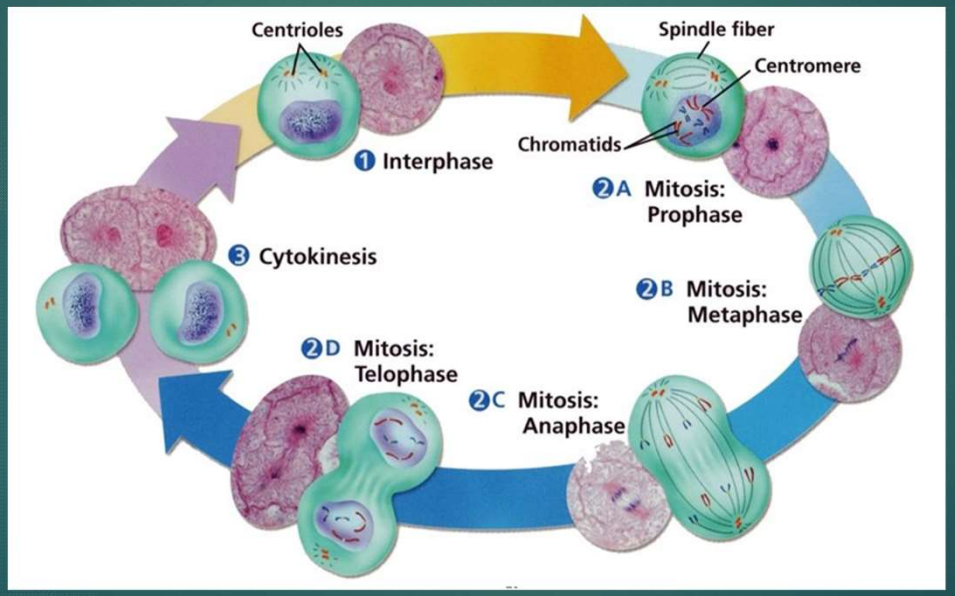
The University Of Jordan
Faculty Of Medicine

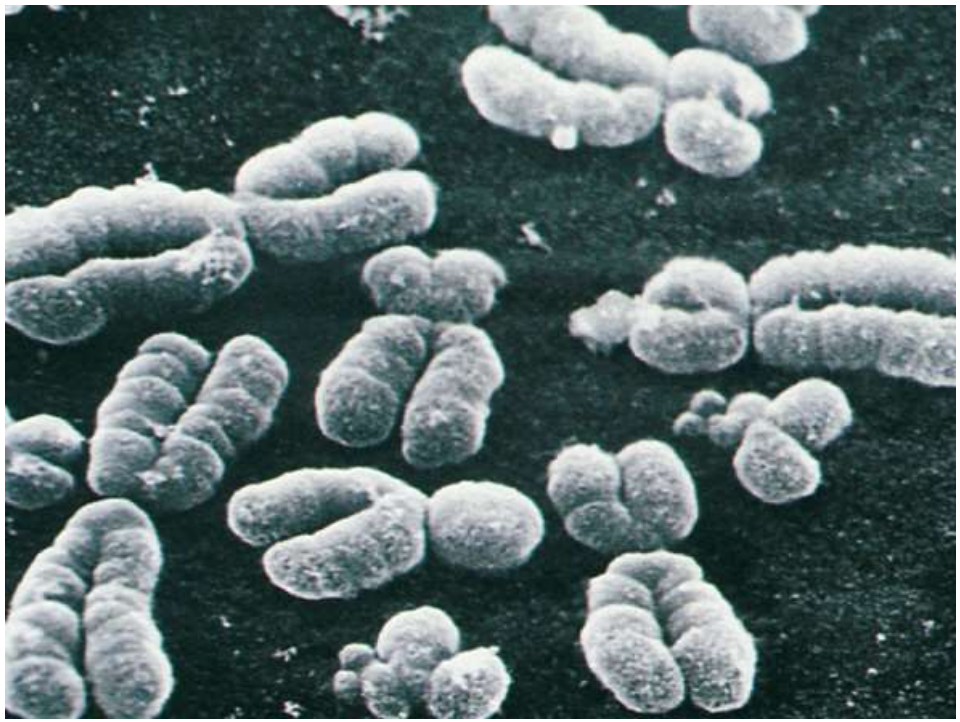
Cell division
(Cell cycle, Mitosis and meiosis)



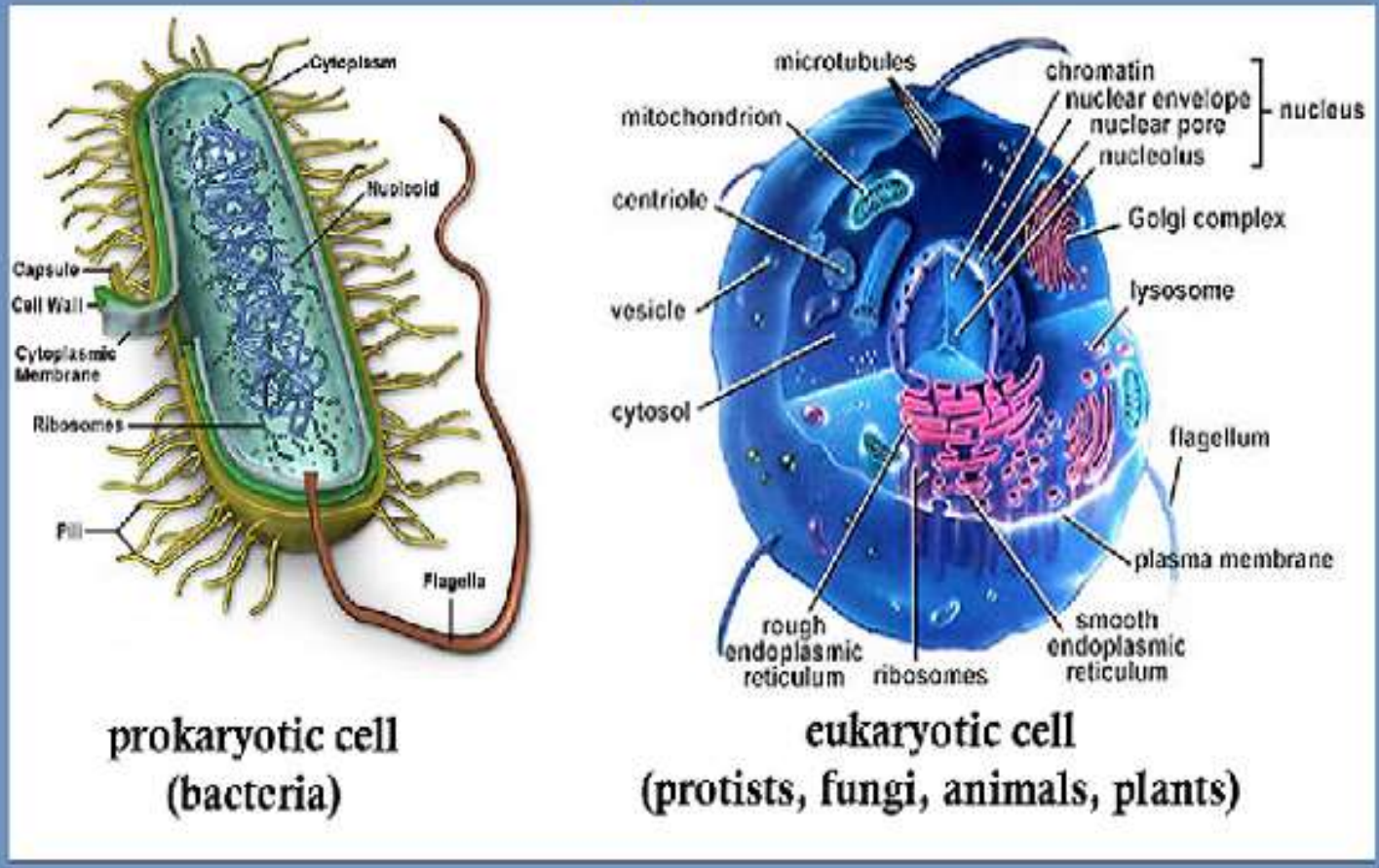
Dr. Ahmed Salman
Associate professor of Anatomy

Chromosomes

- Genetic information is stored in chromosomes
- The somatic cells of human body have 46 chromosomes or 23 identical pairs



Difference between Prokaryotic and Eukaryotic Cells



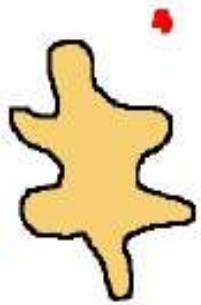
prokaryotic cell
(bacteria)

eukaryotic cell
(protists, fungi, animals, plants)

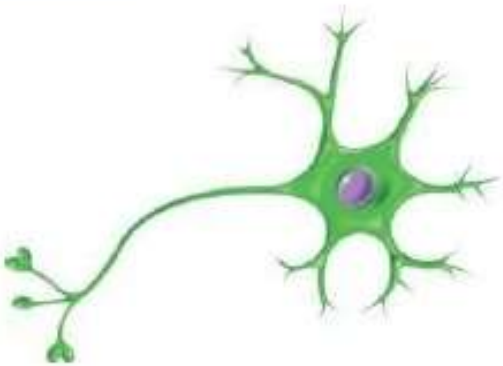
TWO types of cells in the body

Non-reproductive or somatic cells

diploid number of chromosomes



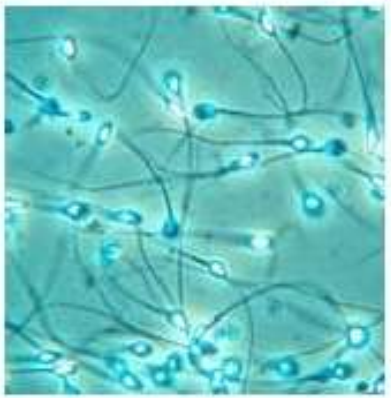
phagocyte



Nerve cell

Gametes (sex cells)

haploid number



sperms

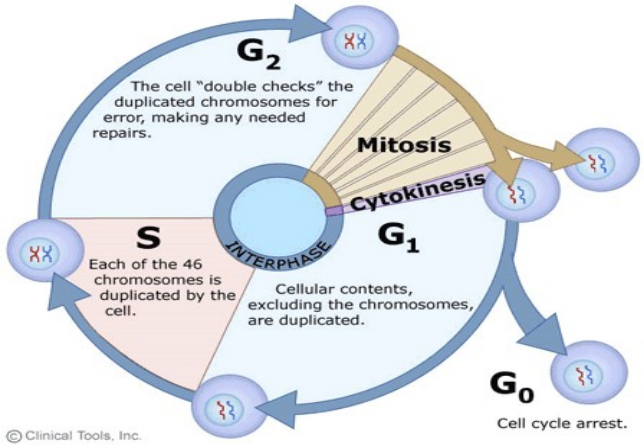
Cell Cycle

- **Definition**: it is the normal sequence of growth and cell division.
- The length of cell cycle varies in each cell type. e.g. human liver cells usually complete a cycle in less than 24 hours.
- The cell cycle of somatic cells composed of four phases:

