Go to the "Slide Show" shade above

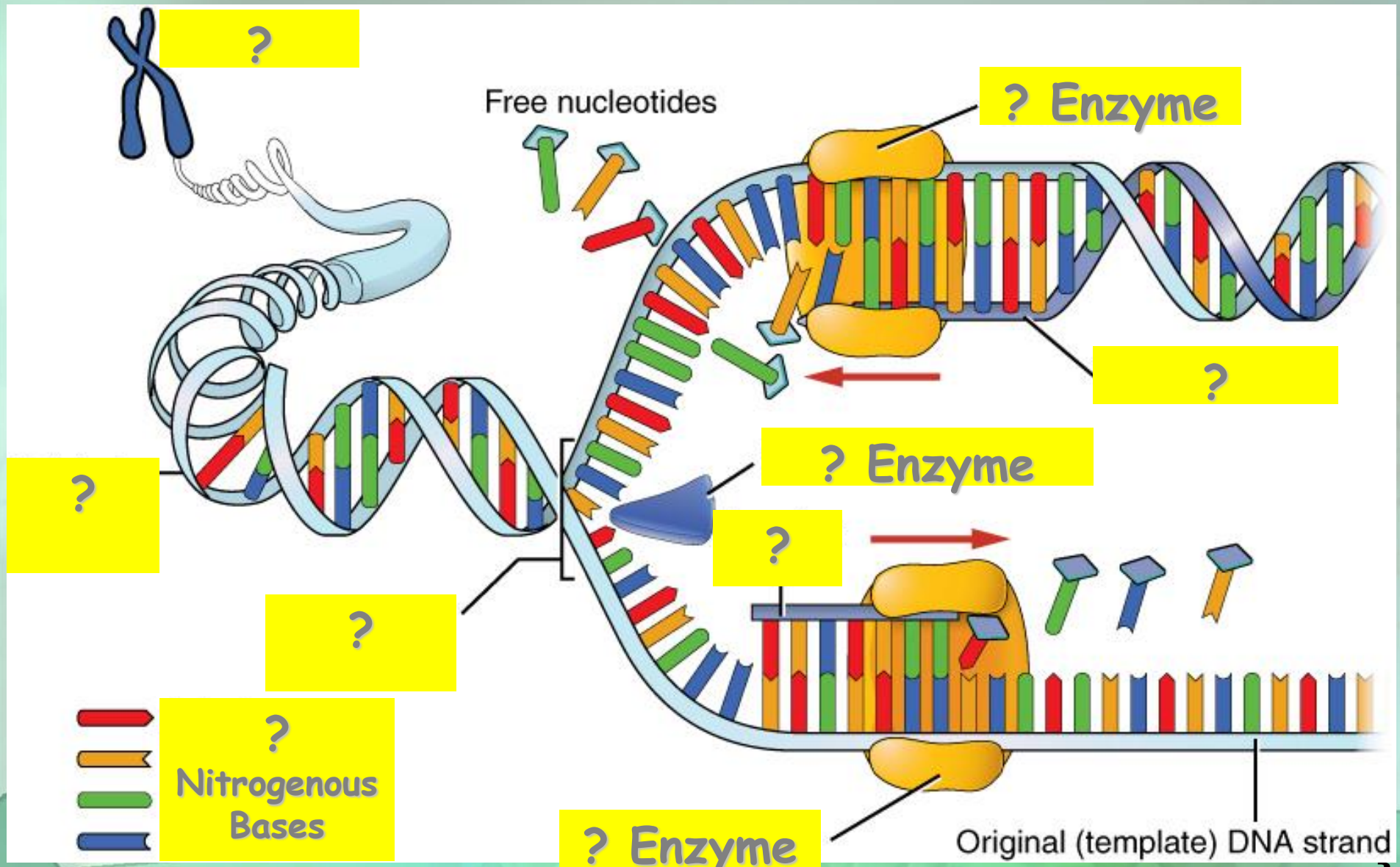
Click on "Play from Beginning"

Organism Reproduction: Meiosis

Chapter 11

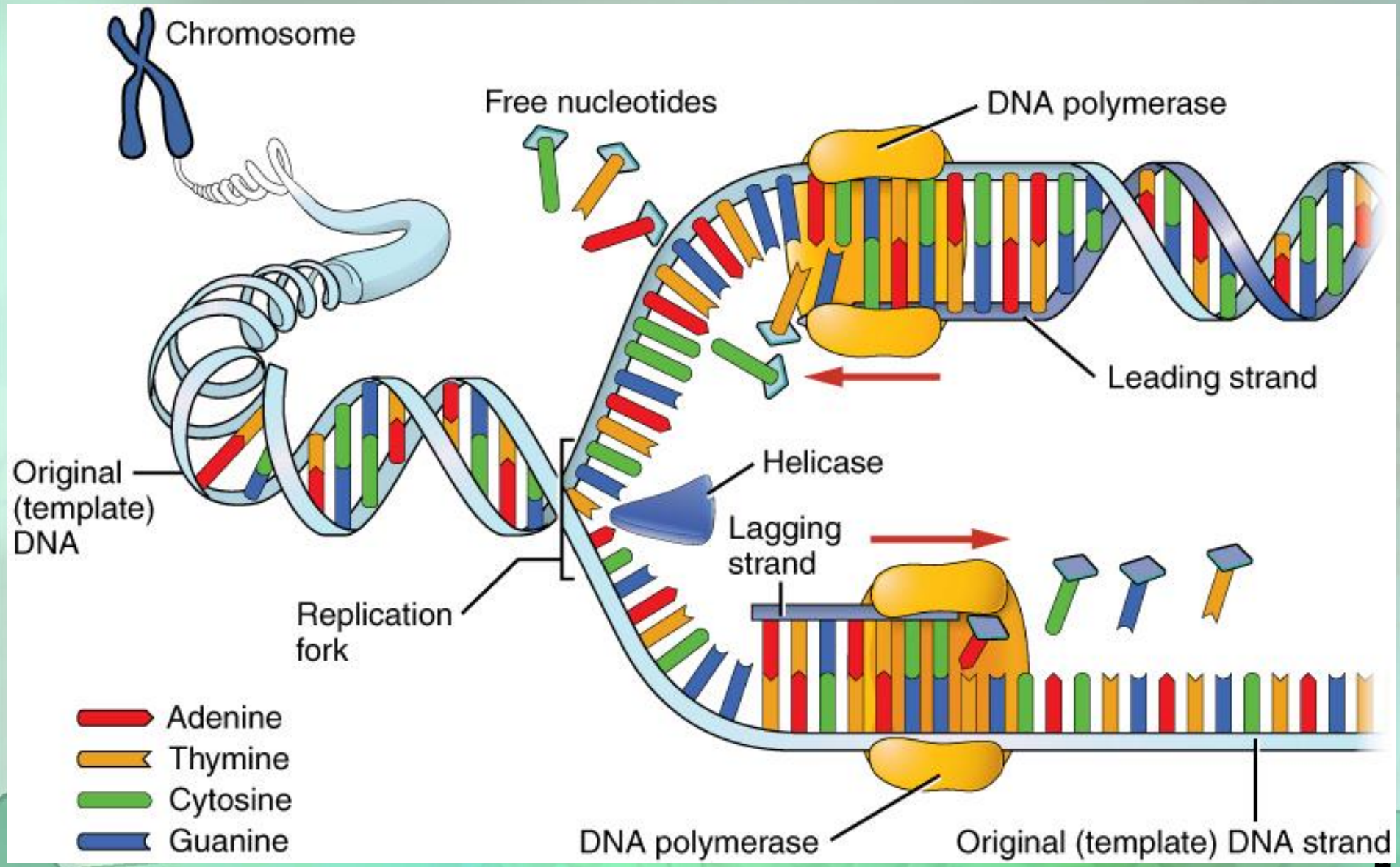
WARM-UP

DNA Replication



WARM-UP

DNA Replication



Question:

WARM-UP

- What would be the complementary DNA strand for the following DNA sequence?

DNA -TAGGCT-

WARM-UP

Answer:

DNA -TAGGCT-

DNA -ATCCGA-

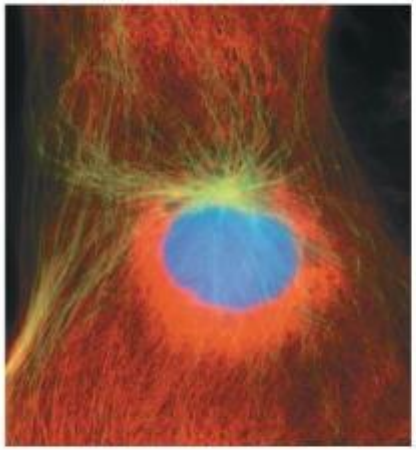
MITOSIS

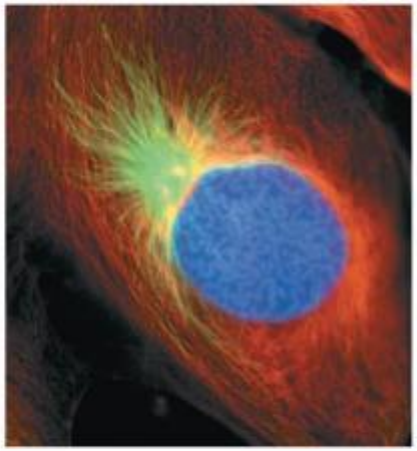
WARM-UP

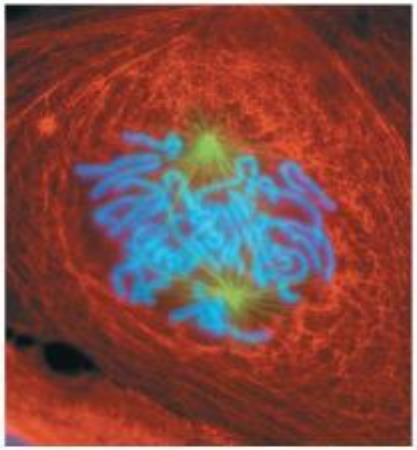
?

?

Prometaphase







?

Chromatin

?

Early mitotic spindle

?

Fragments of the nuclear envelop

?

?

Plasma membrane

?

Chromosome, consisting of two sister chromatids

?

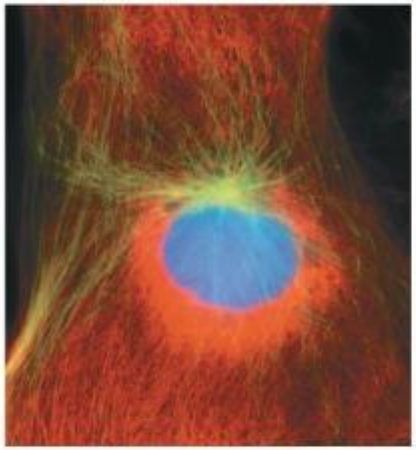
WARM-UP

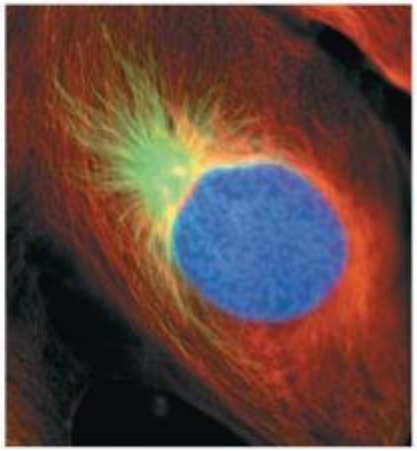
INTERPHASE

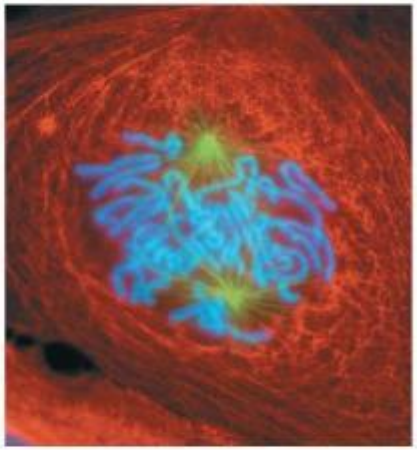
MITOSIS

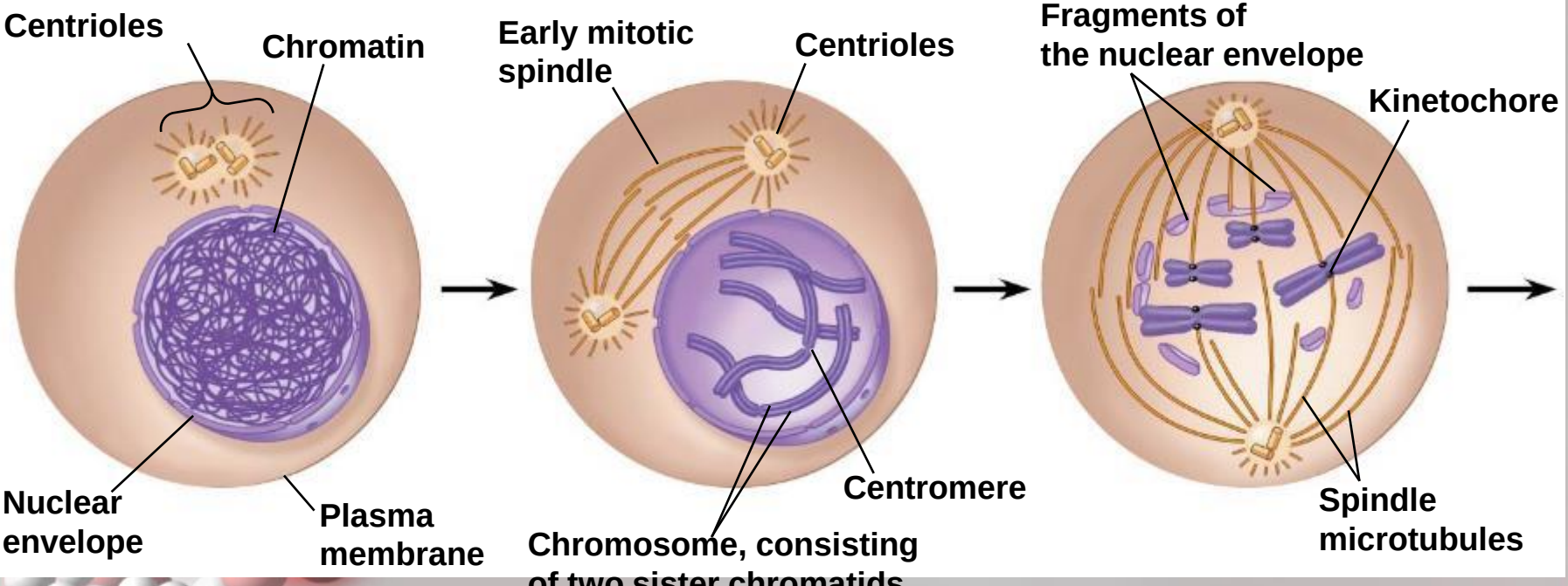
Prophase

Prometaphase









WARM-UP

MITOSIS

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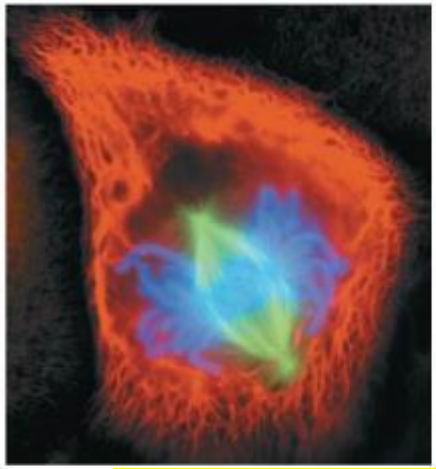

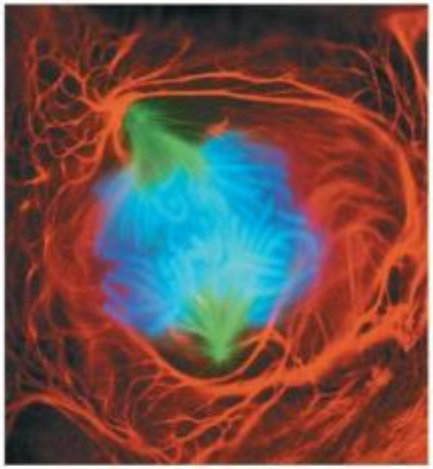

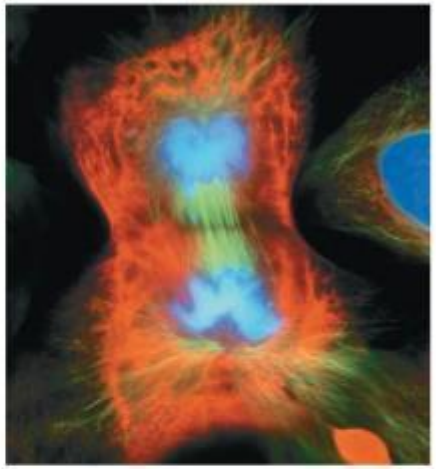

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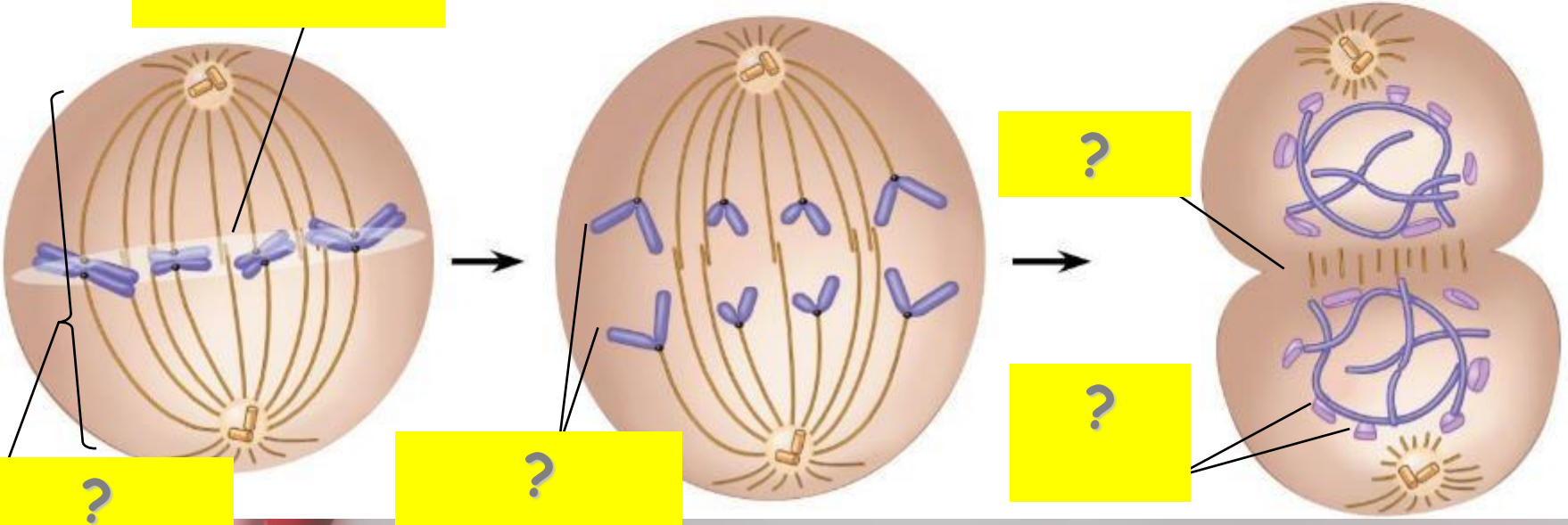

