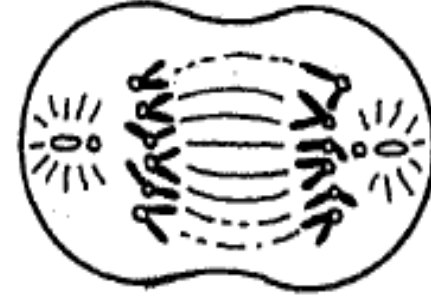
Label each stage with the proper name.



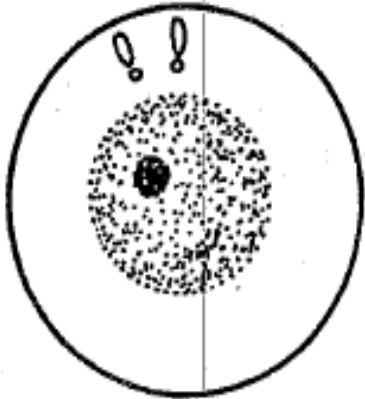
Prophase



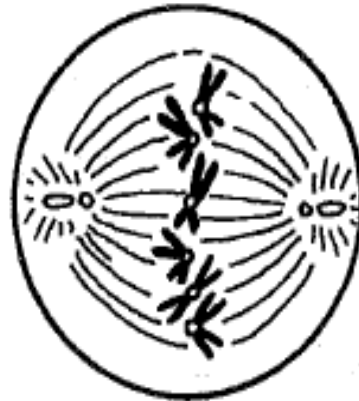
2 daughter cells



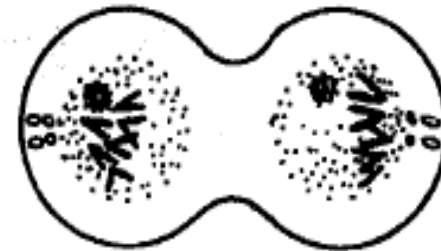
Anaphase



Interphase



Metaphase

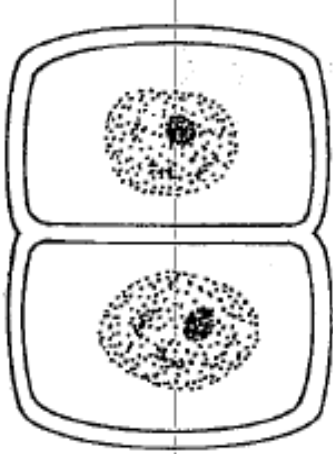


Telophase

**NOTE: NO
CENTRIOLES IN
PLANT CELLS**

Mitosis in Plant Cells

Label each stage with the proper name.



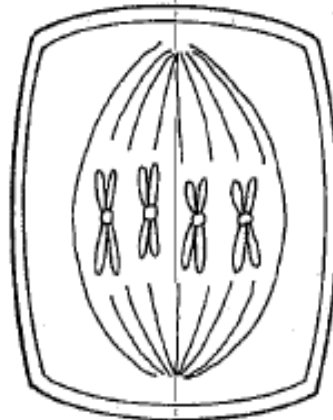
2 daughter cells



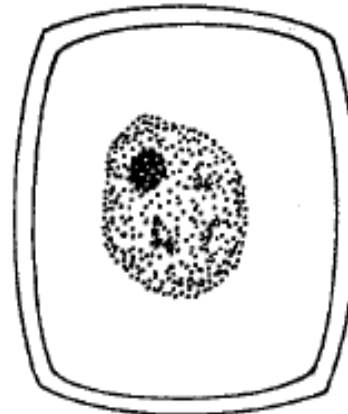
Prophase



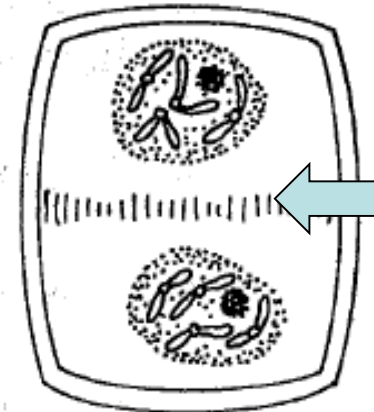
Anaphase



Metaphase

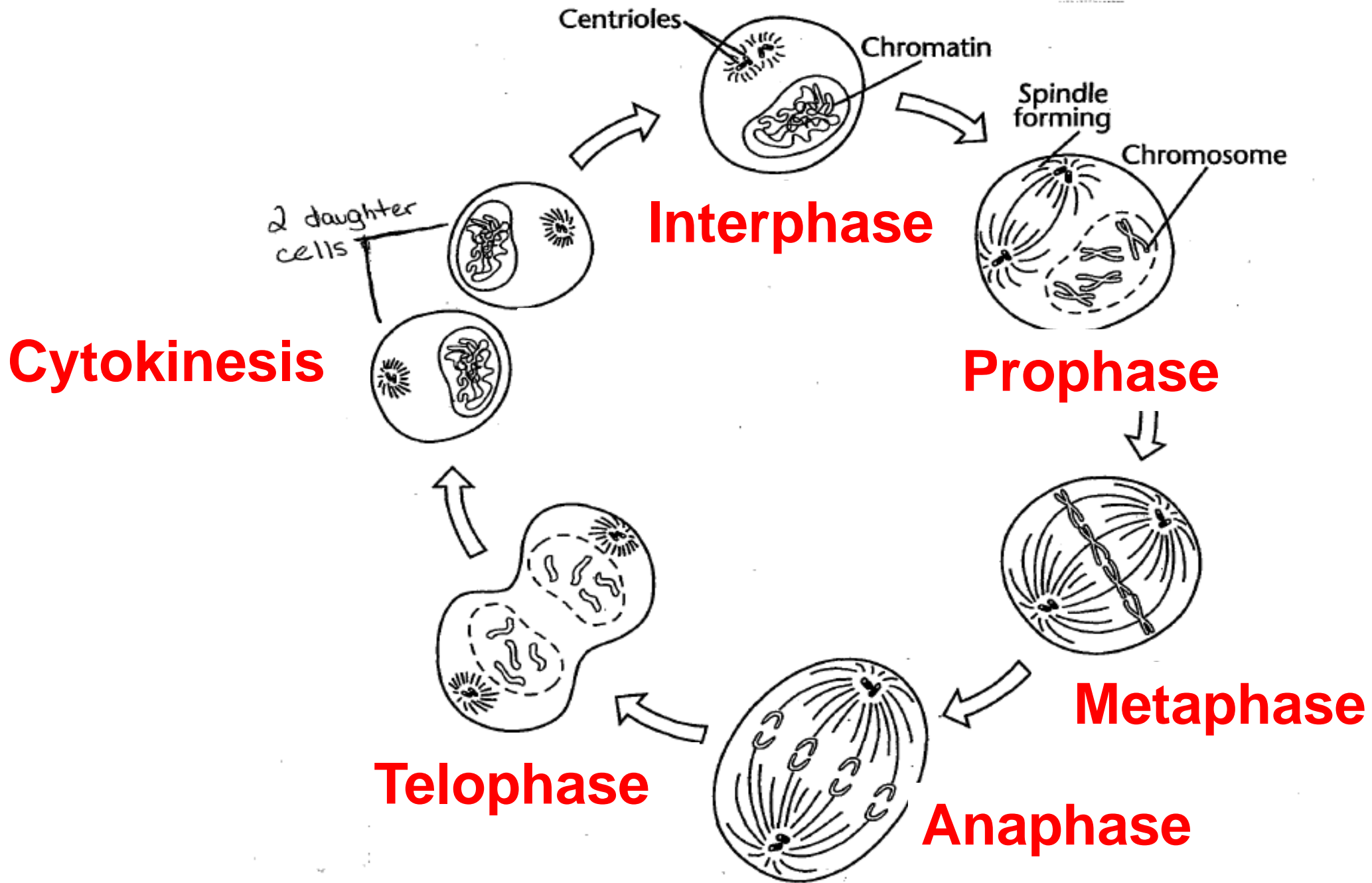


Interphase



Telophase

**Cell plate
forms to
become
cell wall**

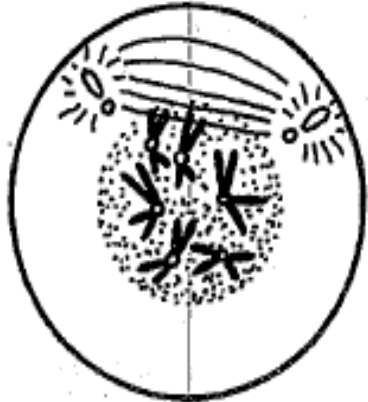


Lesson 2

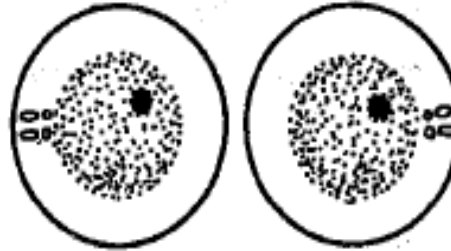
Meiosis differences from Mitosis

Mitosis in Animal Cells

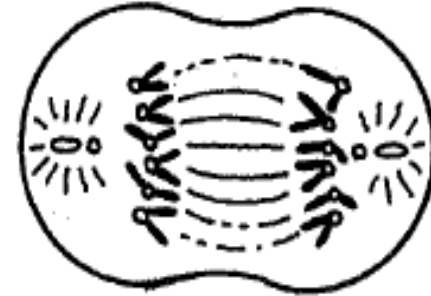
Label each stage with the proper name.



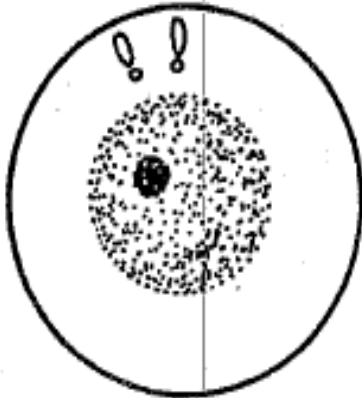
Prophase



2 daughter cells



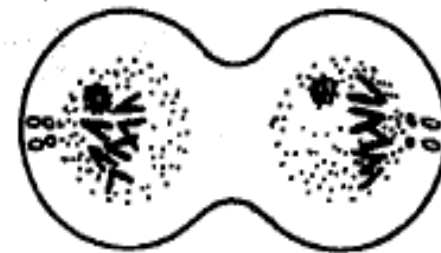
Anaphase



Interphase



Metaphase

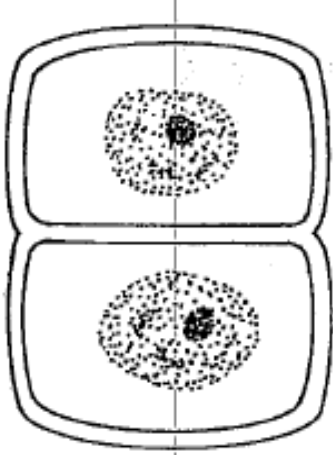


Telophase

**NOTE: NO
CENTRIOLES IN
PLANT CELLS**

Mitosis in Plant Cells

Label each stage with the proper name.