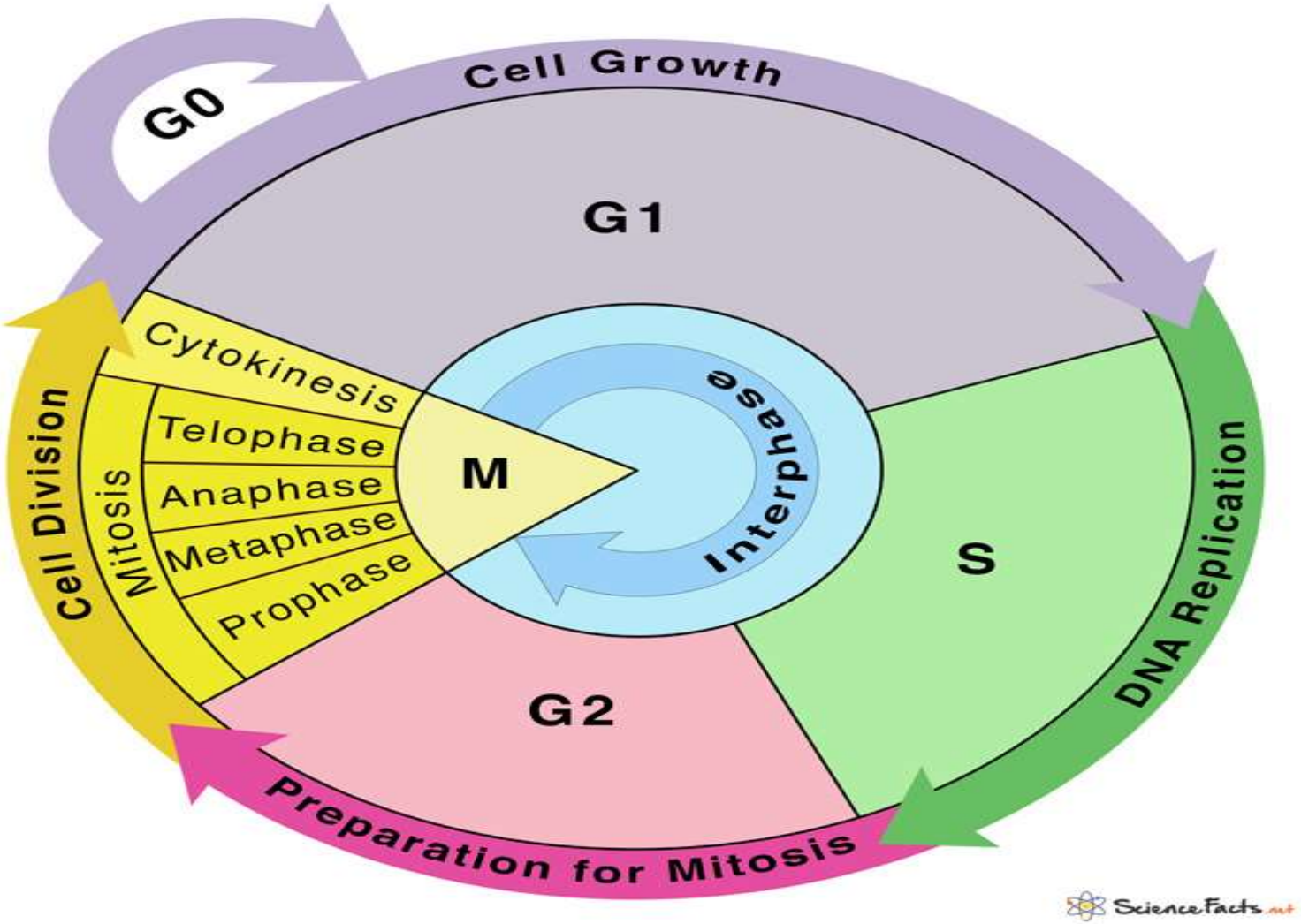
A. Interphase (G1, S, G2 phases)

B. Cell division is composed of:

1. Mitosis: the division of the genetic materials in the nucleus (division of the nucleus).
2. Cytokinesis: division of cytoplasm.



Cell Cycle


G0
Cell Growth
G1
Cytokinesis
Telophase
Anaphase
Metaphase
Prophase
Mitosis
Cell Division
M
Interphase
S
DNA Replication
G2
Preparation for Mitosis
ScienceFacts.net

A. Interphase

- Interphase is the time between two cell divisions.
- It is the longest stage of the cell cycle (about 90% of the cell cycle).
- It is often known as the resting phase; however, the cells are not resting.
- The **cell grow** during the three phases, but **duplication** of chromosomes (DNA) occurs only in the S phase.

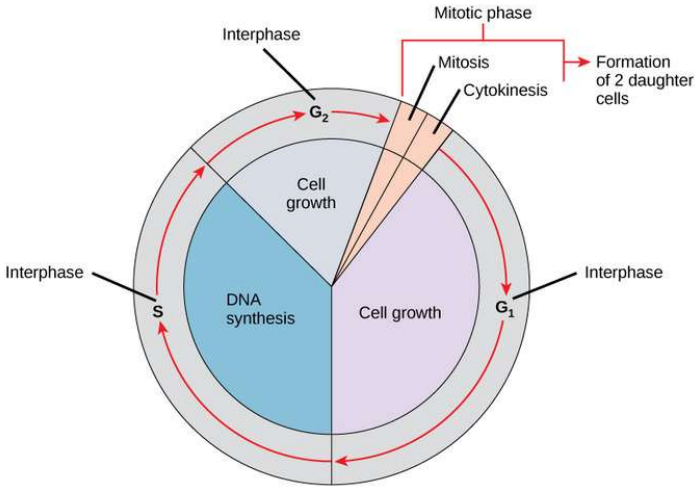
- Interphase is composed of the following phases:

1- **G1 phase** (first gap)

2- **S phase**: synthesis of DNA

3- **G2 phase**: (second gap)

- During interphase, the cell is busy carrying out all its normal metabolic activities, preparing itself for next division.

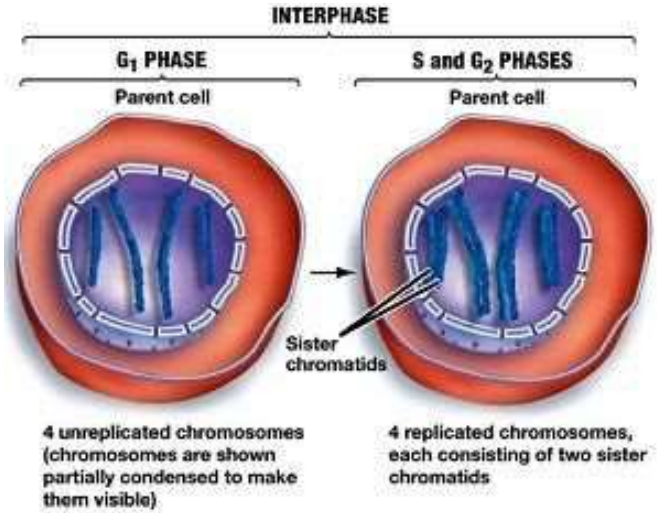


A. Interphase G_1 Stage

✓Period of rapid growth. The cell grows and nearly **double in size.**

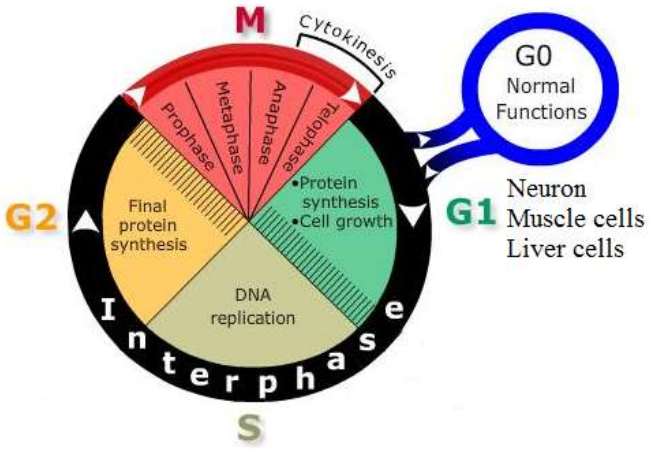
✓New proteins and organelles are produced.

✓Preparing for DNA synthesis in the next phase.



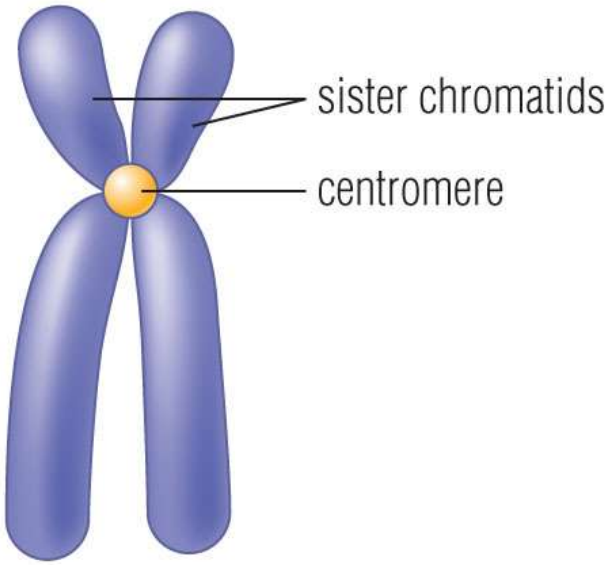
A. Interphase G0 Stage

- Some cells specialize and their cycle activities may be temporarily or permanently suspended.
- It enters a G0 phase which is known as cell cycle arrest (the cells are alive).
- The cells in G0 phase are neither dividing nor preparing to divide.
- Examples of cells that possibly enter the G0 phase are liver, nerve and muscle cells.



A- Interphase S Stage

- During interphase, chromosomes within the nucleus exist as a mass of thin threads called chromatin. Chromosomes are made up of DNA.
- During S stage, the cell copies its DNA by replication to prepare itself for cell division.
- Duplicated chromosomes will have two sister chromatids.
- Sister chromatids have identical genetic information (identical copies of DNA).



