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Lecture – 3

Cell division : Mitosis & Meiosis

by

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Cell Division

- ✓ All cells are derived from **pre-existing** cells
- ✓ New cells are produced for **growth** and to replace **damaged or old cells**
- ✓ Differs in **prokaryotes** (bacteria) and **eukaryotes** (protists, fungi, plants, & animals)



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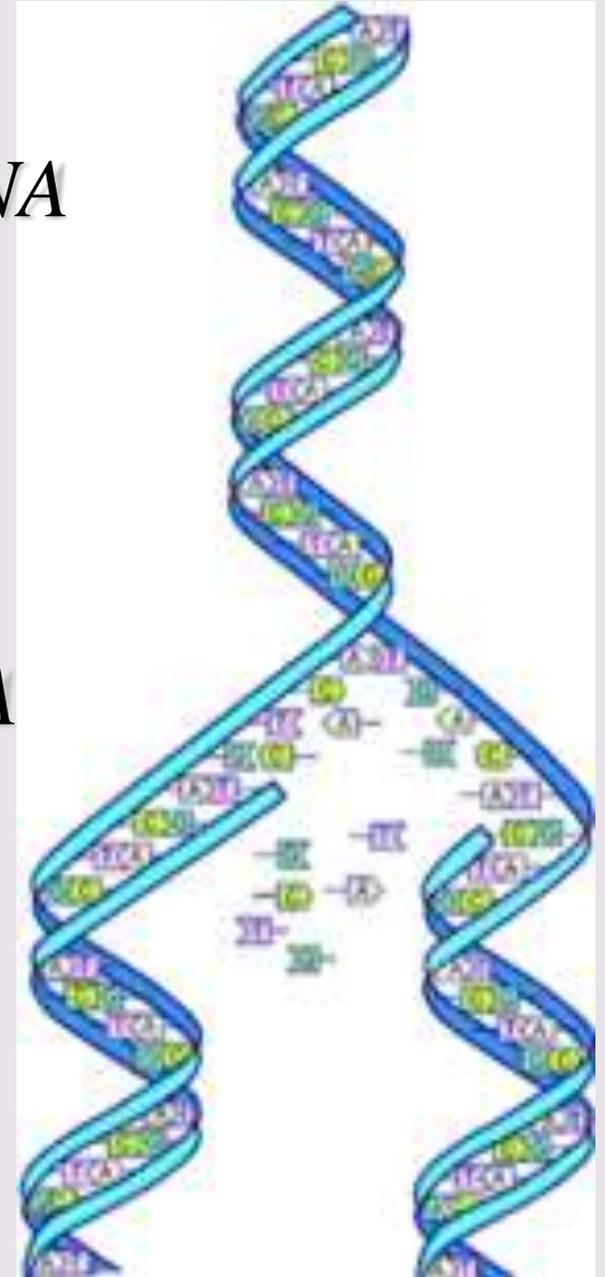
DNA Replication

- ✓ DNA must be copied or replicated before cell division

- ✓ Each new cell will then have an identical copy of

Original DNA strand

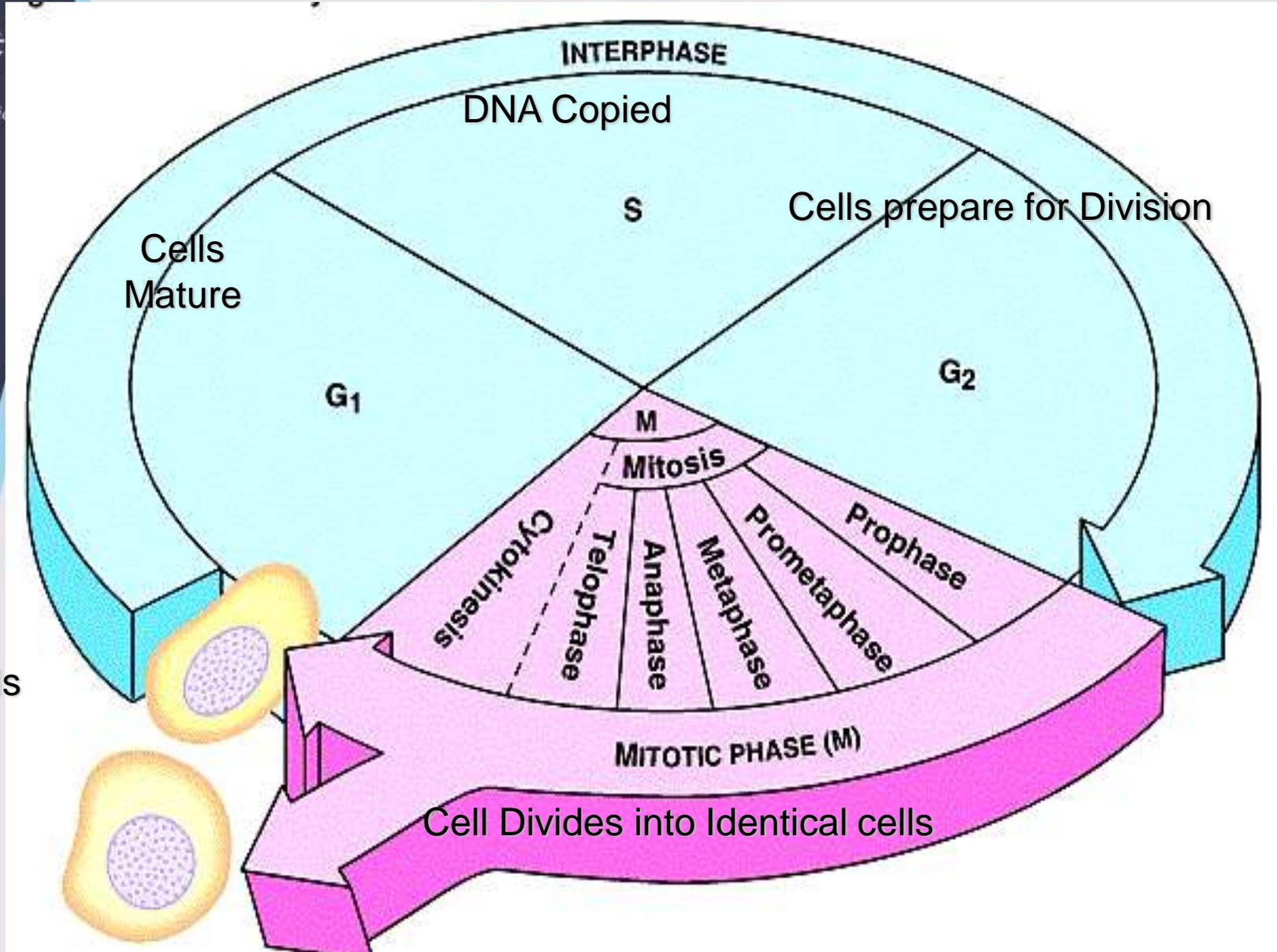
Two new, identical DNA strands





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Cell Cycle



Daughter Cells



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Interphase - G_1 Stage

- ✓ **1st growth stage** after cell division
- ✓ Cells **mature** by making more cytoplasm & organelles
- ✓ Cell carries on its **normal metabolic activities**



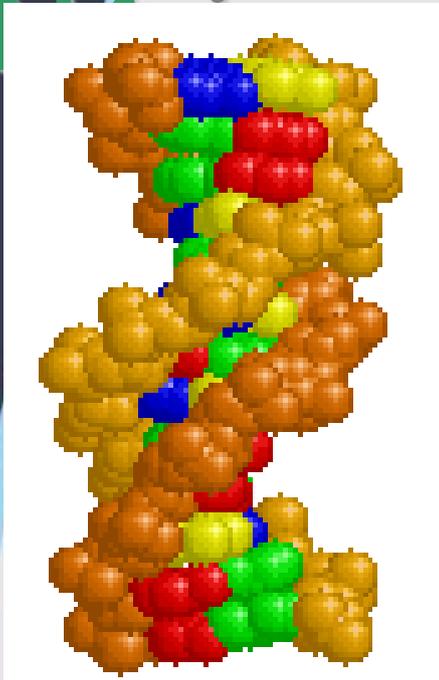
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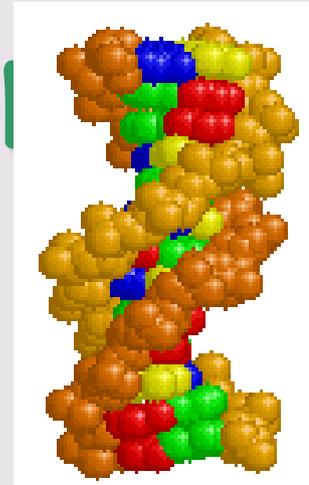
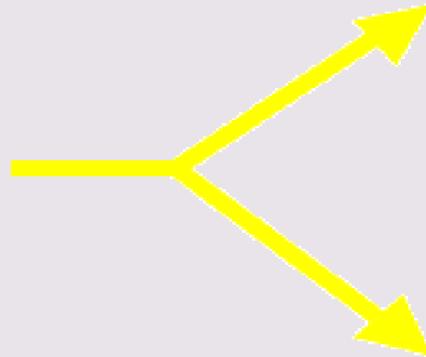
Interphase - S Stage