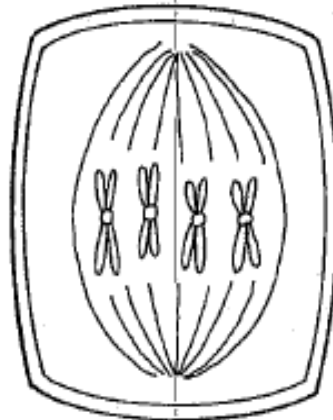
2 daughter cells



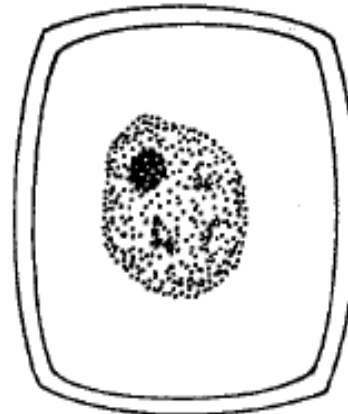
Prophase



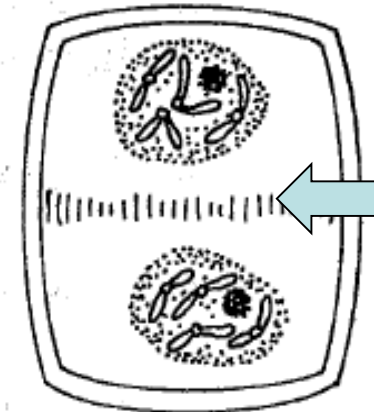
Anaphase



Metaphase

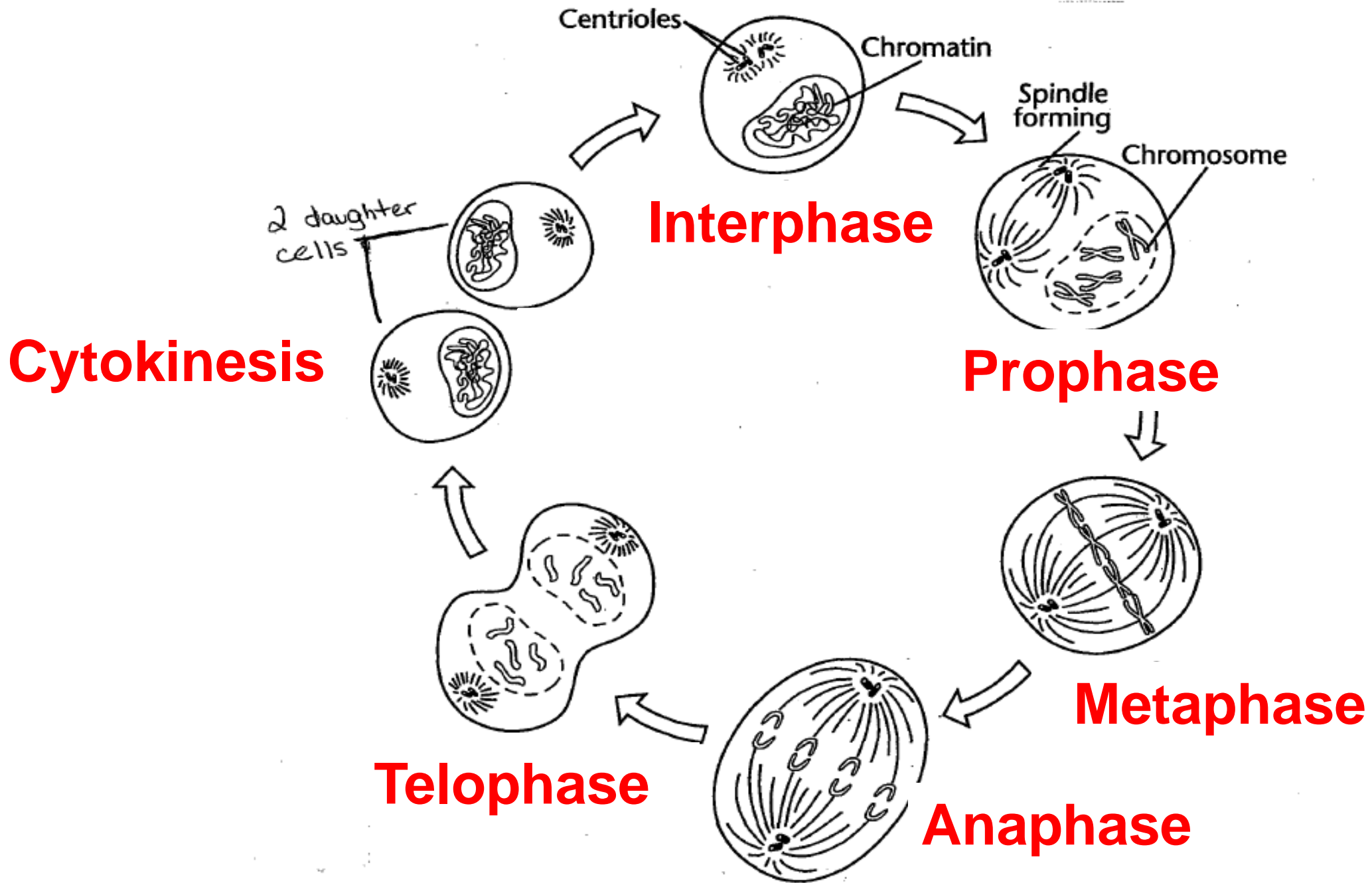


Interphase



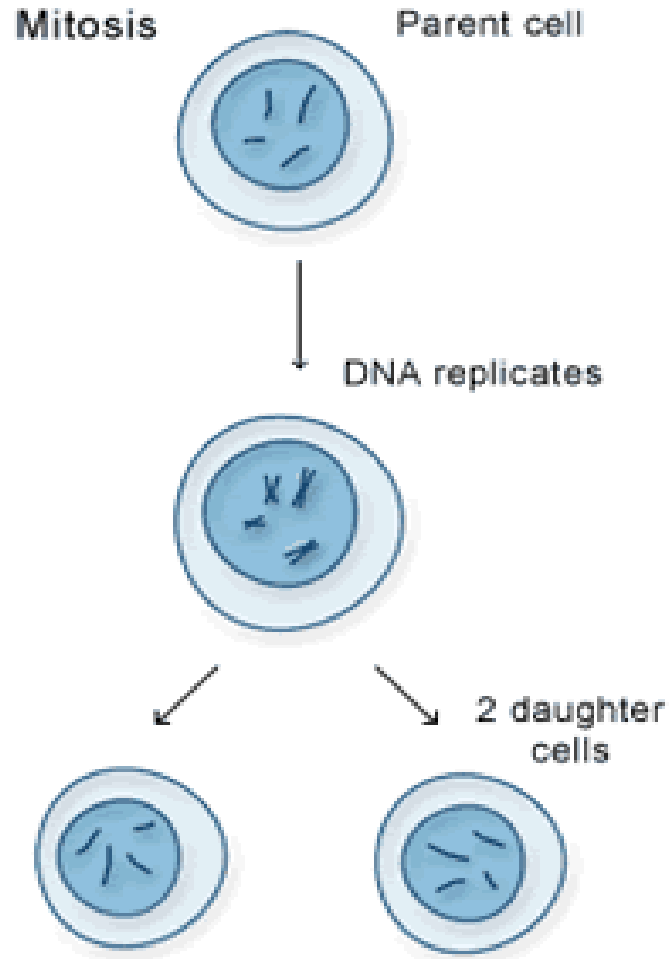
Telophase

Cell plate
forms to
become
cell wall



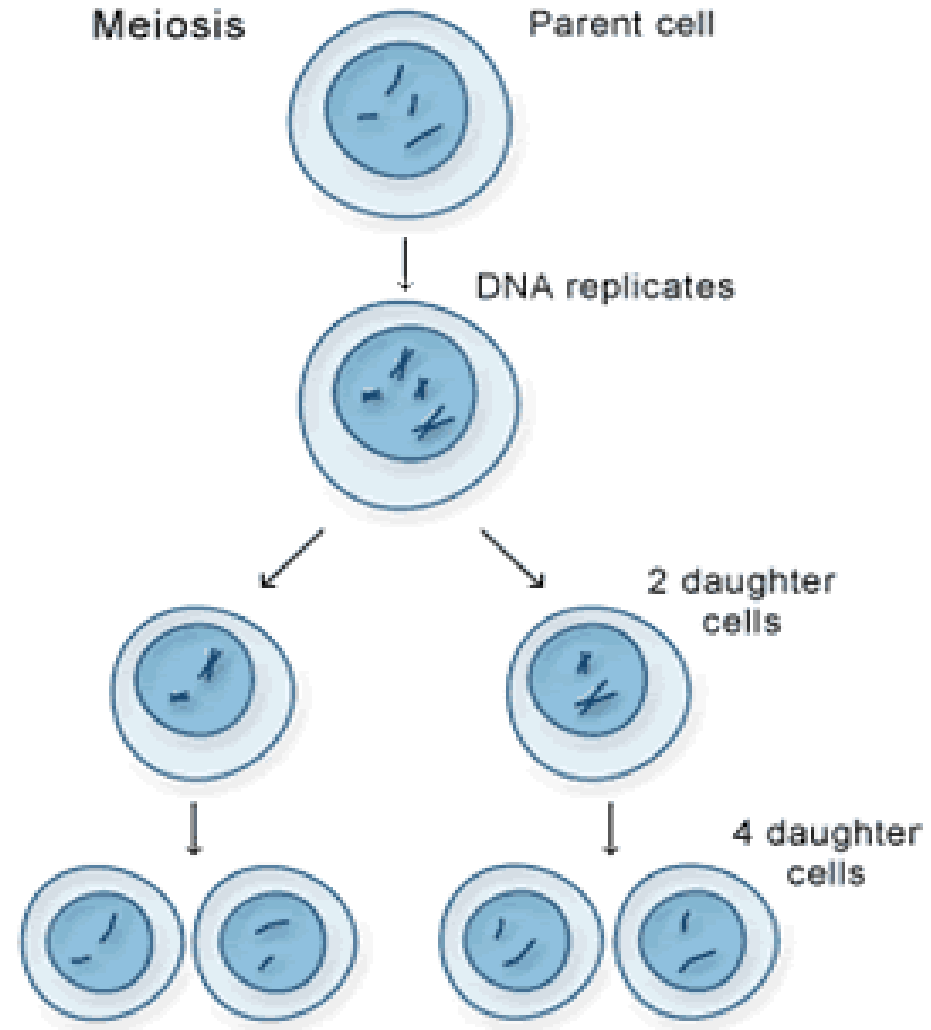
Cells can divide in two different ways...

MITOSIS



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MEIOSIS



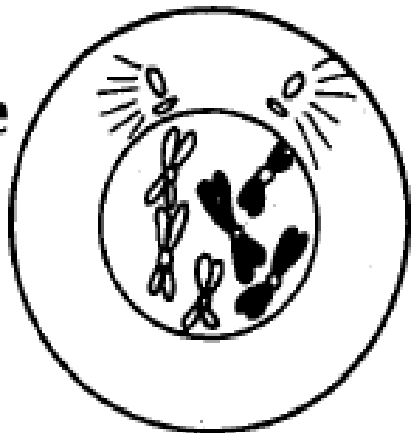
Organism	Diploid chromosome # (2n) in body cells	Haploid chromosome # (n) in gametes
Human *(memorize)	46	23
Goat	60	30
Guinea pig	64	32
Bat	44	22
Squirrel	40	20
Alligator	32	16
Chicken	78	39
King crab	208	104
Fruit fly	8	4
Pea	14	7
Apple	34	17
Potato	48	24
Soybean	40	20
Lettuce	18	9
Rice	24	12
Leopard Frog	26	13

Meiosis I

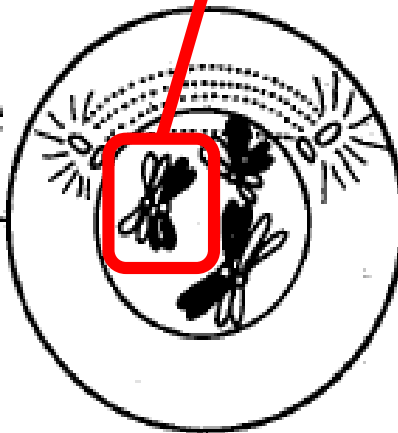
Synapsis – pairing of homologous chromosomes

Diploid #
(2n) = 6

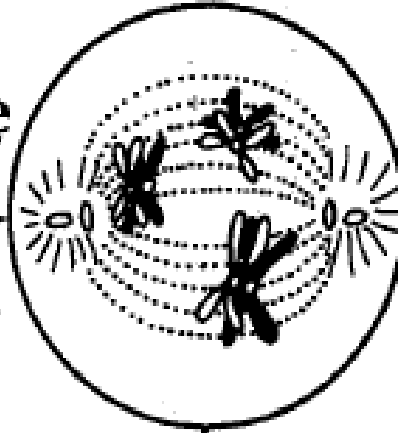
Early Prophase



Mid-prophase

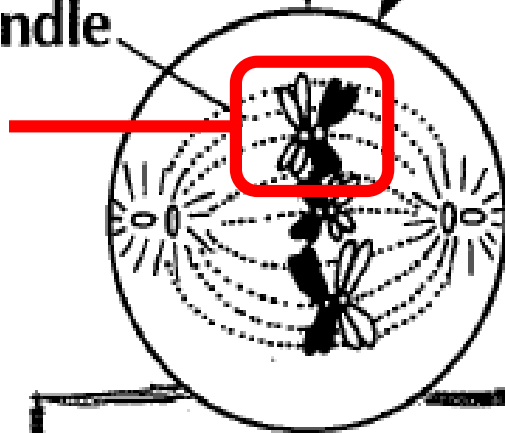


Late Prophase



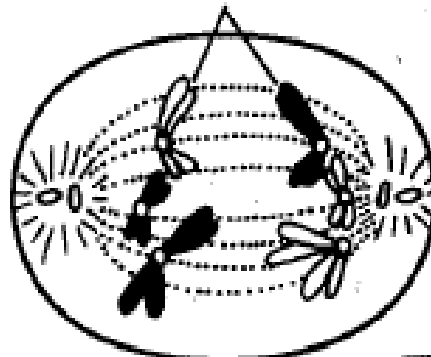
equator
spindle

Line up
as
tetrads



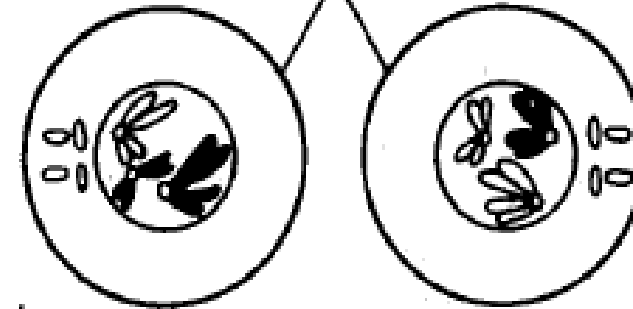
Metaphase I

homologous chromosomes



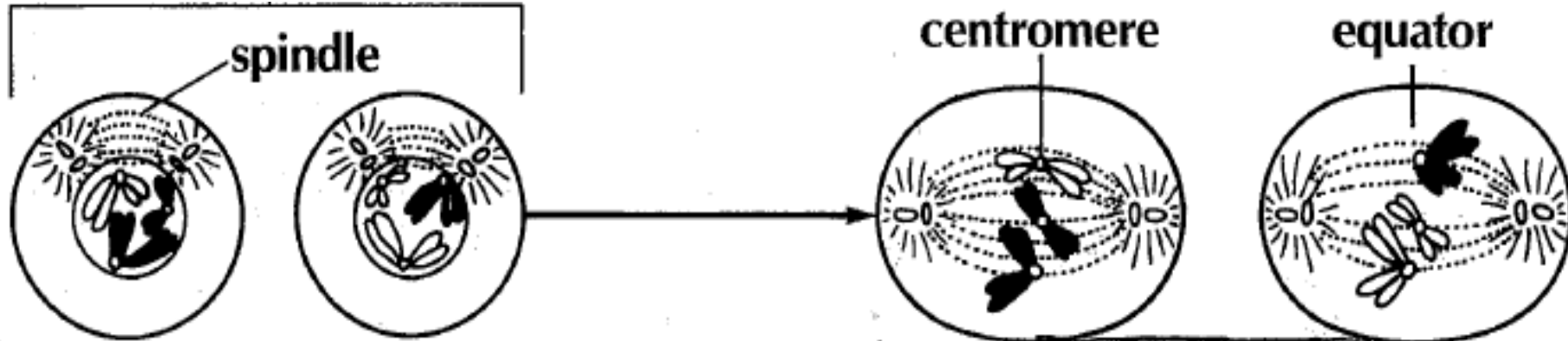
Anaphase I

daughter cells



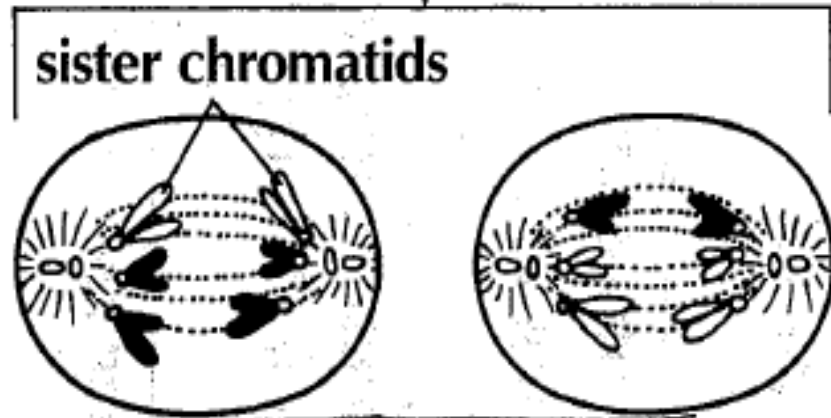
Telophase

Meiosis II (same as Mitosis)



Prophase

Metaphase II



Anaphase II

4 daughter cells Haploid #
(n) = 3
(single stranded chromosomes)
Telophase

	Mitosis	Meiosis
In what types of cells does it occur?	Body Cells (Somatic Cells)	Cells in Gonads that make Gametes
What type of reproduction is this process involved in?	Asexual	Sexual
How many divisions occur?	One (PMAT 1x)	Two (PMAT 2x)
Number of daughter cells produced?	2 daughter cells	4 daughter cells
Chromosome number of daughter cells produced?	Diploid # (2n) = 46	Haploid # (n) = 23
Genetic comparison with the original cell?	Identical	Varied
Does crossing over occur?	No	Yes

Comparison of Mitosis and Meiosis

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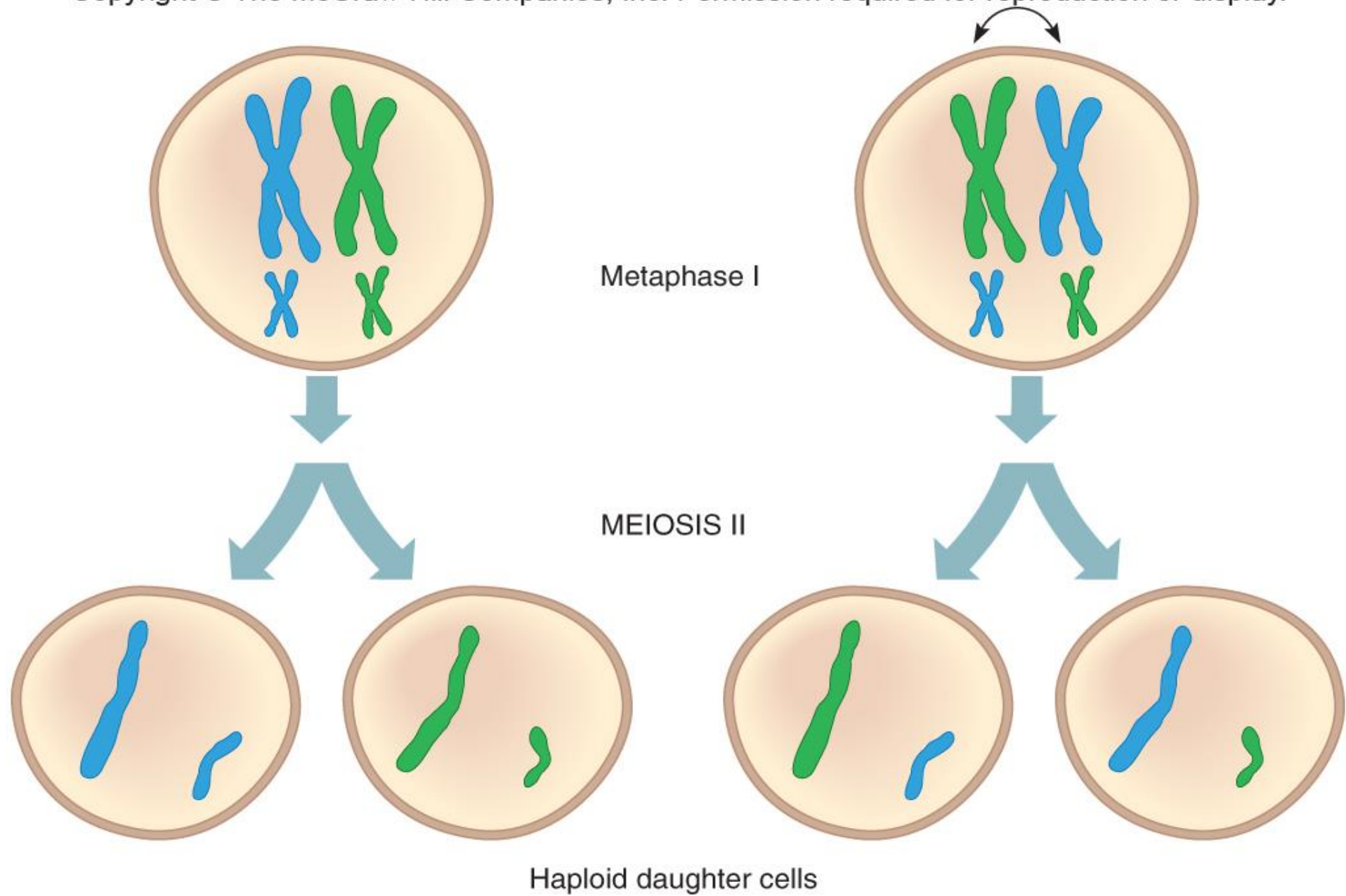
Table 3.1