- **Chromosome Structure**

1-Sister chromatid

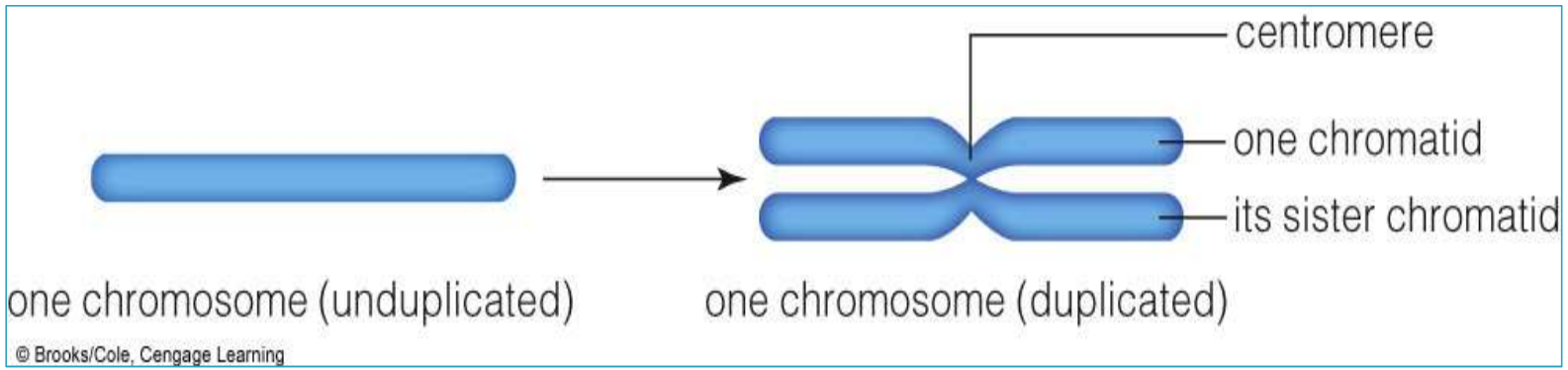
One of two attached members of a **duplicated** eukaryotic chromosome

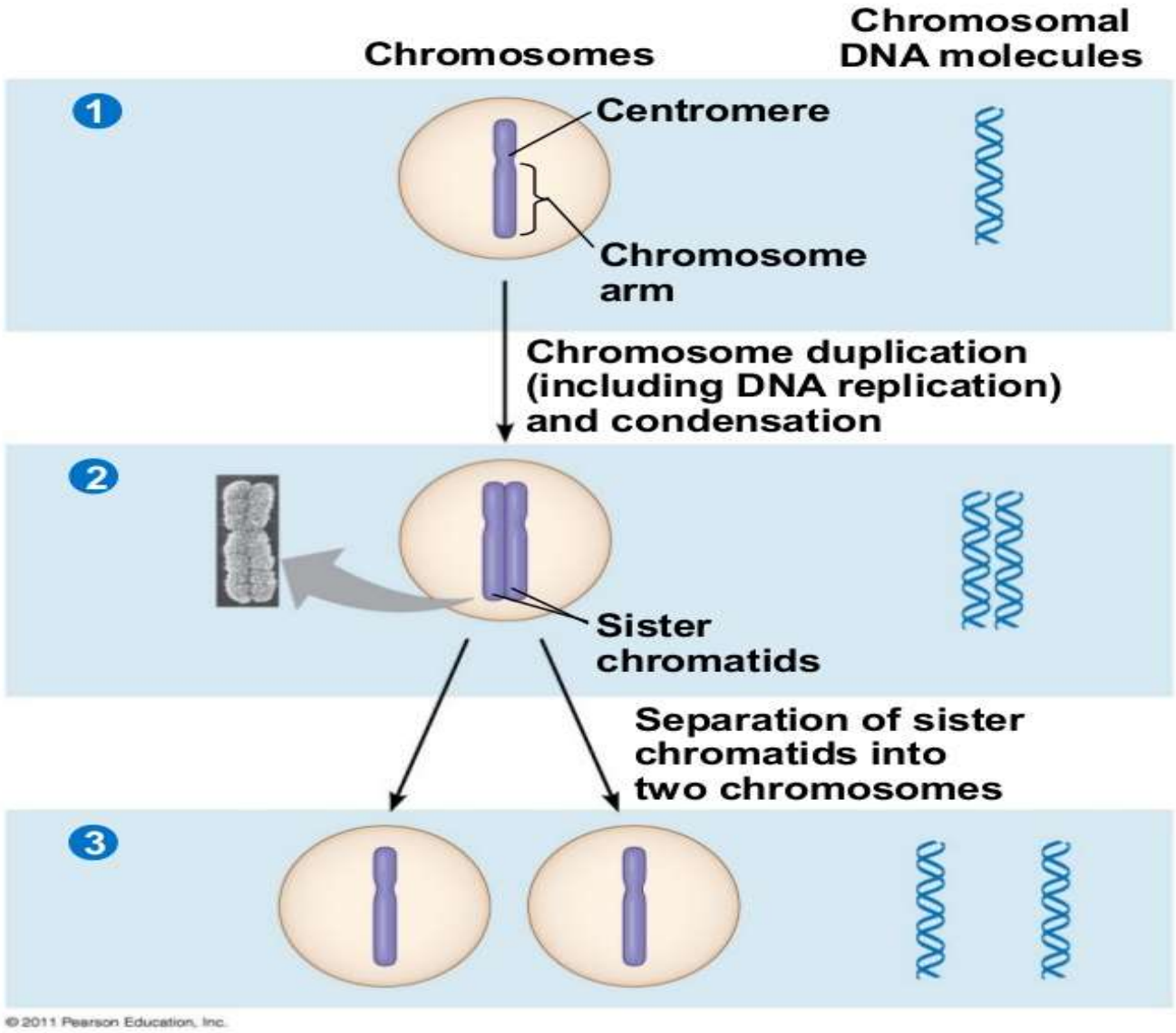
2-Centromere

Constricted region in a chromosome where sister chromatids are attached

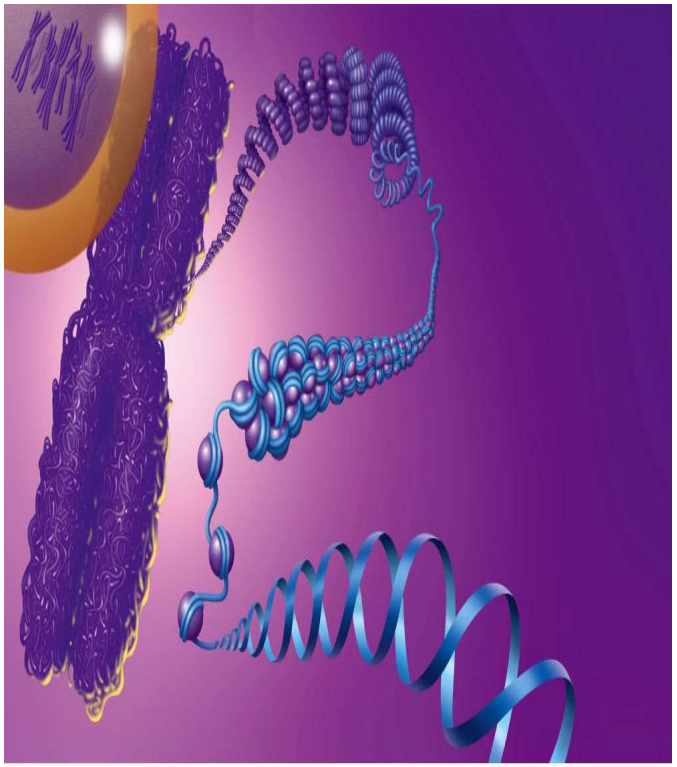
3- Histone

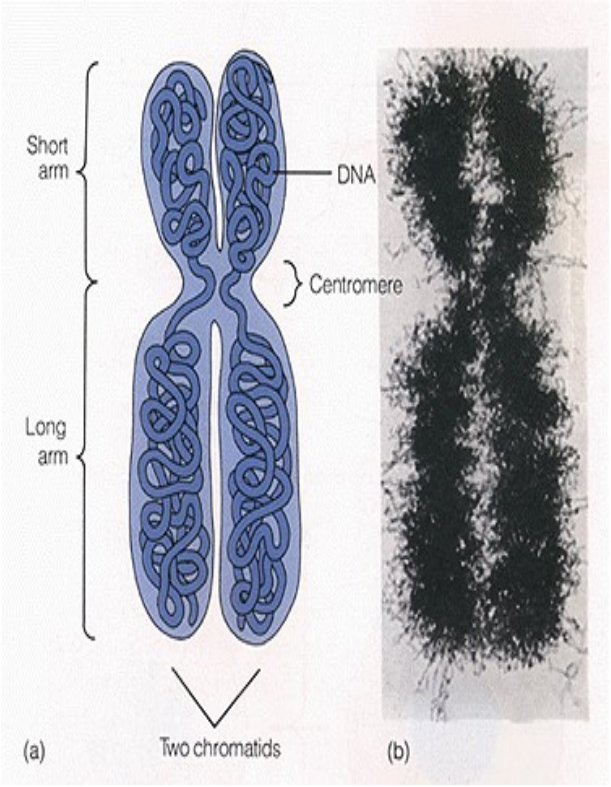
Type of protein that structurally organizes eukaryotic chromosomes





Chromosomes in Dividing Cells

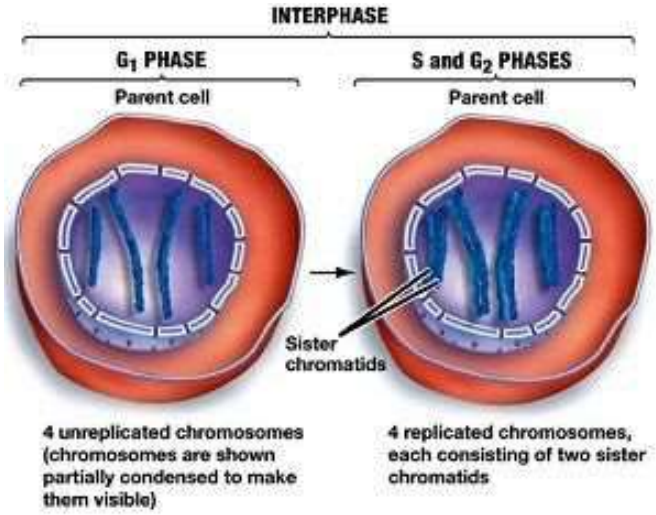




DNA coiled over histone protein

A- Interphase G2 Stage

- ✓Shortest phase of interphase.
- ✓2nd Growth Stage in preparation of cell division.
- ✓Occurs after DNA has been copied
- ✓Produce all organelles and cell structures needed for division (e.g. centrioles)
- ✓Both organelles & proteins are synthesized



B- Cell division

Cell division is composed of two stages:

1.Mitosis: the division of the genetic materials in the nucleus (division of the nucleus = karyokinesis).