Synthesis stage

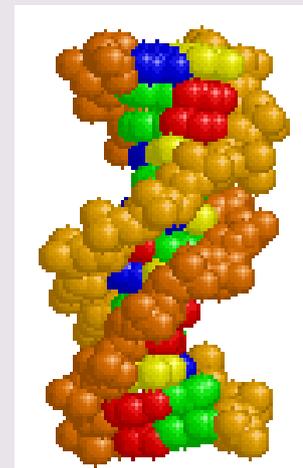
DNA is copied or replicated



Original DNA



Two identical
copies of
DNA





Interphase - G₂ Stage

✓ 2nd Growth Stage

- ✓ Occurs after DNA has been copied
- ✓ All cell structures needed for division are made (e.g. centrioles)
- ✓ Both organelles & proteins are synthesized



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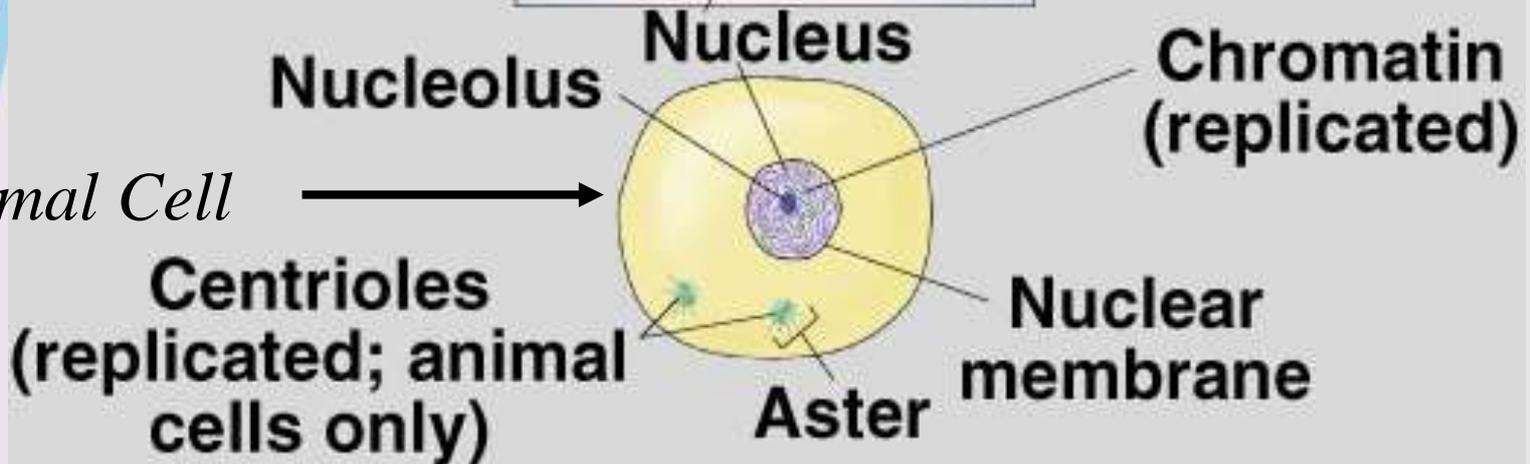
What the cell looks like

Animal Cell

What's occurring

What's Happening in Interphase?

INTERPHASE (G₂)



- DNA replicates
- Centrioles, if present, replicate
- Cell prepares for division