Comparison of Mitosis and Meiosis

Mitosis	Meiosis
One division	Two divisions
Two daughter cells per cycle	Four daughter cells per cycle
Daughter cells genetically identical	Daughter cells genetically different
Chromosome number of daughter cells same as that of parent cell ($2n$)	Chromosome number of daughter cells half that of parent cell ($1n$)
Occurs in somatic cells	Occurs in germline cells
Occurs throughout life cycle	In humans, completes after sexual maturity
Used for growth, repair, and asexual reproduction	Used for sexual reproduction, producing new gene combinations

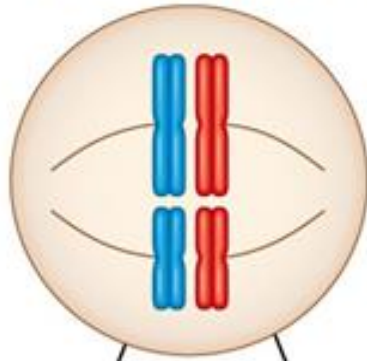
Meiosis

- Cell division that produces **gametes** with half the number of chromosomes
- Occurs in **germline** cells found in the **gonads**
- Maintains the chromosome number of a species over generations via fertilization
- Ensures genetic variability via the processes of **independent assortment** and **crossing over** of chromosomes

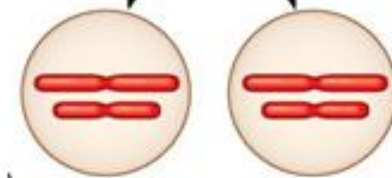
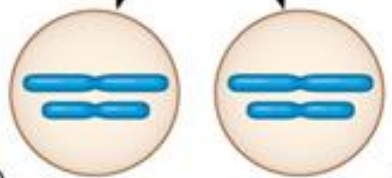
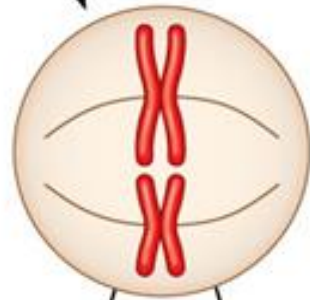
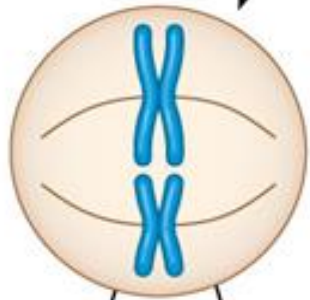


Independent Assortment

Possibility 1

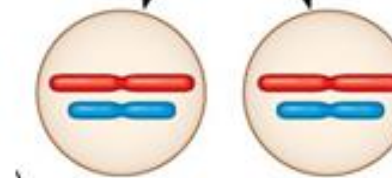
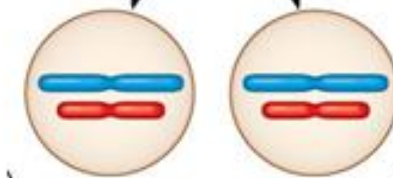
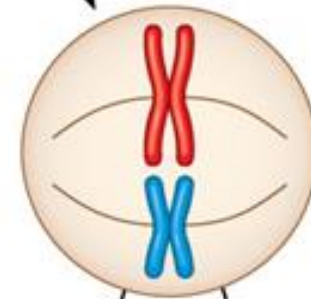
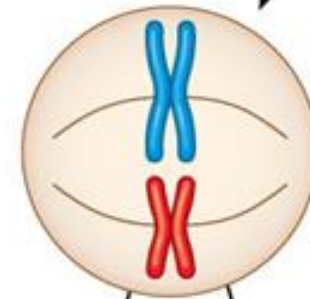
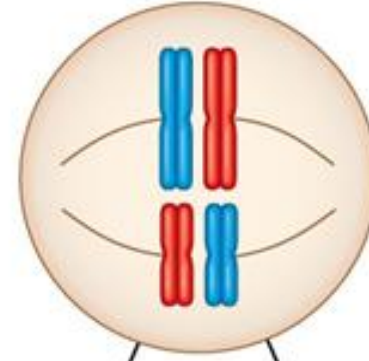


Two equally probable arrangements of chromosomes at metaphase I



Combination 1 Combination 2

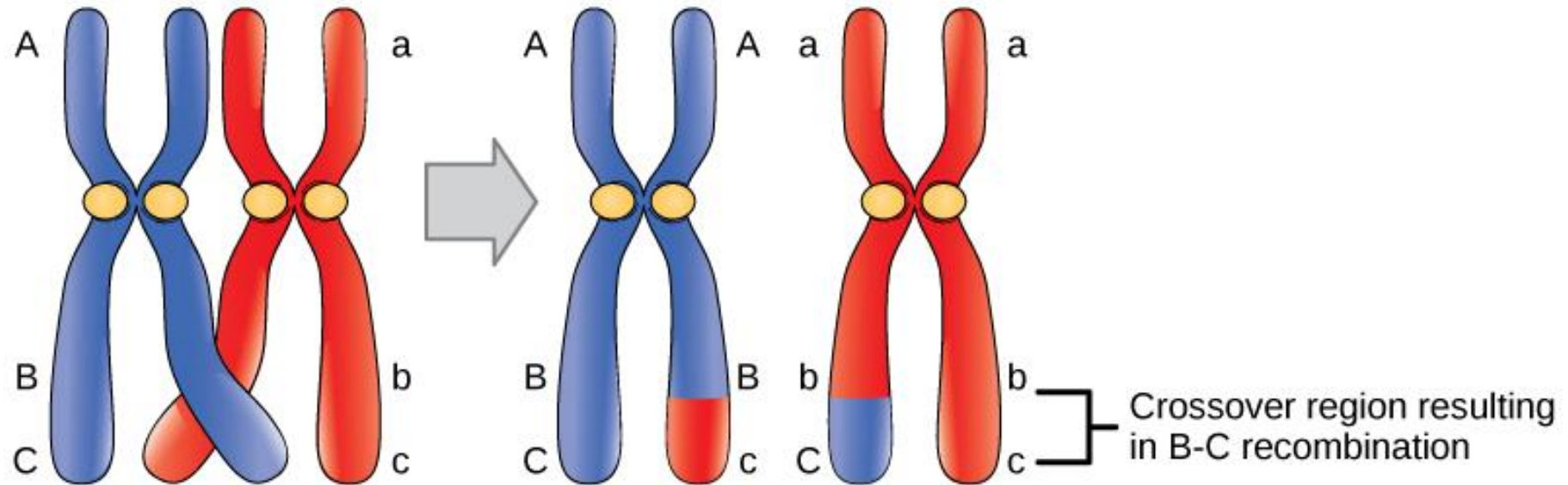
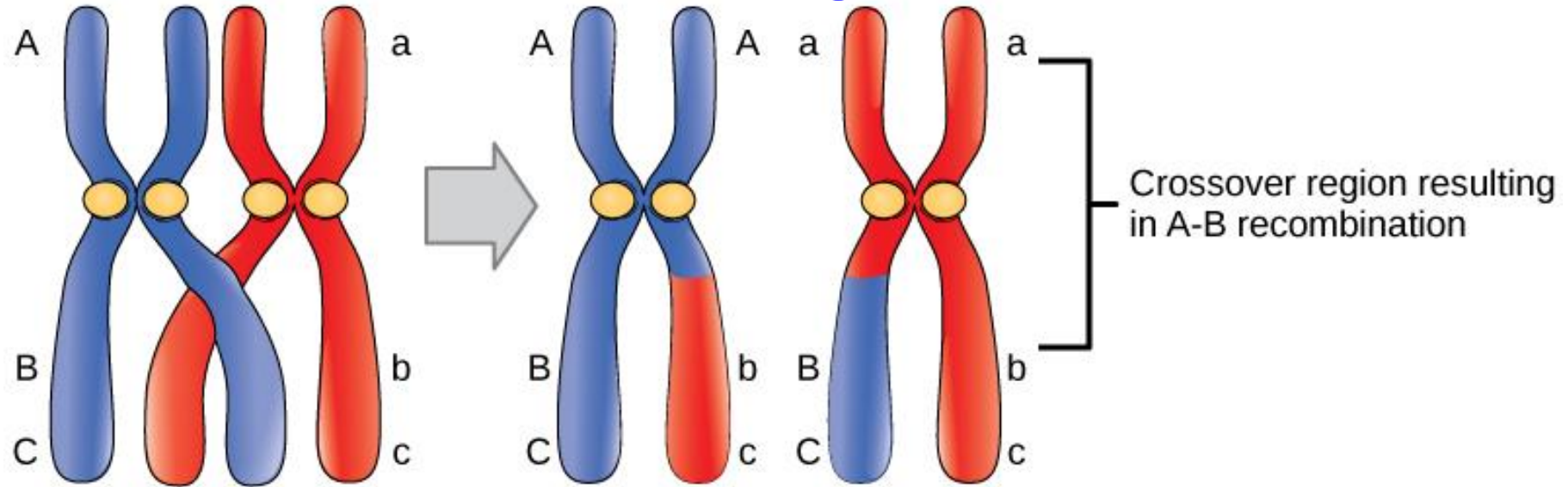
Possibility 2



Daughter cells

Combination 3 Combination 4

Crossing-over



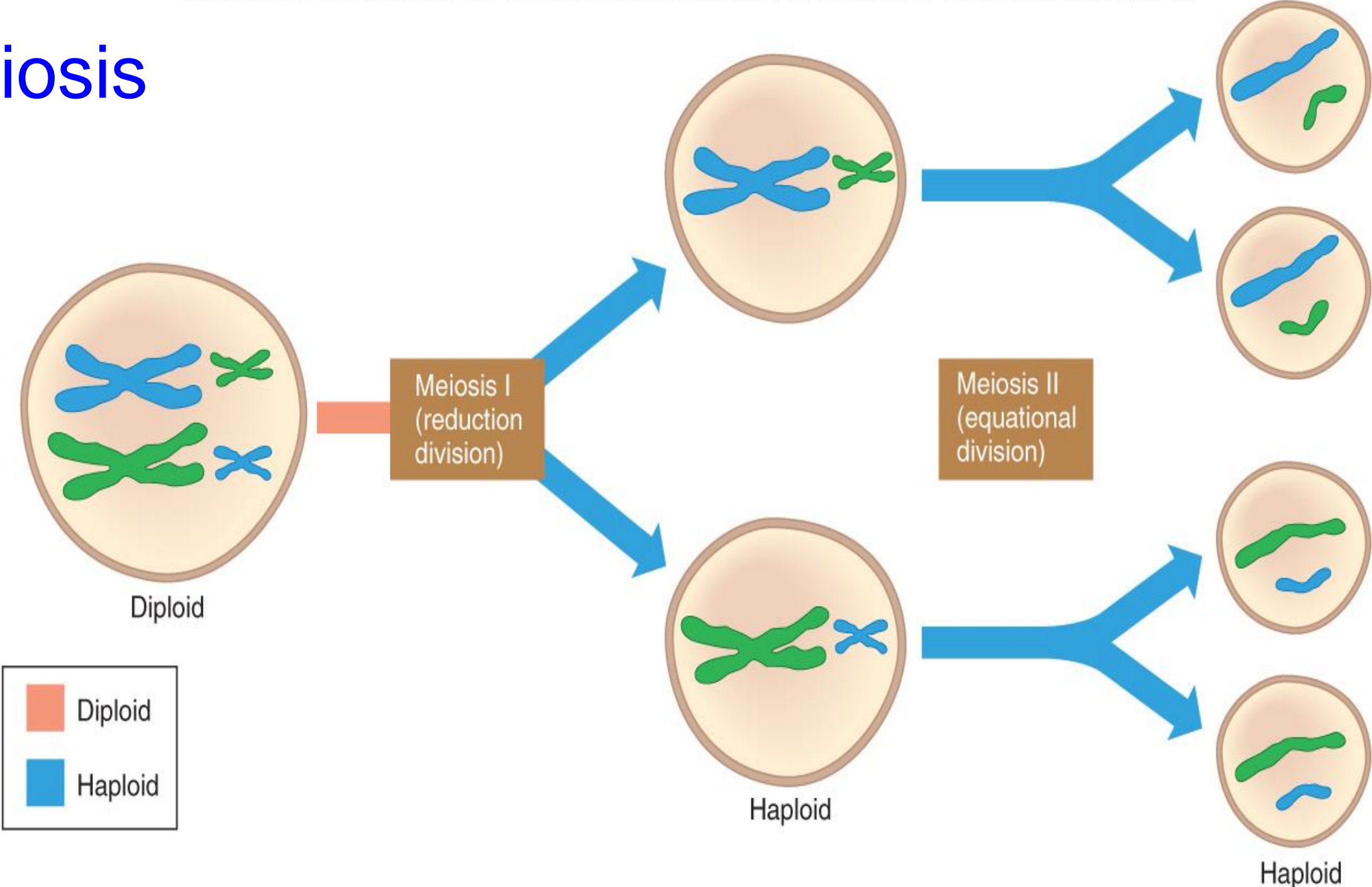
Meiosis consists of two divisions (PMAT 2x)

- **Meiosis I** = The reduction division
 - Reduces the number of chromosomes from 46 to 23 (still double-stranded)
- **Meiosis II** = The equational division
 - Produces four cells with single-stranded chromosomes

Note: Each division has the 4 phases (PMAT)

Prophase, Metaphase, Anaphase, Telophase

Meiosis



Lesson 3

short period (fill in blank notes)

Steps of Meiosis

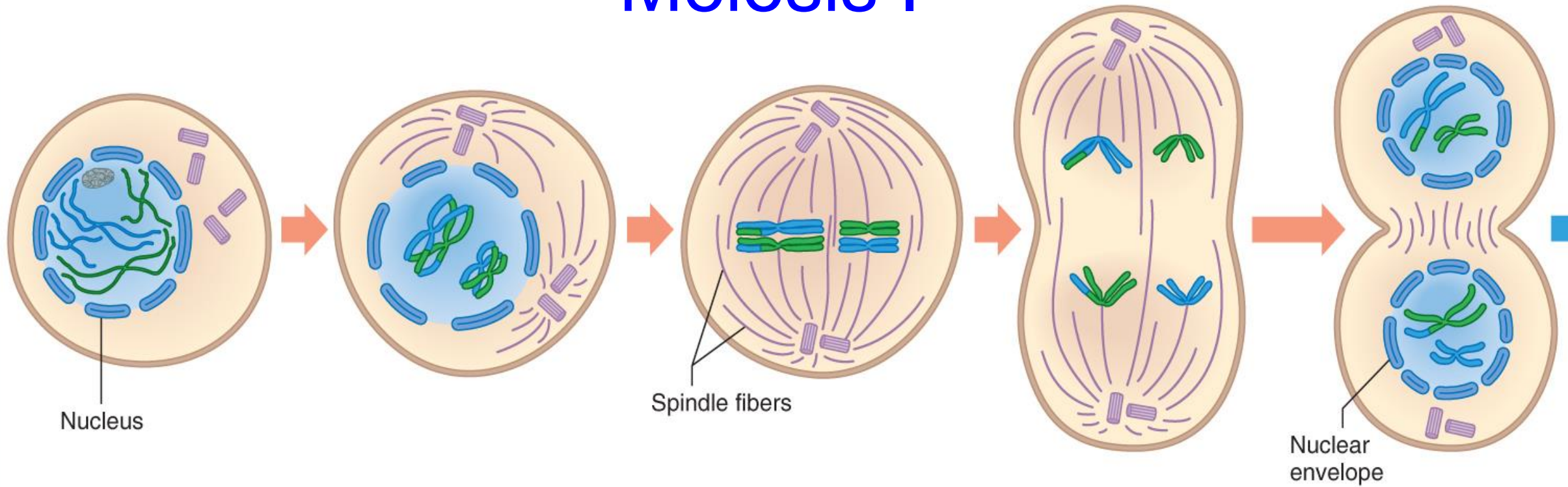
Gametogenesis

- spermatogenesis
- oogenesis

Meiosis

- Cell division that produces **gametes** with half the number of chromosomes
- Occurs in **germline** cells found in the **gonads**
- Maintains the chromosome number of a species over generations via fertilization
- Ensures genetic variability via the processes of **independent assortment** and **crossing over** of chromosomes

Meiosis I



Prophase I (early)

Synapsis and crossing over occurs.