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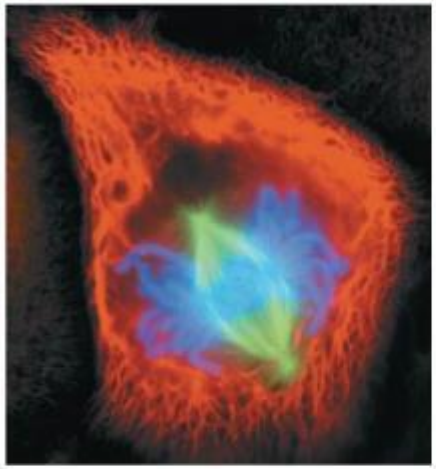
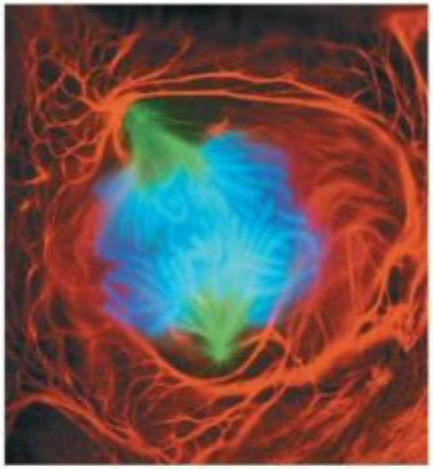
WARM-UP

MITOSIS

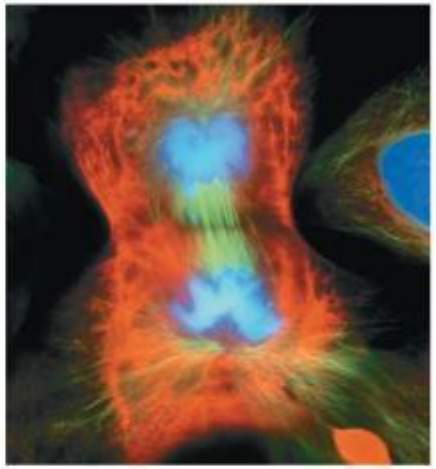
Metaphase

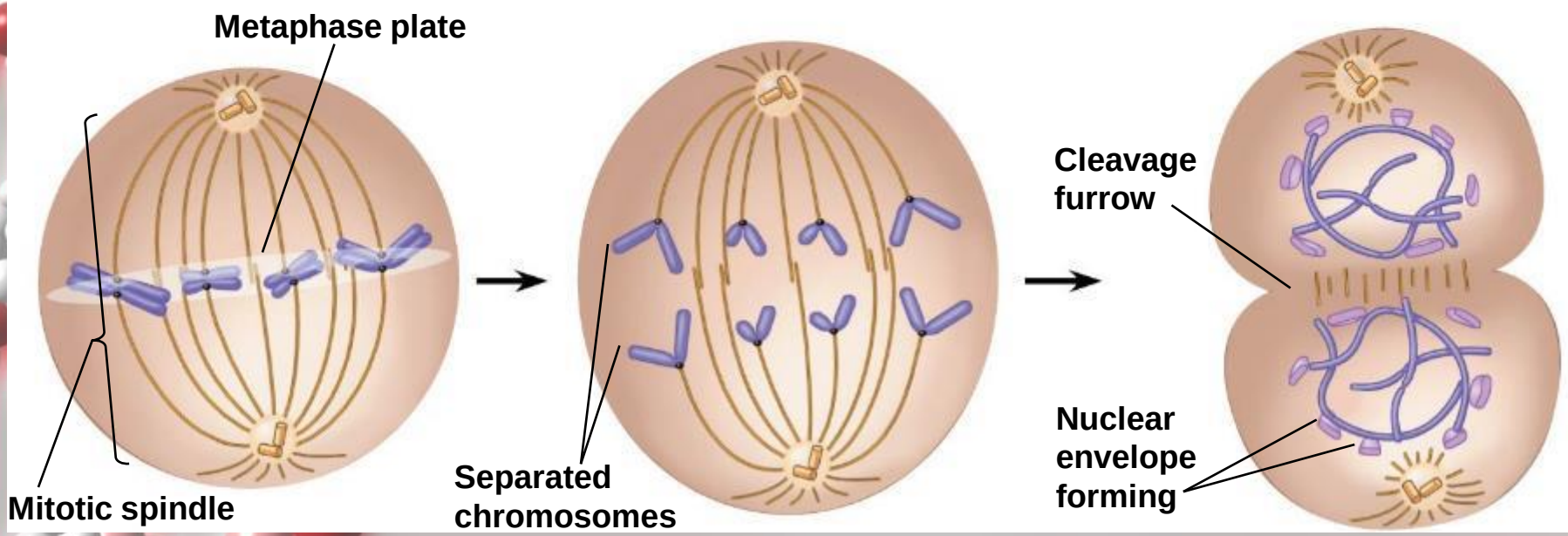


Anaphase

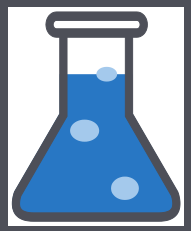


Telophase and Cytokinesis





Lesson Objectives



By the end of this lesson, you should be able to:

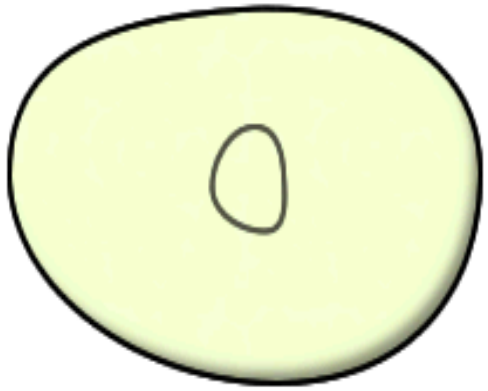
- Investigate the asexual cell/organism reproductive processes of binary fission and budding.
- Review more information regarding chromosomes and how they align during the sexual reproductive cell division process of meiosis.
- Illustrate the steps of meiosis (two major stages of meiosis I and meiosis II).
- Identify and define the differences between male and female meiosis in humans.
- Describe ways in which genetic variation occurs – the roles of crossing over and independent assortment in meiosis.
- Explain the importance of meiosis to living organisms.

- **Science Practice: Meiosis Simulation**

Processes of Asexual Reproduction

Binary fission

- The process of cell division (asexual reproduction).
- in prokaryotic organisms
- by which the parent cell divides into two genetically identical cells.



- Produces two identical cells in prokaryotes.

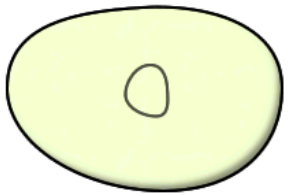
Asexual Reproduction

Advantages

- It is faster.
- Large numbers of offspring are produced.
- The parent does not have to find a mate.

Disadvantages

- All of the offspring are exactly alike. There is no variation.
- The ability to adapt to a changing environment is greatly reduced.

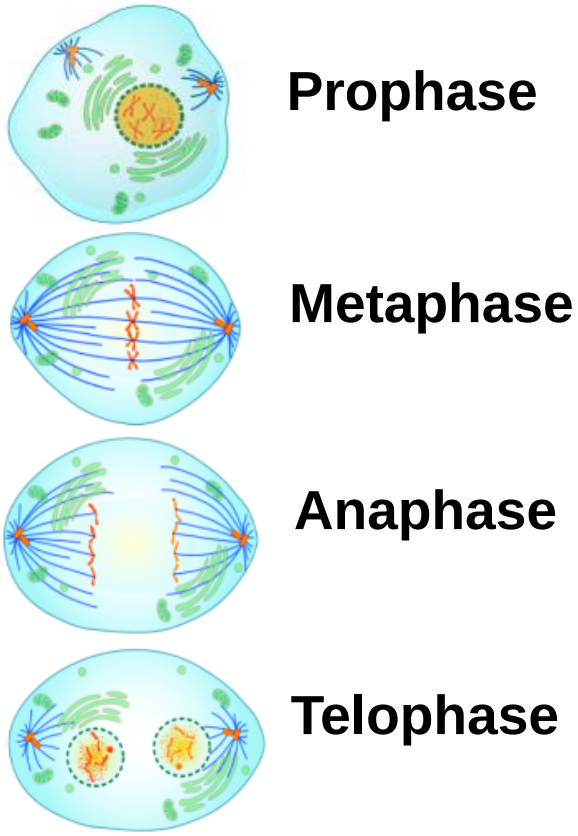


Processes of Asexual Reproduction

Mitosis is the process of cell division by which exact copies of chromosomes are divided

- to create two daughter cells,
- each with a complete set of identical chromosomes.

- Has four steps (PMAT)
- Produces two identical cells in eukaryotes.



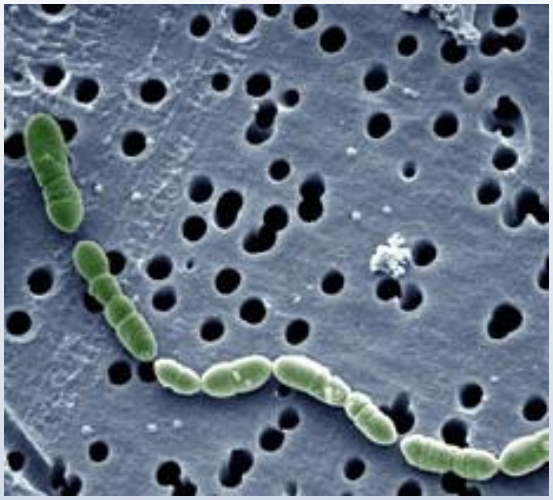
Importance of mitosis to Living Organisms

- Living organisms depend on asexual reproduction for life.

- **Growth**
  Allows organisms to grow.

Photo by Chuck B.

- **Repair**
  Replaces damaged or dead cells.



- **Reproduction**
  Creates new organisms

Overview

- ✓ **Asexual Reproduction** results in the production of organisms that are **genetically identical**, called **clones**.
- ✓ Organisms formed through **Sexual Reproduction** receive **half** their chromosomes from the **male** parent and **half** from the **female** parent.

Sexual Reproduction

Sexual reproduction requires two parent cells.

Each parent cell passes HALF its genes to its offspring.

Must have male and female:

- male to produce sperm
- and female to produce eggs.

Sexual Reproduction

Advantages

- All of the offspring are genetically different from each other (variation).

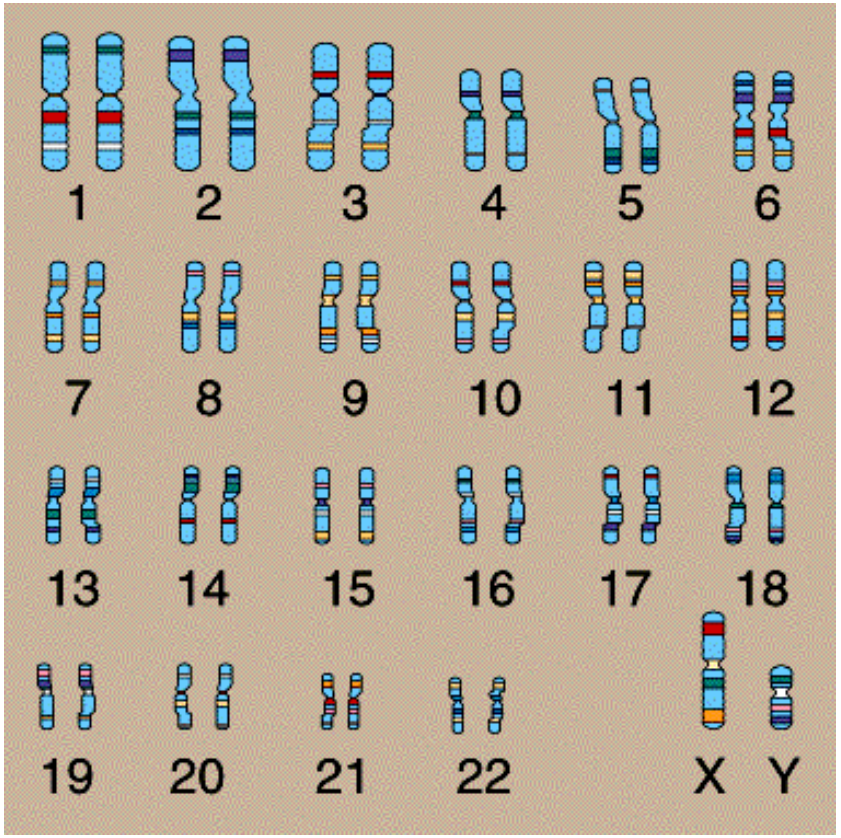
Disadvantages

- The parent must find a mate.
- Fewer offspring will be produced.
- It takes longer.

Chromosomes are Matched in Homologous Pairs

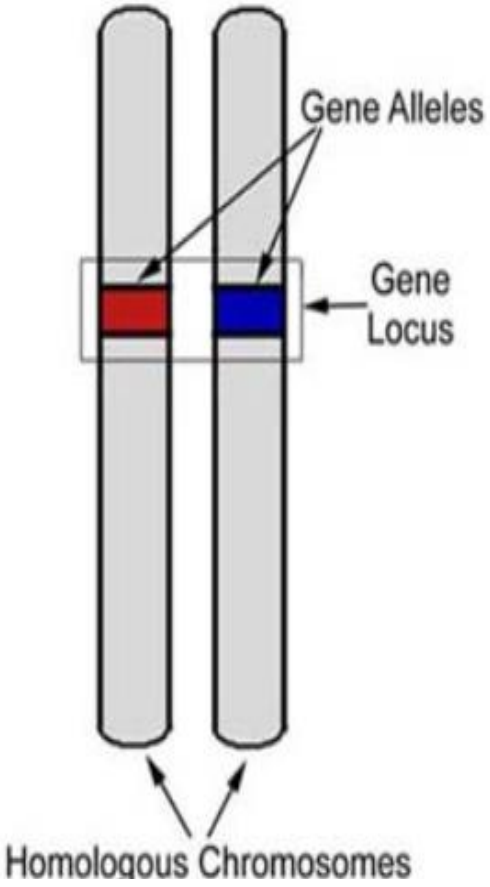
- In humans, **Somatic (Body) Cells** have **46 chromosomes** forming **23 pairs of Homologous Chromosomes**.

Homologous Chromosomes are the two copies of each chromosome, one coming from the **mother** and one coming from the **father**.



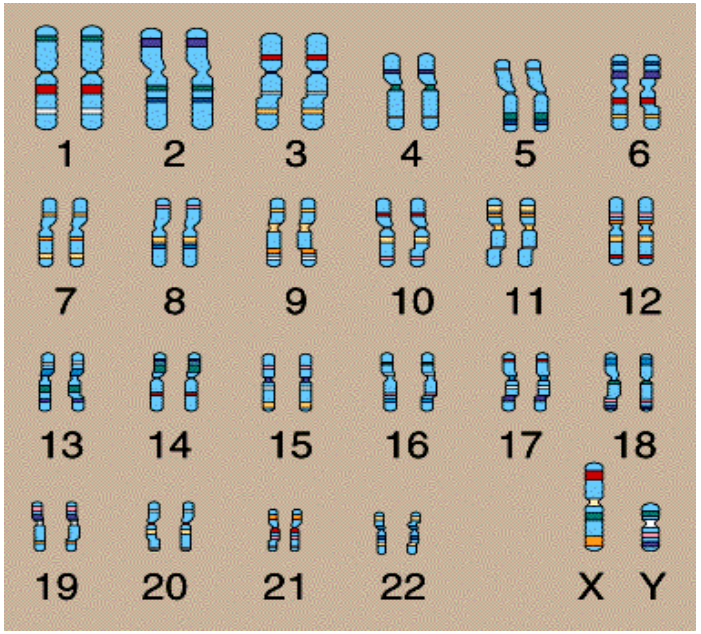
Chromosomes are Matched in Homologous Pairs

- **Homologous Chromosomes** are matched in
  - length
  - centromere position
  - staining pattern
- A **LOCUS** (plural, *loci*) is the **position of a gene**.
- Different versions of a gene may be found at the same locus on the two chromosomes of a homologous pair.



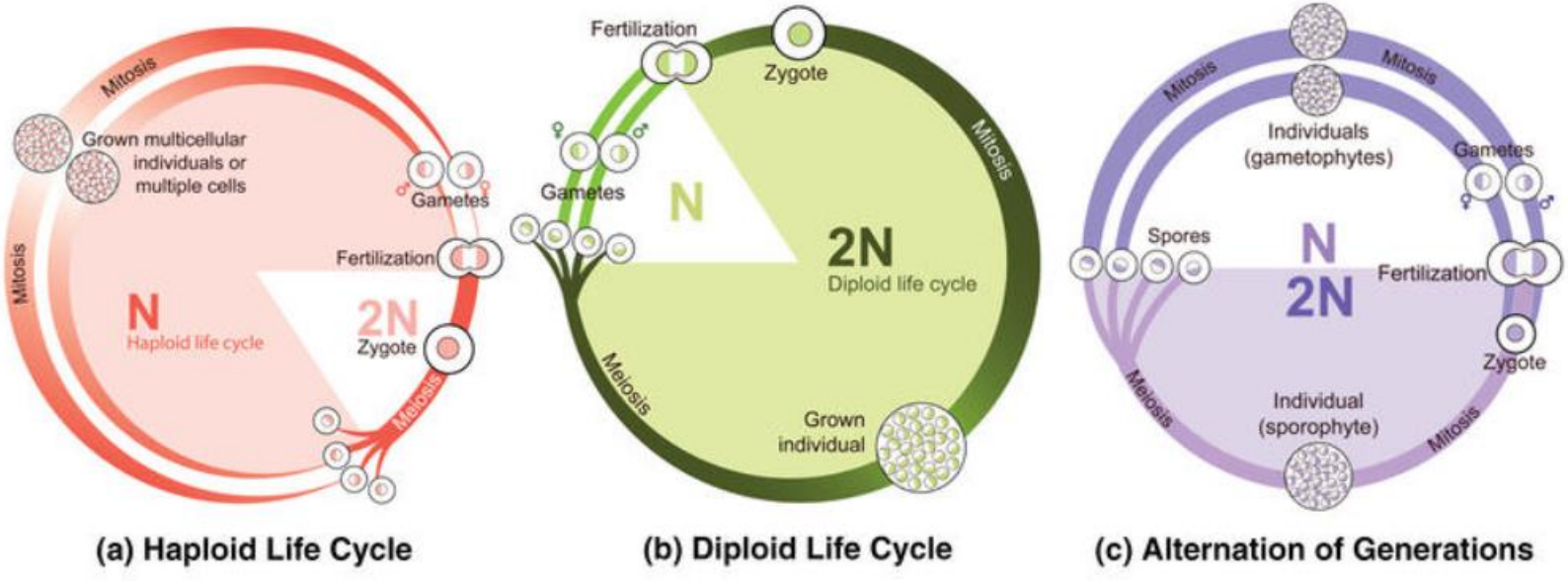
Chromosomes are Matched in Homologous Pairs

- The human **Sex Chromosomes X** and **Y** differ in size and genetic composition.
- The other 22 pairs of chromosomes are **Autosomes** with the same size and genetic composition.