Mitosis



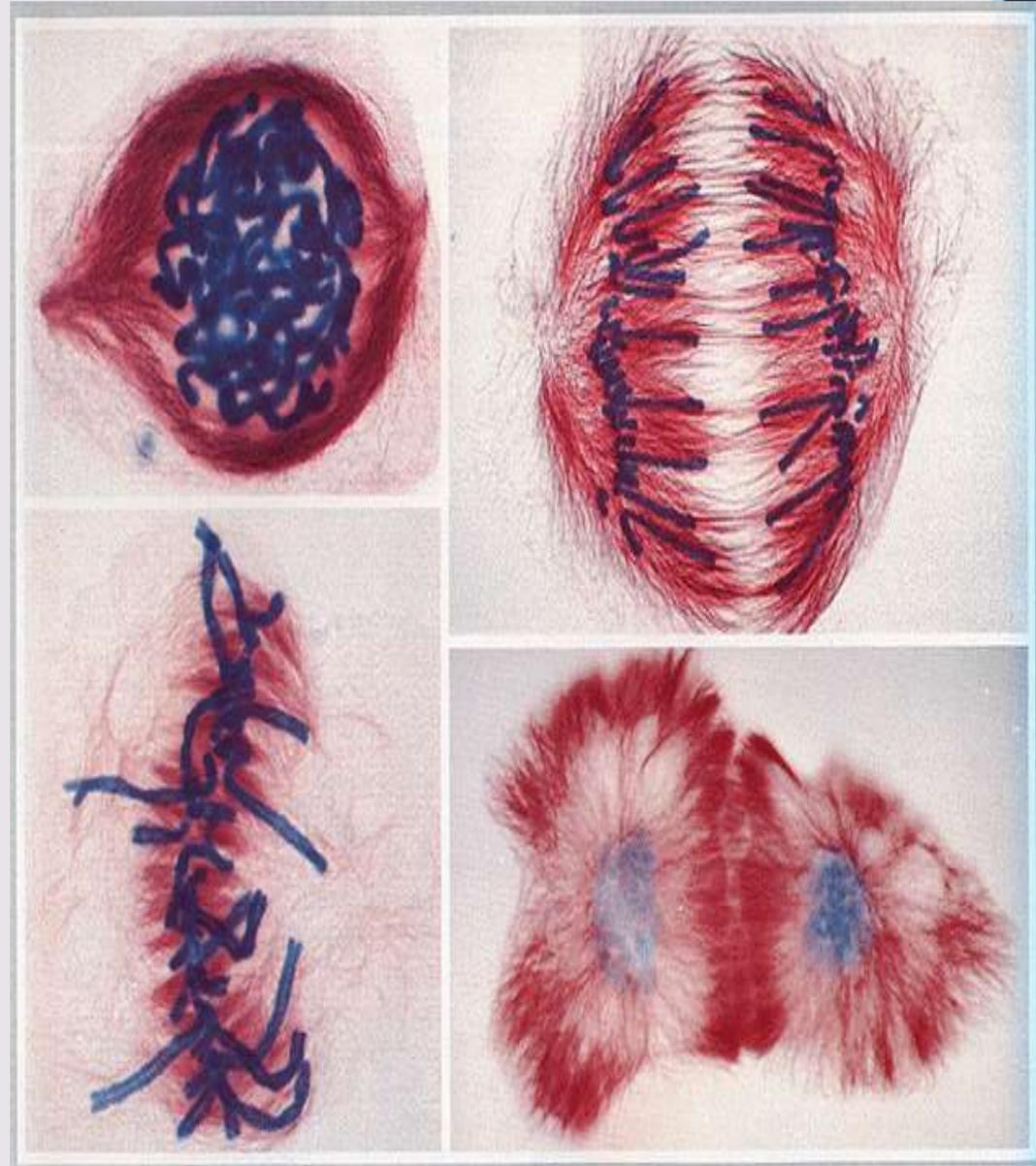
✓ Division of the
nucleus

✓ Also called
karyokinesis

✓ Only occurs in
eukaryotes

✓ Has four stages

✓ Doesn't occur in
some cells such
as brain cells

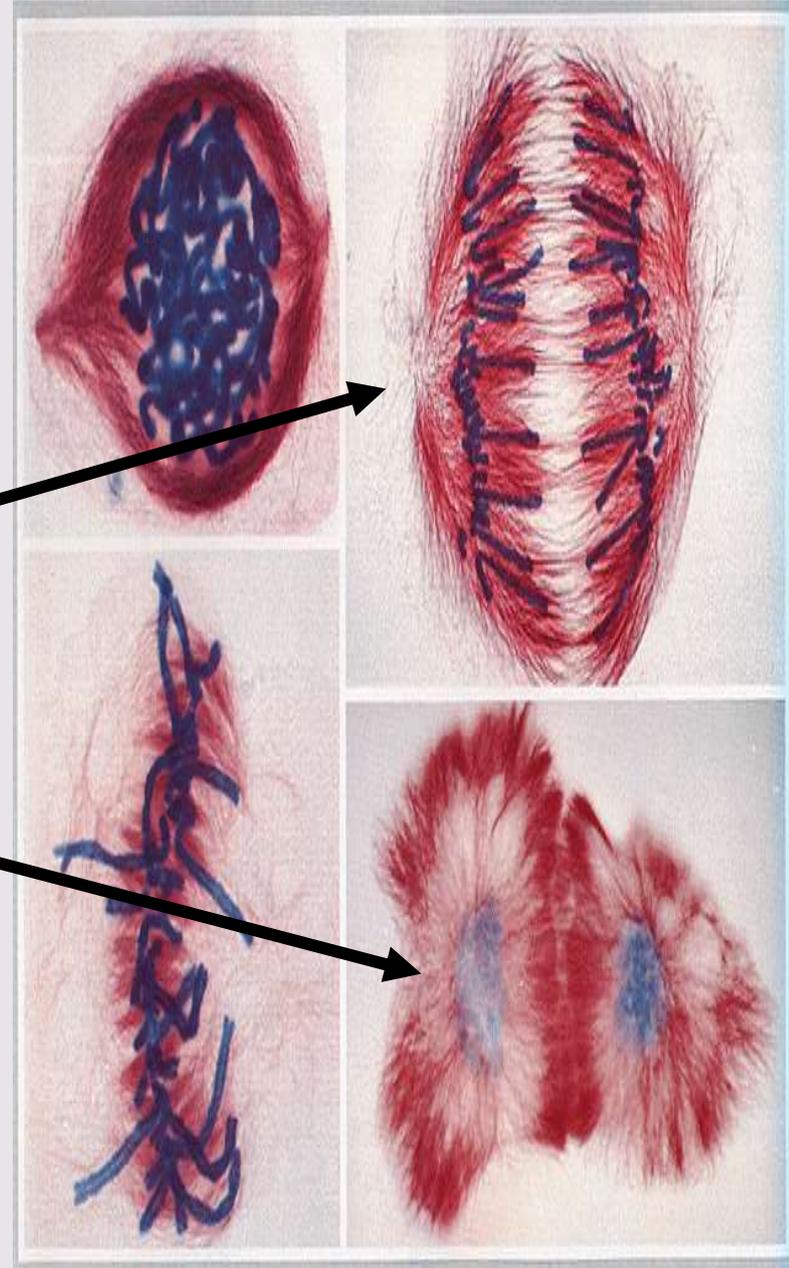




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Four Mitotic Stages

- ✓ **Prophase**
- ✓ **Metaphase**
- ✓ **Anaphase**
- ✓ **Telophase**





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Early Prophase

- ✓ **Chromatin** in nucleus condenses to form **visible chromosomes**
- ✓ **Mitotic spindle** forms from fibers in cytoskeleton or **centrioles (animal)**

Nucleolus

Cytoplasm



Nuclear Membrane

Chromosomes



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Late Prophase

- ✓ Nuclear membrane & nucleolus are broken down
- ✓ Chromosomes continue condensing & are clearly visible
- ✓ Spindle fibers called kinetochores attach to the centromere of each chromosome
- ✓ Spindle¹² finishes forming

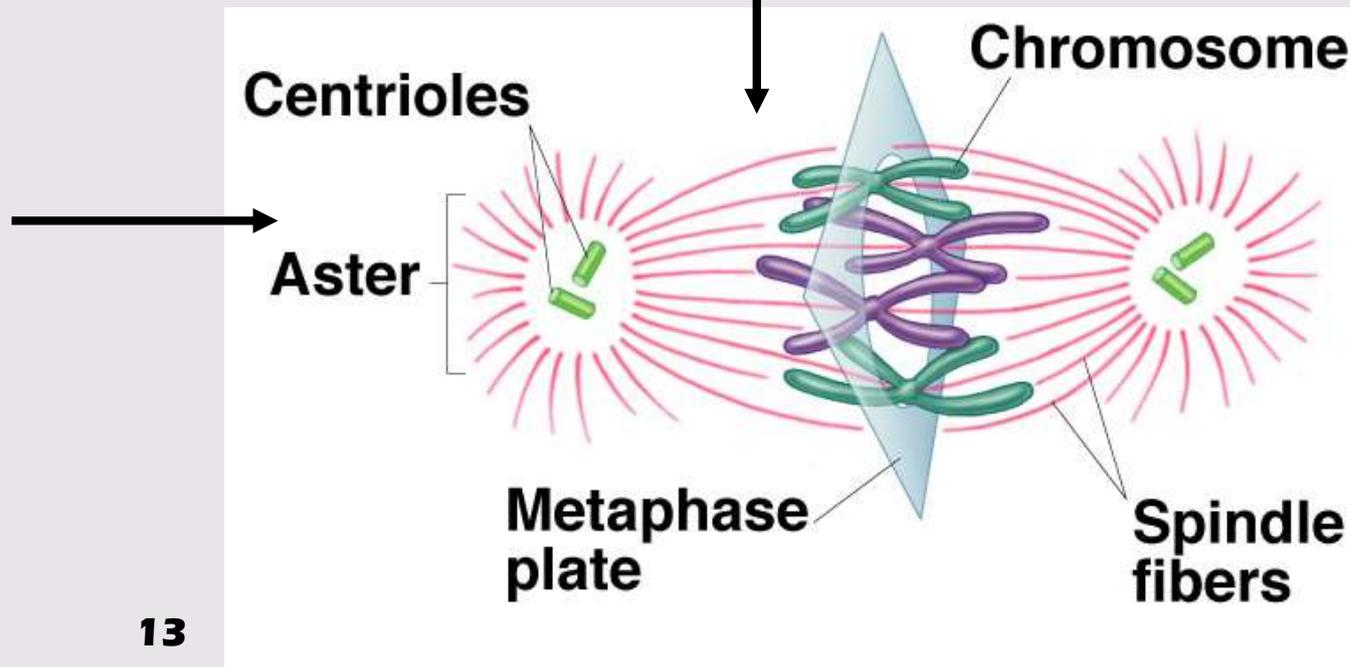


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Metaphase

- ✓ Chromosomes, attached to the **kinetochore fibers**, move to the center of the cell
- ✓ Chromosomes are now lined up at the **equator**

Pole of
the Cell

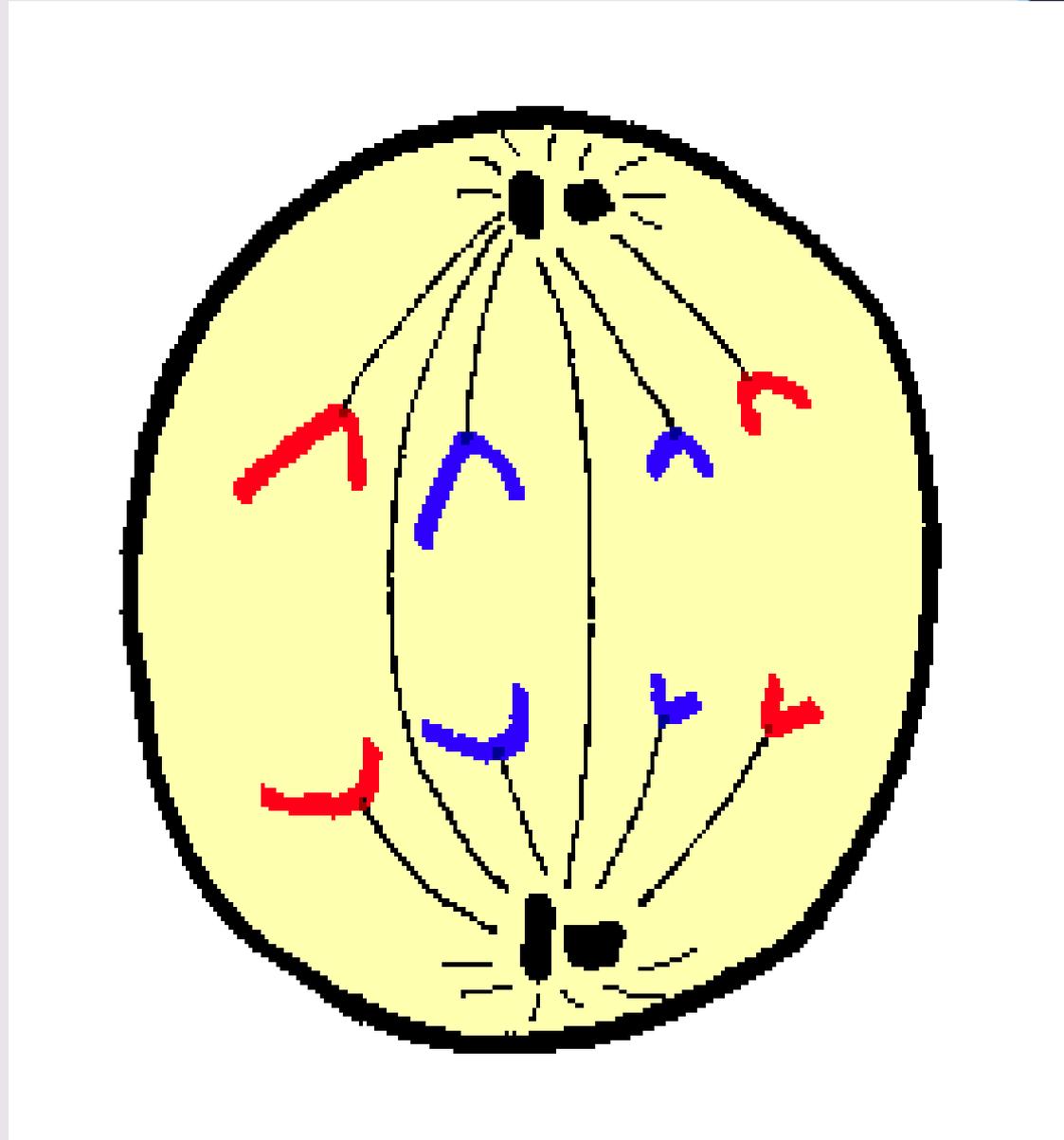




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Anaphase

- ✓ Occurs rapidly
- ✓ Sister chromatids are pulled apart to opposite poles of the cell by kinetochore fibers