Prophase I (late)

Chromosomes condense, become visible. Spindle forms. Nuclear envelope fragments. Spindle fibers attach to each chromosome.

Metaphase I

Paired homologous chromosomes align along equator of cell.

Anaphase I

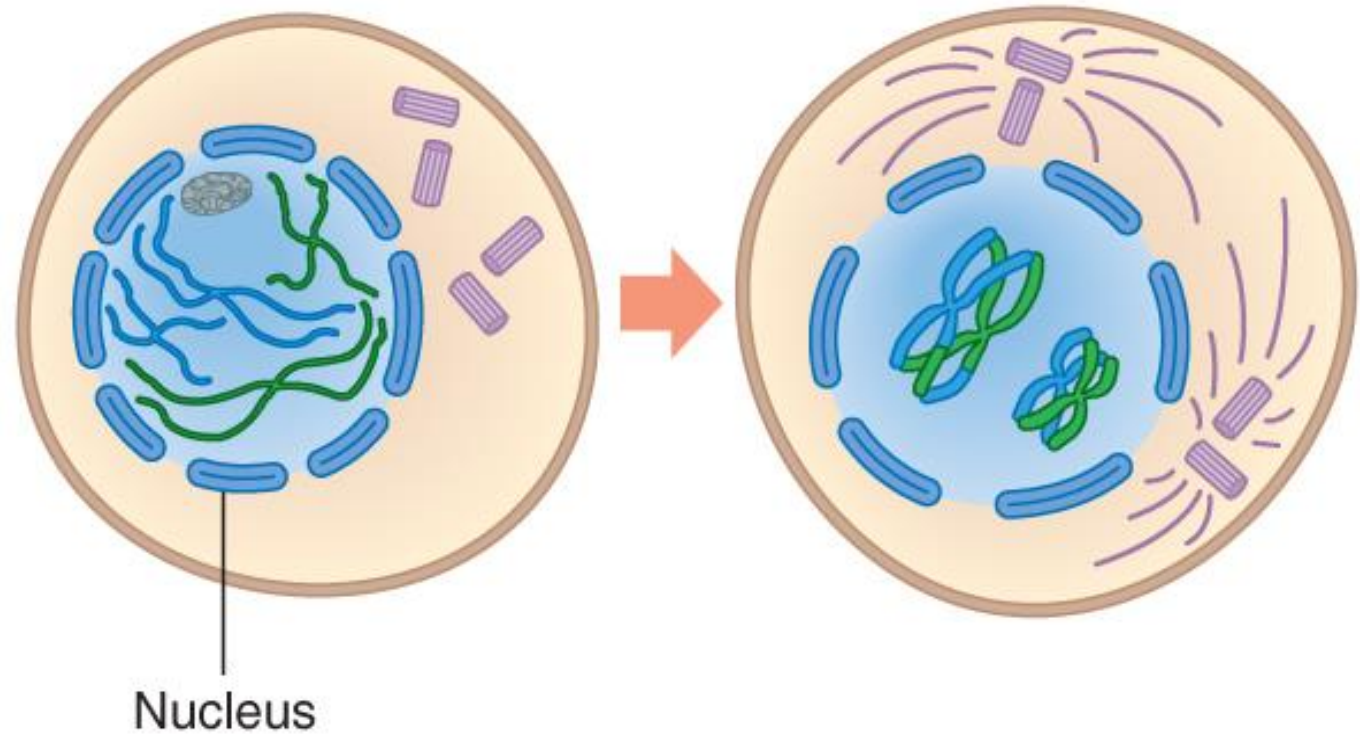
Homologous chromosomes separate to opposite poles of cell.

Telophase I

Nuclear envelopes partially assemble around chromosomes. Spindle disappears. Cytokinesis divides cell into two.

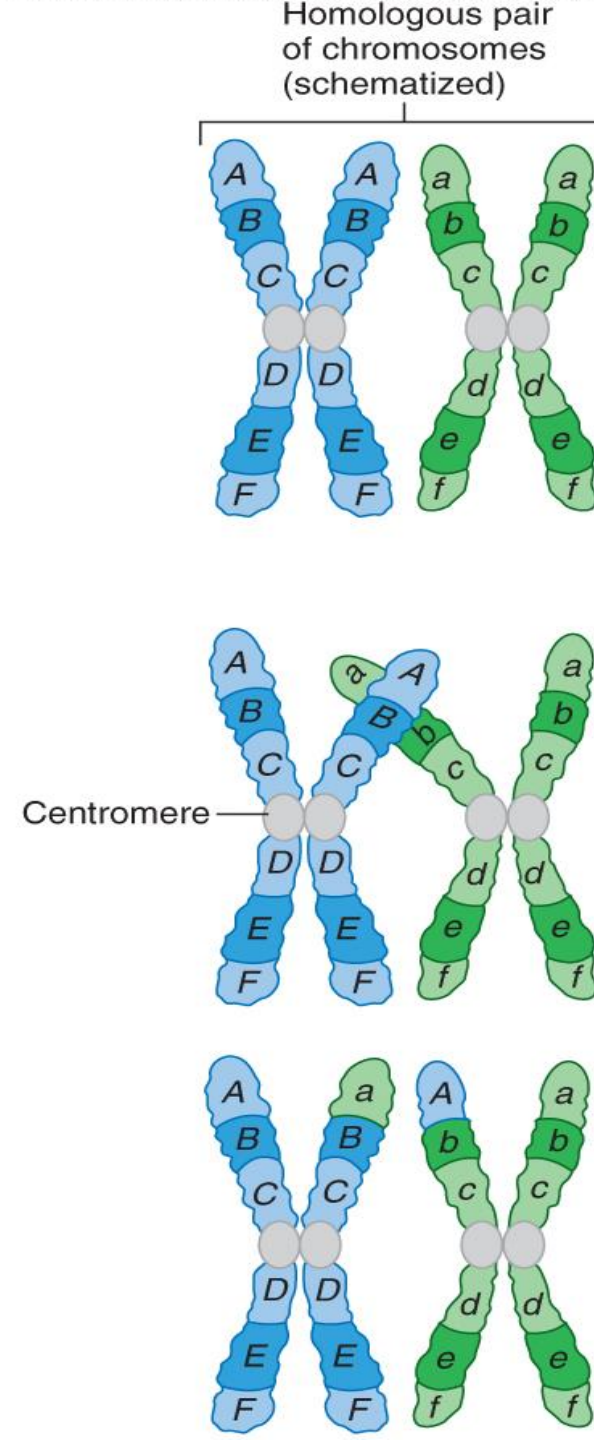
Prophase I

- **Homologs pair-up and undergo crossing over**
- Nuclear membrane breaks down
- Chromosomes condense
- Spindle forms



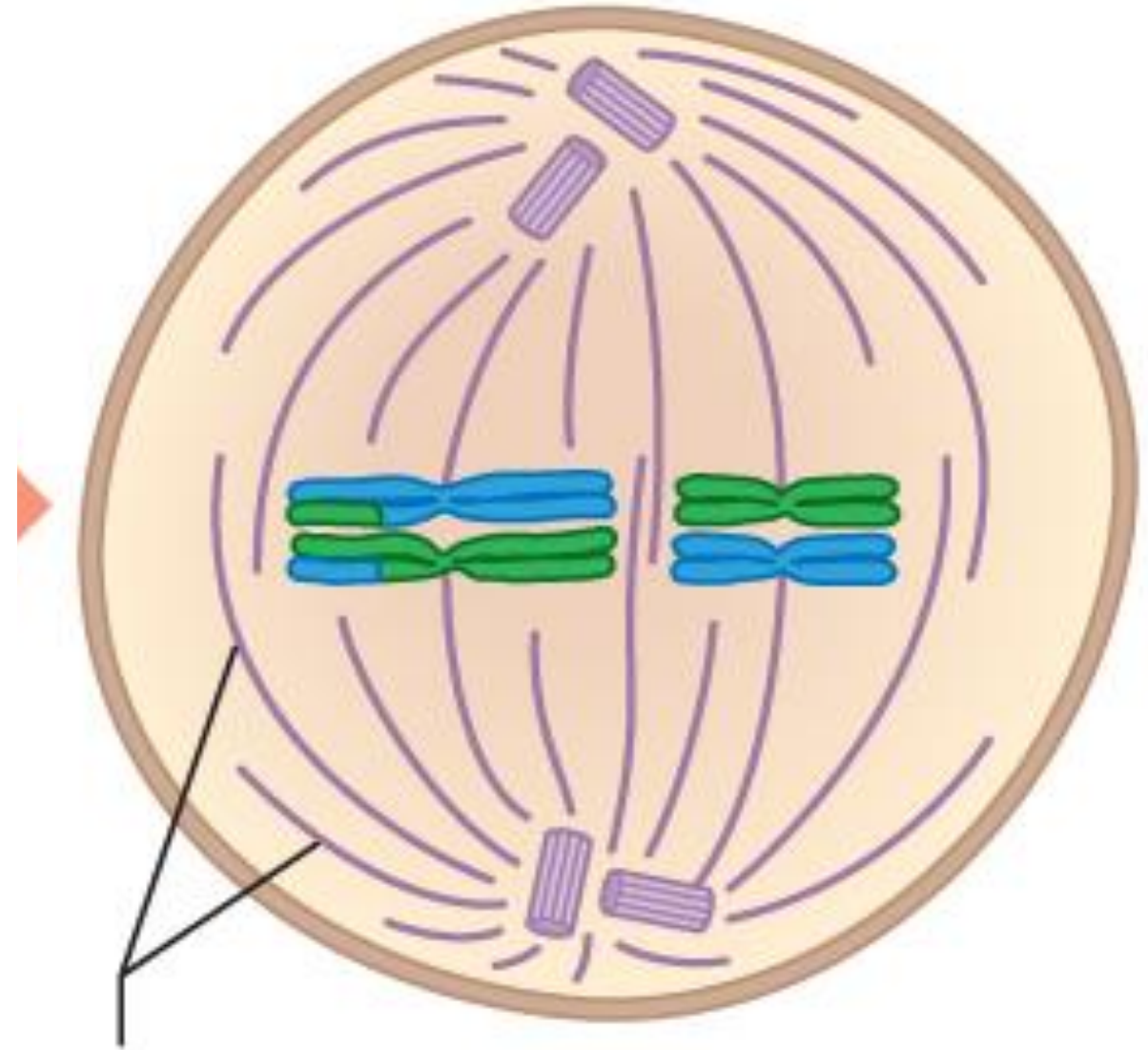
Crossing-over

- Paired chromosomes (**homologs**) exchange genetic information
- Results in **genetic variation** in each gamete produced
- Occurs during **synapsis** in **Prophase I**



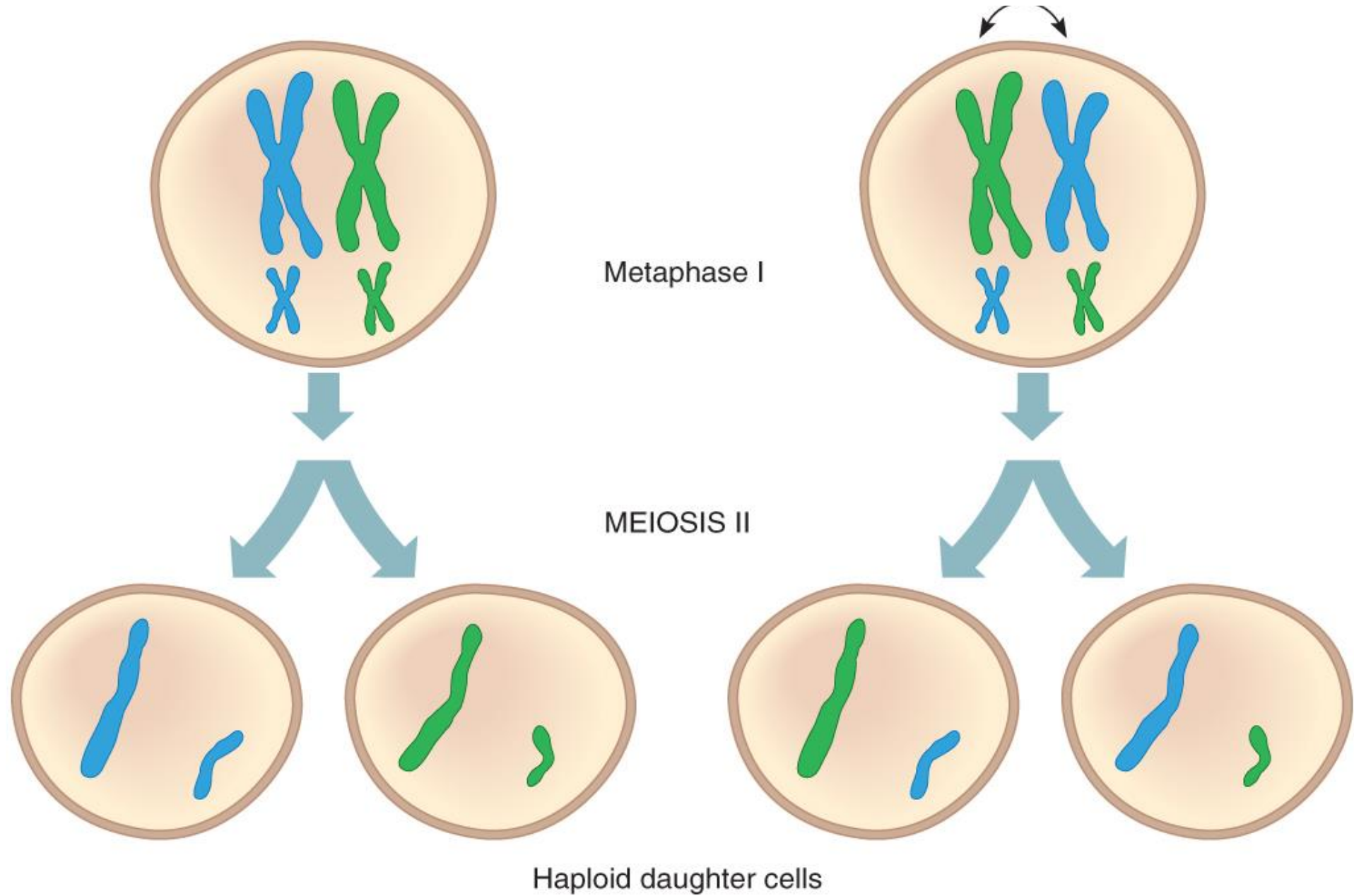
Metaphase I

- **Homologous pairs** align along the cell's equator (double file)
- **Random** alignment pattern determines the **independent assortment** of chromosomes