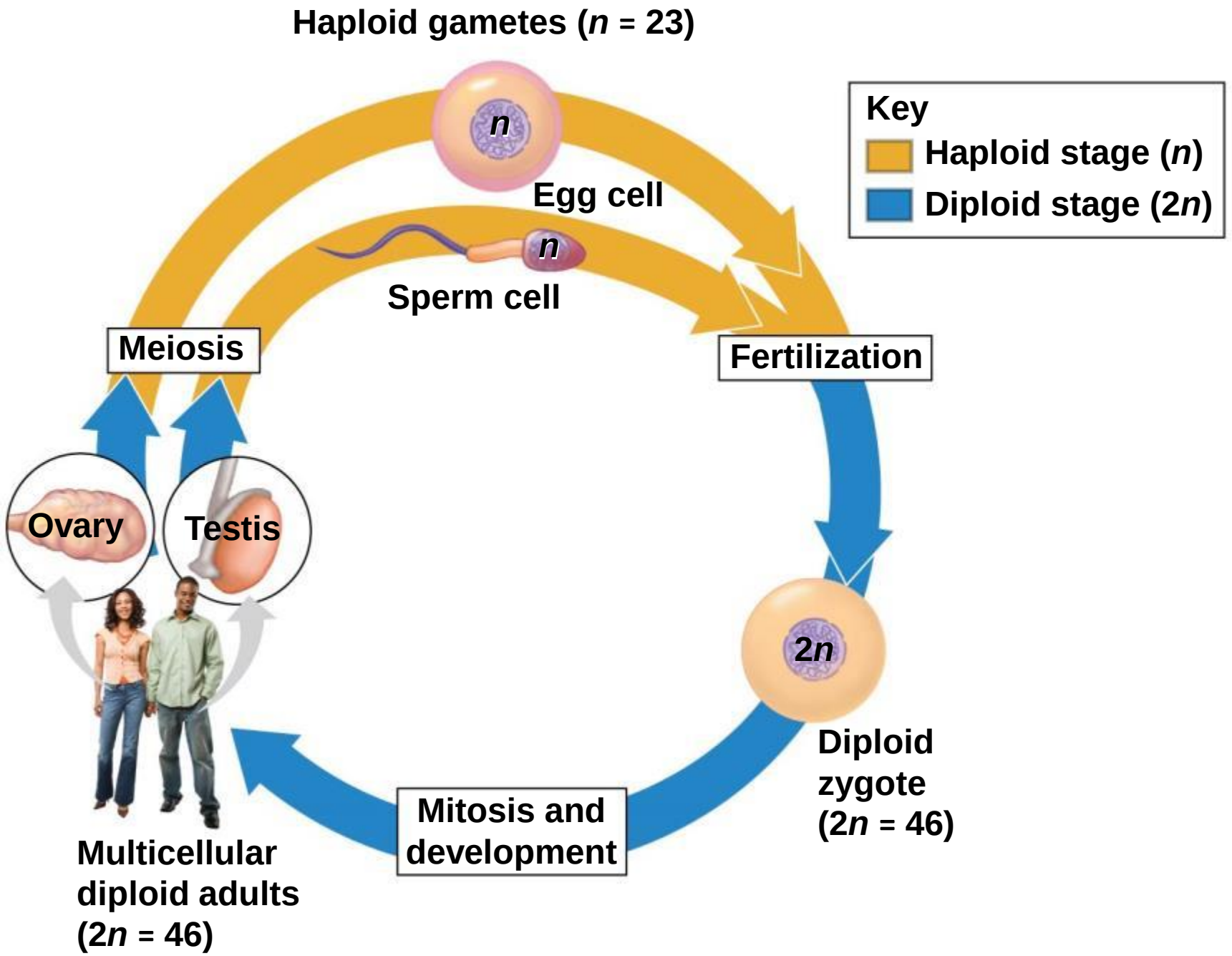
Gametes have a Single Set of Chromosomes

- An organism's **Life Cycle** is the sequence of stages leading from the adults of one generation to the adults of the next.
- Humans and many animals and plants are **Diploid (2n)**, because all somatic cells contain pairs of homologous chromosomes.

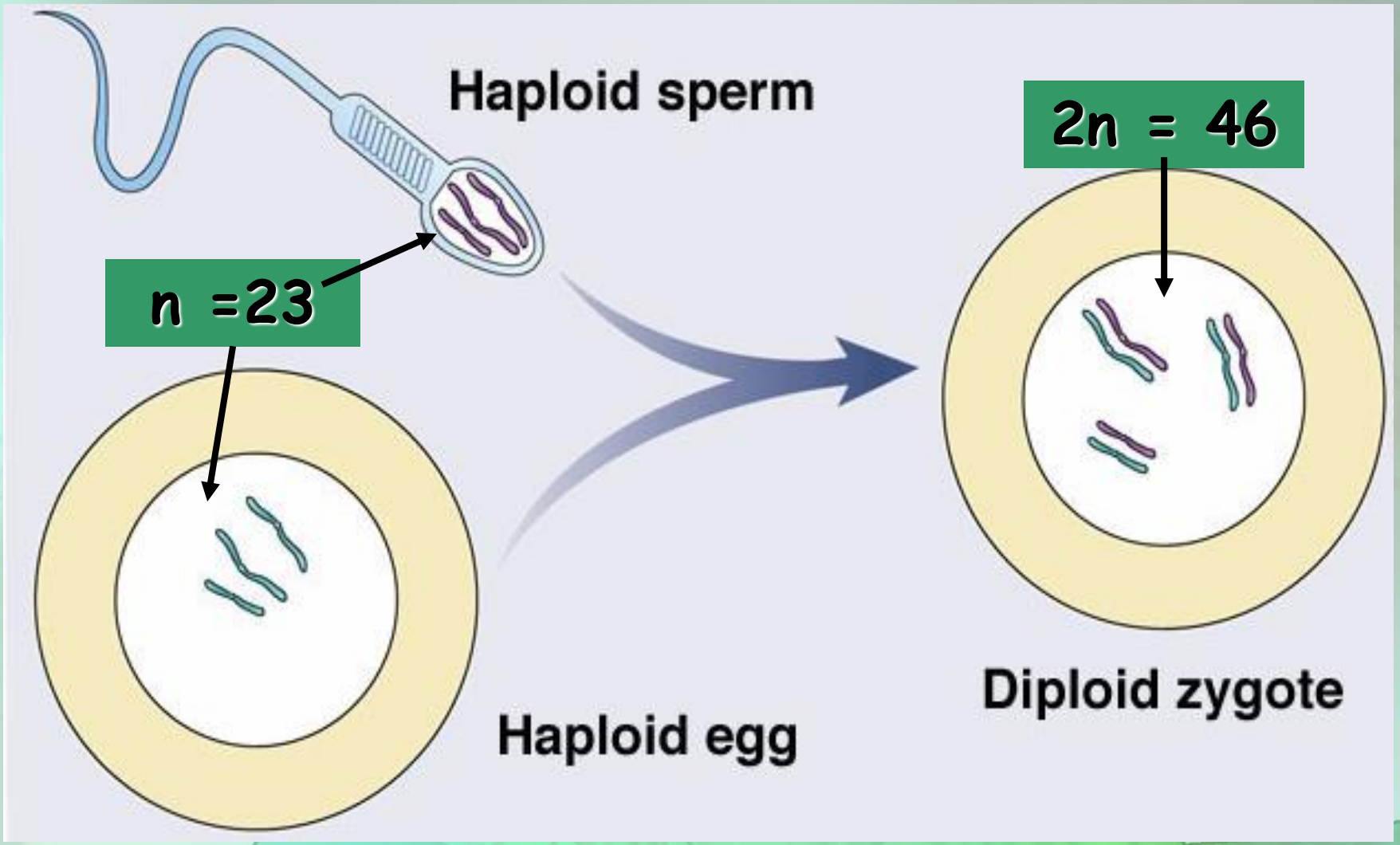


Gametes have a Single Set of Chromosomes

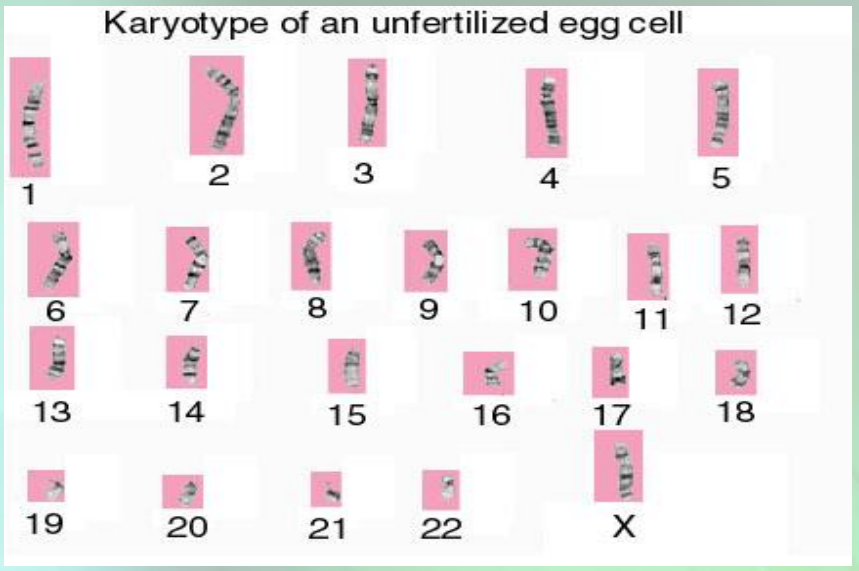
- **GAMETES**
  - are eggs and sperm
  - are **Haploid (n)** because each cell has a single set of chromosomes.
- The human life cycle begins when a haploid sperm fuses with a haploid egg in **Fertilization**.
- The **Zygote**, formed by fertilization, is now diploid.
- **Mitosis** of the zygote and its descendants generates all the somatic cells into the adult form.

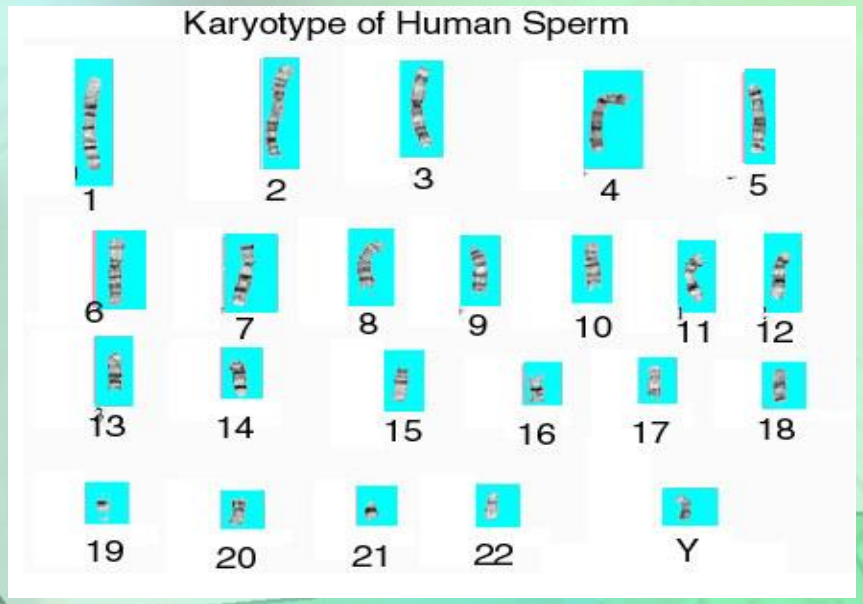

Haploid gametes (n = 23)
Key
Haploid stage (n)
Diploid stage (2n)
n
Egg cell
n
Sperm cell
Meiosis
Fertilization
Ovary
Testis
2n
Diploid zygote (2n = 46)
Mitosis and development
Multicellular diploid adults (2n = 46)

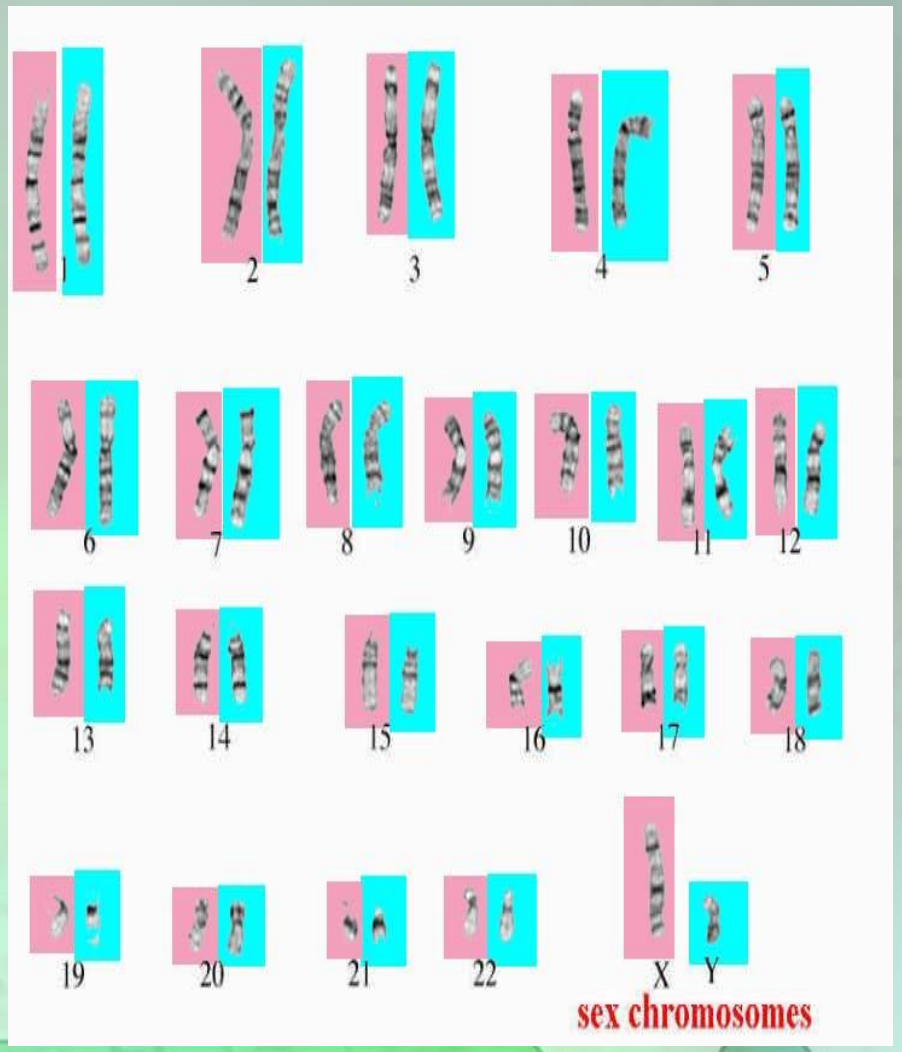
Fertilization: "Putting it all together"



Fertilization – "Putting it all together"

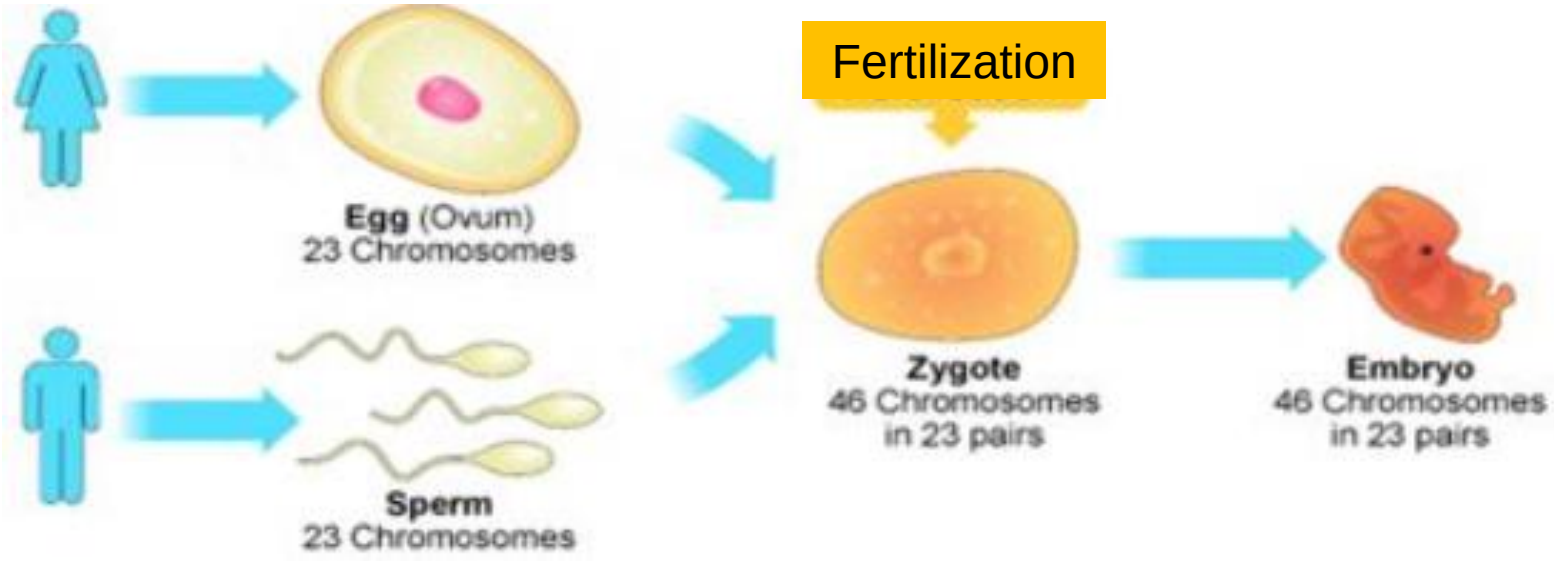






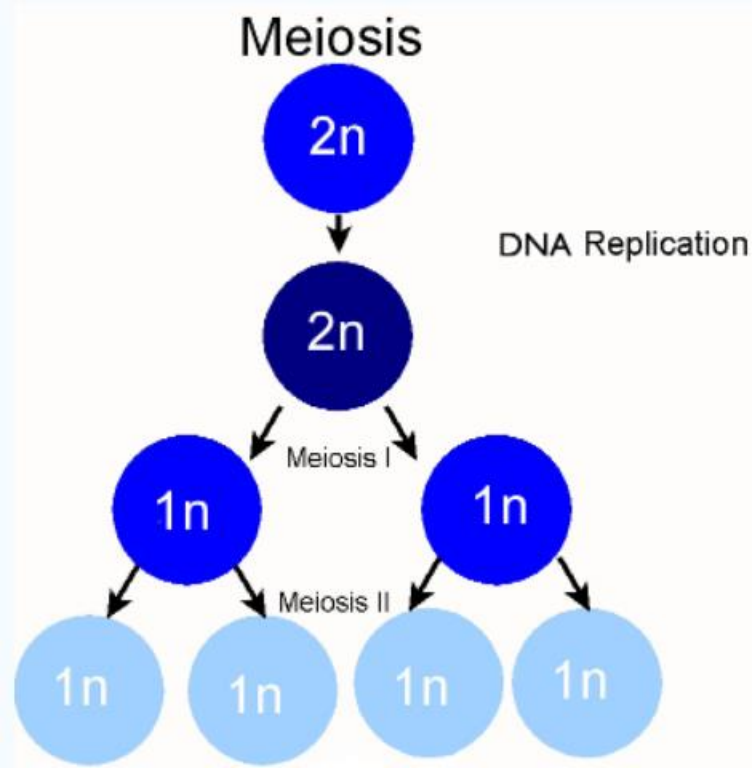
Gametes have a Single Set of Chromosomes

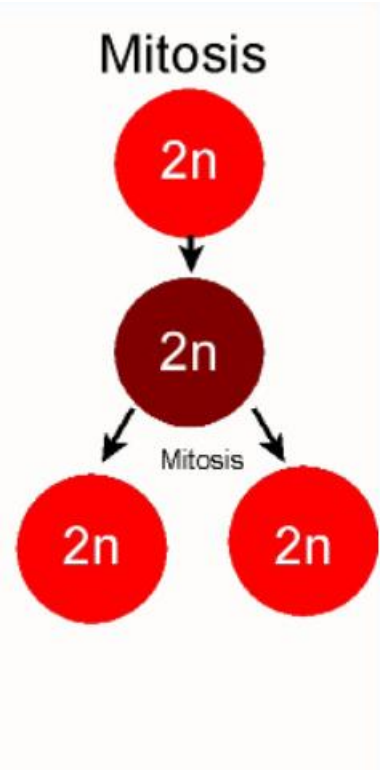
- **Gametes (haploid sex cells)** are made by **MEIOSIS** in the **ovaries** and **testes.**
- **MEIOSIS** is a type of cell division that produces **haploid gametes** in diploid organisms.
- Two haploid gametes may then combine in fertilization to restore the diploid state in the zygote.