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Telophase

- ✓ Sister chromatids at **opposite poles**
- ✓ Spindle **disassembles**
- ✓ **Nuclear envelope** forms around each set of sister chromatids
- ✓ **Nucleolus** reappears
- ✓ **CYTOKINESIS** occurs
- ✓ Chromosomes reappear as **chromatin**



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Cytokinesis

- ✓ Means division of the cytoplasm
- ✓ Division of cell into two, identical halves called daughter cells
- ✓ In plant cells, cell plate forms at the equator to divide cell
- ✓ In animal cells, cleavage furrow forms to split cell



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Daughter Cells of Mitosis

- ✓ Have the same number of chromosomes as each other and as the parent cell from which they were formed
- ✓ Identical to each other, but smaller than parent cell
- ✓ Must grow in size to become mature cells (G_1 of Interphase)



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Meiosis

Formation of Gametes (Eggs & Sperm)



Facts About Meiosis

- ✓ Preceded by interphase which includes chromosome replication
- ✓ Two meiotic divisions ---- Meiosis I and Meiosis II
- ✓ Called Reduction- division
- ✓ Original cell is diploid ($2n$)
- ✓ Four daughter cells produced that are monoploid ($1n$)



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Facts About Meiosis

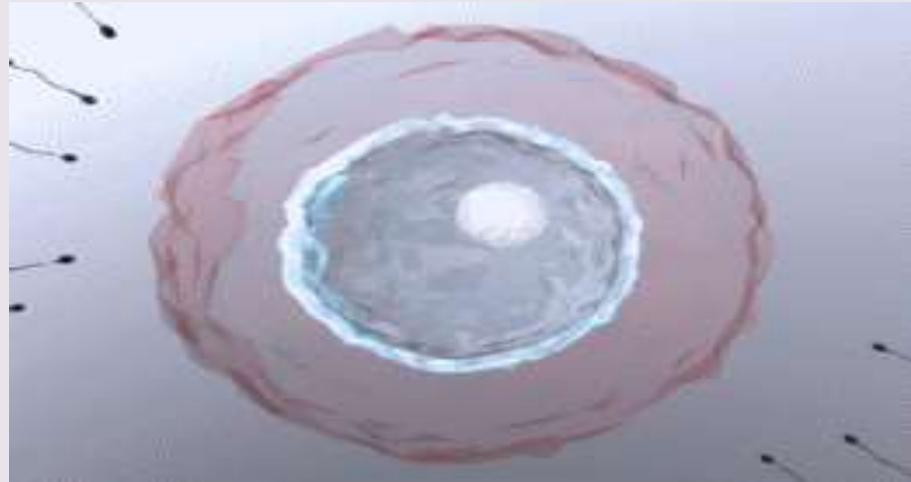
- ✓ Daughter cells contain half the number of chromosomes as the original cell
- ✓ Produces gametes (eggs & sperm)
- ✓ Occurs in the testes in males (Spermatogenesis)
- ✓ Occurs in the ovaries in females (Oogenesis)



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Why Do we Need Meiosis?

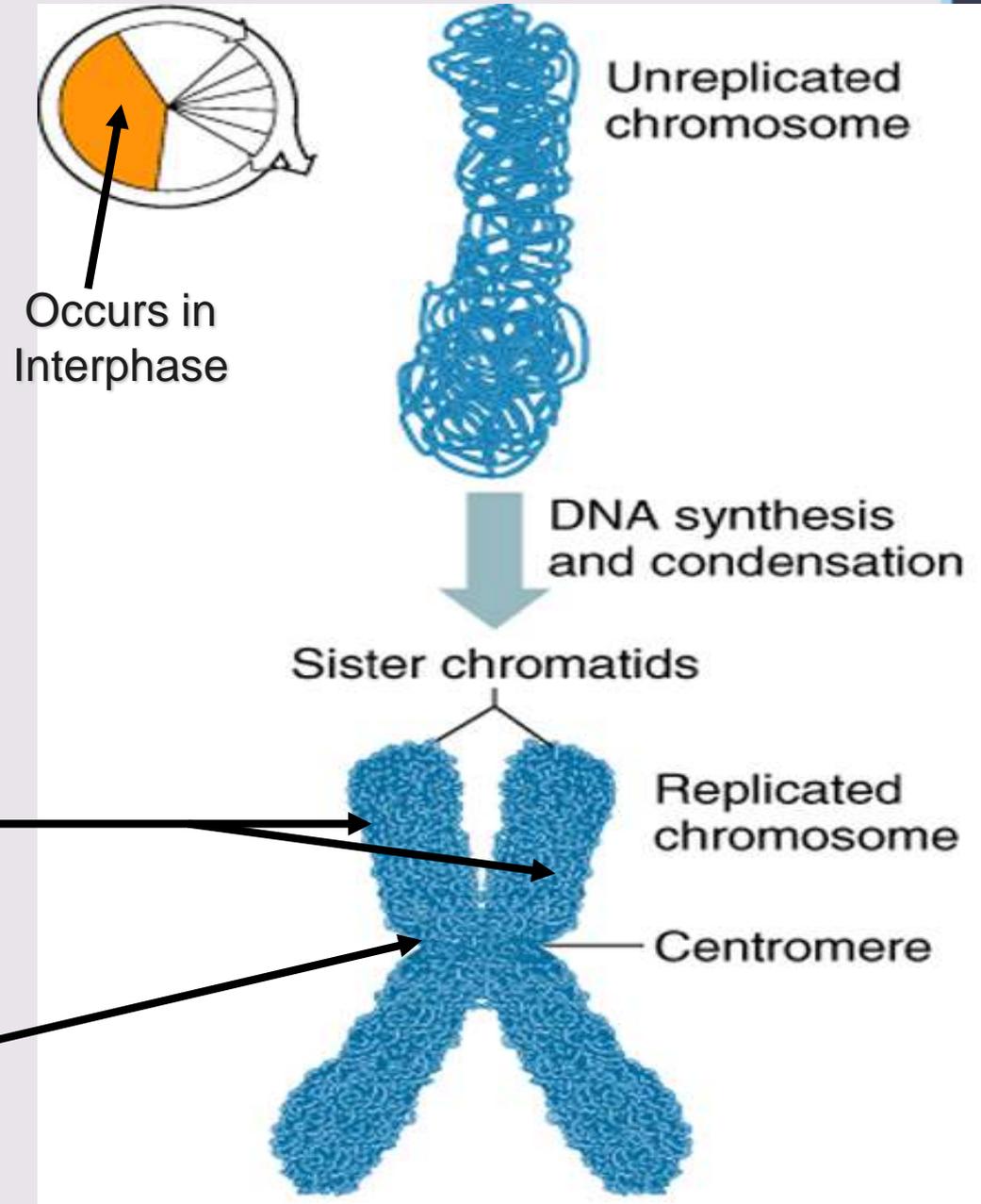
- ✓ It is the fundamental basis of **sexual reproduction**
- ✓ Two haploid ($1n$) gametes are brought together through **fertilization** to form a diploid ($2n$) zygote