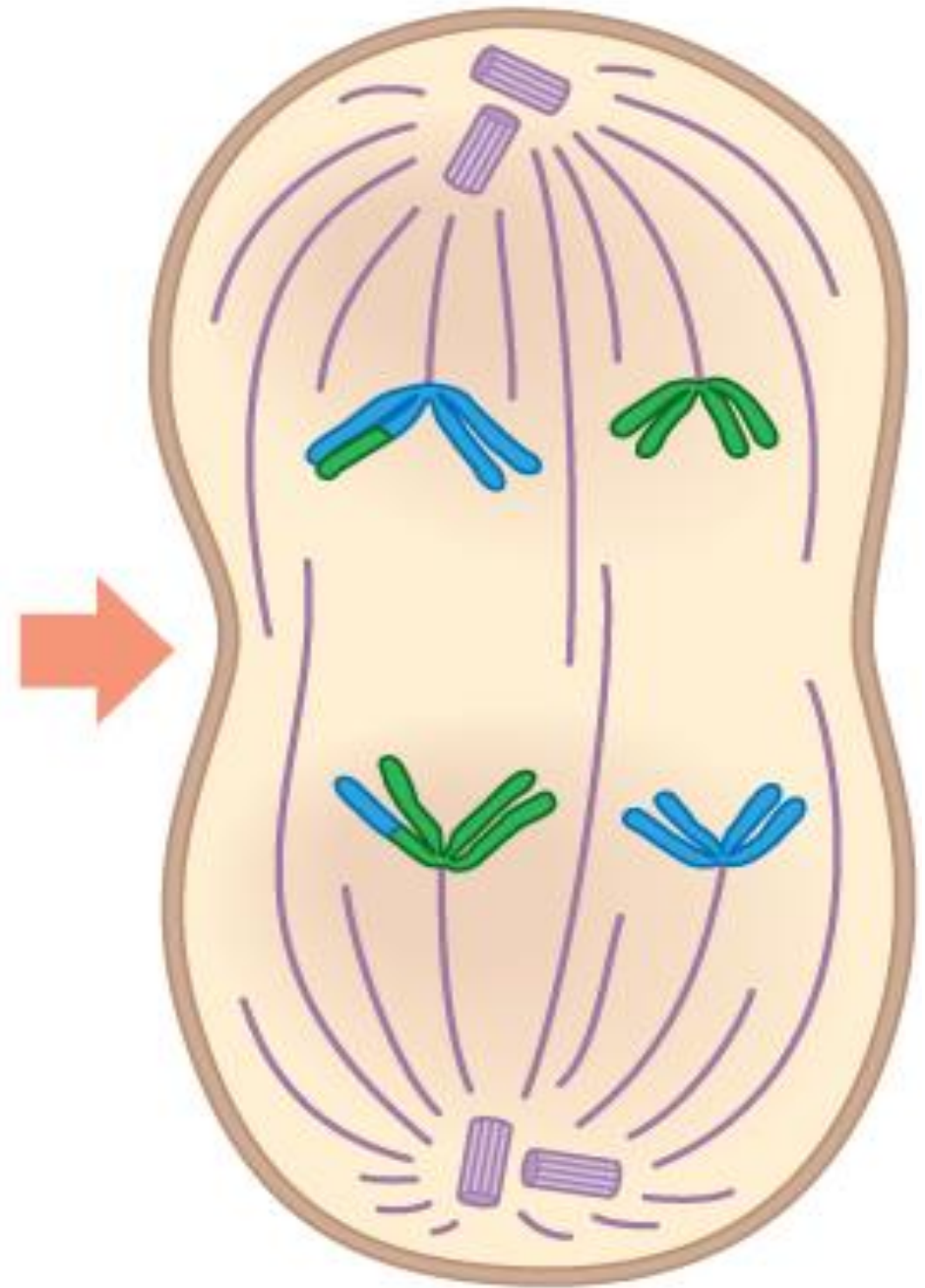
Spindle fibers

Independent Assortment



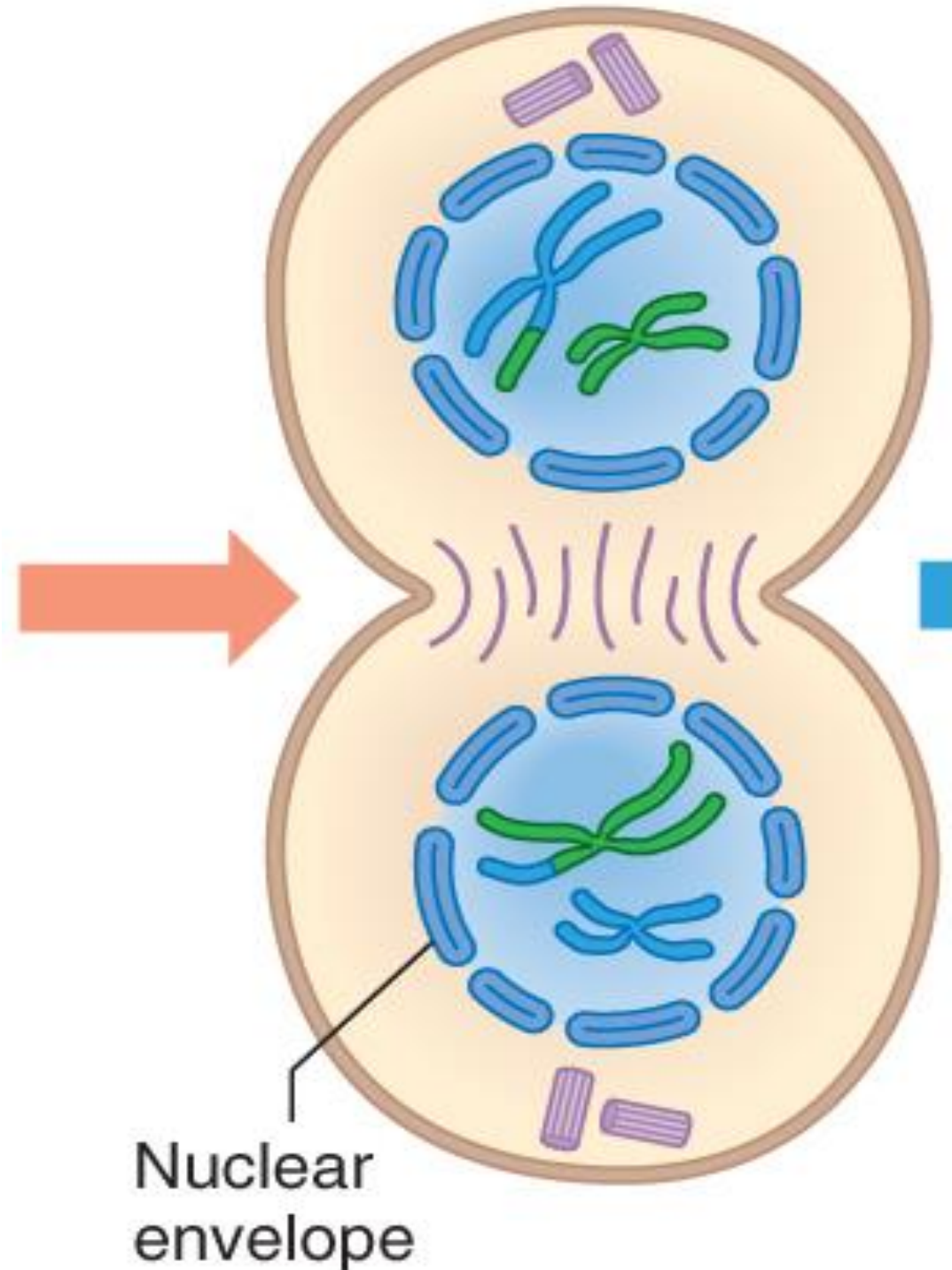
Anaphase I

- Homologs separate and move to opposite poles of the cell
- Sister chromatids remain attached at their **centromeres**



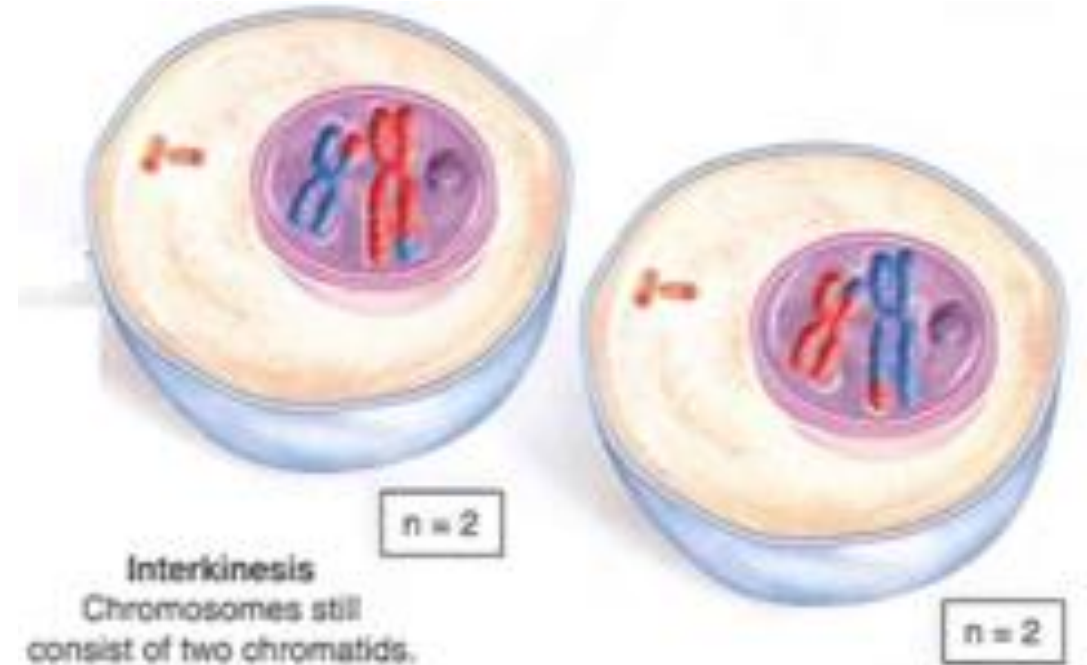
Telophase I

- Nuclear envelope (membrane) reforms
- Spindle disappears
- Cytokinesis divides the rest of the cell into two

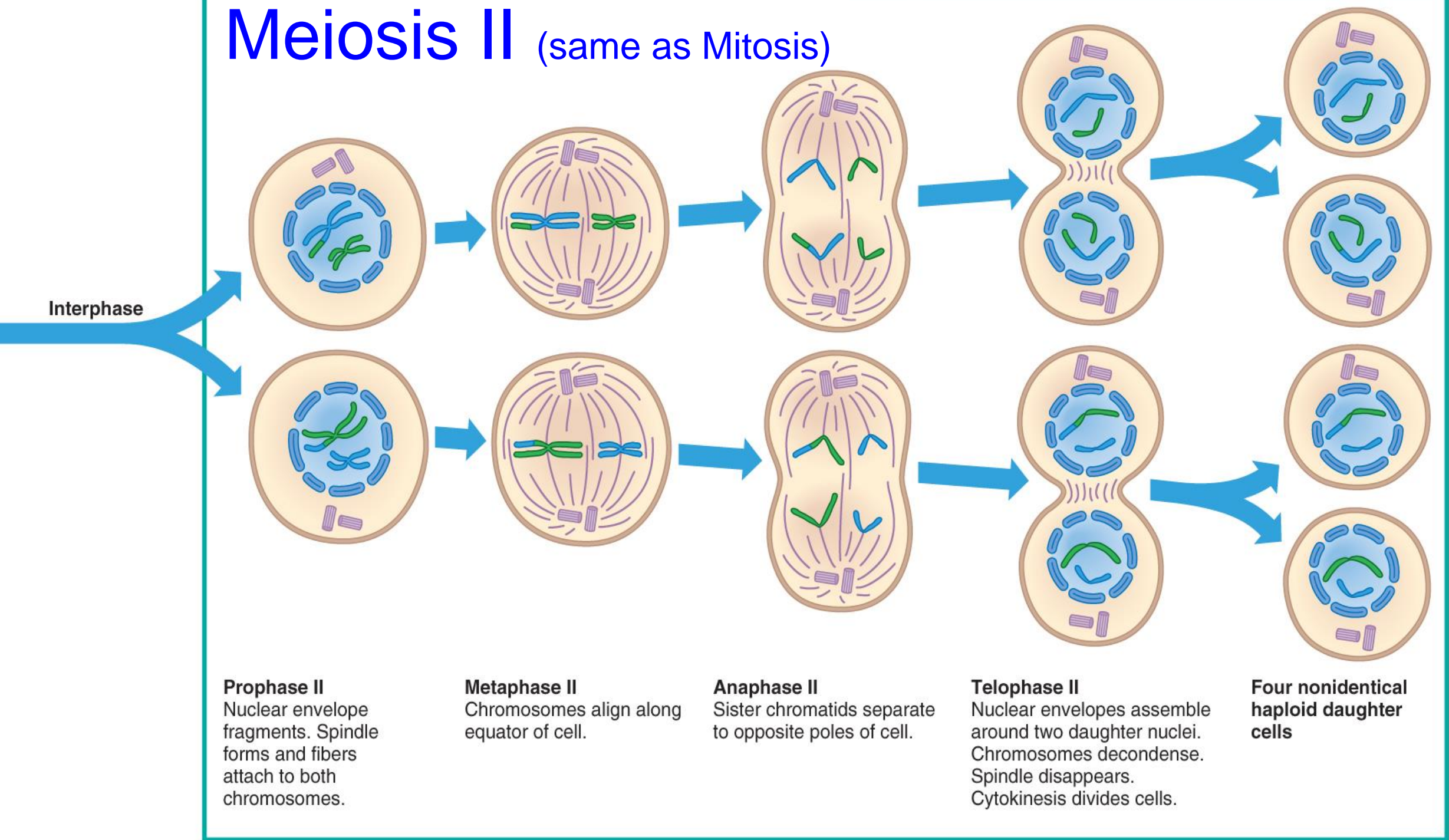


Interkinesis

- A short **interphase** between the two meiotic divisions
- Chromosomes unfold into very thin threads
- Proteins are manufactured
- However, **DNA is NOT replicated** a second time



Meiosis II (same as Mitosis)



Interphase

Prophase II

Nuclear envelope fragments. Spindle forms and fibers attach to both chromosomes.

Metaphase II

Chromosomes align along equator of cell.

Anaphase II

Sister chromatids separate to opposite poles of cell.