Gametes have a Single Set of Chromosomes

- **MEIOSIS reduces the chromosome number by HALF:**

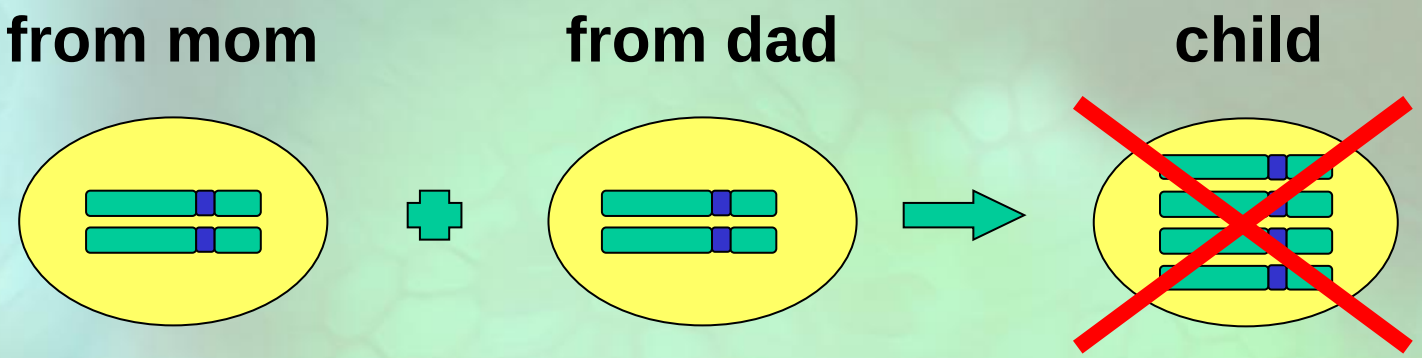




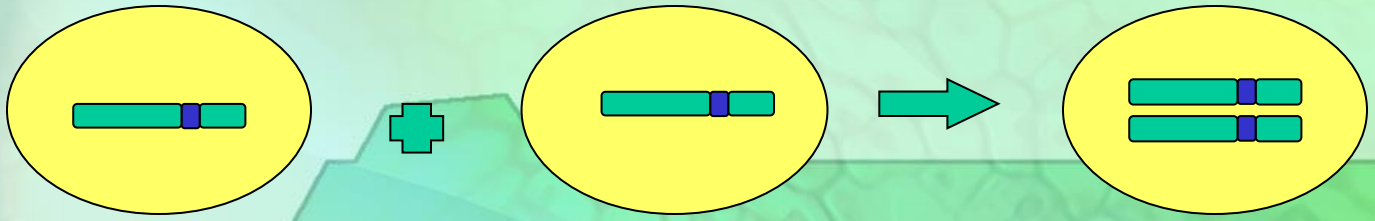
- ✓ Daughter cells **contain half the number of chromosomes** as the parent cell.
- ✓ Preceded by **Replication** and followed by two divisions: **Meiosis I** and **Meiosis II.**

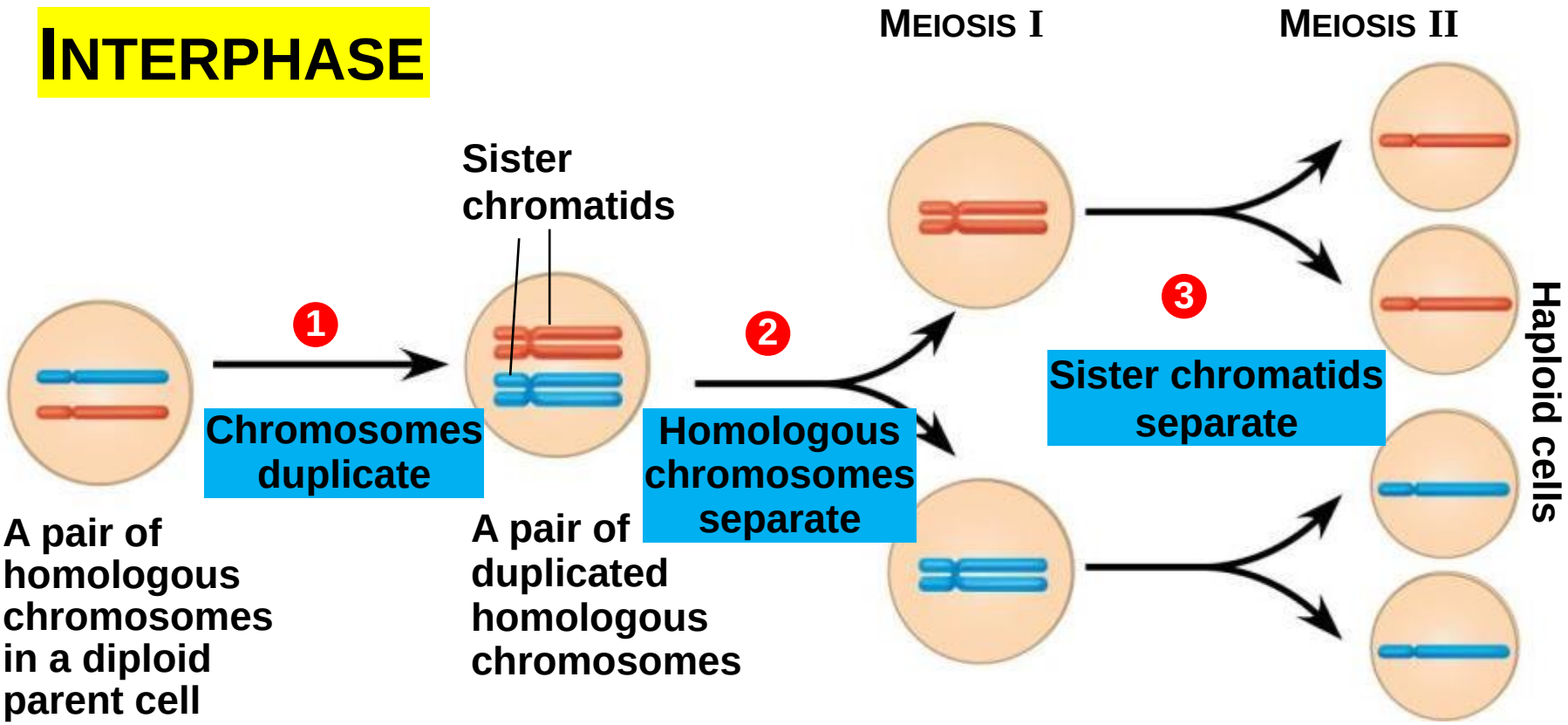
Meiosis Forms Haploid Gametes

- ✓ Meiosis must reduce the chromosome number by half.
- ✓ Fertilization then restores the diploid (2n) number.



Meiosis reduces chromosome number



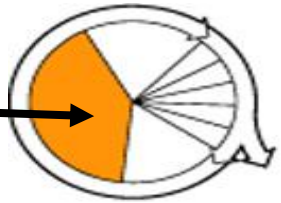

INTERPHASE
MEIOSIS I
MEIOSIS II
Sister chromatids
1
Chromosomes duplicate
2
Homologous chromosomes separate
3
Sister chromatids separate
Haploid cells
A pair of homologous chromosomes in a diploid parent cell
A pair of duplicated homologous chromosomes

MEIOSIS reduces the Chromosome Number from Diploid (2n) to Haploid (n)

- **Meiosis** and **Mitosis** are **preceded** by the duplication of chromosomes **(DNA Replication).**
- However,
  - **Meiosis** is followed by **two** consecutive cell divisions
  - **Mitosis** is followed by only **one** cell division.
- **Meiosis** involves **one duplication** of chromosomes followed by **two divisions**,
- Each of the four daughter cells produced possess an haploid set of chromosomes.

MEIOSIS reduces the Chromosome Number from Diploid (2n) to Haploid (n)

INTERPHASE:

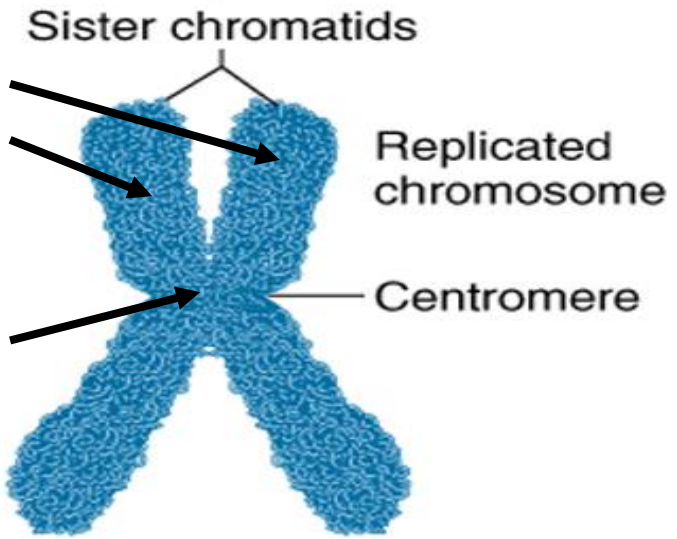


- ✓Like mitosis, meiosis is preceded by an interphase.
- ✓during which the **chromosomes duplicate.**

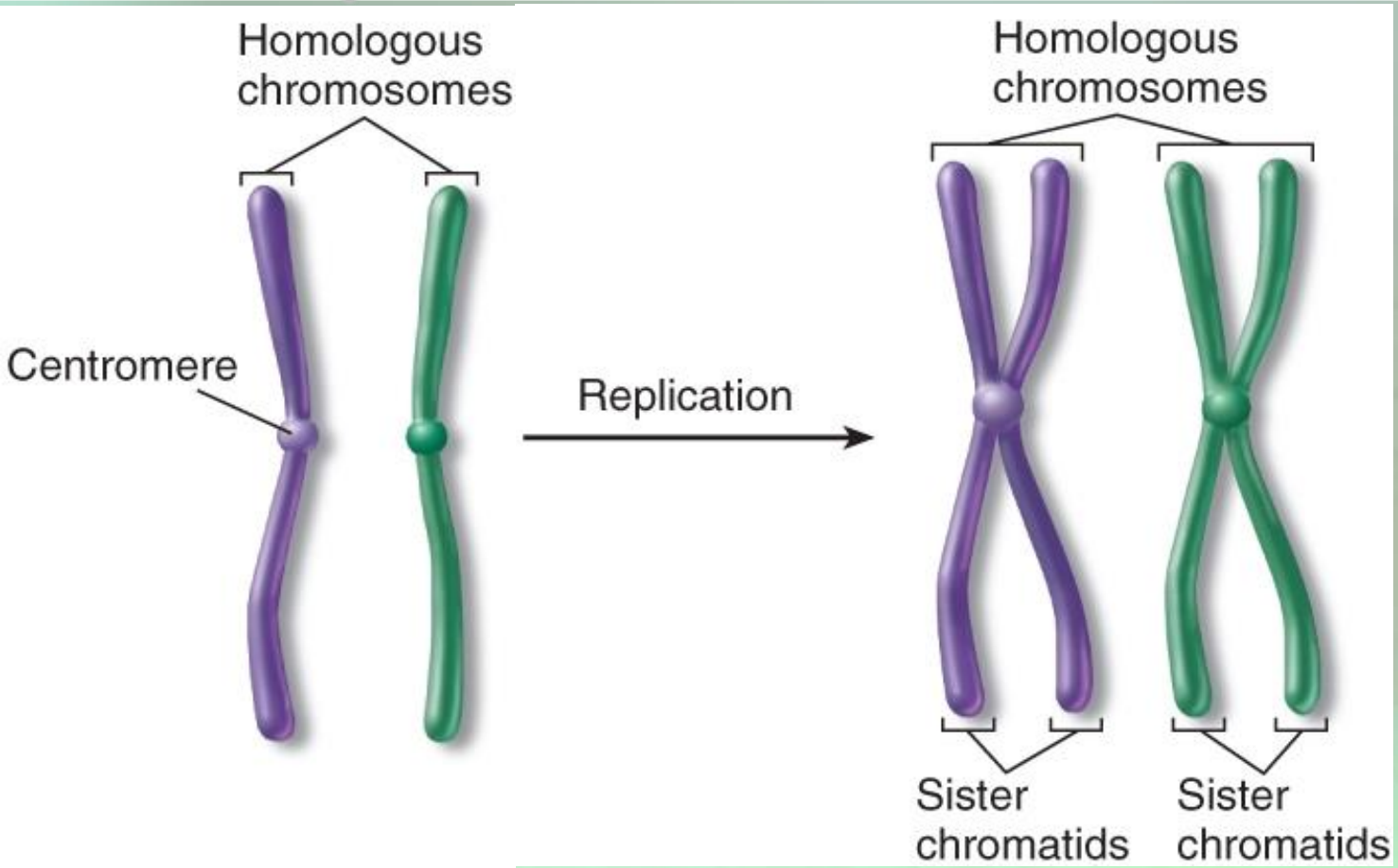
DNA synthesis and condensation

Replicated copies are called sister chromatids

Held together at centromere



A Replicated Chromosome



Homologous chromosomes are chromosomes that share: the same structural features (e.g. same size, same banding patterns, same centromere positions). The same genes at the same loci positions (while the genes are the same, alleles may be different).

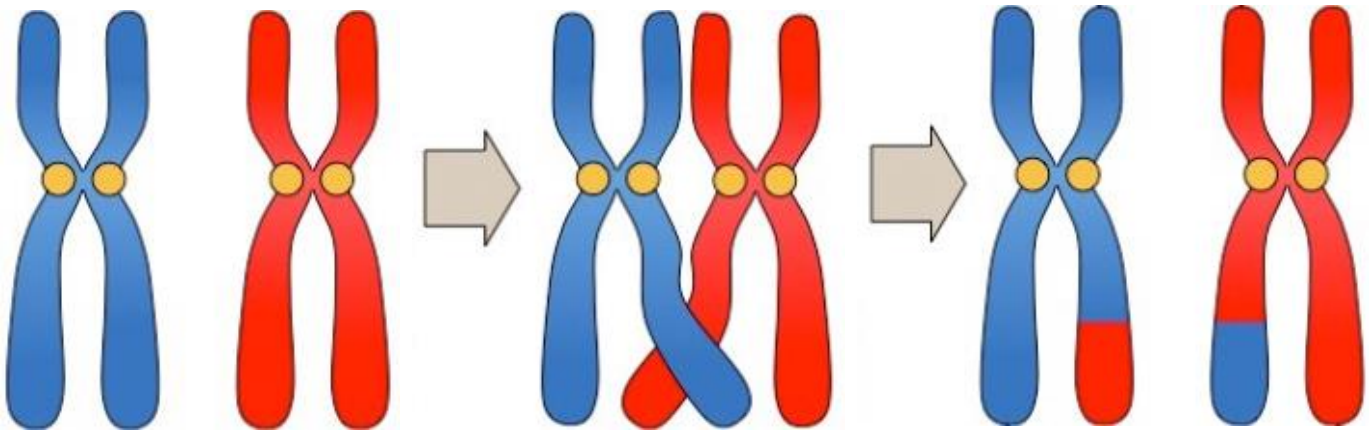
MEIOSIS reduces the Chromosome Number from Diploid (2n) to Haploid (n)

MEIOSIS I – Prophase I key events:

- The nuclear membrane dissolves.
- **Chromatin** tightly coils up.
- **Homologous chromosomes**, each composed of **two sister chromatids**, come together in pairs in a process called **Synapsis**.

MEIOSIS reduces the Chromosome Number from Diploid (2n) to Haploid (n)

- **MEIOSIS I – Prophase I** key events:
  - During synapsis, chromatids of homologous chromosomes exchange segments in a process called **Crossing Over**.

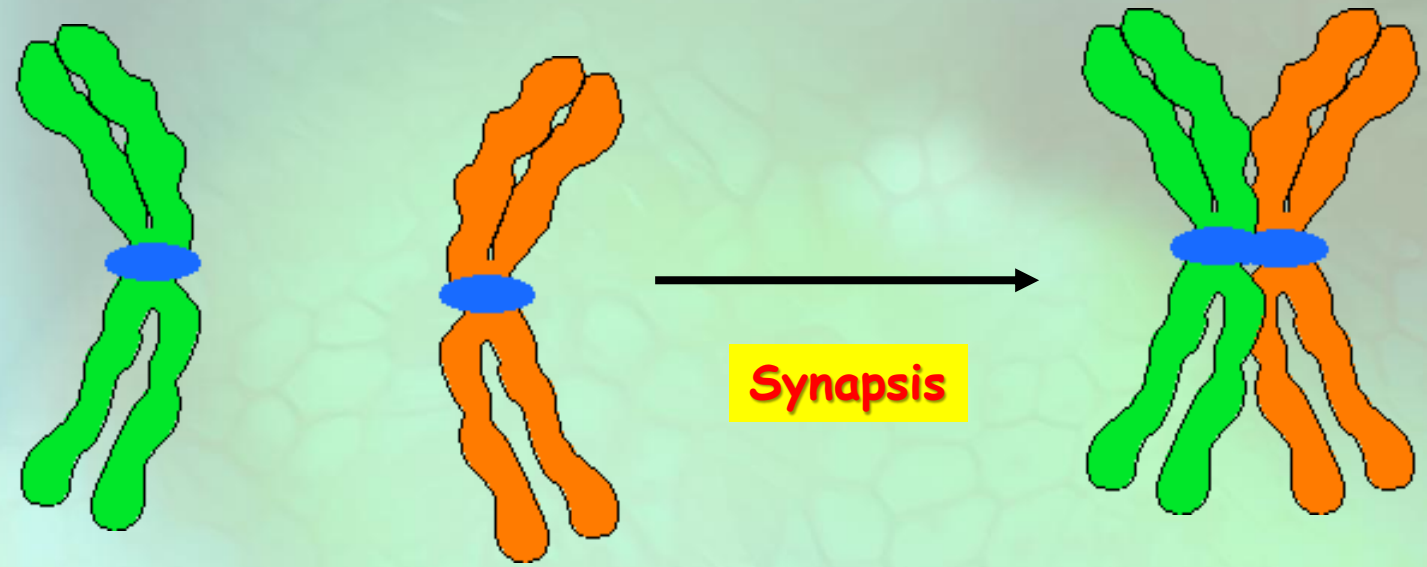


  - The chromosome tetrads move toward the center of the cell.