Replication of Chromosomes



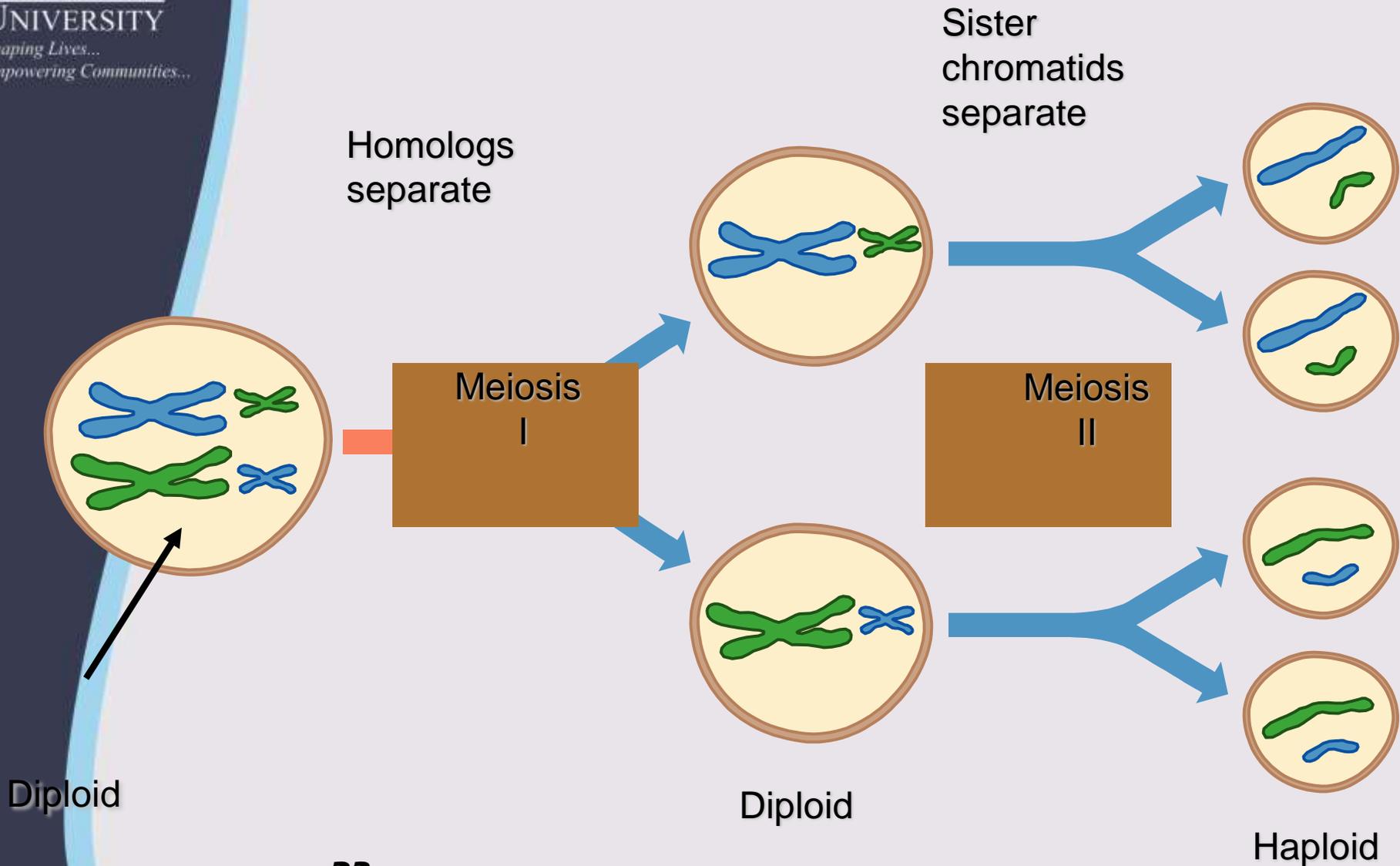
- ✓ **Replication** is the process of duplicating a chromosome
- ✓ Occurs **prior to division**
- ✓ Replicated copies are called **sister chromatids**
- ✓ Held together at **centromere**





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Meiosis: Two Part Cell Division

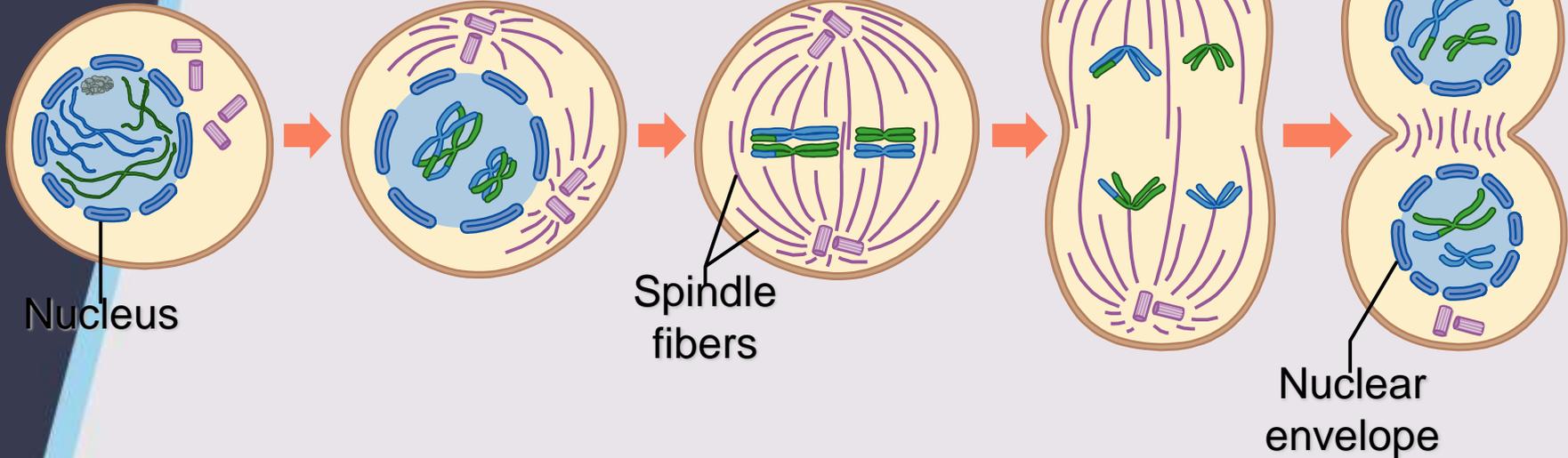




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Meiosis I: Reduction Division



Early Prophase I
(Chromosome
number doubled)

Late Prophase
I

Metaphase I

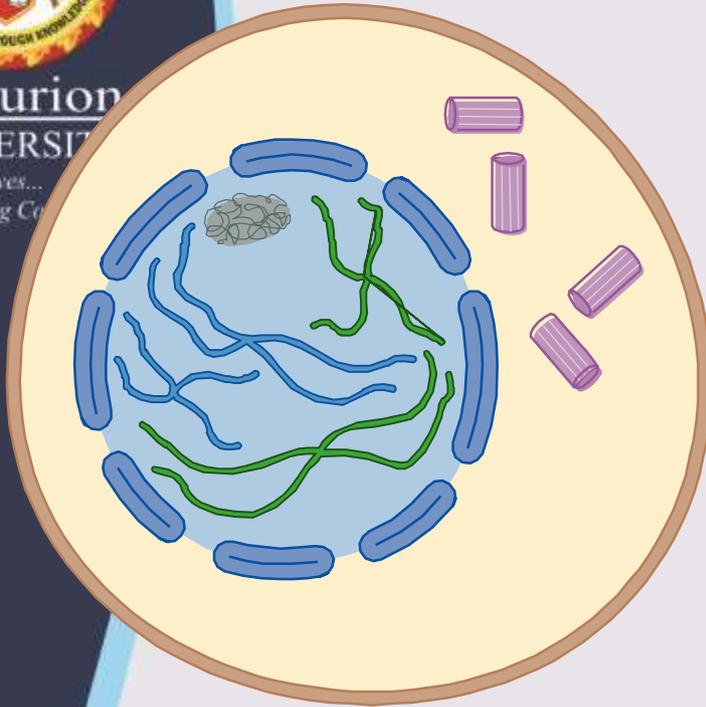
Anaphase I

Telophase I (diploid)

Prophase I

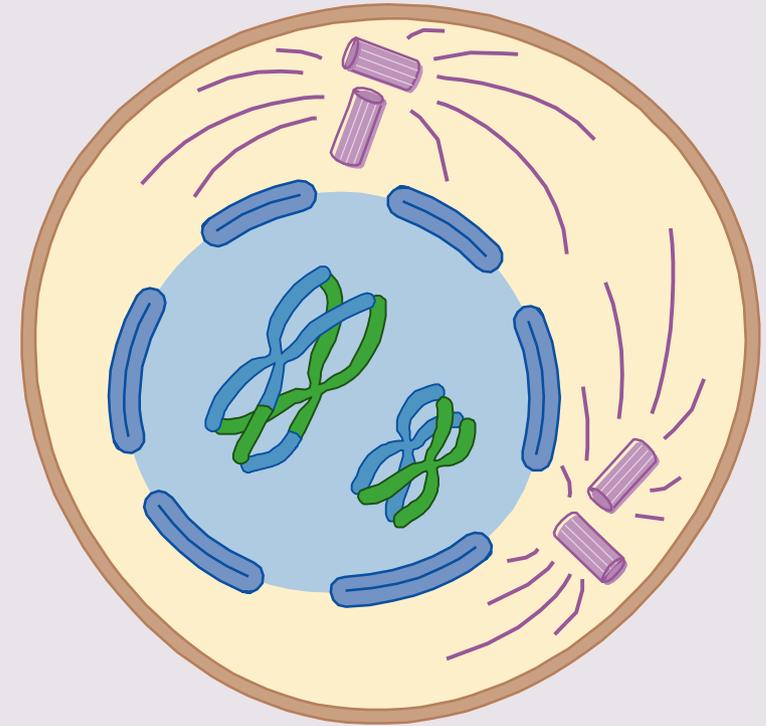


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Early prophase

- ✓ Homologs pair.
- ✓ Crossing over occurs.