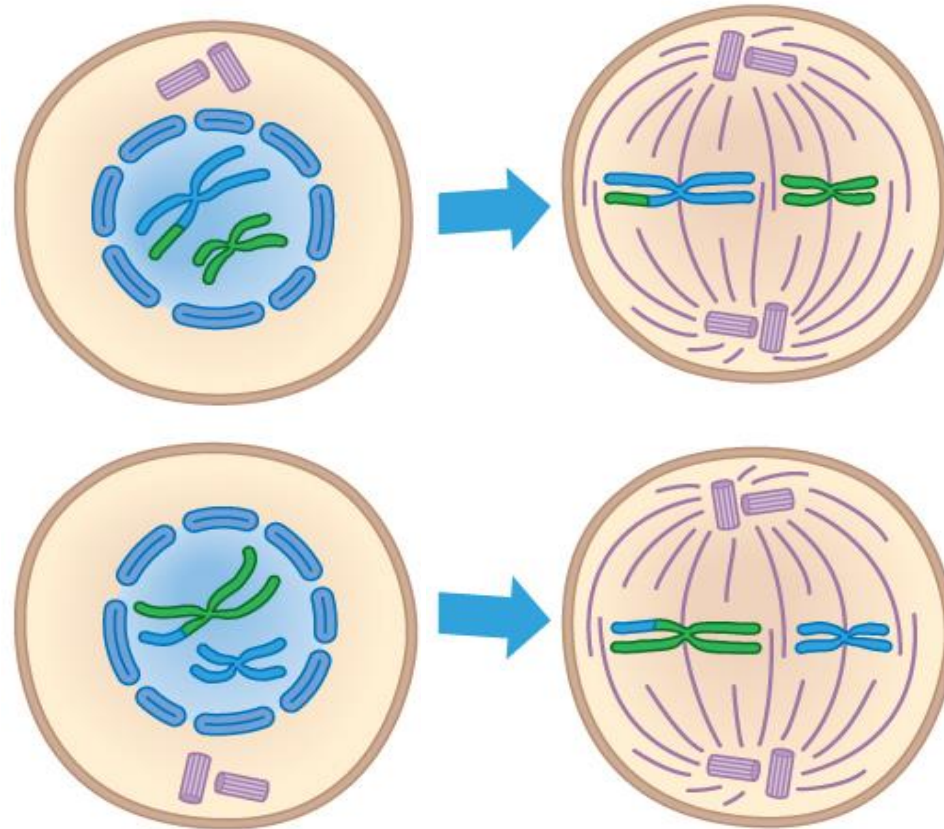
Telophase II

Nuclear envelopes assemble around two daughter nuclei. Chromosomes decondense. Spindle disappears. Cytokinesis divides cells.

Four nonidentical haploid daughter cells

Prophase II

- Chromosomes condense and become visible again
- Spindles form
- Nuclear envelope degenerates

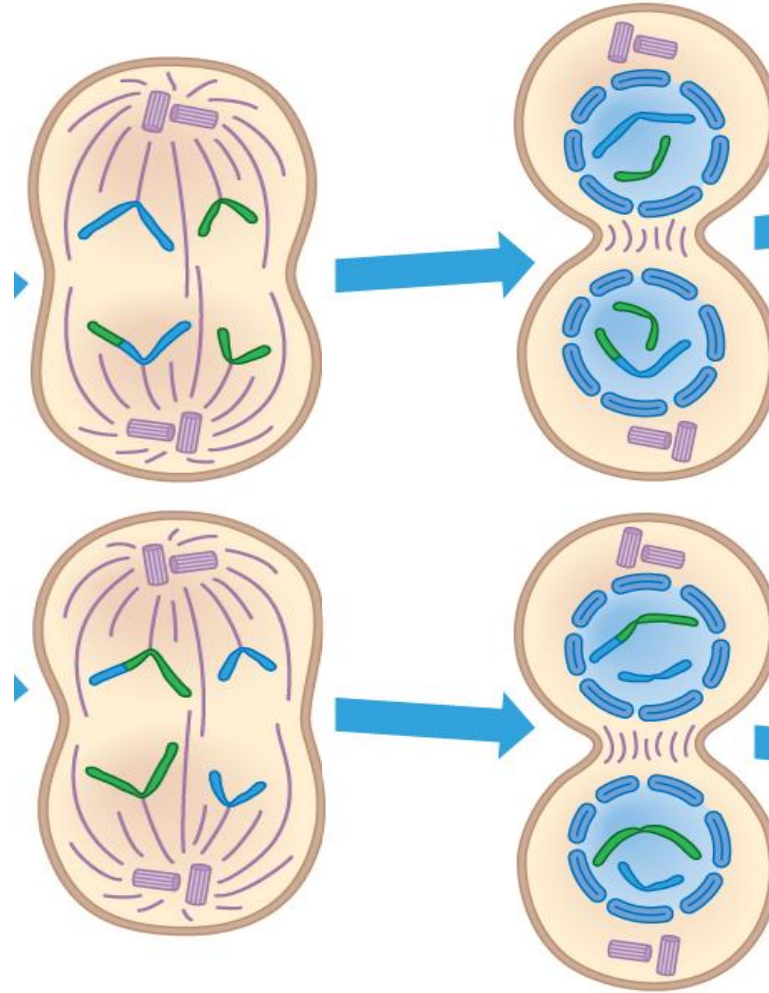


Metaphase II

- Chromosomes align along the equator

Anaphase II

- Centromeres divide
- Sister chromatids separate to opposite cell poles

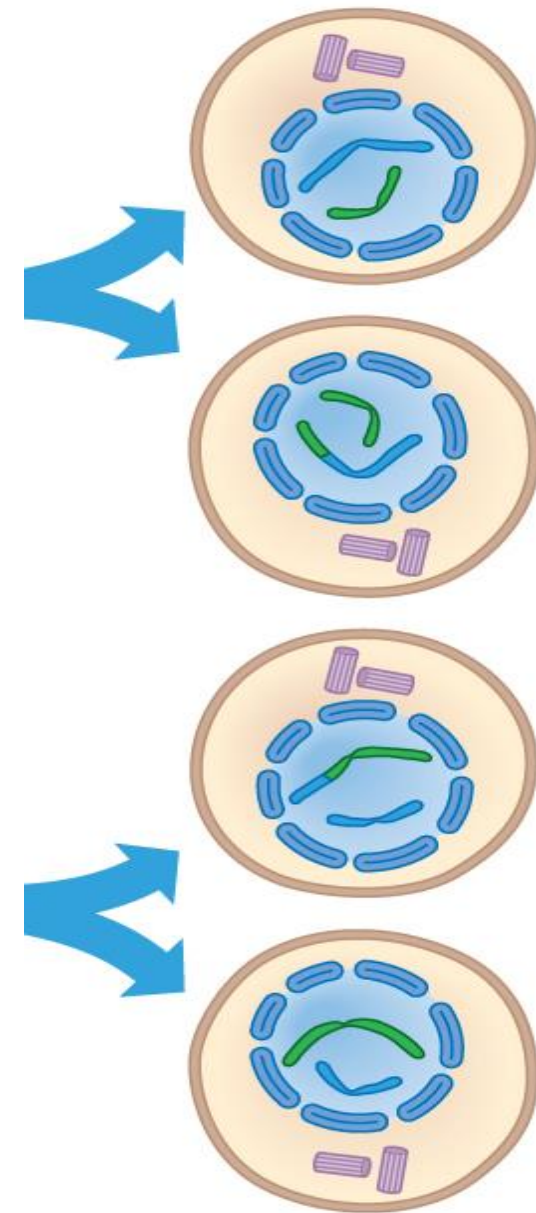


Telophase II

- Nuclear envelope (membrane) reforms
- Chromosomes uncoil
- Spindles disappear

Results of Meiosis

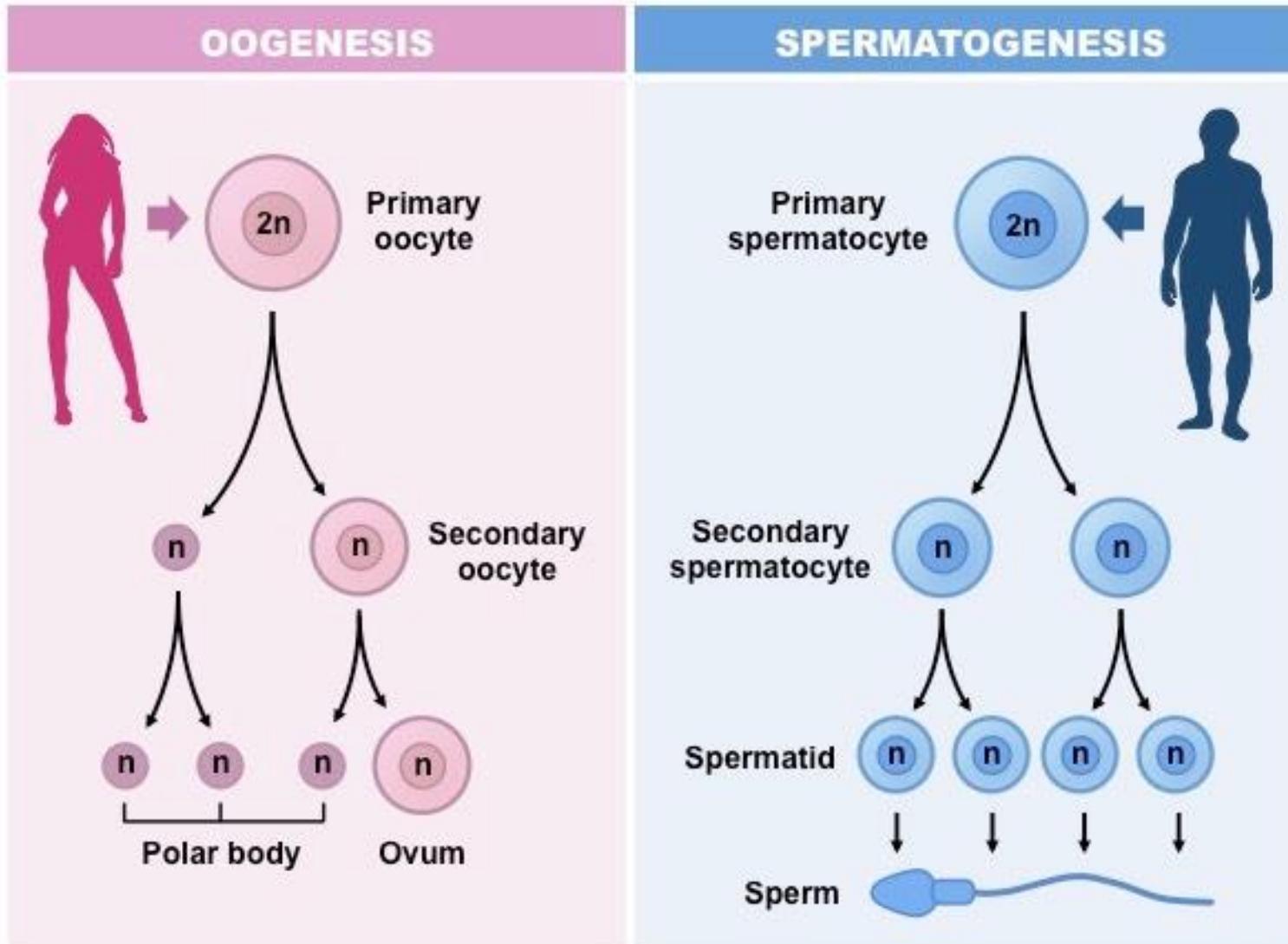
- **Four haploid cells** containing a single copy of the genome (23 chromosomes each)
- Each cell is **unique** – carries a different assortment of genes and chromosomes



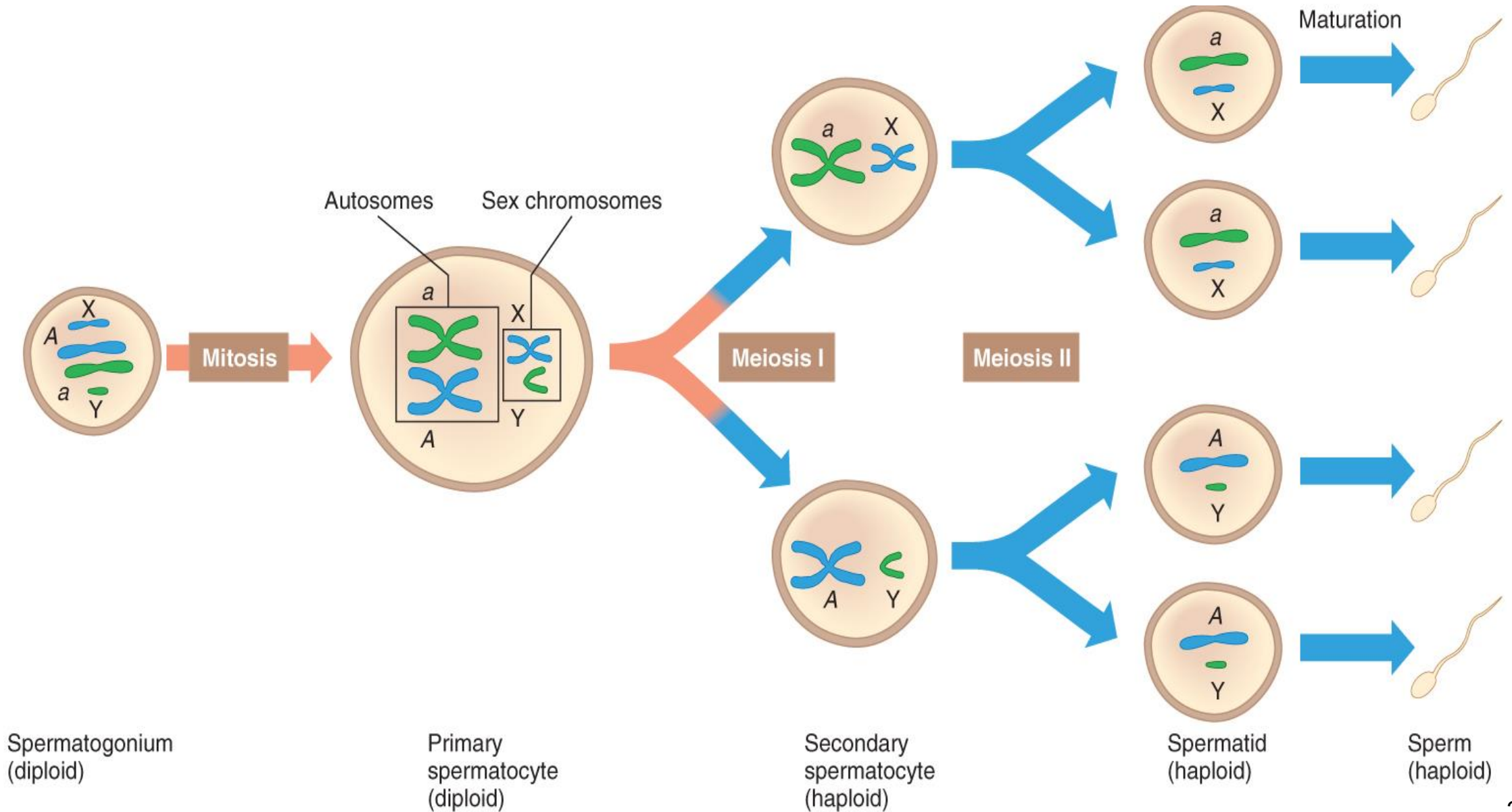
Four nonidentical
haploid daughter
cells