Tetrads Form in Prophase I

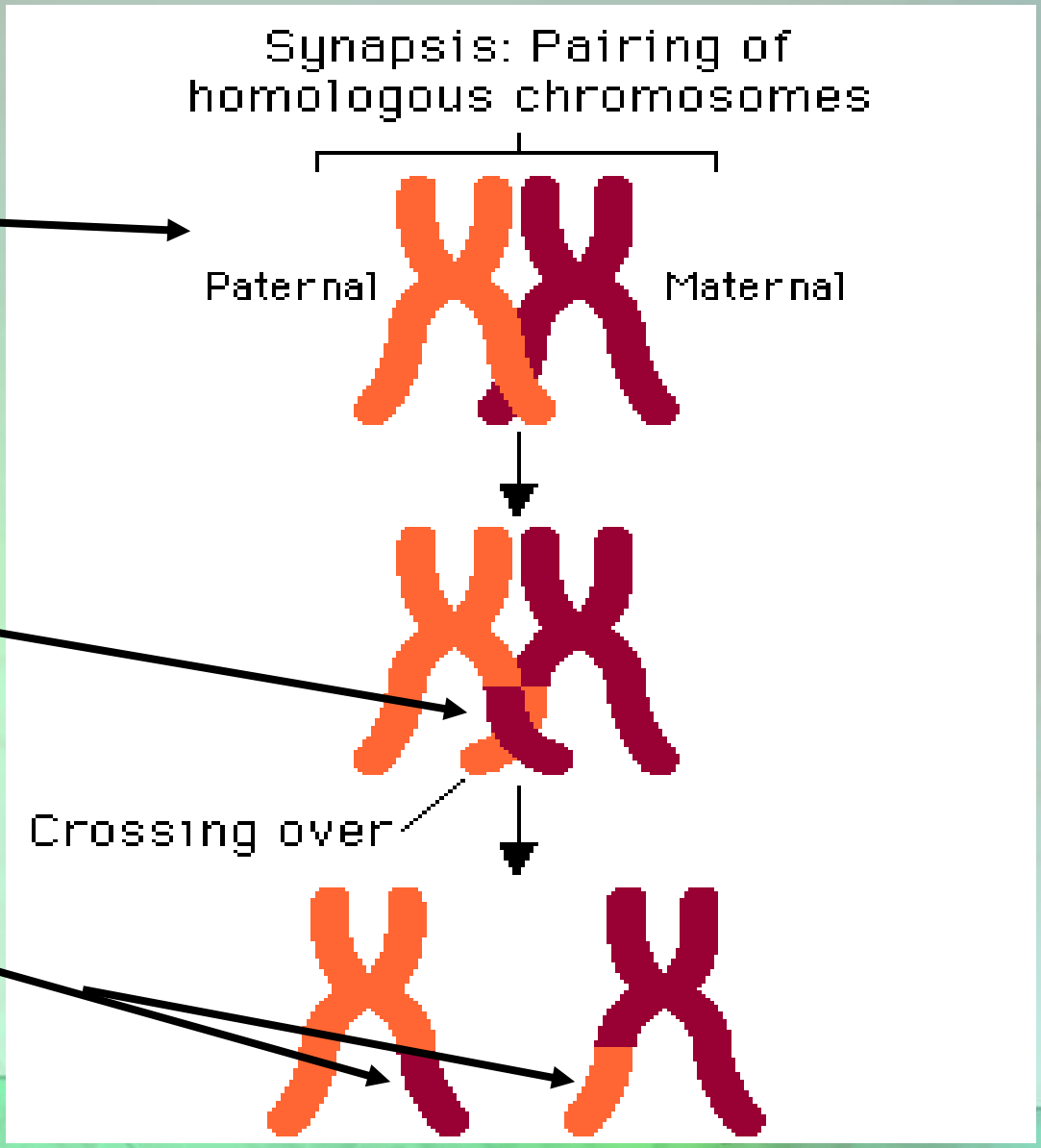
Homologous chromosomes **align with sister chromatids).**

Joining to form a **TETRAD.**

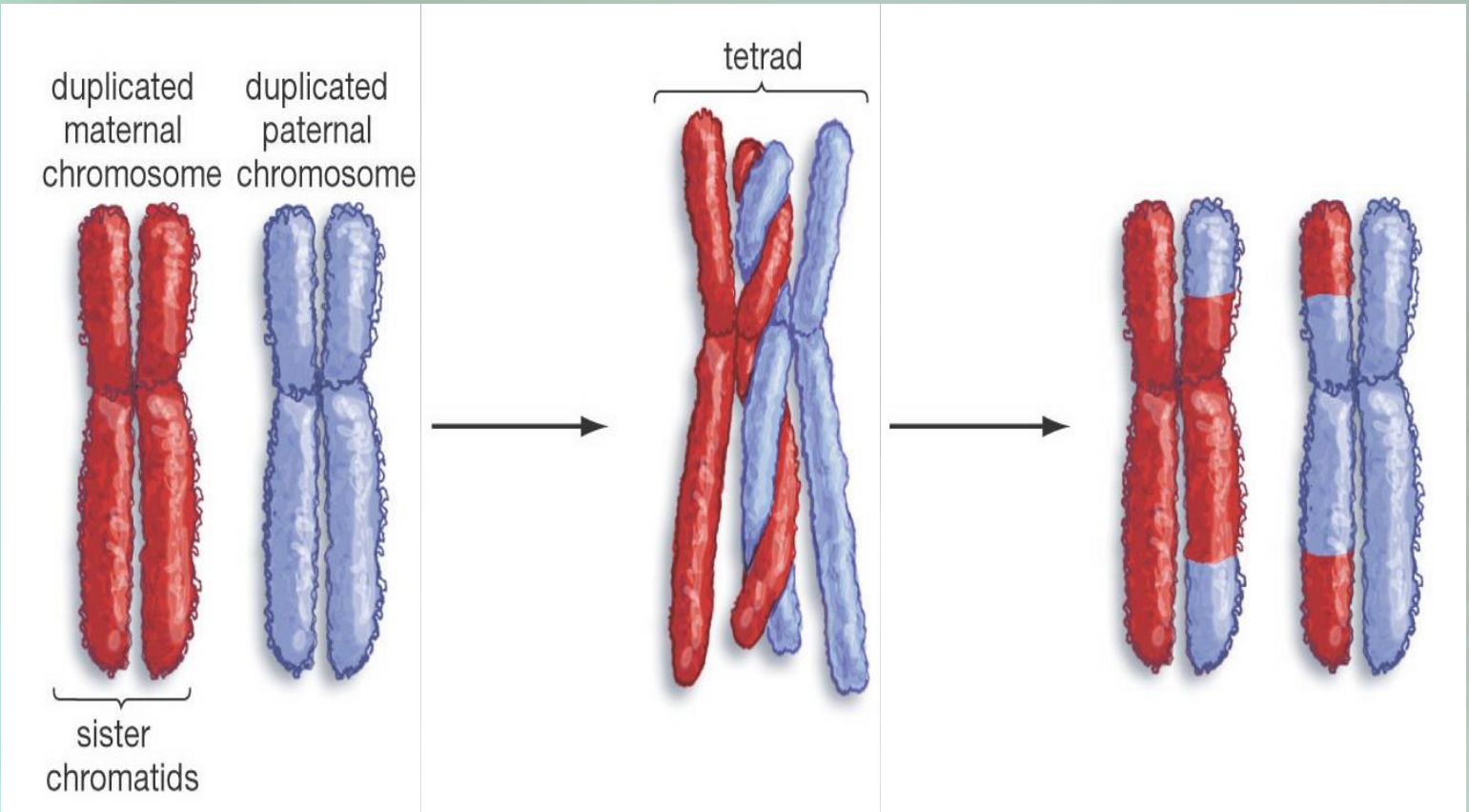


Crossing-Over

- ✓ Homologous chromosomes in a tetrad cross over each other.
- ✓ Pieces of chromosomes or genes are exchanged.
- ✓ Produces Genetic Recombination in the offspring.



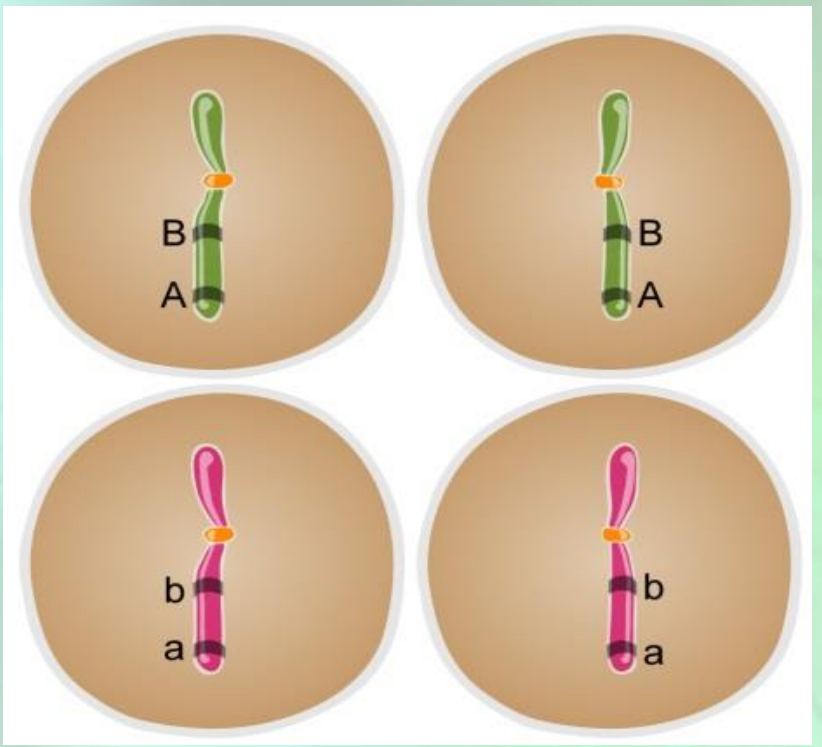
Crossing-Over



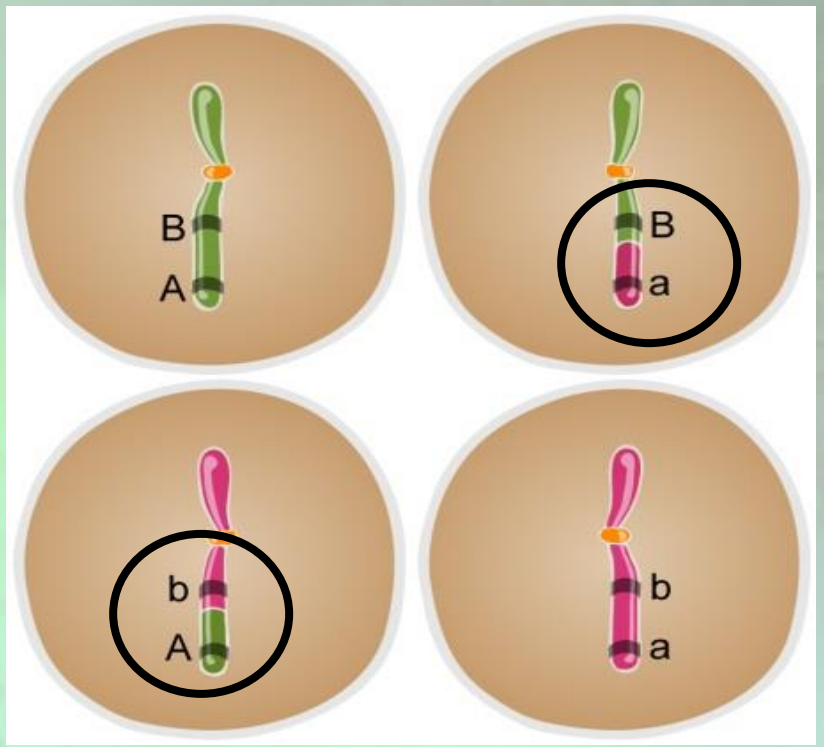
Crossing-Over multiplies the already huge number of different gamete types produced.

The Process of Meiosis: Crossing Over

- **WITHOUT crossing over**



- **With crossing over**



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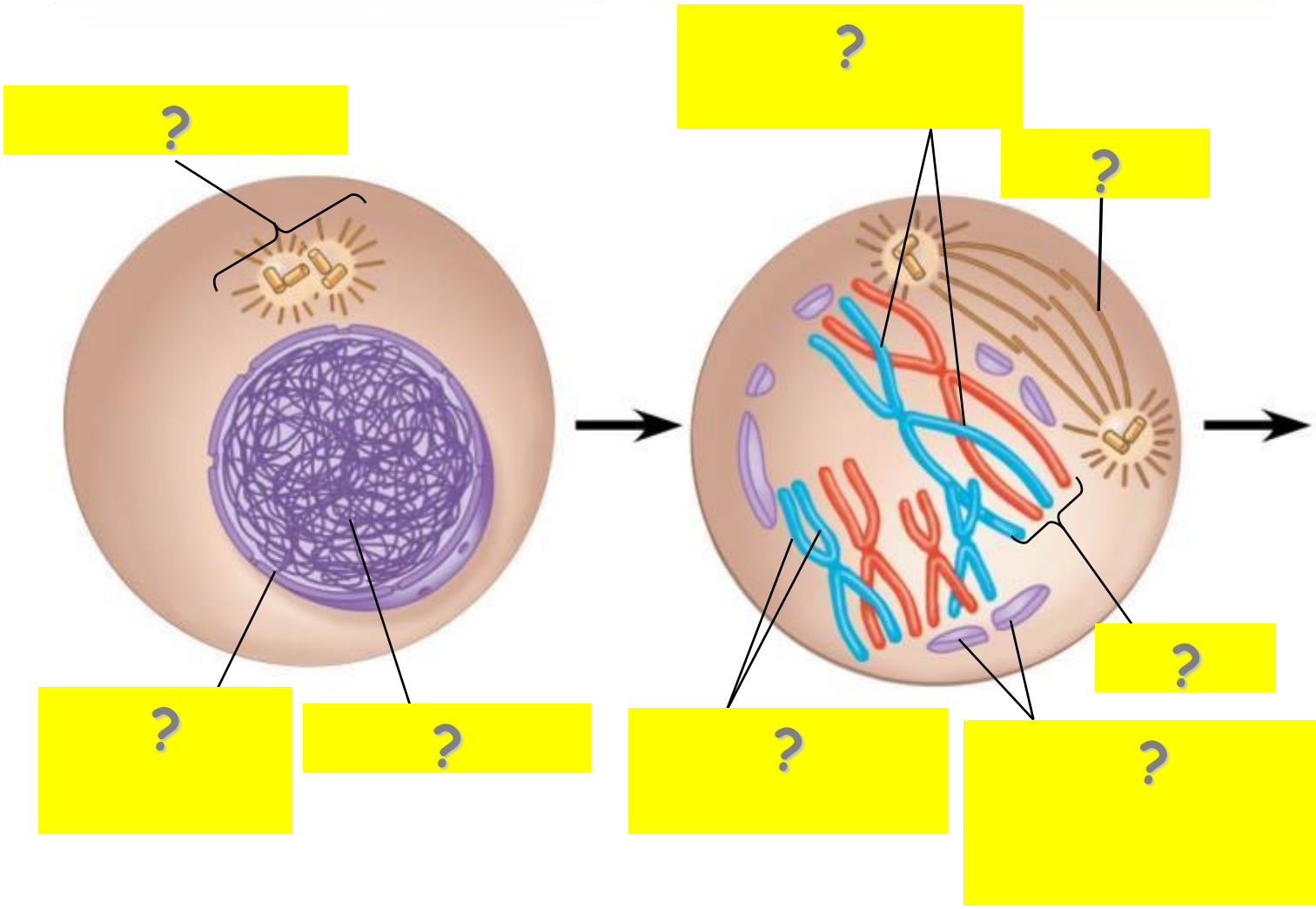
QUICK CHECK

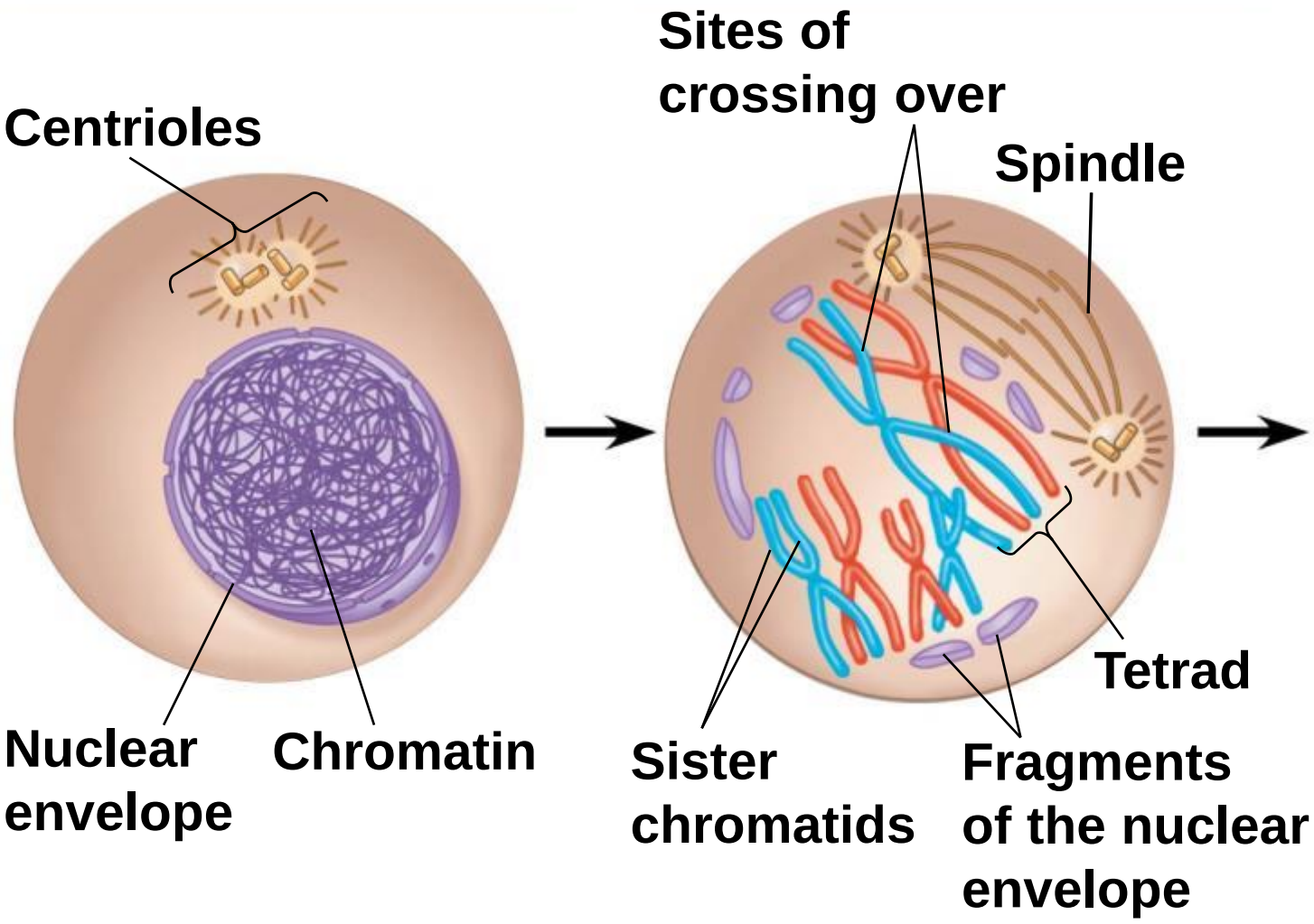


INTERPHASE:
Chromosomes duplicate

MEIOSIS I:

Prophase I

QUICK CHECK



MEIOSIS reduces the Chromosome Number from Diploid (2n) to Haploid (n)

MEIOSIS I – Metaphase I:

- Tetrads align at the cell equator.
- Homologous chromosome alignment.