Late prophase

- ✓ Chromosomes condense.
- ✓ Spindle forms.
- ✓ Nuclear envelope fragments.



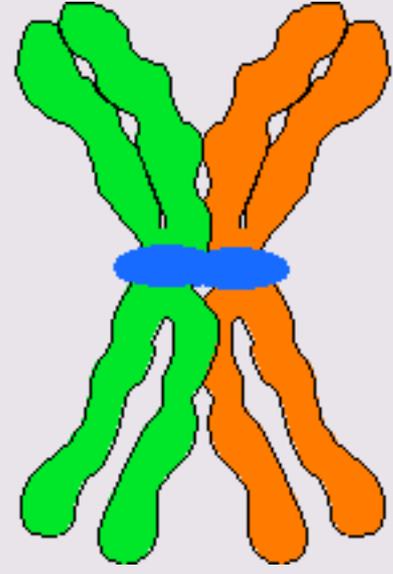
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Tetrads Form in Prophase I

Homologous chromosomes
(each with sister chromatids)

Join to form a TETRAD



Called Synapsis

Crossing-Over



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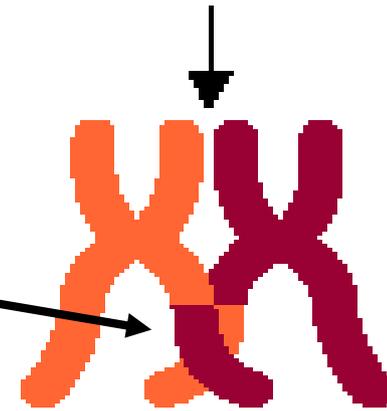
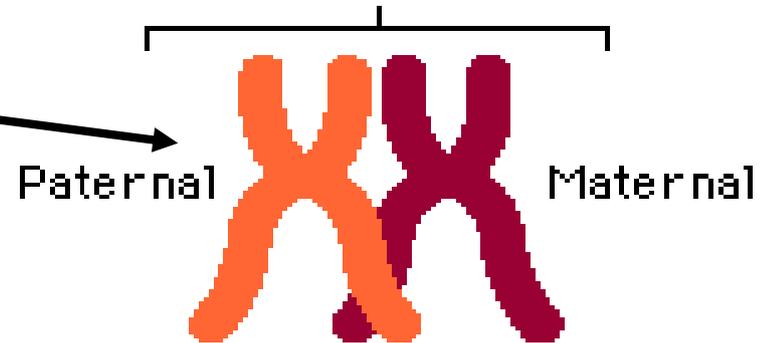
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✓ Homologous chromosomes in a tetrad cross over each other

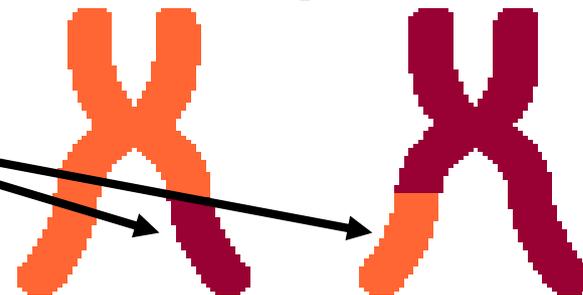
✓ Pieces of chromosomes or genes are exchanged

✓ Produces Genetic recombination in the offspring

Synapsis: Pairing of homologous chromosomes



Crossing over

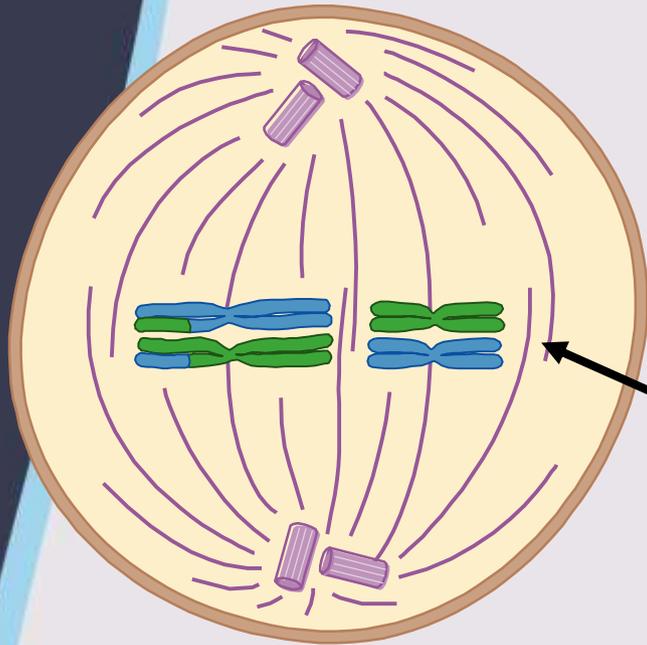


Metaphase I



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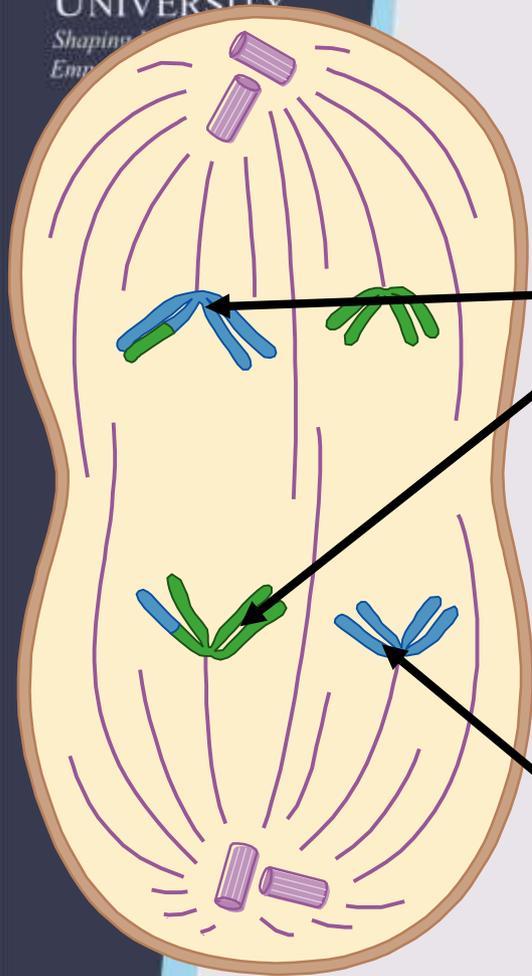
Homologous pairs
of chromosomes
align along the
equator of the cell

Anaphase I



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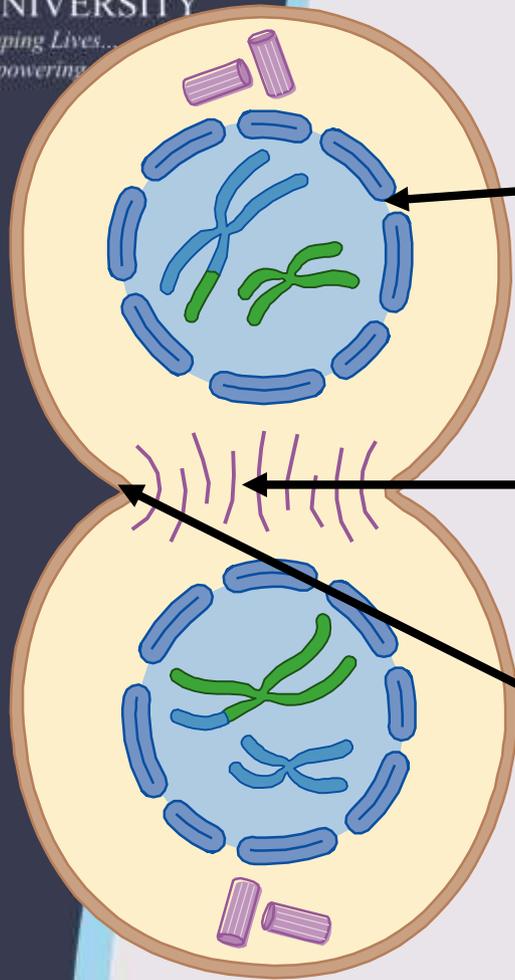
Homologs separate and move to opposite poles.

Sister chromatids remain attached at their centromeres.

Telophase I



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Nuclear envelopes
reassemble.

Spindle disappears.