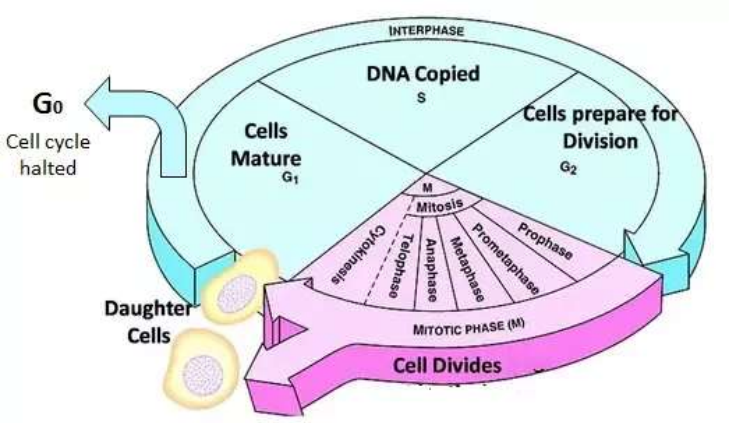
Mitosis is divided into four phases:

I. Prophase

II. Metaphase

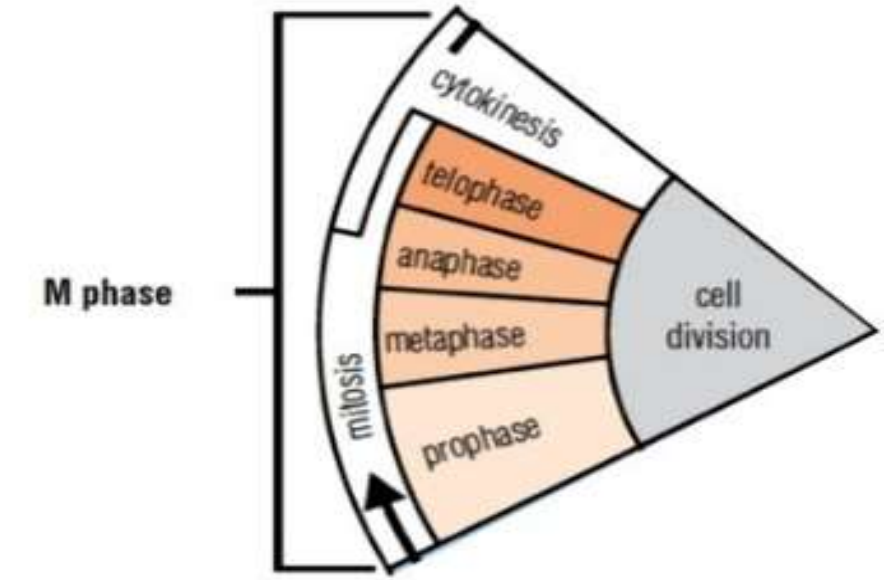
III. Anaphase

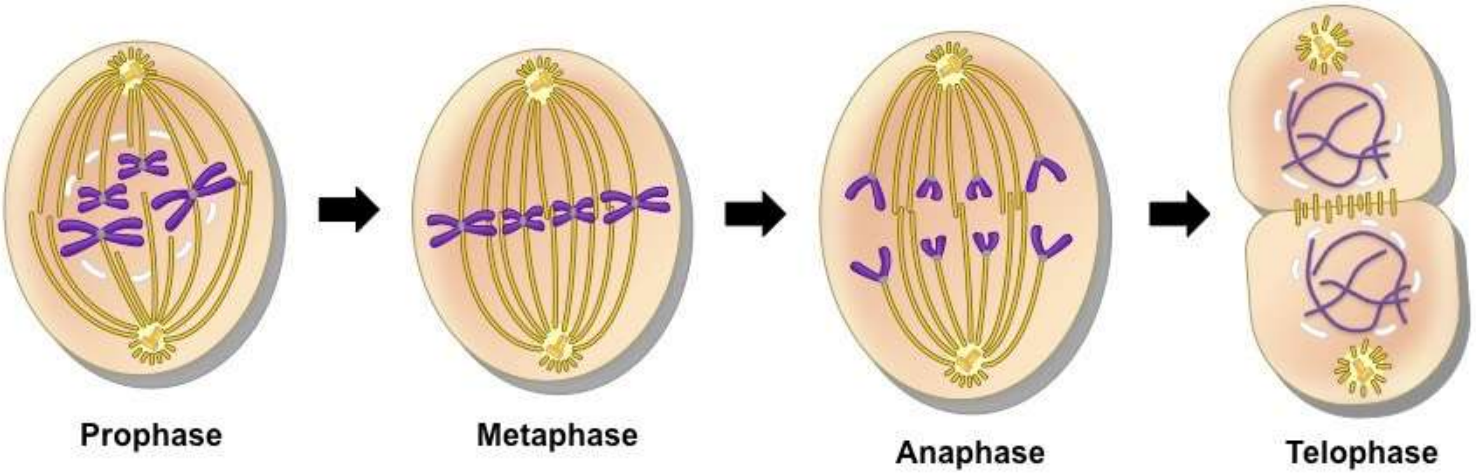
IV. Telophase



2. Cytokinesis: division of cytoplasm.

1. Mitosis


M phase
cytokinesis
telophase
anaphase
metaphase
prophase
mitosis
cell division


Prophase
Metaphase
Anaphase
Telophase

Functions of Mitosis

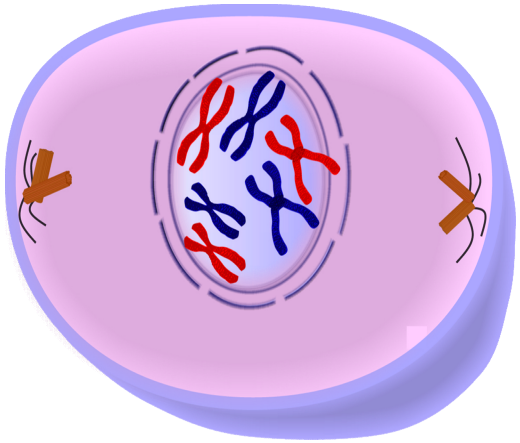
- ✓ Used for growth, repairing damaged tissue, replacing worn-out cells and producing new body parts.
- ✓ Produce two new daughter cells identical to the parent cell.
- ✓ Cells are diploid (46 chromosomes= 23 pairs of chromosomes)

I- Prophase

It is characterized by the following events:

1- **Chromosomes condense** and become visible with light microscope.

Each chromosome consists of two identical copies called **chromatid** held together by **centromere.**



2- The nuclear envelope breaks down and disappears and the nucleolus disappears.

3- Centrioles separate and take positions on the opposite poles of the cell.

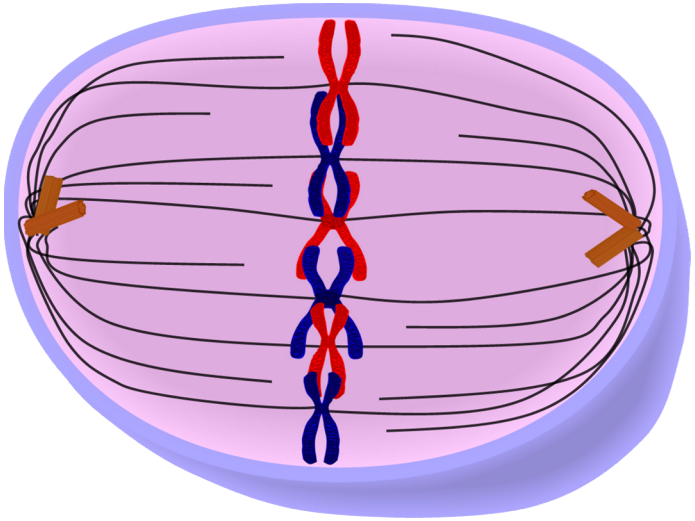
4- **Spindle fibers** form between opposite sides of the cell.

II- Metaphase

It is the **shortest phase** of mitosis and is characterized by two events:

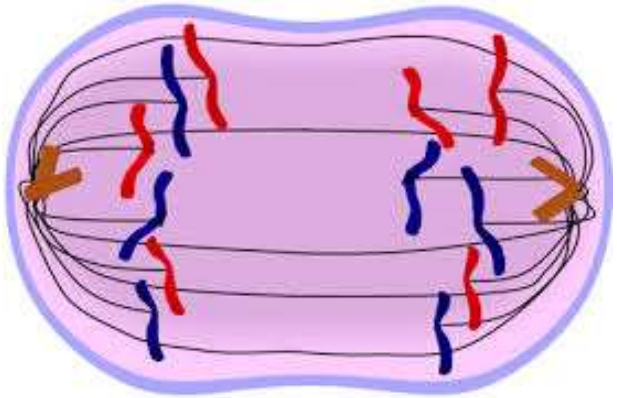
1- Chromosomes line up across the middle of the cell.

2- The centromere of each chromosome attaches to the spindle fibers.



III- Anaphase

It is characterized by the following events:



1- Centromeres that join the sister chromatids split.

2- Sister chromatids separate and are pulled to the opposite poles of the cell by the spindle fibers.

3- **Each chromatid is now called chromosome.**

IV- Telophase

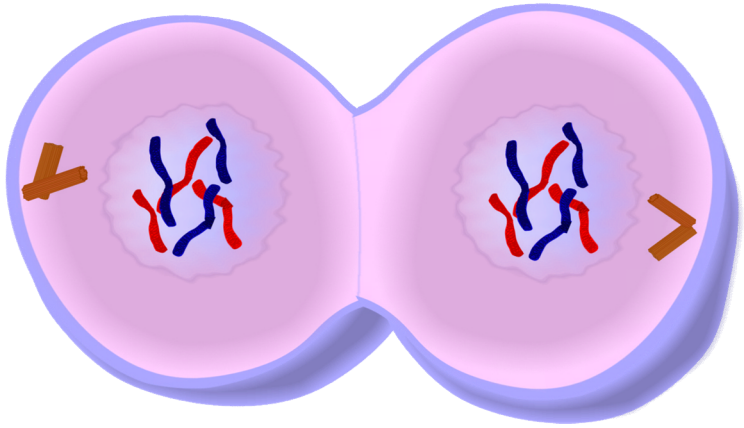
- It is the last phase of mitosis.
- It consists of the following events:

1- Chromosomes (each consisting of a single chromatid) **uncoil** to forms threads of chromatin.

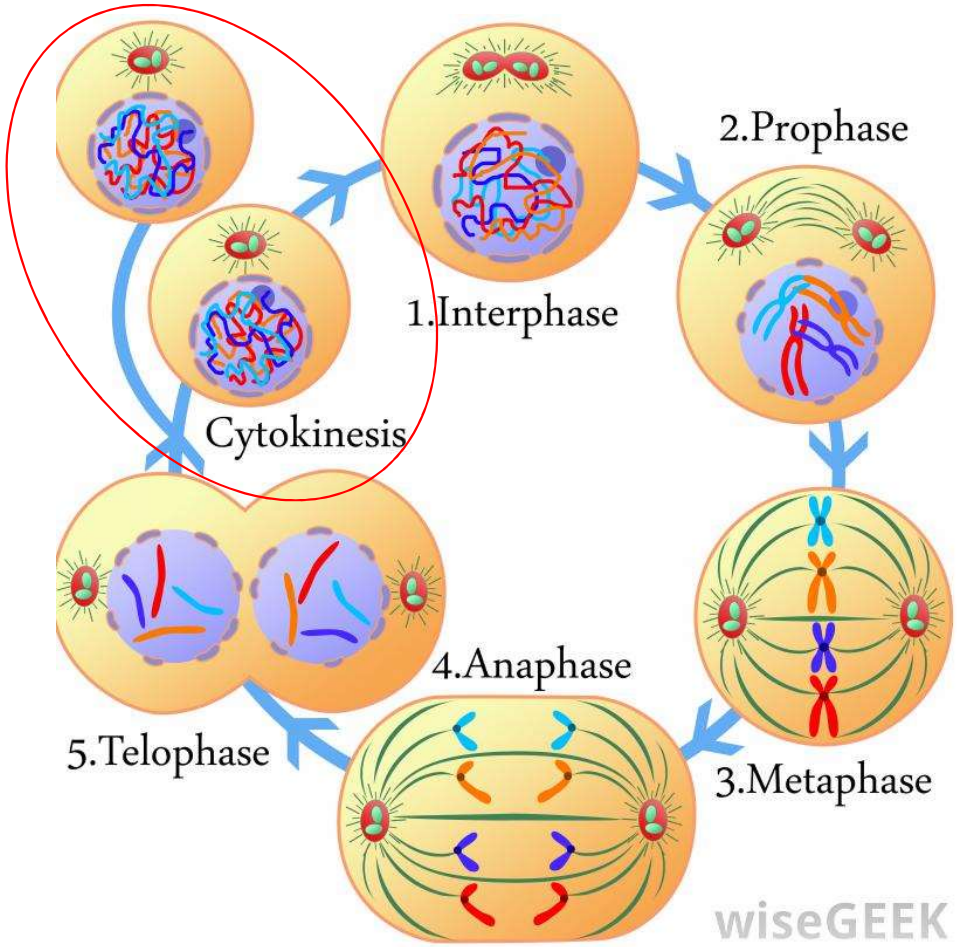
2- **A new nuclear envelope forms** around the chromosomes at each pole of the cell to form two nuclei.