Gametogenesis

- The process in which cells undergo meiosis to form gametes



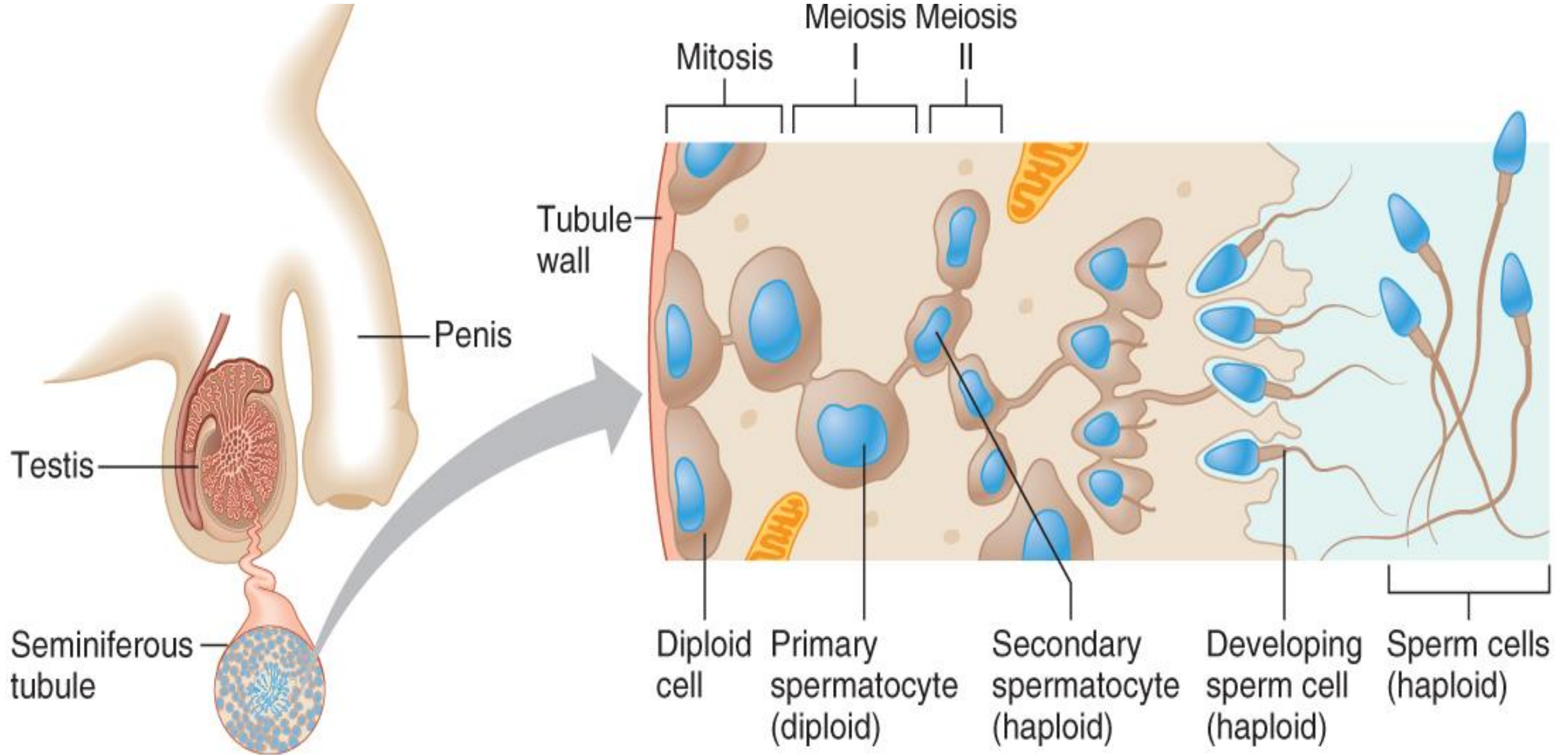
Spermatogenesis



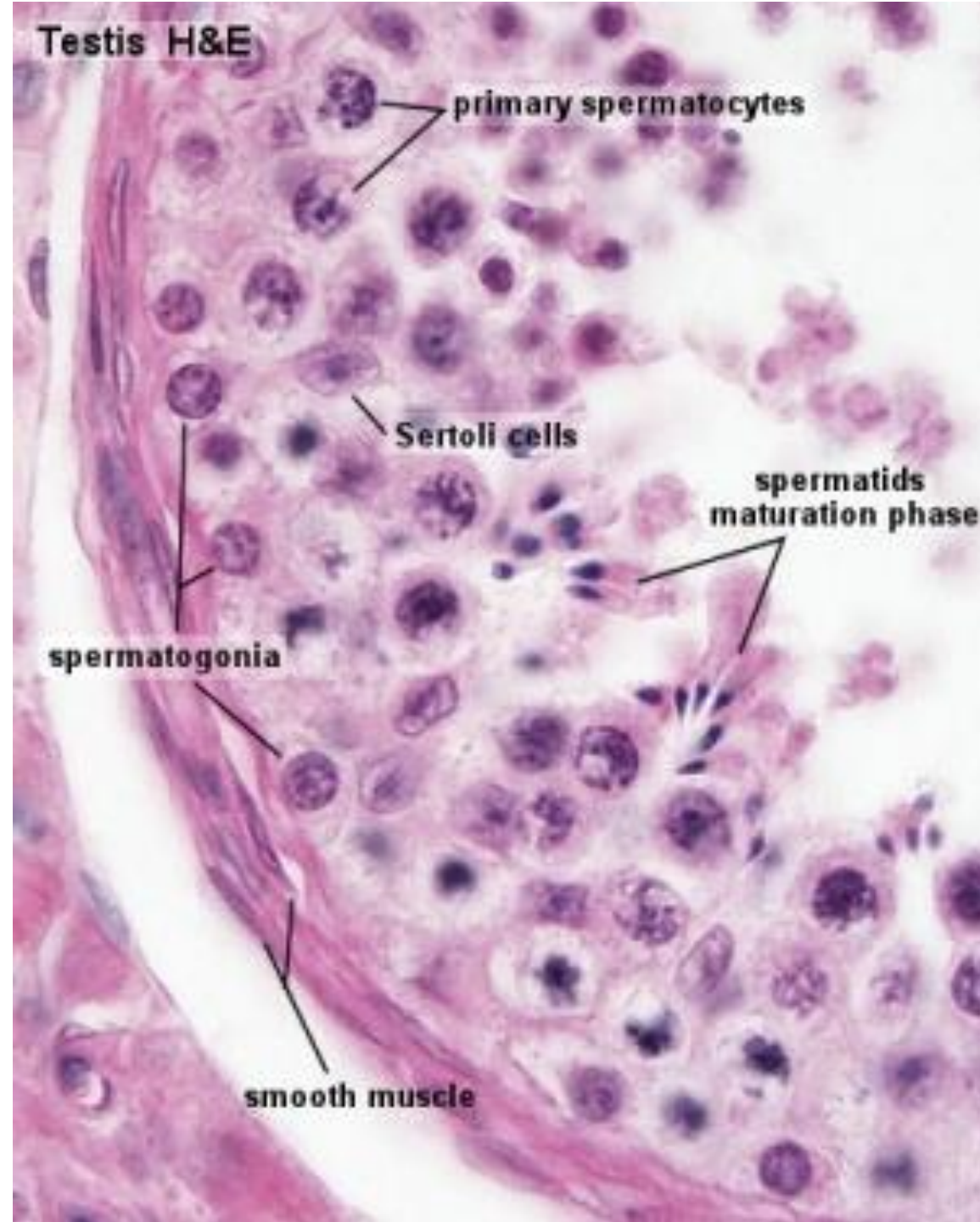
Spermatogenesis

- Occurs in the seminiferous tubules of the testes, beginning at puberty continuing throughout the man's life
- A diploid spermatogonium (stem cell) divides by mitosis to produce another stem cell and a cell that specializes into a primary spermatocyte
- In meiosis I, the primary spermatocyte produces two haploid secondary spermatocytes
- In meiosis II, each secondary spermatocyte produces two haploid spermatids
- Spermatids then mature into tad-pole shaped spermatozoa
(4 sperm cells in total)

Spermatogenesis



Testis H&E



primary spermatocytes

Sertoli cells

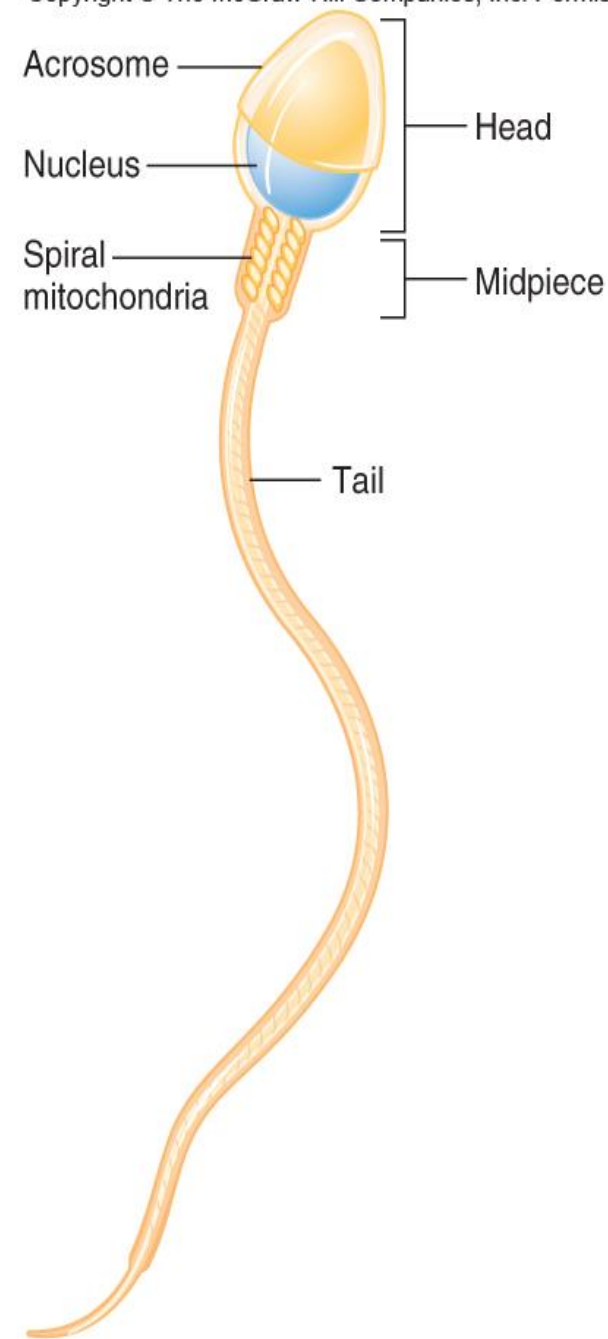
**spermatids
maturation phase**

spermatogonia

smooth muscle

Sperm Structure

- **Acrosome** on head contains digestive enzymes to help **penetrate egg**
- Nucleus contains **23** chromosomes
- Mitochondria in midpiece provide **energy**
- Tail provides **motility**

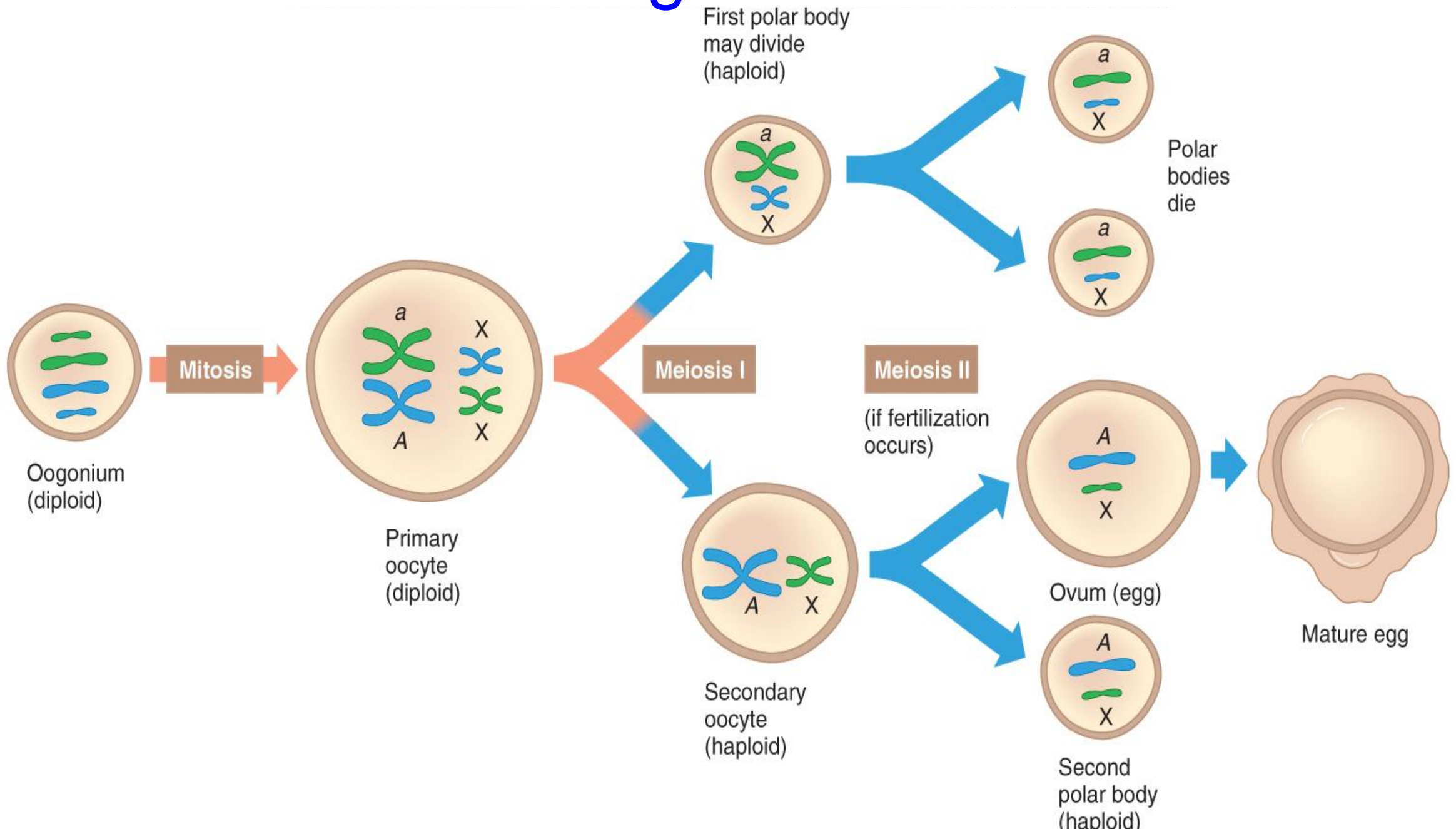


a.



b.