MEIOSIS reduces the Chromosome Number from Diploid (2n) to Haploid (n)

MEIOSIS I – Anaphase I:

- **Homologous Pairs Separate** and move toward opposite poles of the cell.
- Unlike mitosis, the sister chromatids making up each doubled chromosome remain attached.
- When the **Homologous Pairs** are pulled apart, this **reduces** the **diploid number (2n)** to the **haploid number (n).**

MEIOSIS I: CONTINUED

QUICK CHECK

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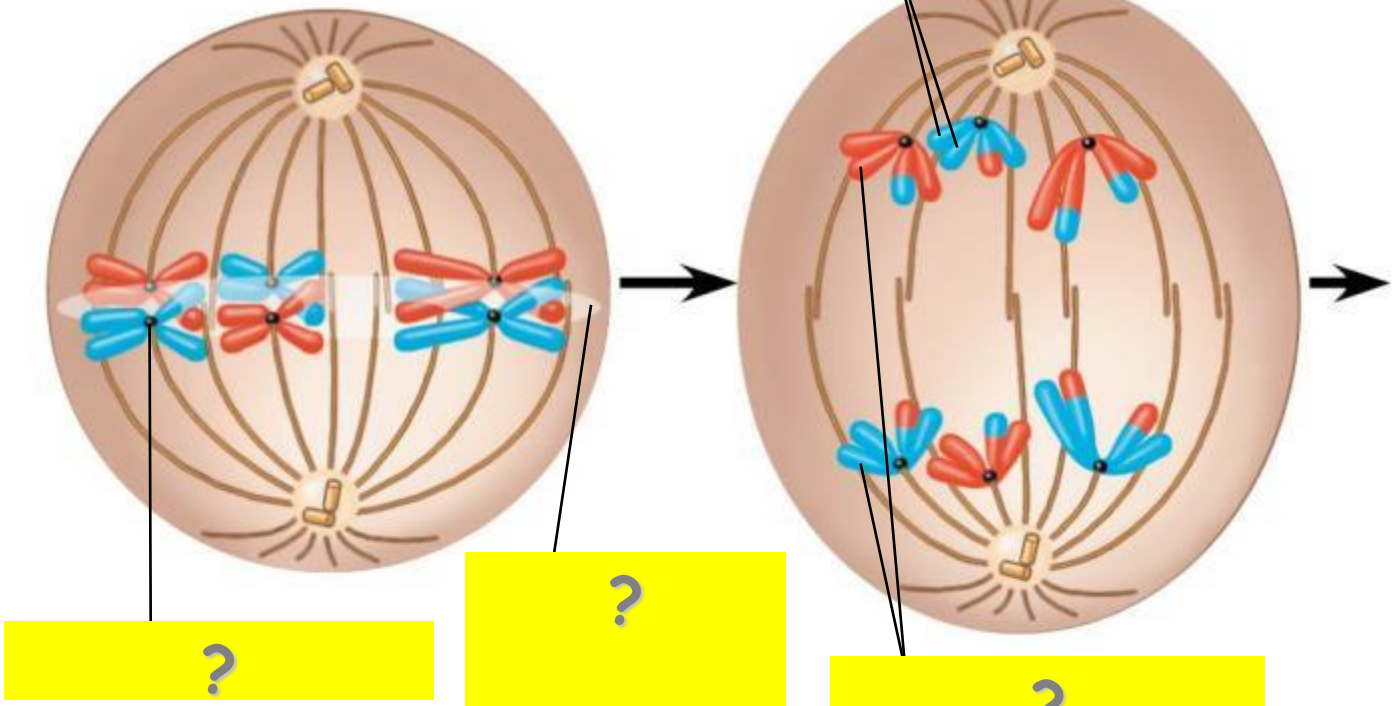

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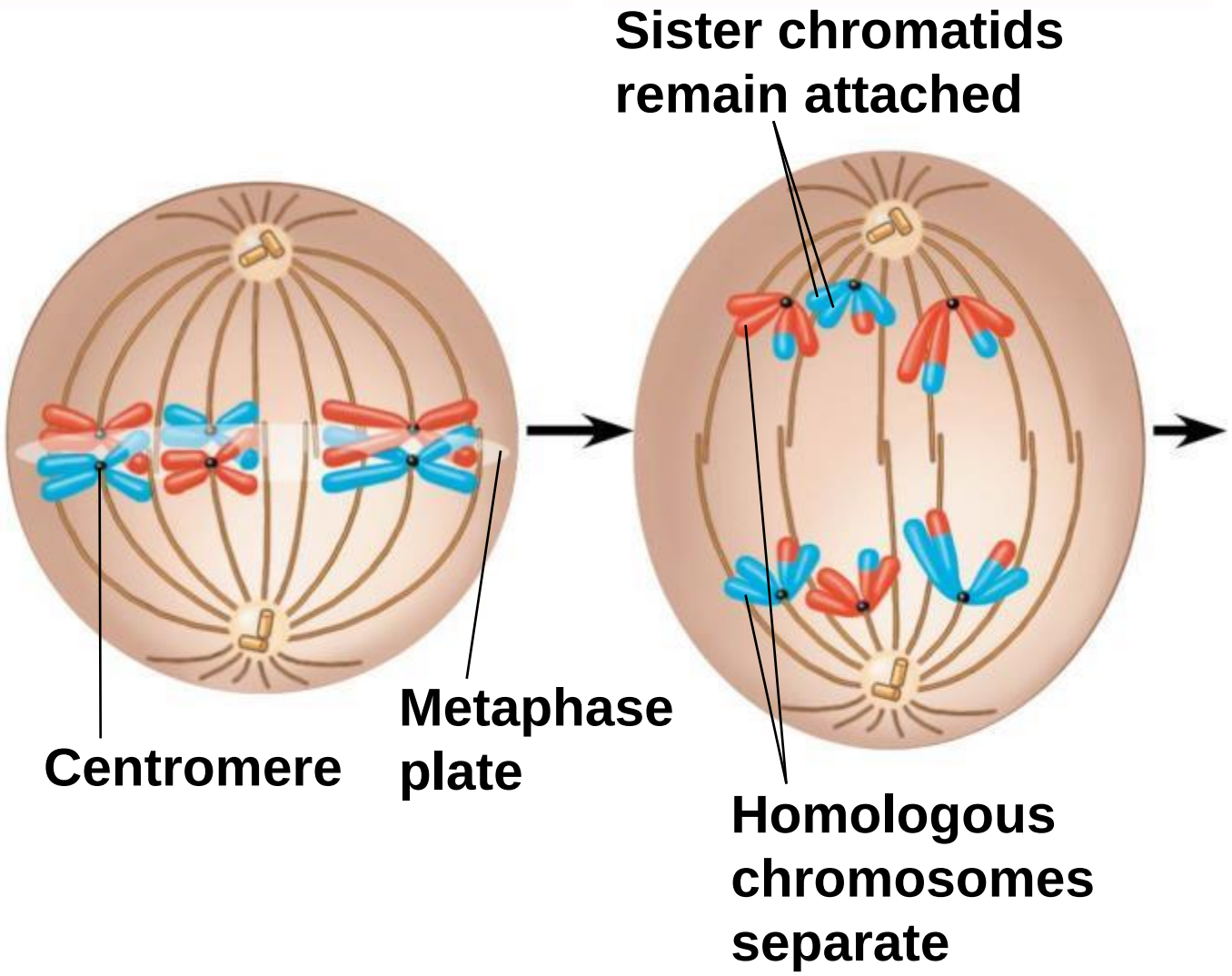
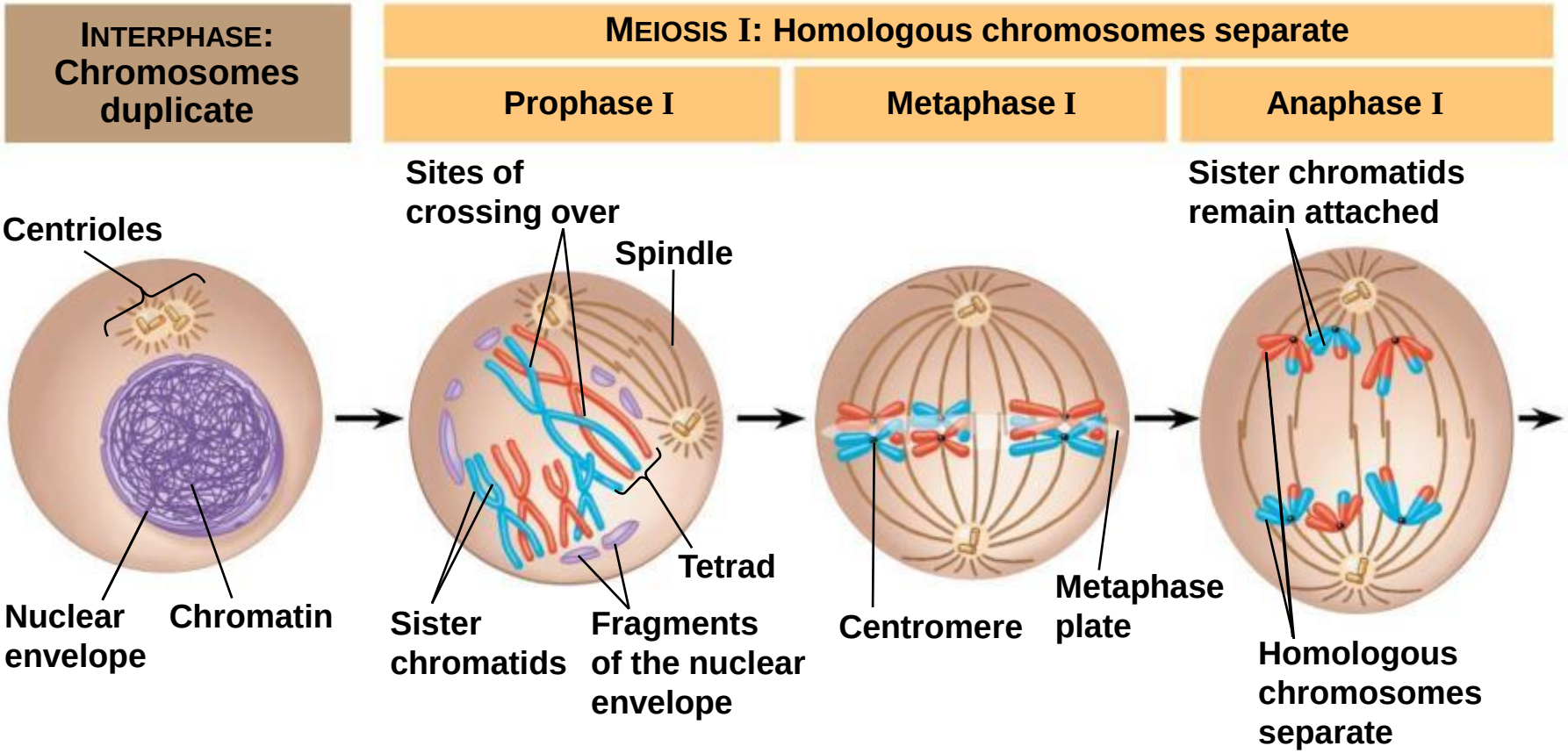
MEIOSIS I: CONTINUED

Metaphase I

Anaphase I



QUICK CHECK


INTERPHASE:
Chromosomes duplicate
MEIOSIS I: Homologous chromosomes separate
Prophase I
Metaphase I
Anaphase I
Centrioles
Nuclear envelope
Chromatin
Sites of crossing over
Spindle
Sister chromatids
Fragments of the nuclear envelope
Tetrad
Centromere
Metaphase plate
Sister chromatids remain attached
Homologous chromosomes separate

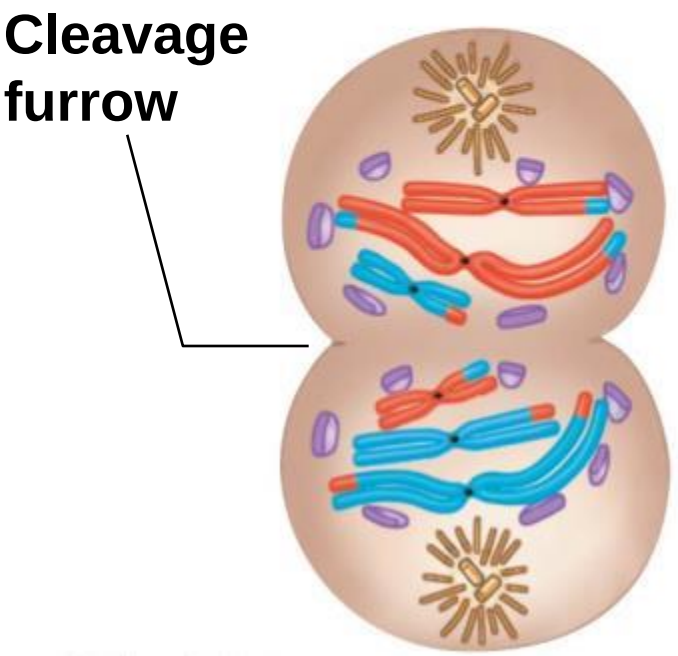
MEIOSIS reduces the Chromosome Number from Diploid (2n) to Haploid (n)

MEIOSIS I –

Telophase I

Telophase I and Cytokinesis

- Duplicated chromosomes have reached the poles.
- Usually, **cytokinesis** occurs along with telophase.
- These cells are **haploid**; but there are **two copies of the same genetic information** in the chromosomes in each of the two cells formed.



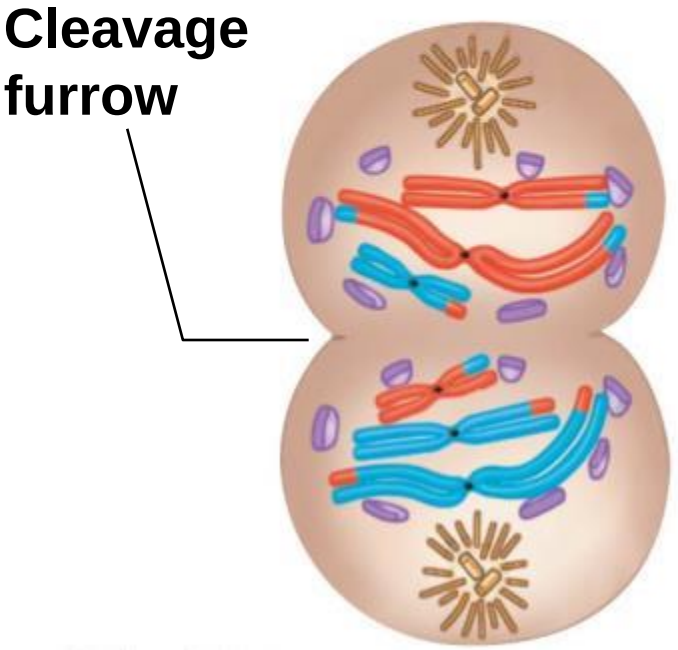
MEIOSIS reduces the Chromosome Number from Diploid (2n) to Haploid (n)

MEIOSIS I –

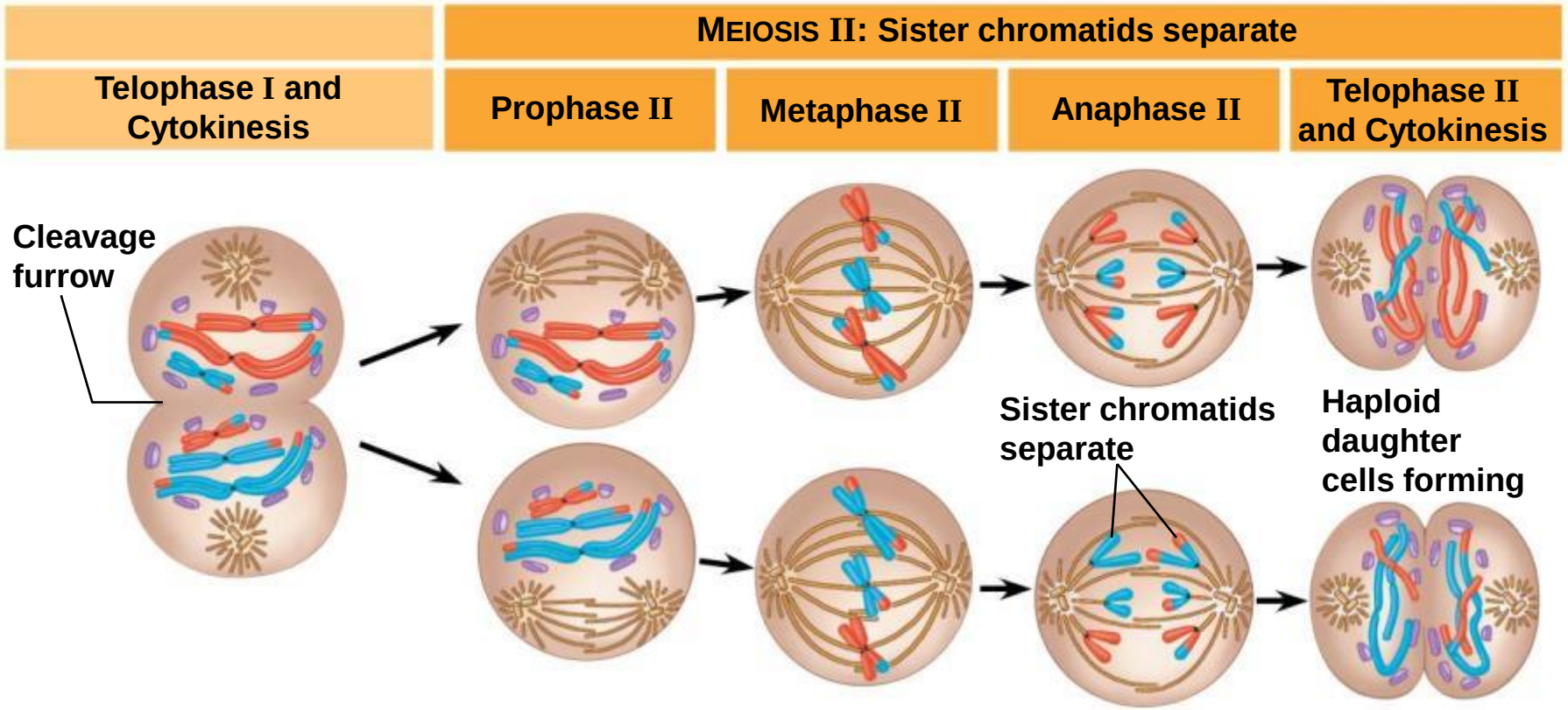
Telophase I

Telophase I and Cytokinesis

- Nuclear envelope reassembly.
- Spindle disappears.
- 2 new cells form with duplicate chromosomes in each.