3- **Spindle fibers break down and dissolve**.

4- Cytokinesis begins.

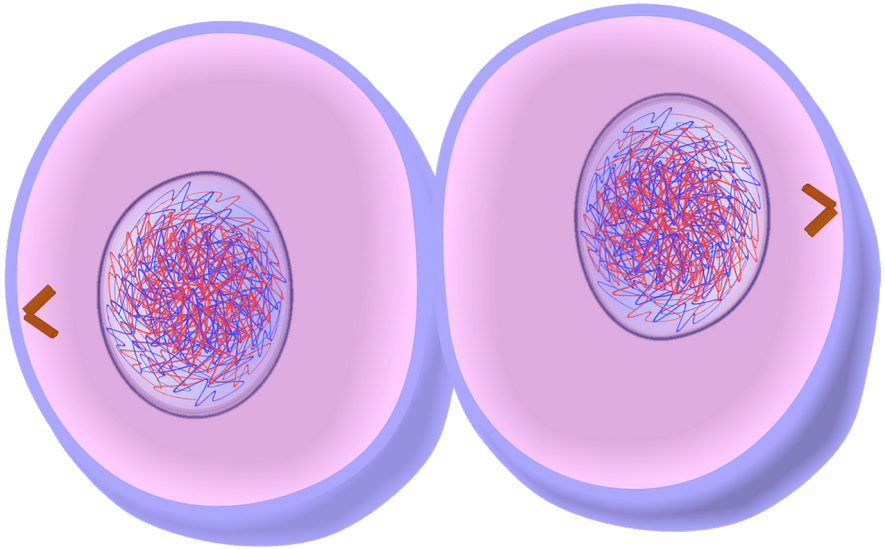


2. Cytokinesis



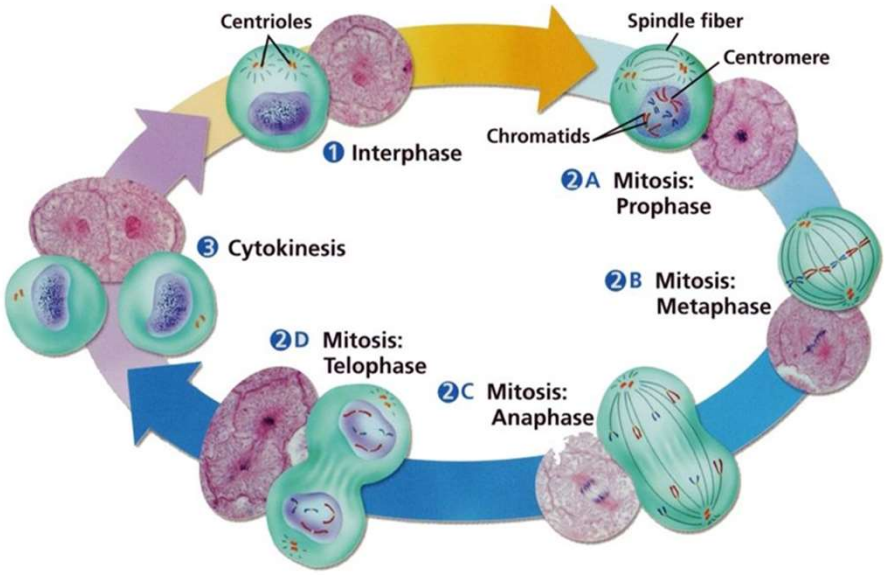
Cytokinesis

- Cytokinesis is the division of the cytoplasm to form two new daughter cells.
- Each new cell containing its own nucleus and cytoplasmic organelles.



Review of Mitosis

Cell division (Meiosis)

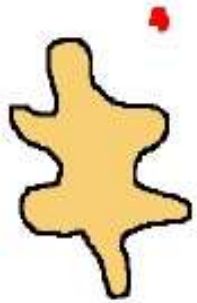


TWO types of cells in the body

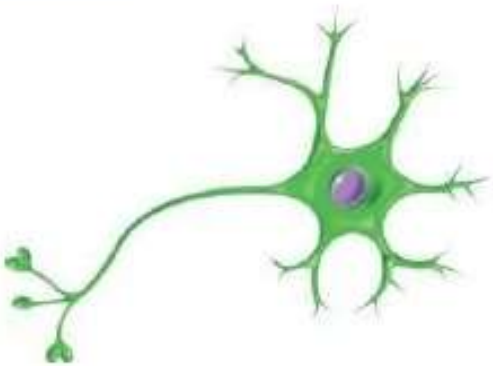
Non-reproductive or somatic cells

↓

diploid number of chromosomes



phagocyte

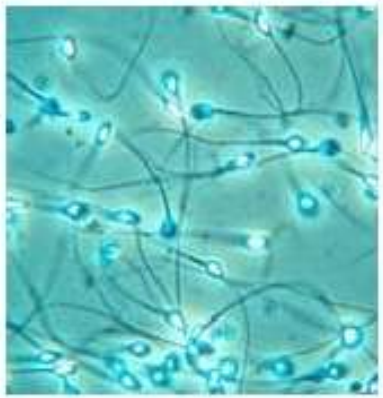


Nerve cell

Gametes (sex cells)

↓

haploid number

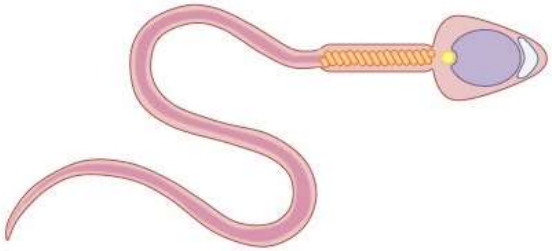


sperms

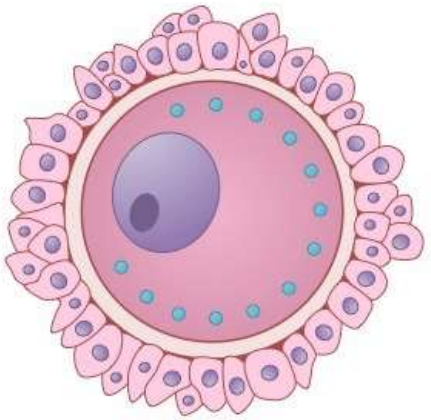
Types of Gametes

- The male gamete is the **Sperm** and is produced in the male gonad the **Testes**.
- Sperms are produced by **spermatogenesis.**
- The female gamete is the **Ovum** and is produced in the female gonad the **Ovaries.**
- Ova produced by **oogenesis**.

Human Sperm (Spermatozoa)



Human Egg (Ovum)



Homologous Chromosomes

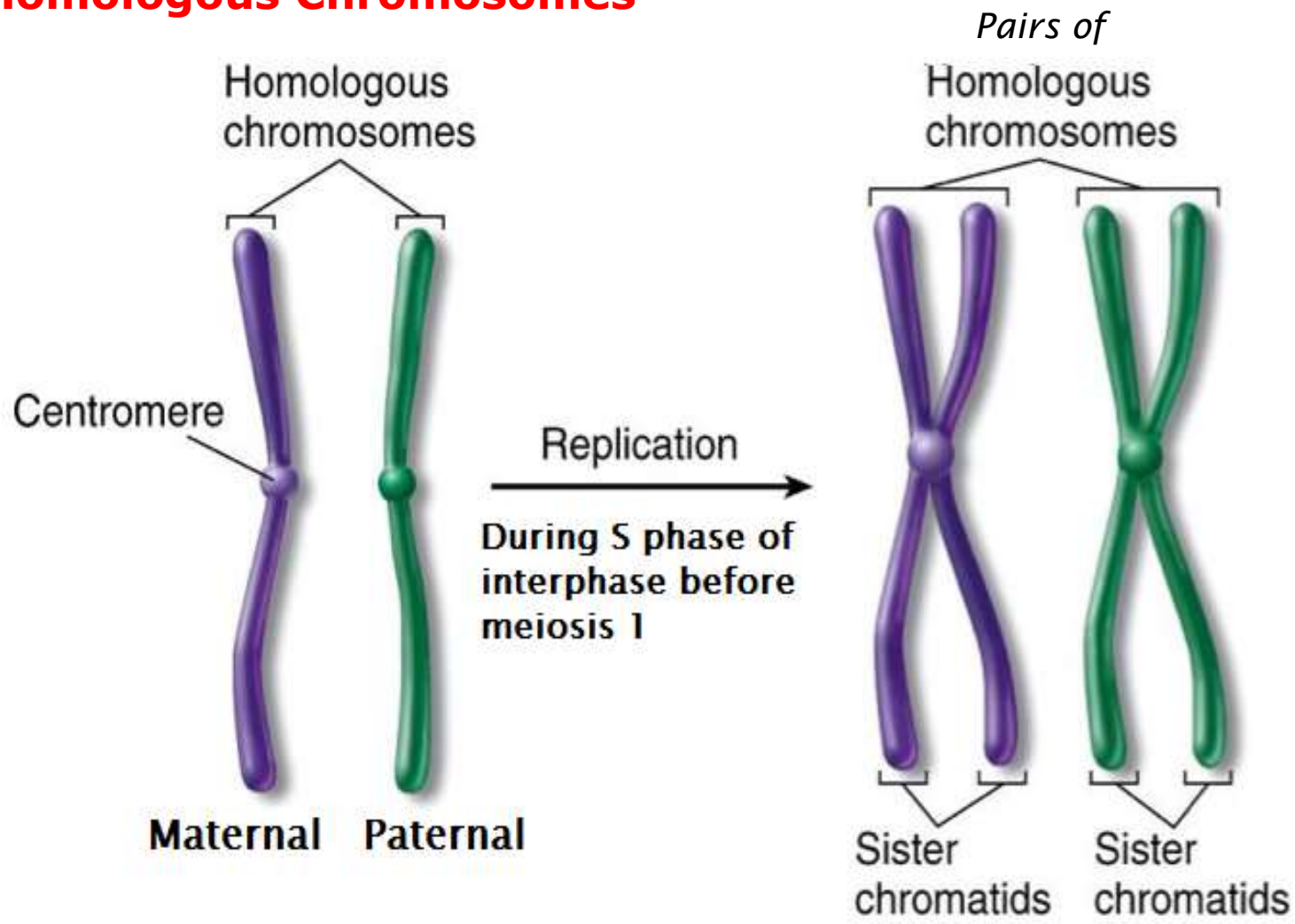
- Two **chromosomes** (**maternal** and **paternal**) that are similar in shape and size.
- Homologous chromosomes carry genes controlling the same inherited characters.
- Humans have 23 pairs of **homologous chromosomes.**