Oogenesis



Oogenesis

- Unlike spermatogenesis, oogenesis is a discontinuous process
- Meiosis begins during fetal development of female
 - Oocytes pause development at prophase I until puberty
 - After puberty, meiosis I continues in one or several oocytes each month but halts again at metaphase II
 - Meiosis is only completed if the ovum is fertilized

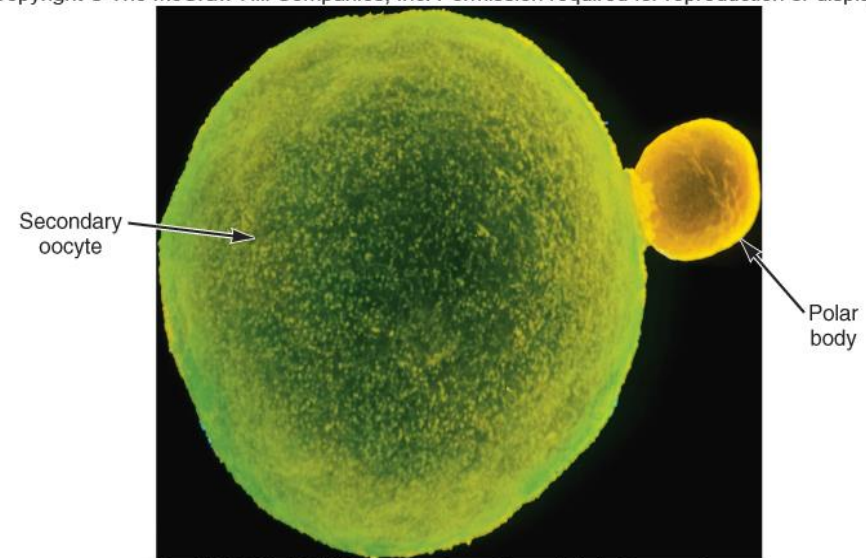
Oogenesis

A diploid oogonium (stem cell) divides by mitosis to produce another stem cell and a cell that specializes into a primary oocyte

In meiosis I, the primary oocyte divides unequally forming a small polar body and a large secondary oocyte

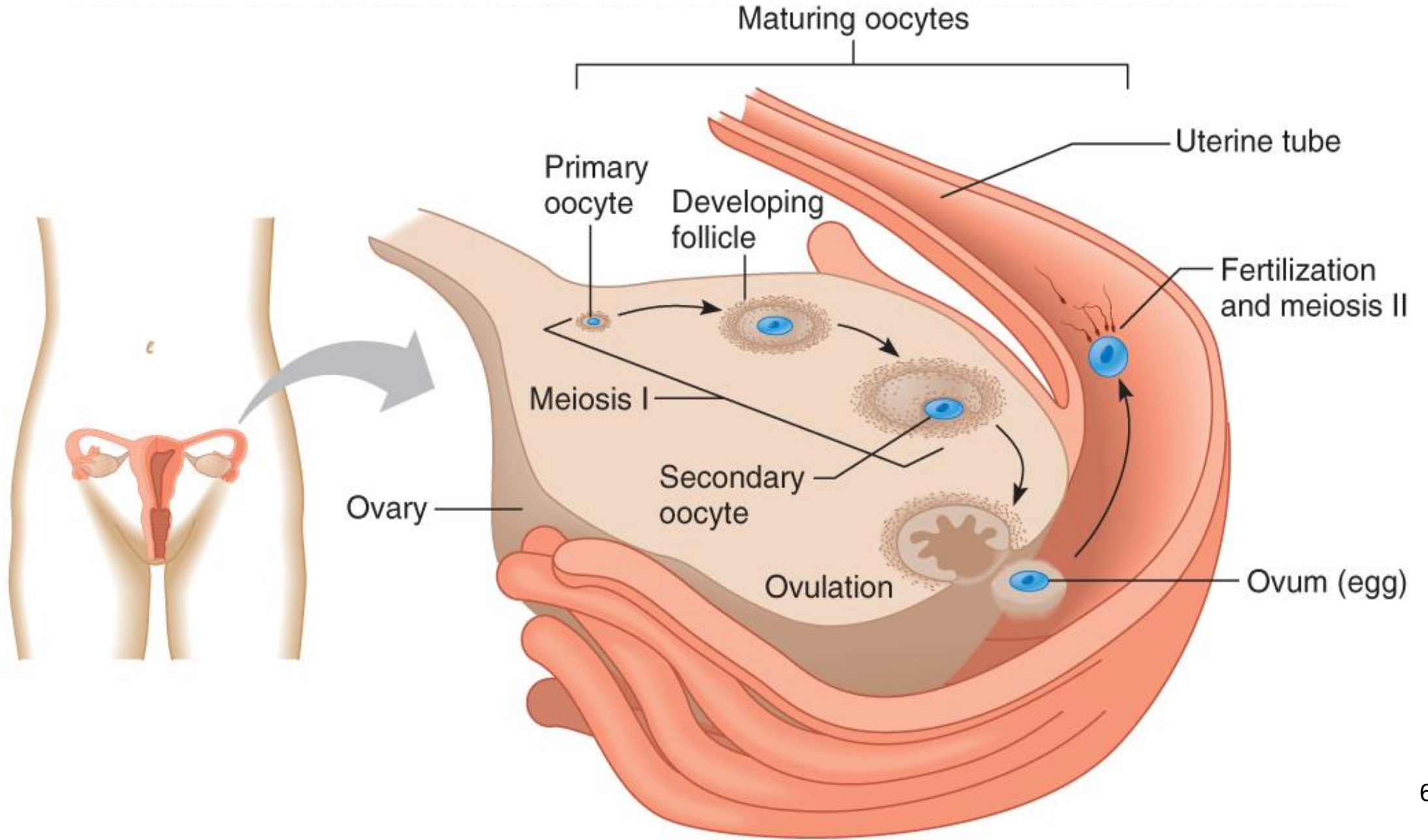
In meiosis II, the secondary oocyte divides to form another polar body and 1 mature haploid ovum

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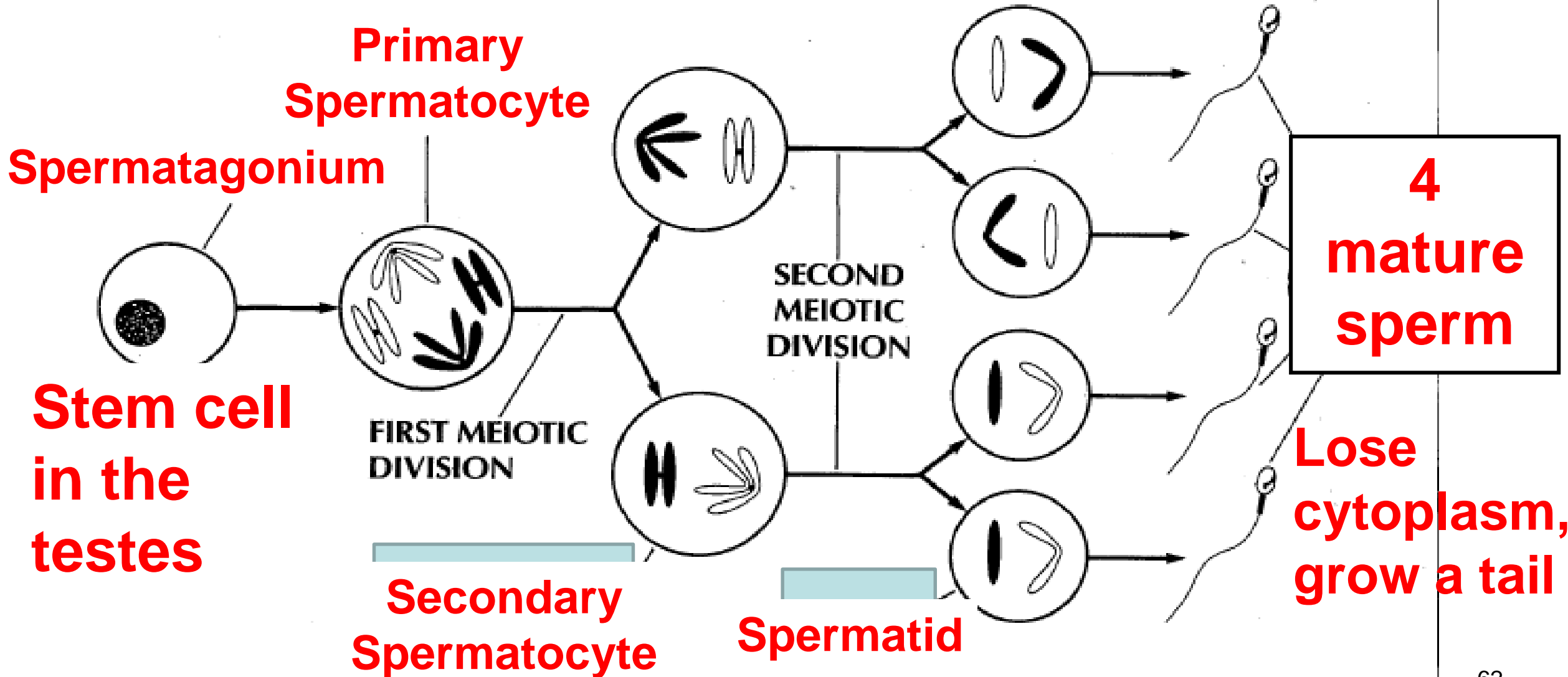
Oogenesis



Lesson 4

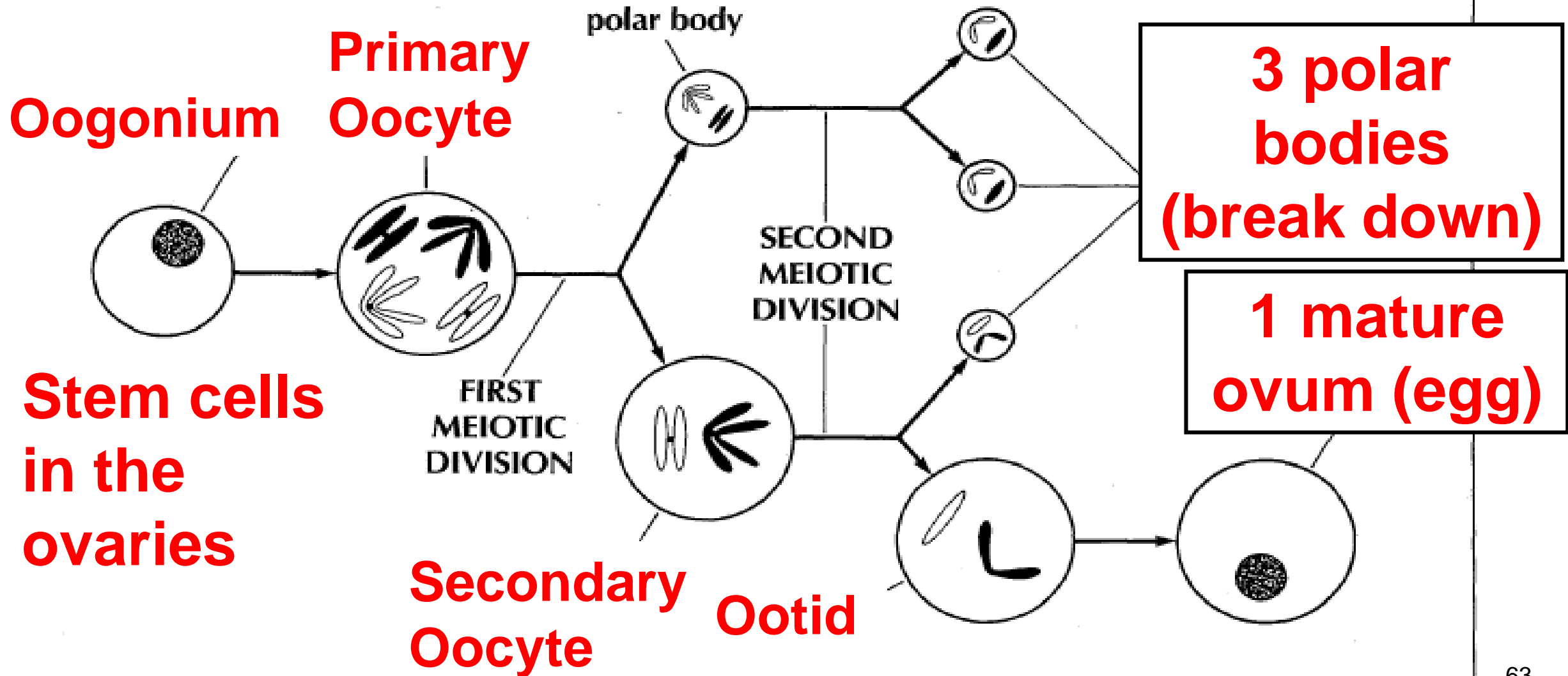
Practice Questions & Review

Spermatogenesis – meiosis in male testes (seminiferous tubules) to produce sperm



Oogenesis

– meiosis in female ovary to produce mature egg cell



STAGES OF MEIOSIS

Name _____

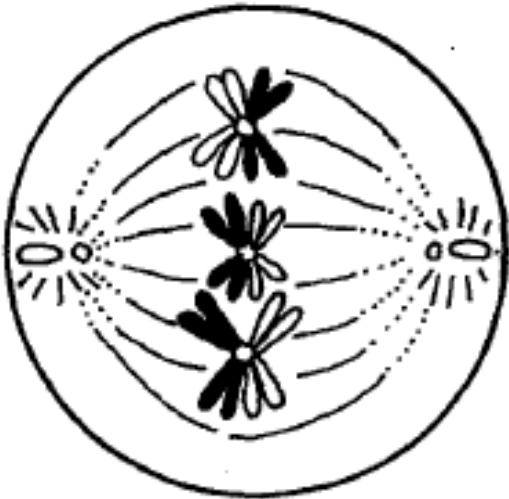
Number the following diagrams of a first meiotic division in the proper order. Label each phase correctly as prophase I, metaphase I, anaphase I or telophase I.

Metaphase I

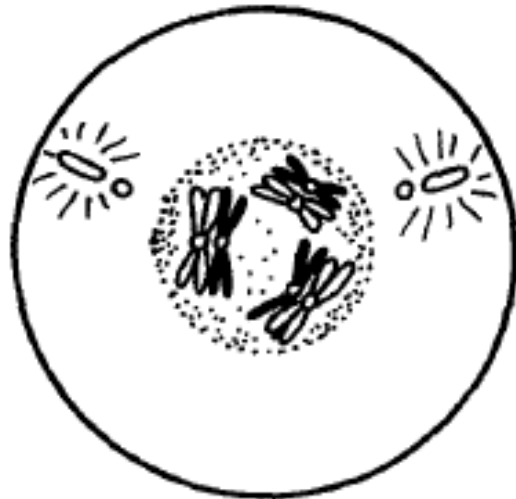
Prophase I

Anaphase I

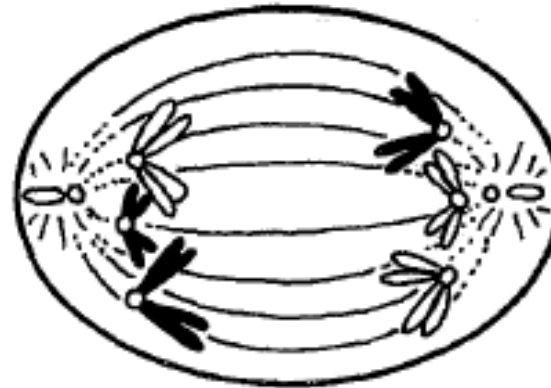
Telophase I



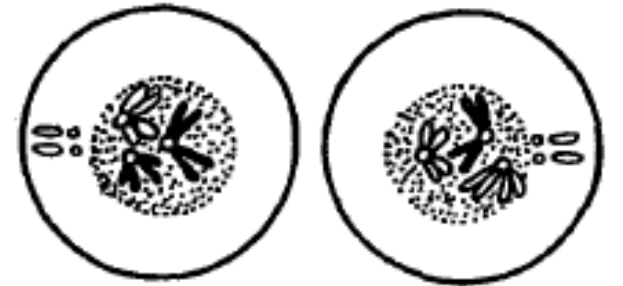
2



1

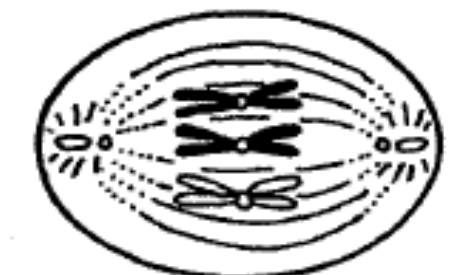
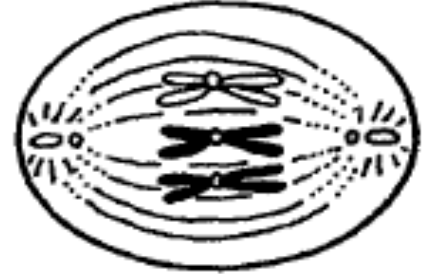
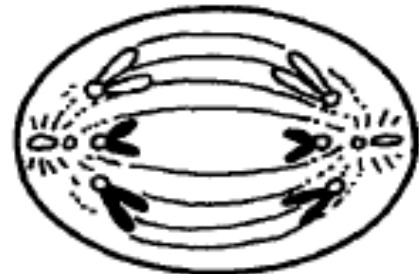


3



4

Do the same for the diagrams of the second meiotic division. Label each phase correctly as prophase II, metaphase II, anaphase II, telophase II .



Prophase II

1

Telophase II

4

Anaphase II Metaphase II

3

2