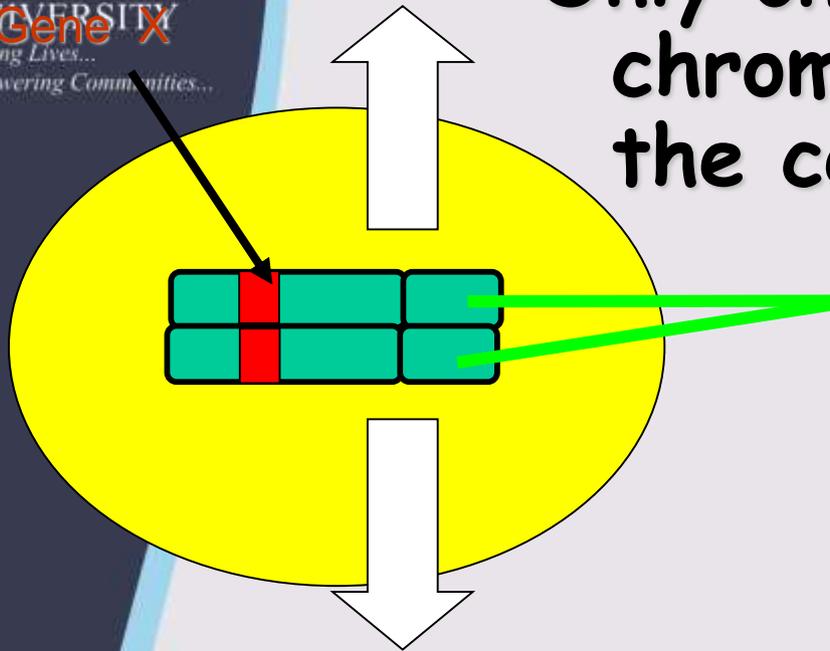
Cytokinesis divides cell into
two.



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Meiosis II

Only one homolog of each chromosome is present in the cell.

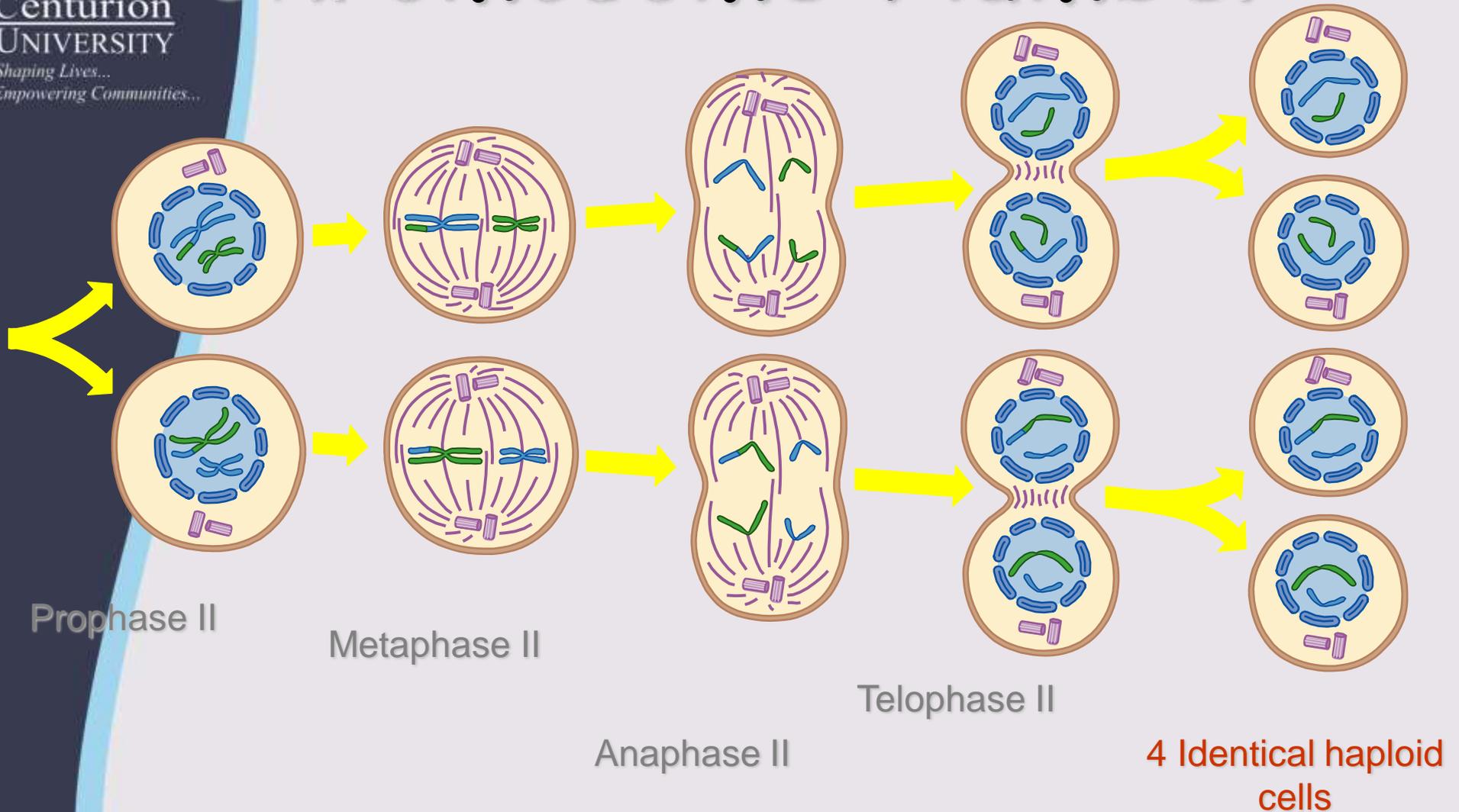


Sister chromatids carry identical genetic information.

Meiosis II produces gametes with one copy of each chromosome and thus one copy of each gene.

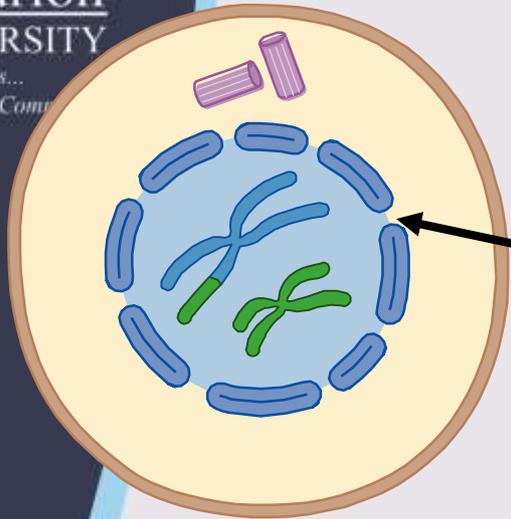


Meiosis II: Reducing Chromosome Number

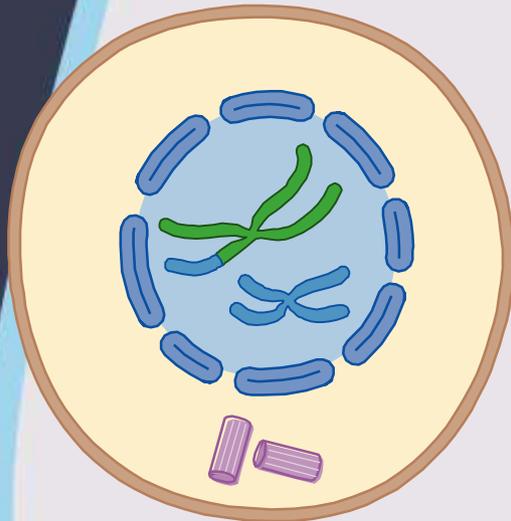




Prophase II



Nuclear envelope fragments.

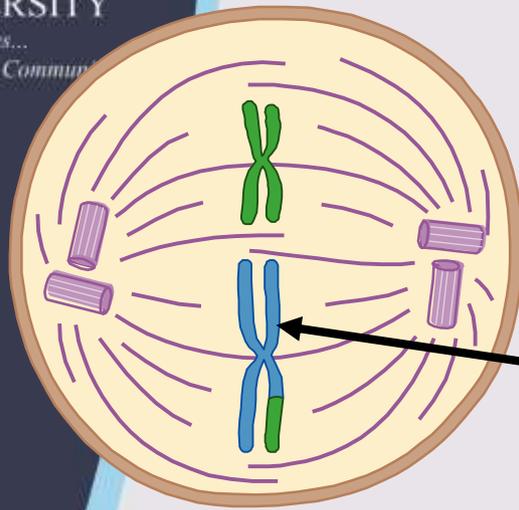


Spindle forms.