  22 pairs of **autosomes**

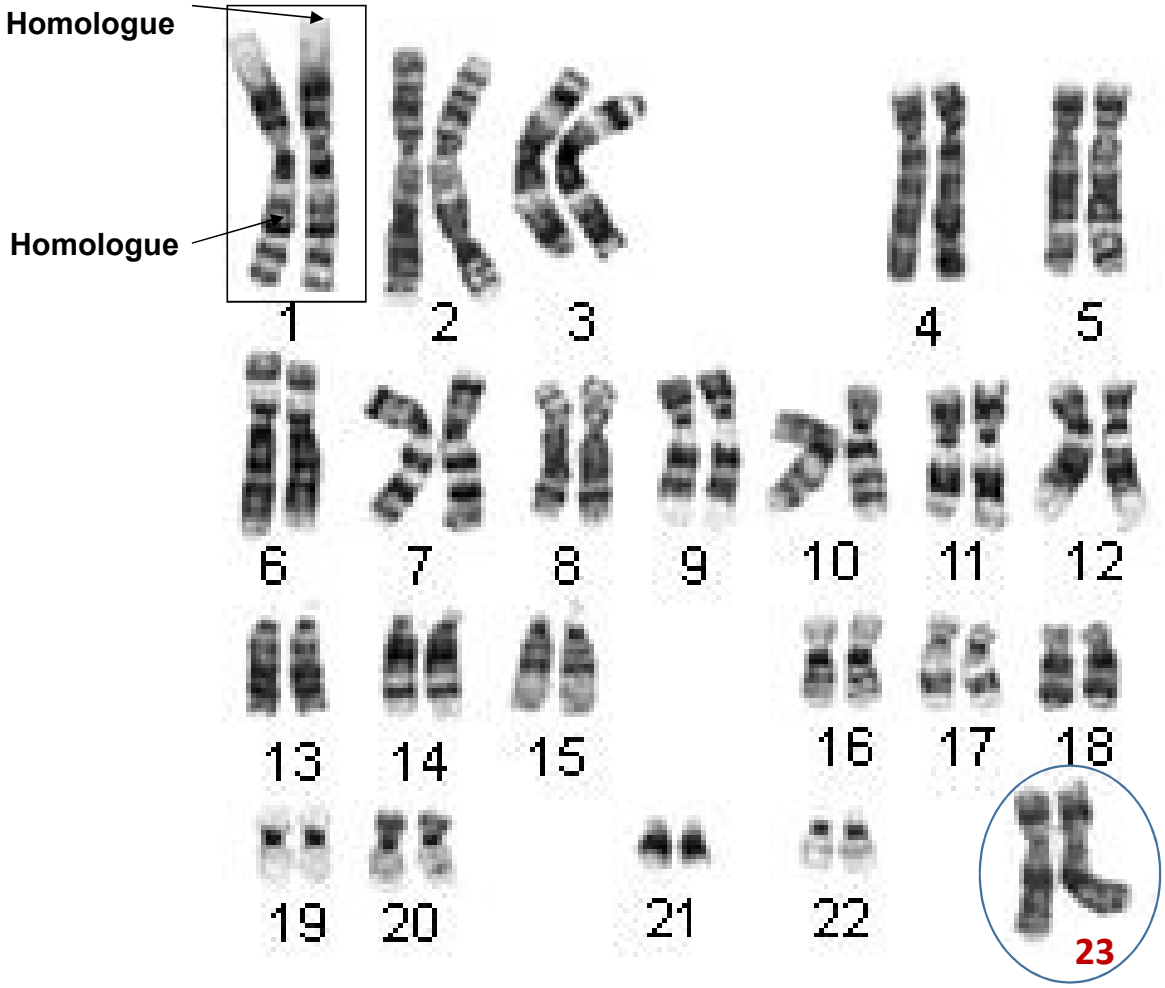
  1 pair of **sex chromosomes**

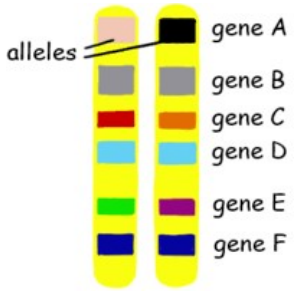
- During S phase of interphase, DNA duplication occurs → homologous pairs of chromosomes.
- Because a homologous pair consists of 4 chromatids it is called a "Tetrad".

Homologous Chromosomes



Homologous Chromosomes





Humans have 23 Sets of Homologous Chromosomes

Each Homologous set is made up of 2 Homologues.

From 1-22 are autosomes.

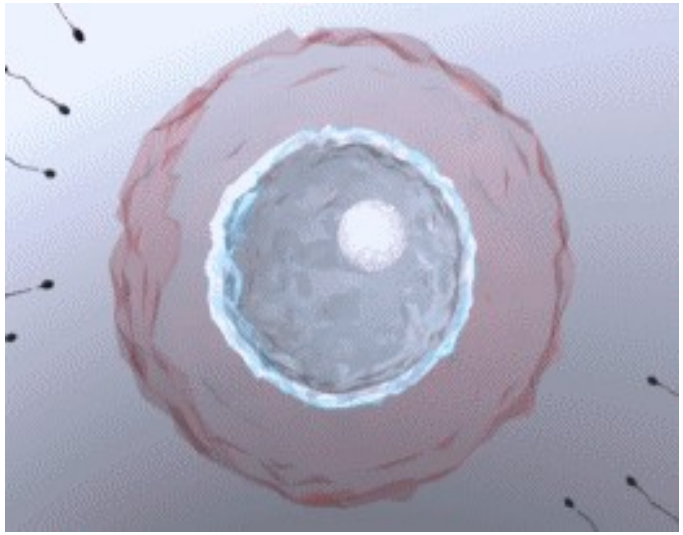
No. 23 is sex chromosome

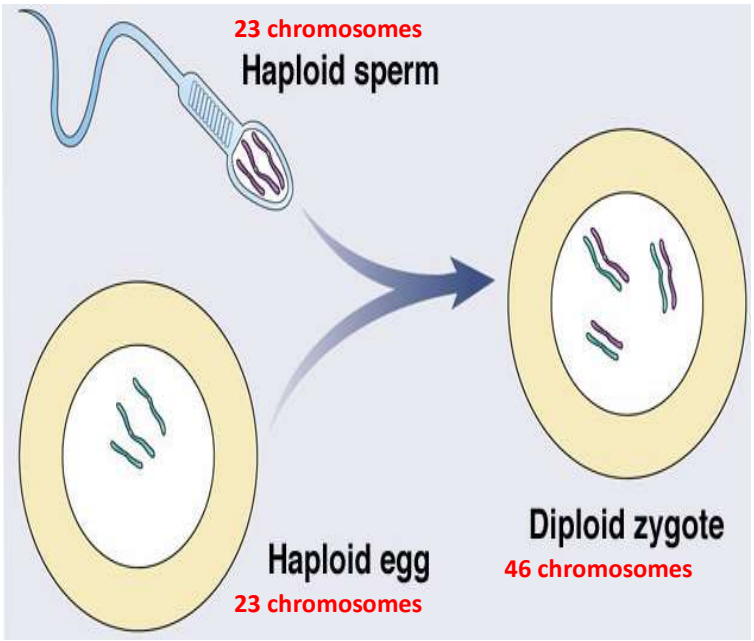
Meiosis

- Definition: It is the process by which ”gametes” (sex cells), with half the number of chromosomes, are produced
- Preceded by **interphase** which includes cell growth & DNA replication.
- Occurs in germ cells of all living organisms which are **diploid** (46 chromosomes).
- During meiosis, the genetic materials of germ cells **divide two times** (Meiosis I and Meiosis II) with **only one duplication of DNA**.

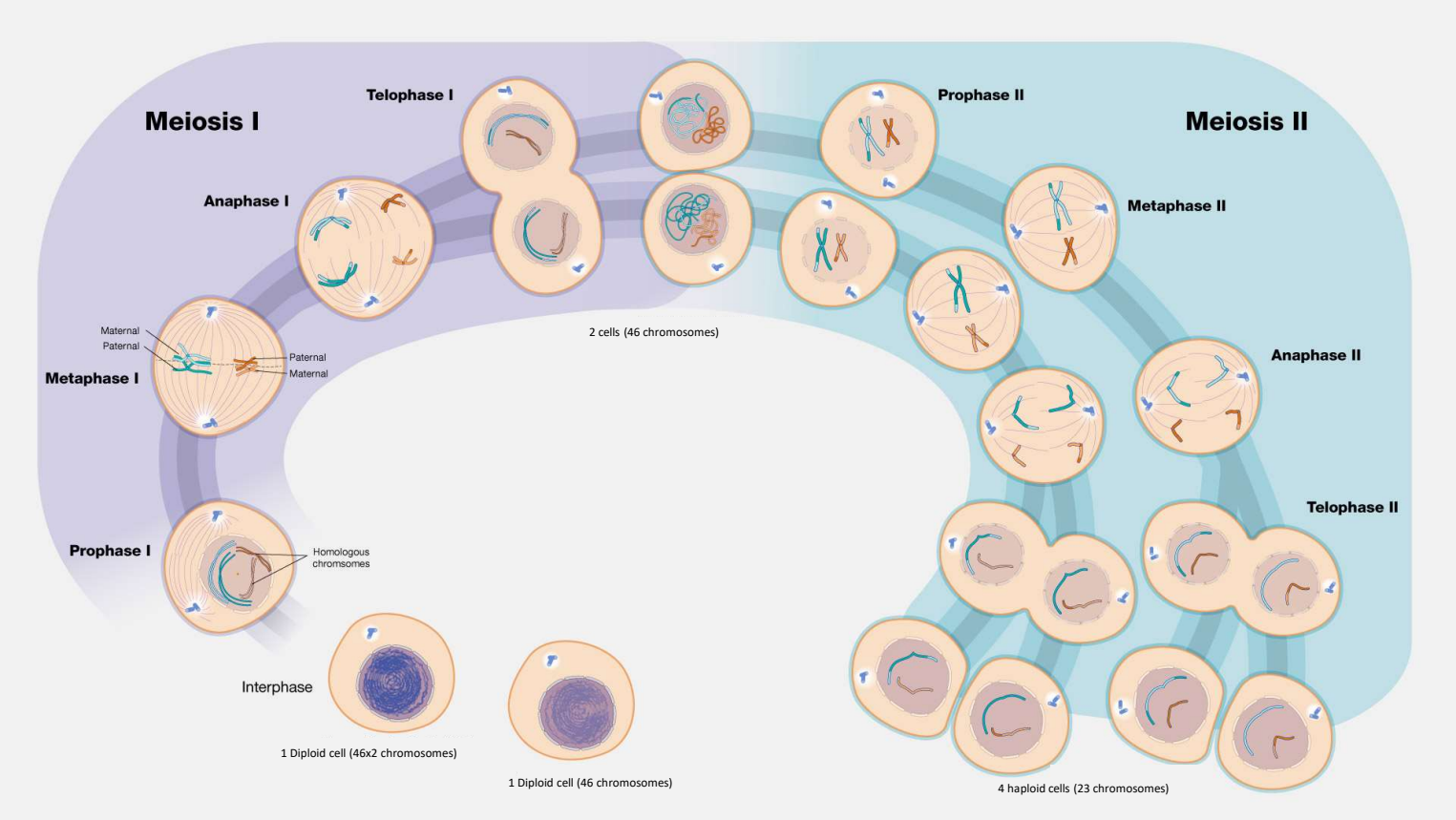
Why Do we Need Meiosis?