Meiosis II Summary



MEIOSIS reduces the Chromosome Number from Diploid (2n) to Haploid (n)

- **MEIOSIS II** follows **MEIOSIS I** **without chromosome duplication**.
- Each of the **two haploid cells** that are products of **MEIOSIS I** enters **MEIOSIS II**.
- **MEIOSIS II** – **Prophase II**
  - A spindle forms and moves chromosomes toward the middle of the cell.
  - Chromatin coils into chromosomes.

MEIOSIS reduces the Chromosome Number from Diploid (2n) to Haploid (n)

- **MEIOSIS II – Metaphase II**
  - Duplicated chromosomes align at the cell equator like they are in mitosis.
  - Chromosomes attach to spindle fiber.
- **MEIOSIS II – Anaphase II**
  - **Sister chromatids separate**.
  - Individual chromosomes move toward opposite poles.
  - Centromeres split.

MEIOSIS reduces the Chromosome Number from Diploid (2n) to Haploid (n)

- **MEIOSIS II – Telophase II**
  - Chromosomes have reached the poles of the cell.
  - A nuclear envelope forms around each set of chromosomes.
  - With **Cytokinesis**, sister chromatids separate into **FOUR HAPLOID CELLS** are produced.

Watch Animation

MEIOSIS II: Sister chromatids separate

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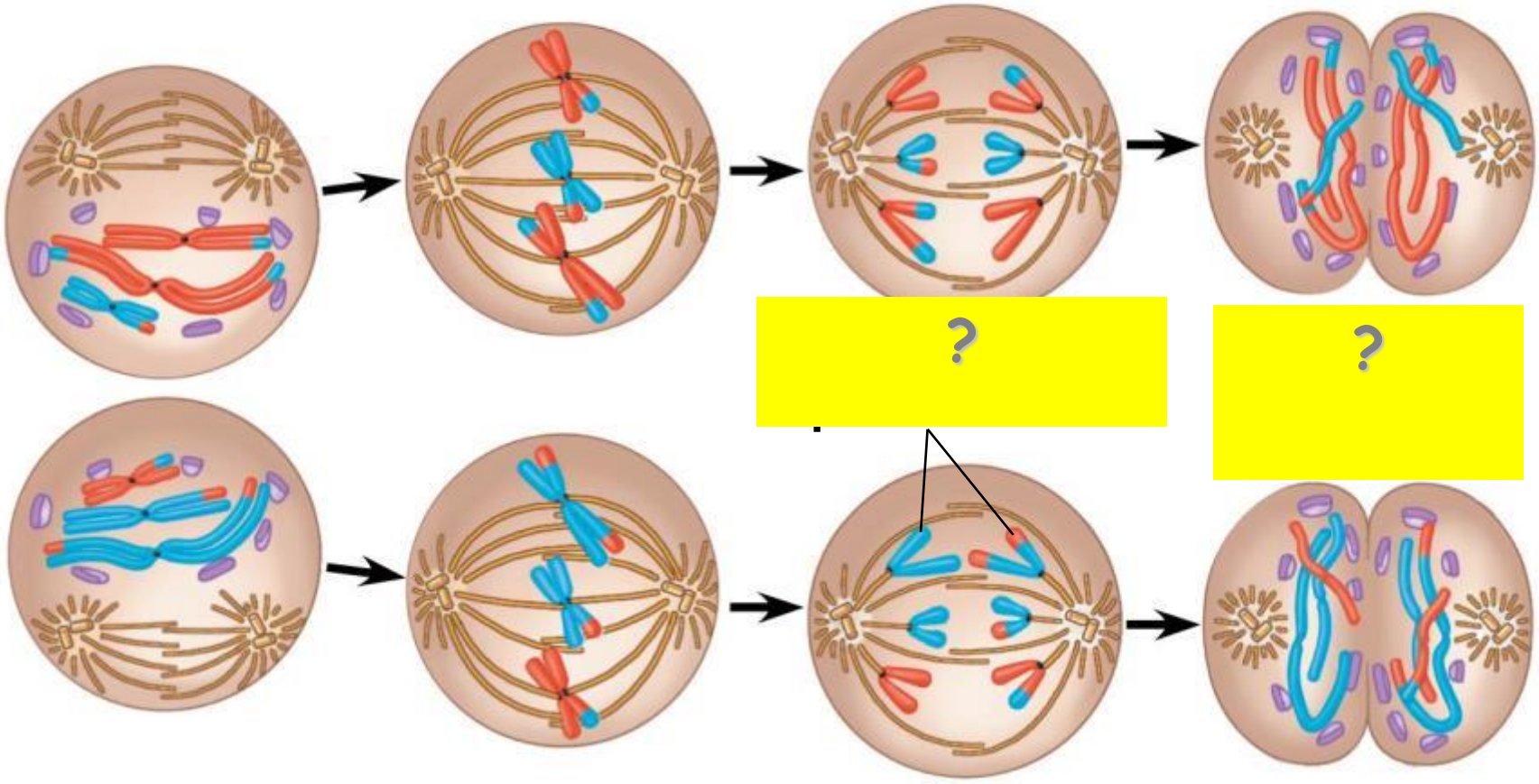

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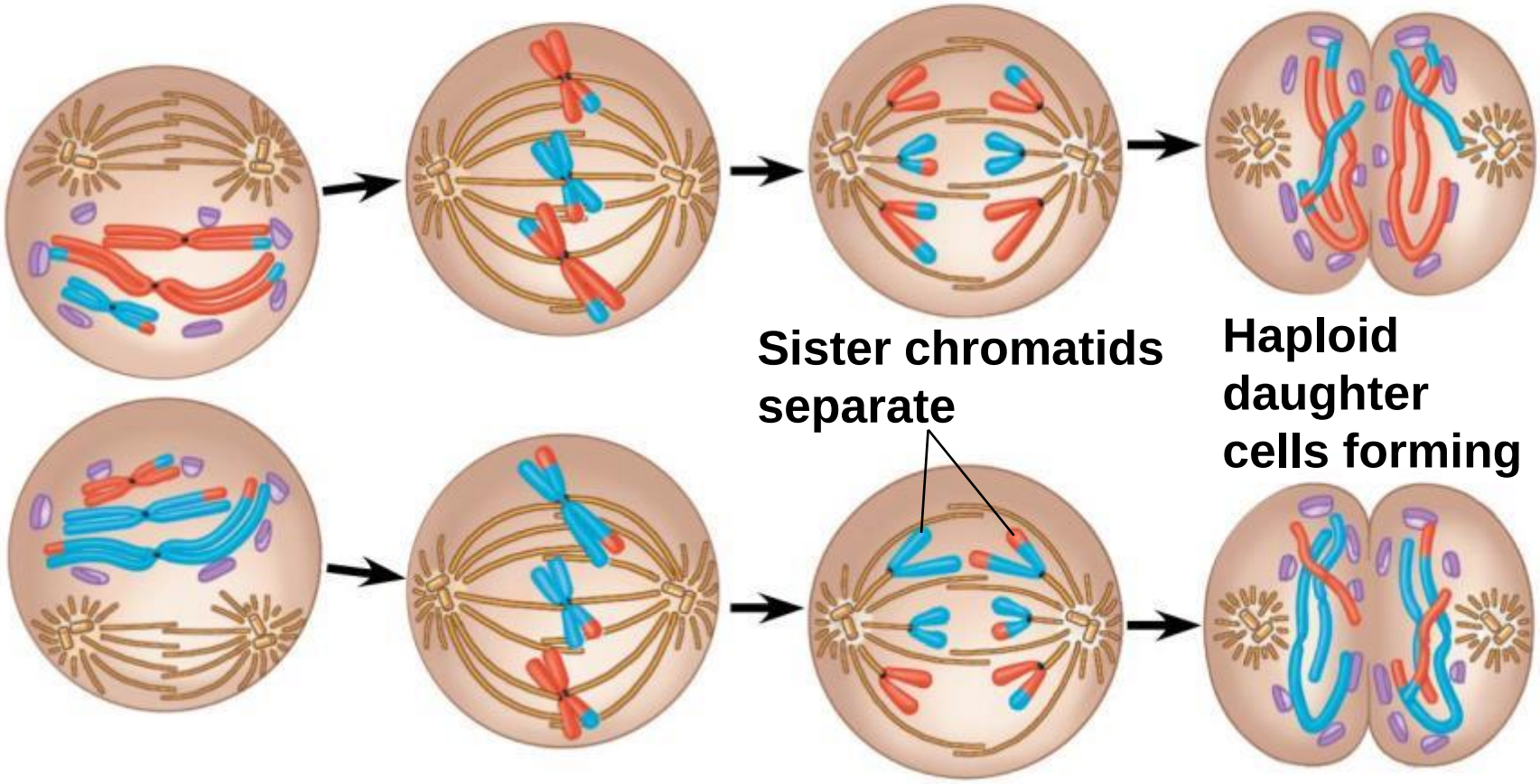
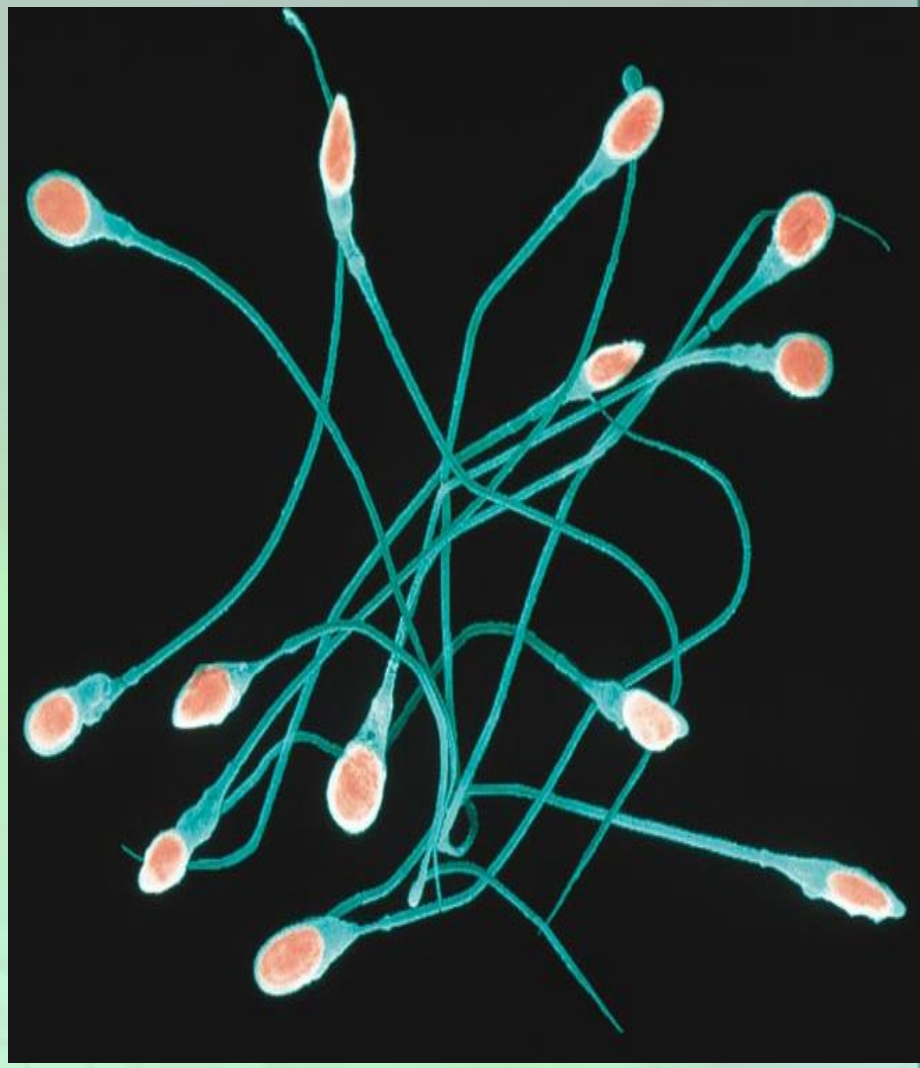
MEIOSIS II: Sister chromatids separate

Prophase II	Metaphase II	Anaphase II	Telophase II and Cytokinesis



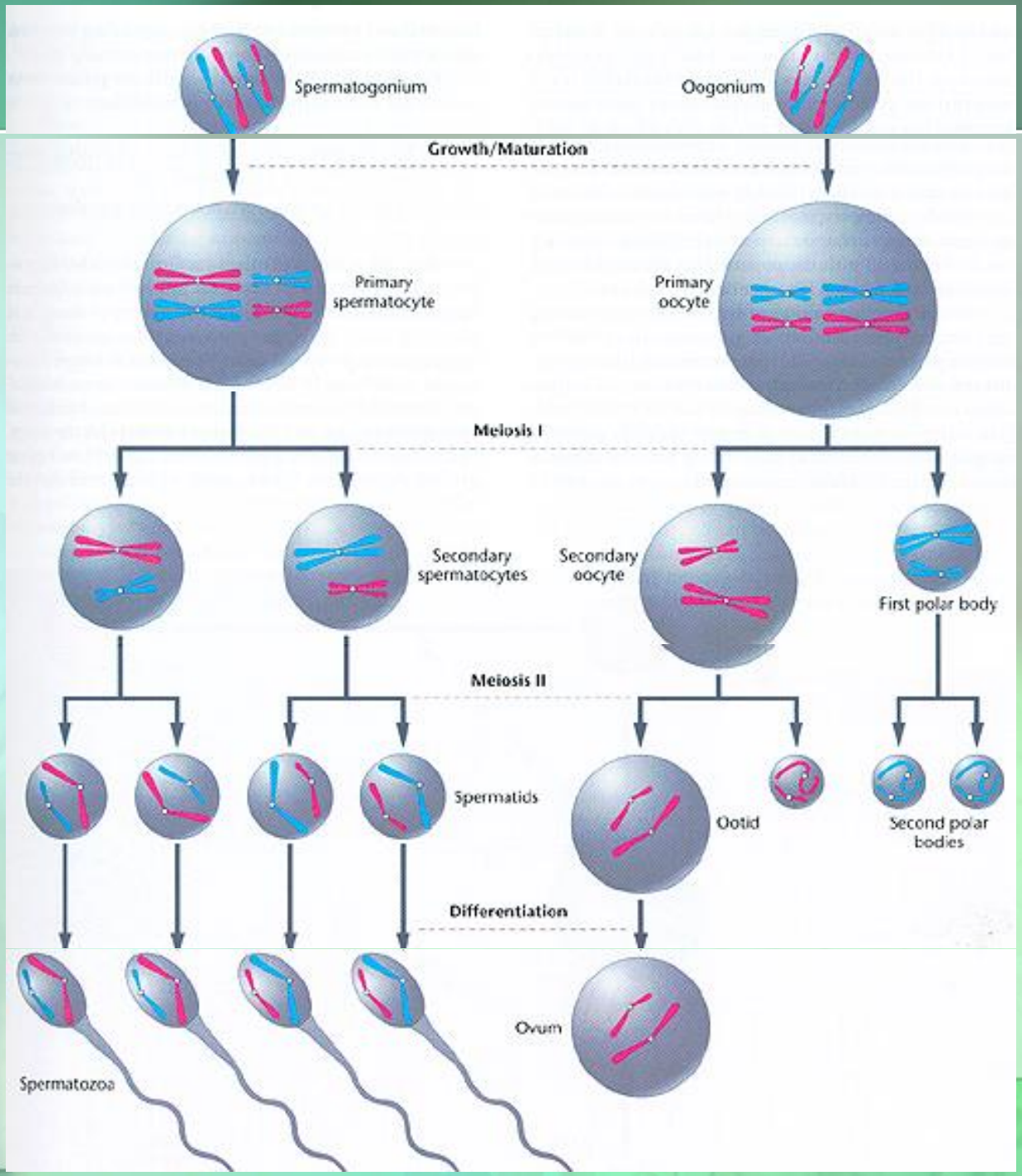
Meiosis in Human Males

- Occurs in the testes.
- Two divisions produce 4 sperm cells.
- Starts at the beginning of puberty.
- Men produce about 250,000,000 sperm per day.



Meiosis in Human Females

- ✓ Occurs in the ovaries.
- ✓ Produces 3 polar bodies that die and 1 egg.
- ✓ Polar bodies die because of unequal division of cytoplasm
- ✓ Immature egg called Oocyte.
- ✓ Starting at puberty, one oocyte matures into an Egg every 28 days.