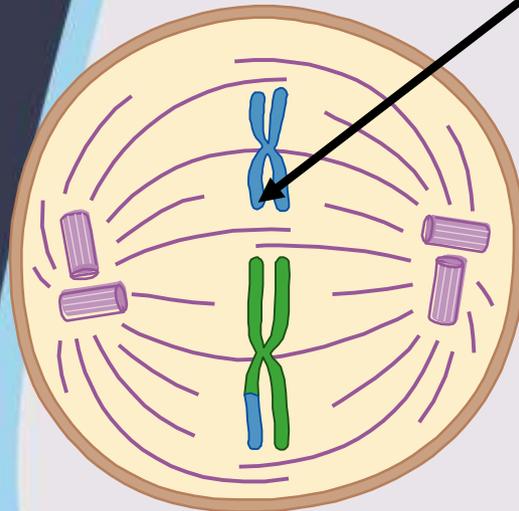


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Metaphase II

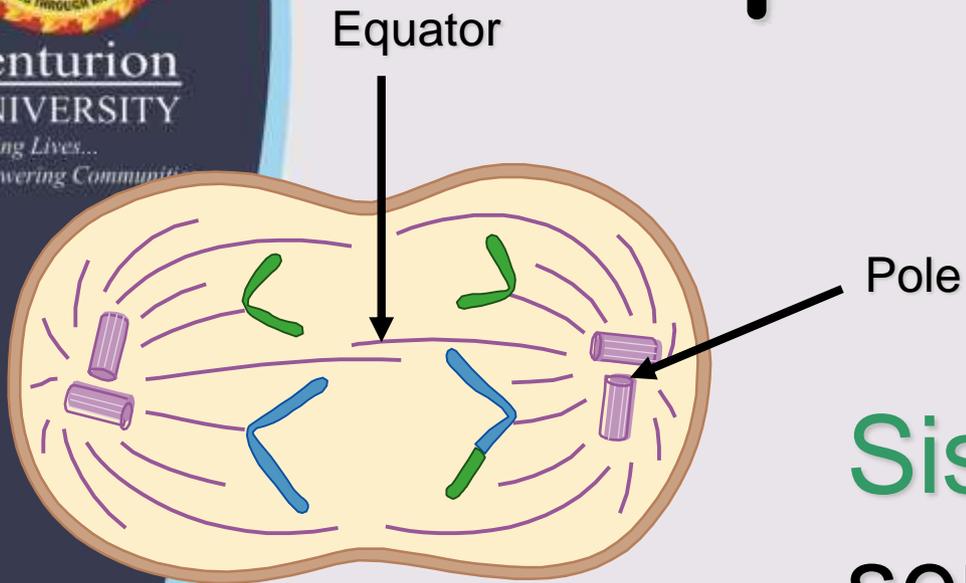


Chromosomes align
along **equator** of cell.

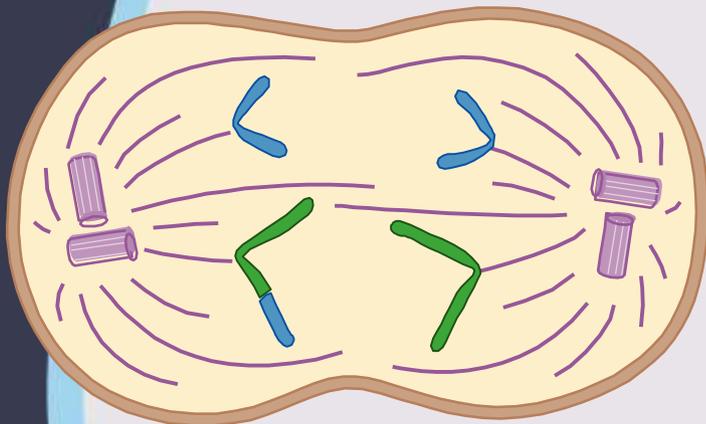




Anaphase II

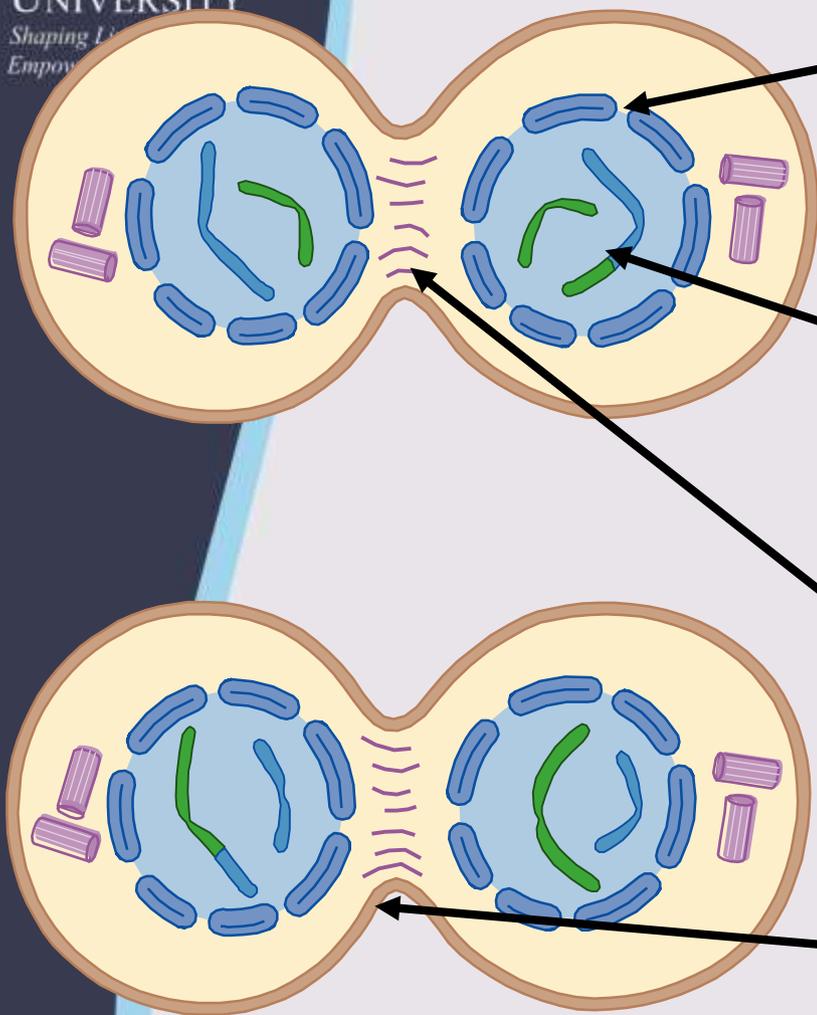


Sister chromatids separate and move to opposite poles.





Telophase II



Nuclear envelope assembles.

Chromosomes decondense.

Spindle disappears.

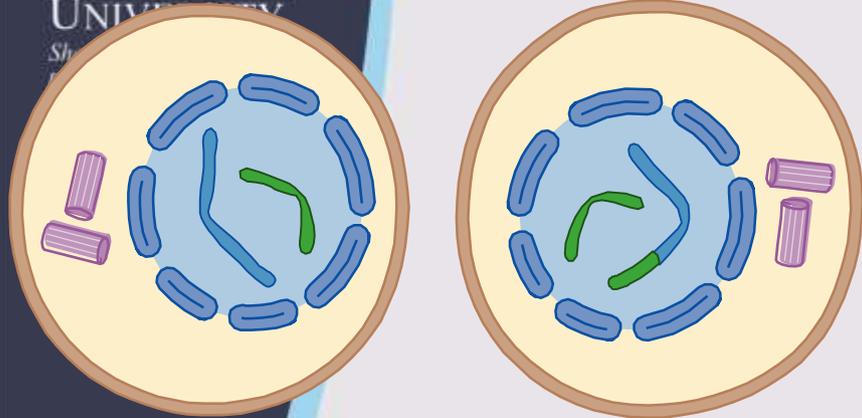
Cytokinesis divides cell into two.



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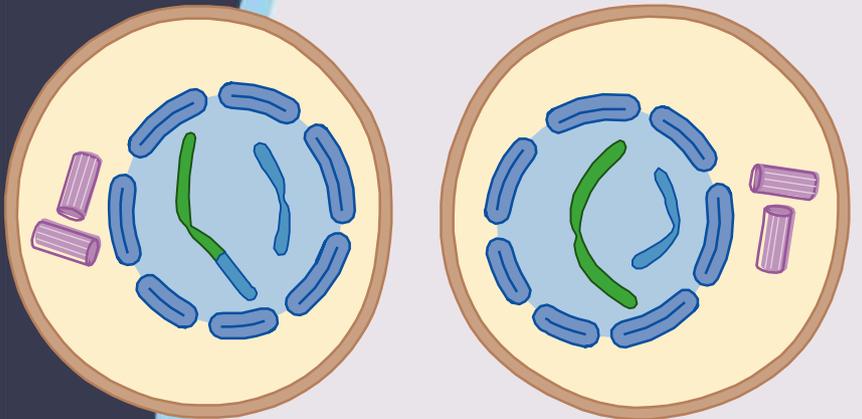
Results of Meiosis

Gametes (egg & sperm)
form



Four haploid cells with one
copy of each chromosome

One allele of each gene



Different combinations of
alleles for different genes
along the chromosome



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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	Germ cells
When	Throughout life	At sexual maturity
Role	Growth and repair	Sexual reproduction



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