- It is the fundamental basis of sexual reproduction
- Two haploid gametes (sperm and ovum) are brought together through fertilization to form a diploid zygote.





Meiosis: Two Part Cell Division



Meiosis I reduction division

- It is known as **reduction division** as the chromosome number is reduced from diploid (46 homologous chromosomes) to haploid (23 homologous chromosomes).
- It consists of four phases:

1. Prophase I
2. Metaphase I
3. Anaphase I
4. Telophase I

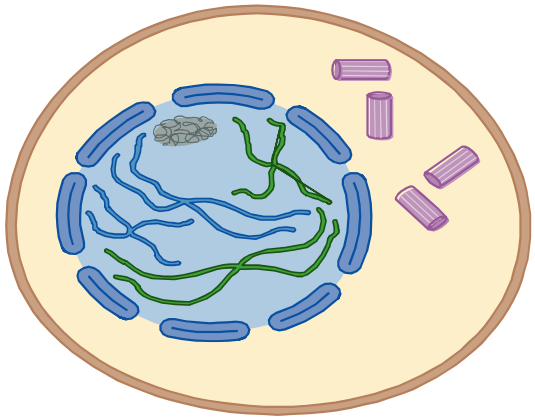
Meiosis I: Prophase I

- Longest and most complex phase (90% of the meiotic process is spent in Prophase I)

Early prophase I

✓Homologs pair.

✓Crossing over occurs.

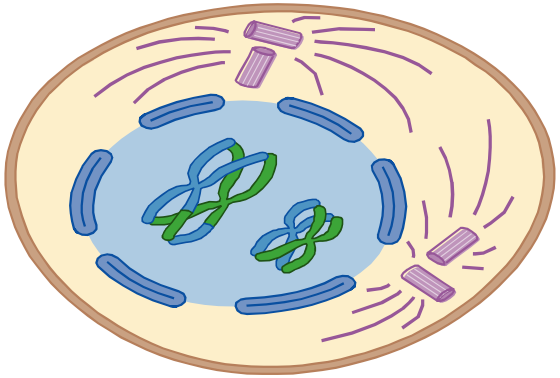


Late prophase I

✓Chromosomes condense.

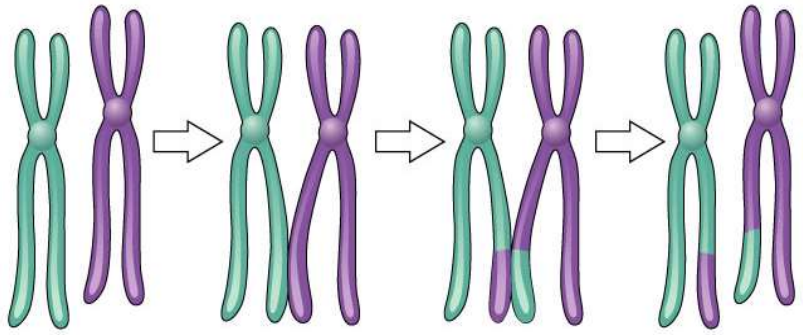
✓Spindle forms.

✓Nuclear envelope fragments

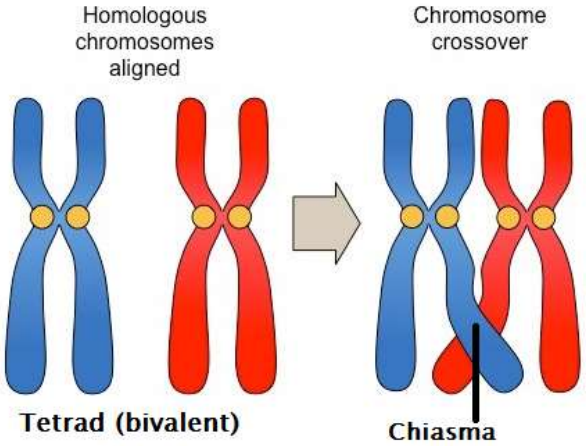


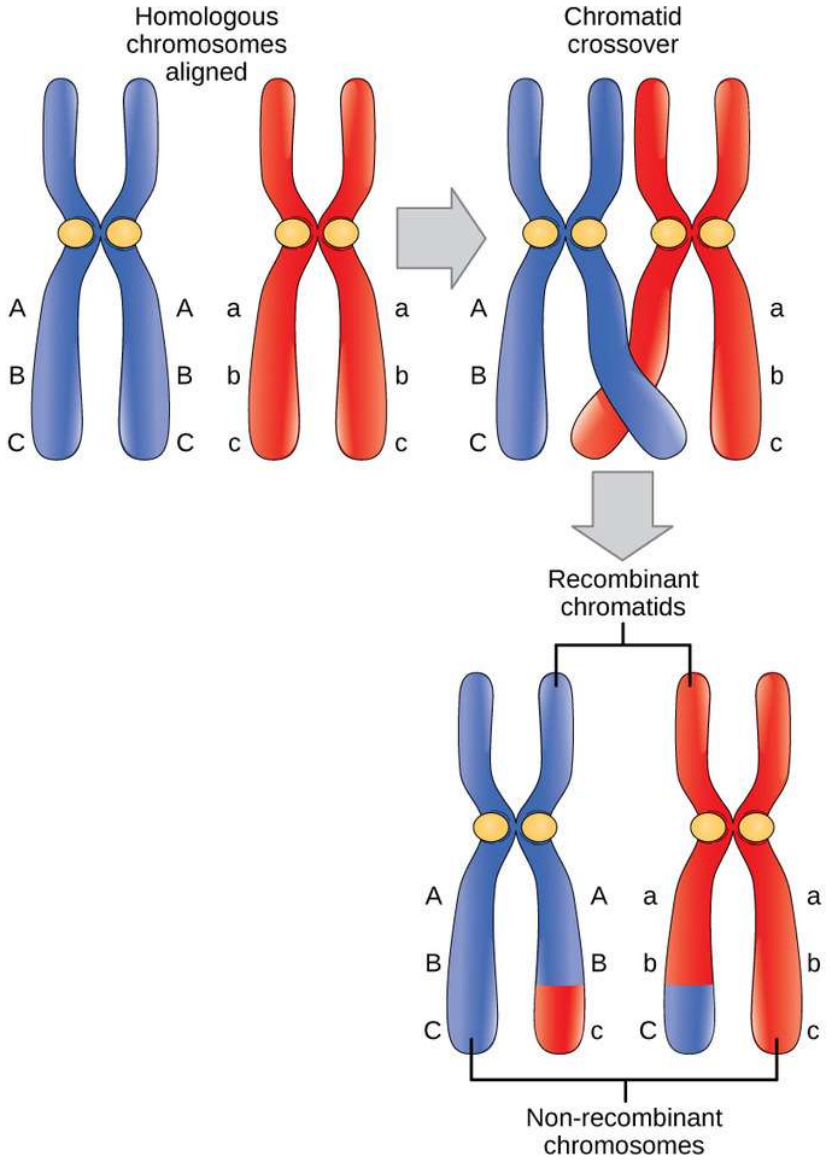
Crossing-Over

- Occurs during prophase I.
- The two pairs of homologous chromosomes joint together very closely.
- **Two non-sister chromatids** of the homologous chromosomes are crossed over at a chiasma point and exchange corresponding segments.
- The resulting chromosomes are called "recombinant chromosomes".
- It is important in genetic variation in the offspring
- New combinations of traits

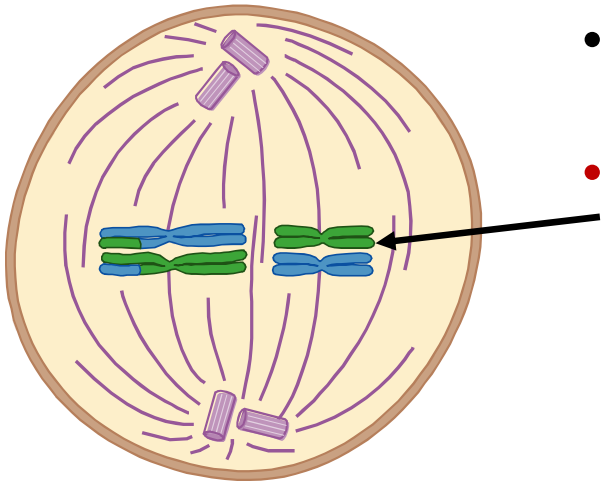


Crossing-Over



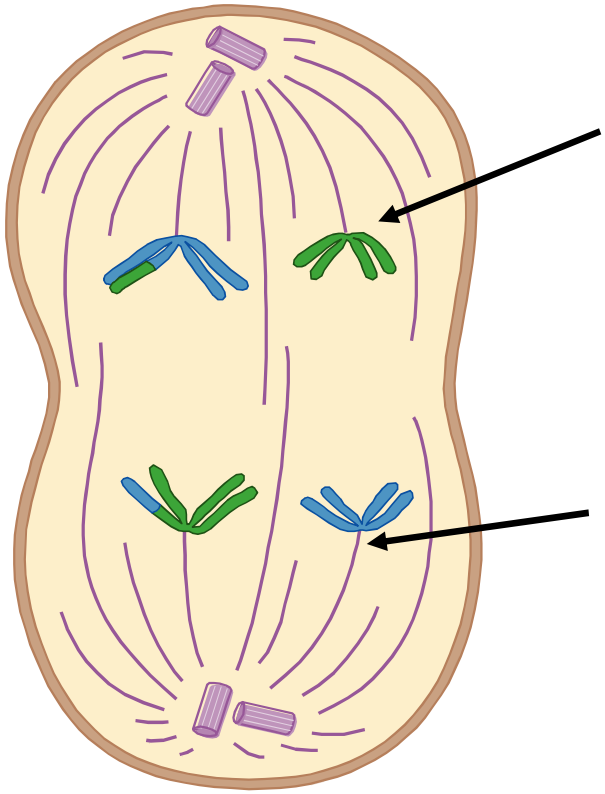


Meiosis I: Metaphase I



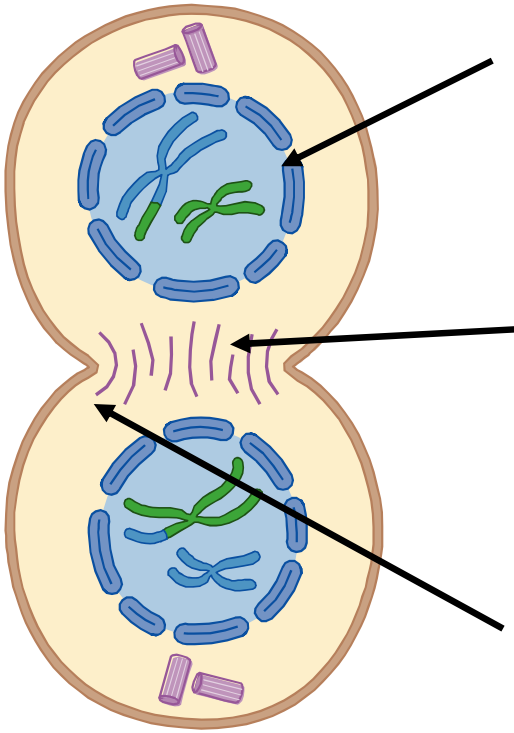
- Shortest phase
- **Homologous pairs of chromosomes** line up across the center of the cell.