Meiosis in Humans

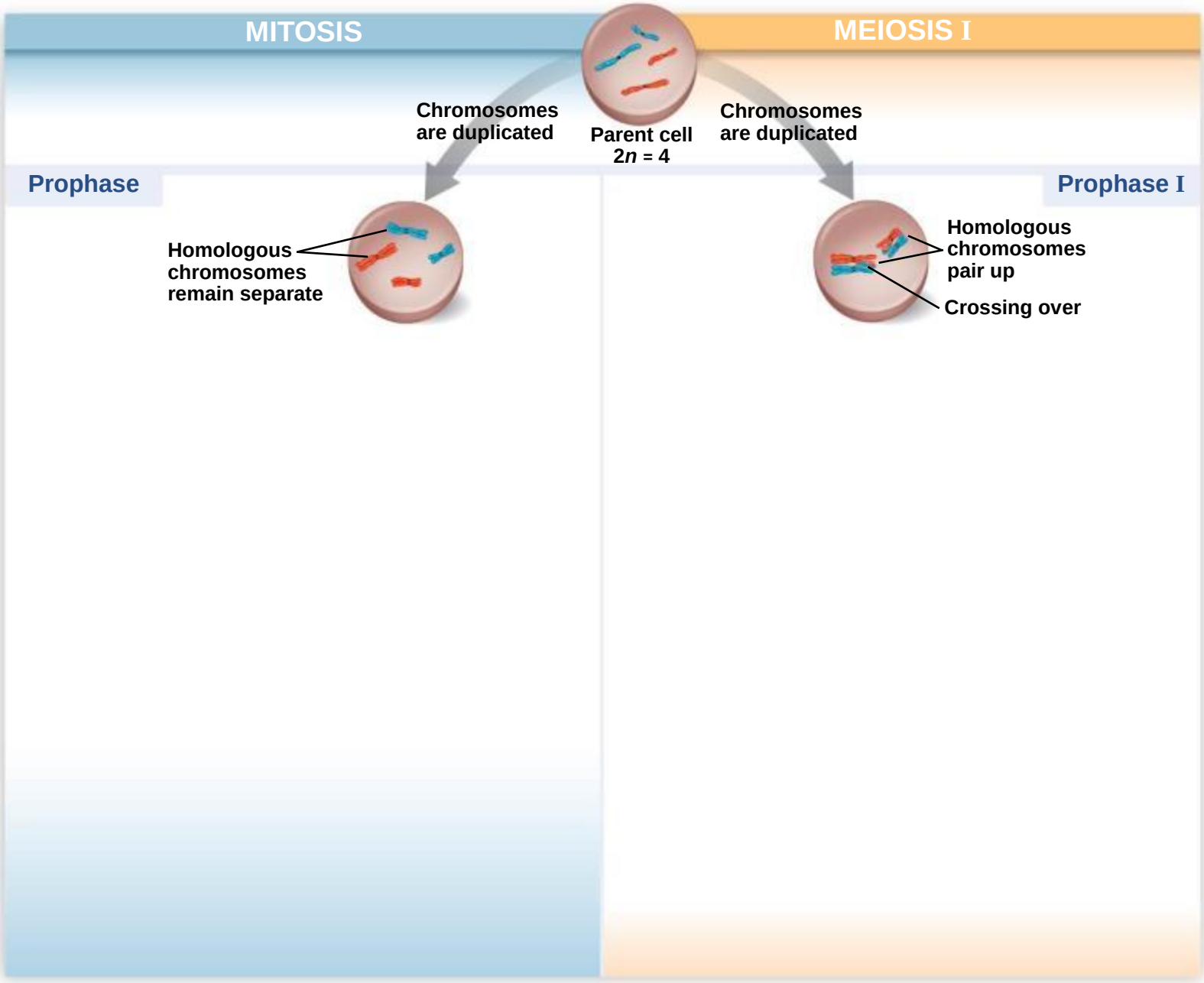
Mitosis and Meiosis have Important Similarities and Differences

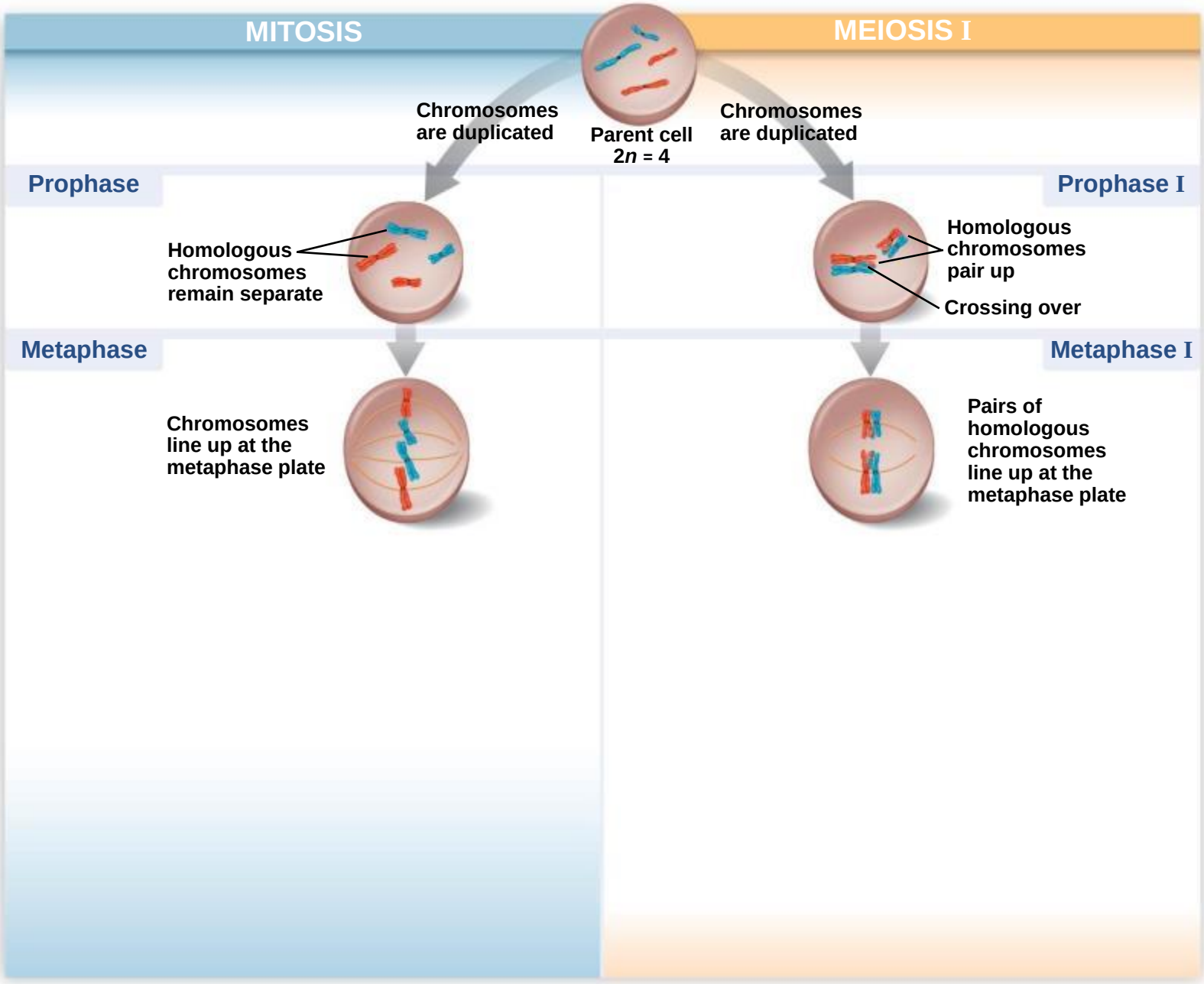
- **Mitosis** and **Meiosis** **both begin** with diploid (2n) parent cells that have **chromosomes duplicated** during the previous **Interphase**.
- However, the **End Products Differ**:
  - **Mitosis** produces **two genetically identical diploid (2n) somatic daughter cells**.
  - **Meiosis** produces **four genetically unique haploid gametes**.

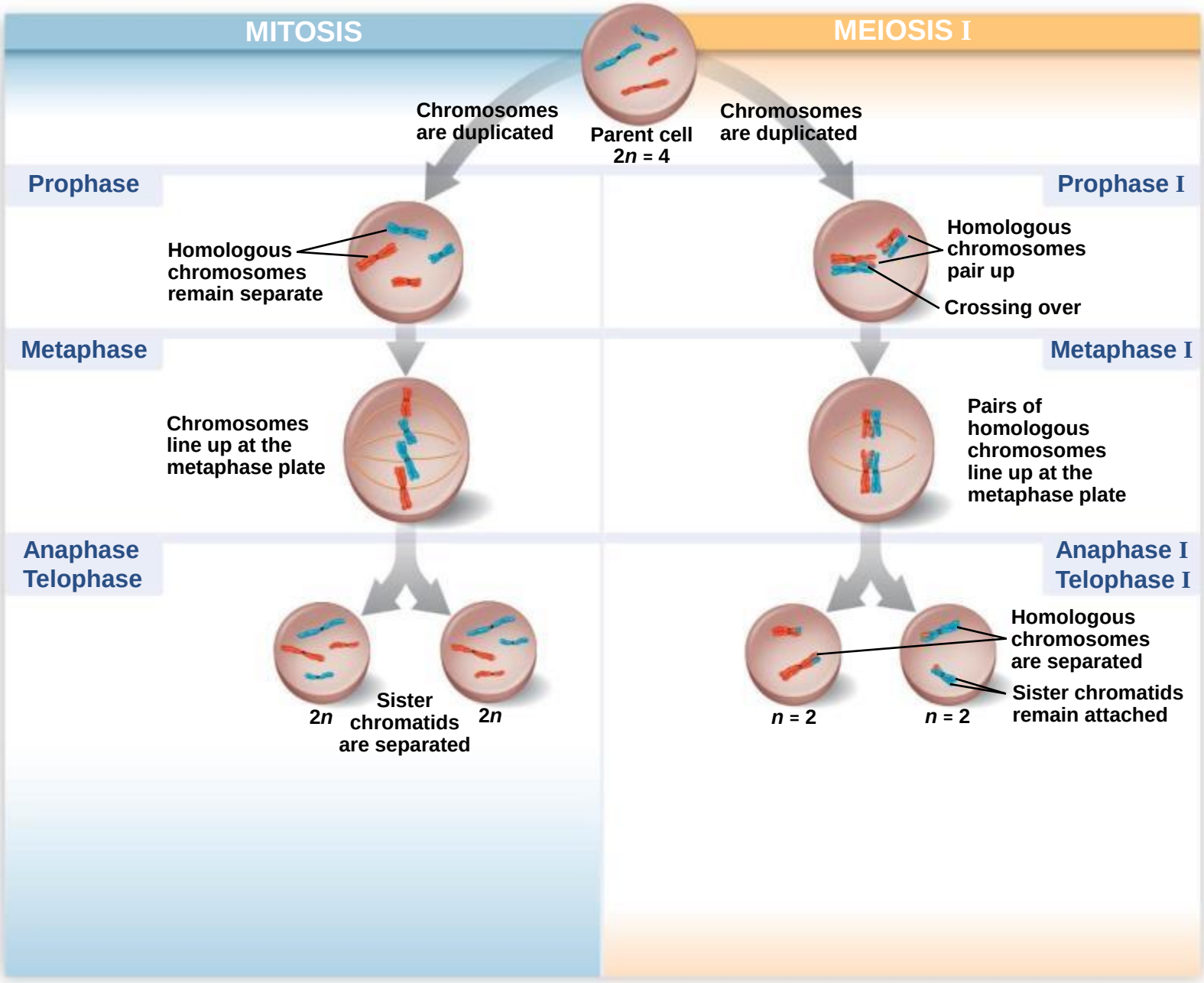
MITOSIS

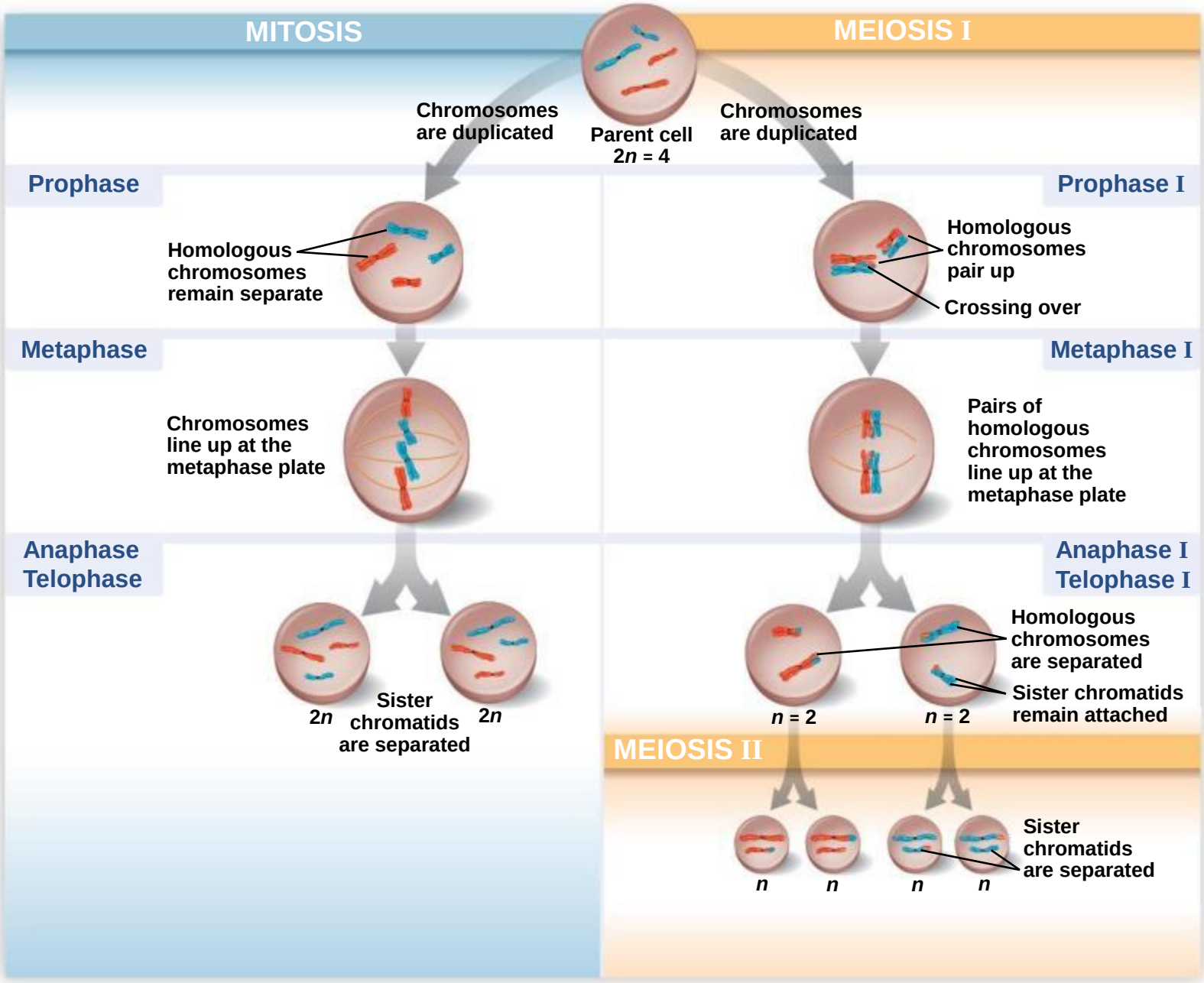
MEIOSIS I

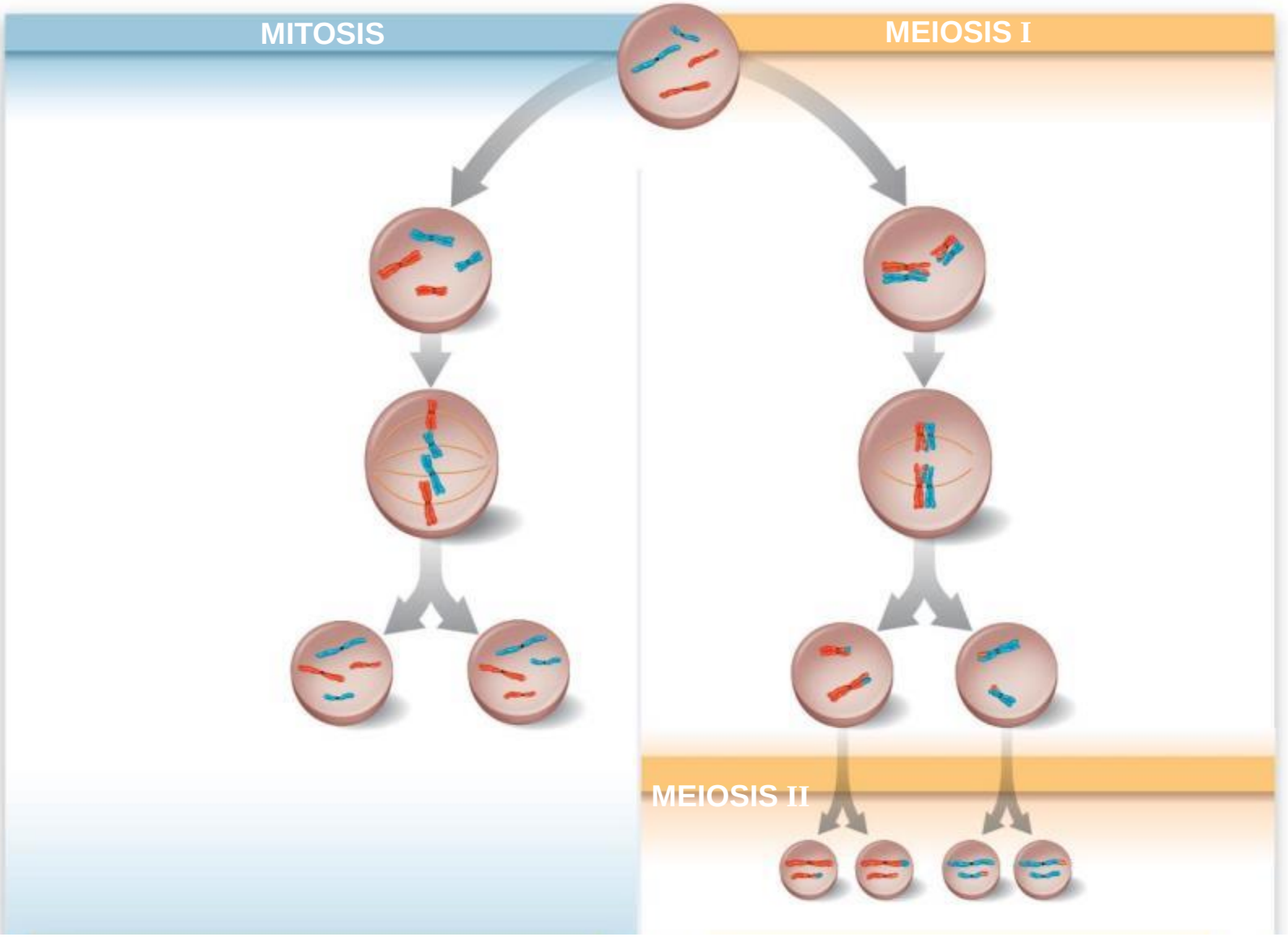
Parent cell
2*n* = 4


MITOSIS
MEIOSIS I
Chromosomes are duplicated
Parent cell
2n = 4
Chromosomes are duplicated
Prophase
Prophase I
Homologous chromosomes remain separate
Homologous chromosomes pair up
Crossing over


MITOSIS
MEIOSIS I
Chromosomes are duplicated
Parent cell
2n = 4
Chromosomes are duplicated
Prophase
Homologous chromosomes remain separate
Prophase I
Homologous chromosomes pair up
Crossing over
Metaphase
Chromosomes line up at the metaphase plate
Metaphase I
Pairs of homologous chromosomes line up at the metaphase plate


MITOSIS
MEIOSIS I
Chromosomes are duplicated
Parent cell
2n = 4
Chromosomes are duplicated
Prophase
Homologous chromosomes remain separate
Prophase I
Homologous chromosomes pair up
Crossing over
Metaphase
Chromosomes line up at the metaphase plate
Metaphase I
Pairs of homologous chromosomes line up at the metaphase plate
Anaphase
Telophase
2n
Sister chromatids are separated
2n
Anaphase I
Telophase I
Homologous chromosomes are separated
Sister chromatids remain attached
n = 2
n = 2


MITOSIS
MEIOSIS I
Chromosomes are duplicated
Parent cell 2n = 4
Chromosomes are duplicated
Prophase
Homologous chromosomes remain separate
Prophase I
Homologous chromosomes pair up
Crossing over
Metaphase
Chromosomes line up at the metaphase plate
Metaphase I
Pairs of homologous chromosomes line up at the metaphase plate
Anaphase Telophase
2n
Sister chromatids are separated
2n
Anaphase I Telophase I
Homologous chromosomes are separated
Sister chromatids remain attached
n = 2
n = 2
MEIOSIS II
n
n
n
n
Sister chromatids are separated



One division of the nucleus and cytoplasm.
Result: **Two** genetically identical **diploid cells.**
Used for: Growth, tissue repair, asexual reproduction.

Two divisions of the nucleus and cytoplasm.
Result: **Four** genetically unique **haploid cells.**
Used for: Sexual reproduction.

TRY IT

Comparison of Divisions

	Mitosis	Meiosis
Number of divisions		
Number of daughter cells		
Genetically identical?		
Chromosome #		
Where		
When		
Role		

TRY IT

Comparison of Divisions

	Mitosis	Meiosis
Number of divisions	1	2
Number of daughter cells	2	4
Genetically identical?	Yes	No
Chromosome #	Same as parent	Half of parent
Where	Somatic Cells	Sex Organs (Ovaries and Testes)
When	Throughout life	At Puberty
Role	Growth and Repair	Sexual Reproduction