Meiosis I: Anaphase I



- Homologous chromosomes separate and move to opposite poles.
- Sister chromatids are still attached at their centromeres.

Meiosis I: Telophase I



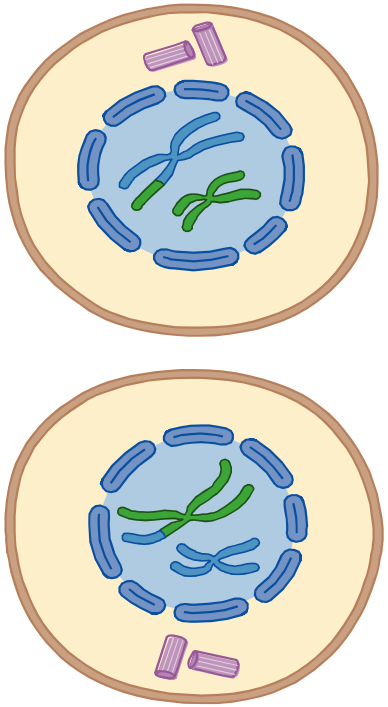
- Nuclear envelopes reassembly.
- Spindle disappears.
- Cytokinesis divides the cytoplasm into two parts by cleavage furrow.

Meiosis II Equational

- **No interphase between meiosis I and meiosis II.**
- No DNA replication.
- Meiosis II is similar to **mitosis**
- It consists of four phases:

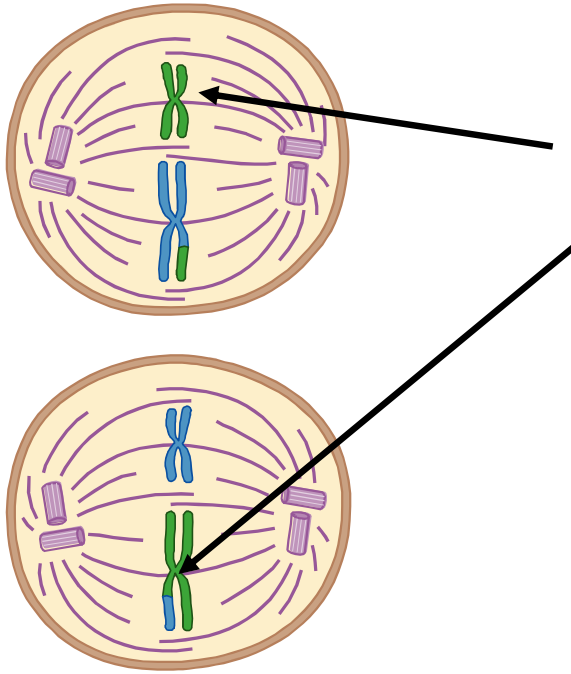
1. Prophase II
2. Metaphase II
3. Anaphase II
4. Telophase II

Meiosis II: Prophase II



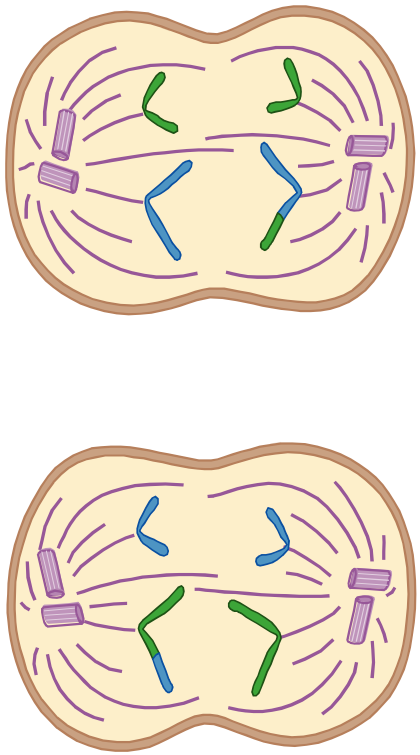
- Similar to prophase of mitosis
- Nuclear envelope fragments.
- Spindle forms.
- The chromosomes are still doubled.

Meiosis II: Metaphase II



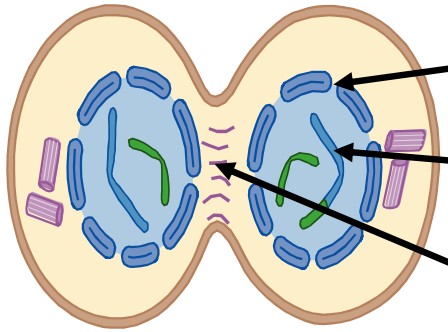
- Chromosomes (two sister chromatids) line up across the center of the cell.

Meiosis II: Anaphase II

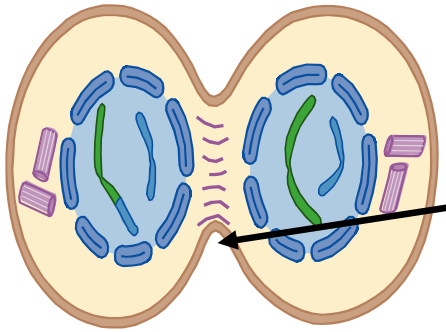


- The centromeres split, and the sister chromatids separate and move to opposite poles.

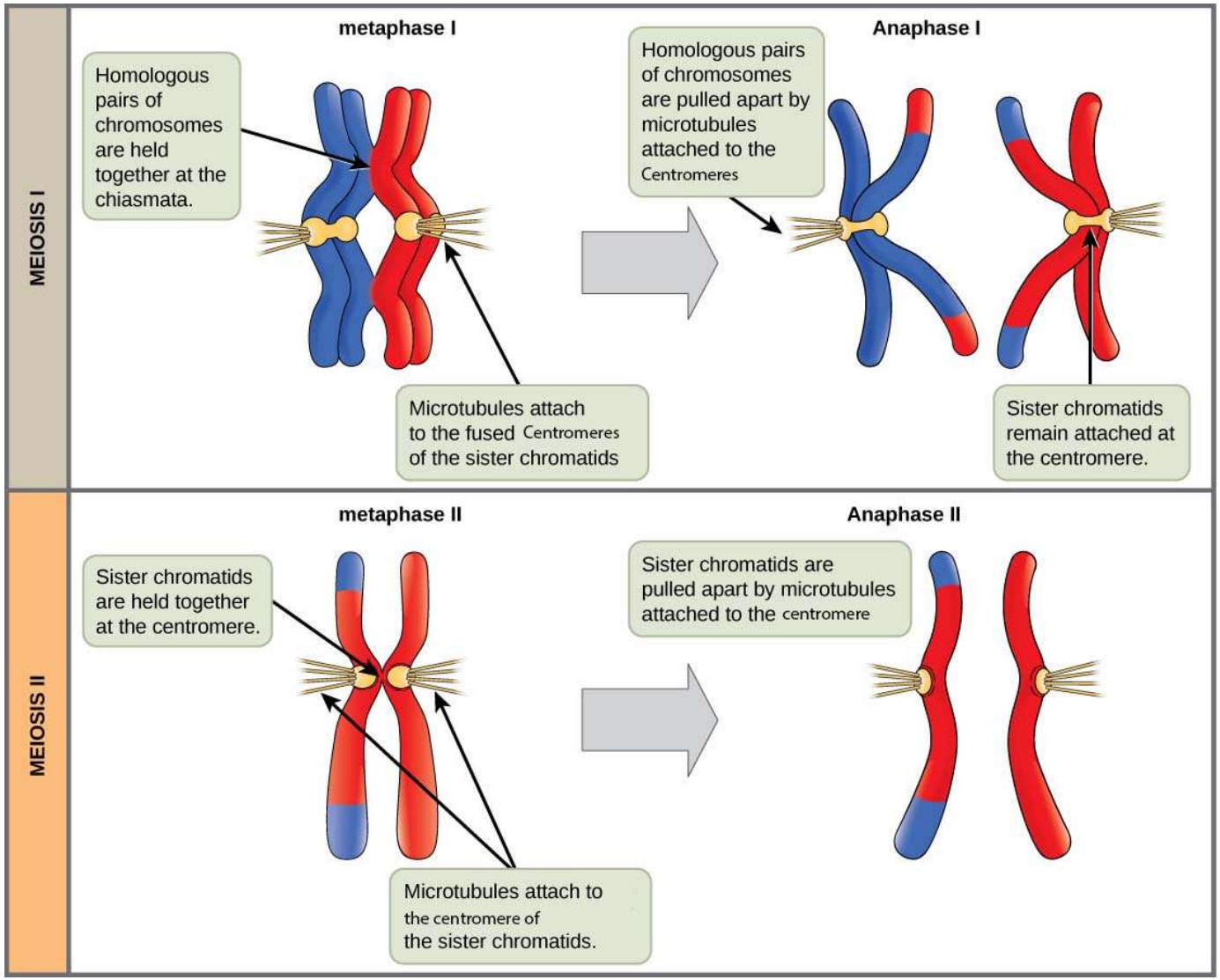
Meiosis II: Telophase II



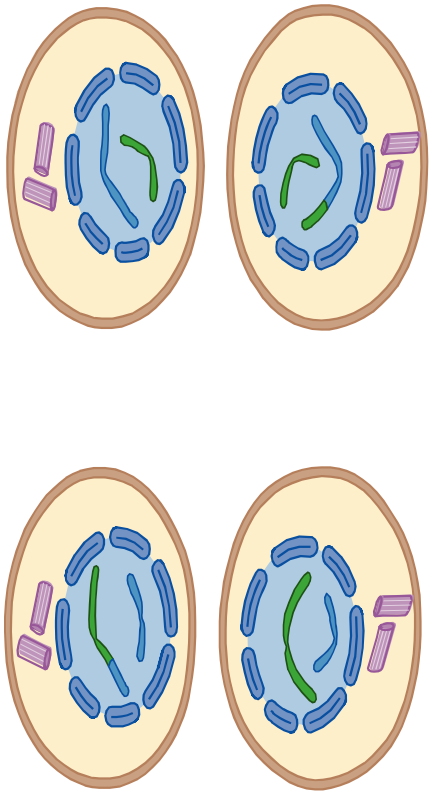
- Nuclear envelope reassembles.
- Chromosomes decondense.
- Spindle disappears.



- Cytokinesis divides cell into two by cleavage furrow.


MEIOSIS I
metaphase I
Homologous pairs of chromosomes are held together at the chiasmata.
Microtubules attach to the fused Centromeres of the sister chromatids
Anaphase I
Homologous pairs of chromosomes are pulled apart by microtubules attached to the Centromeres
Sister chromatids remain attached at the centromere.
MEIOSIS II
metaphase II
Sister chromatids are held together at the centromere.
Microtubules attach to the centromere of the sister chromatids.
Anaphase II
Sister chromatids are pulled apart by microtubules attached to the centromere

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

Thank you