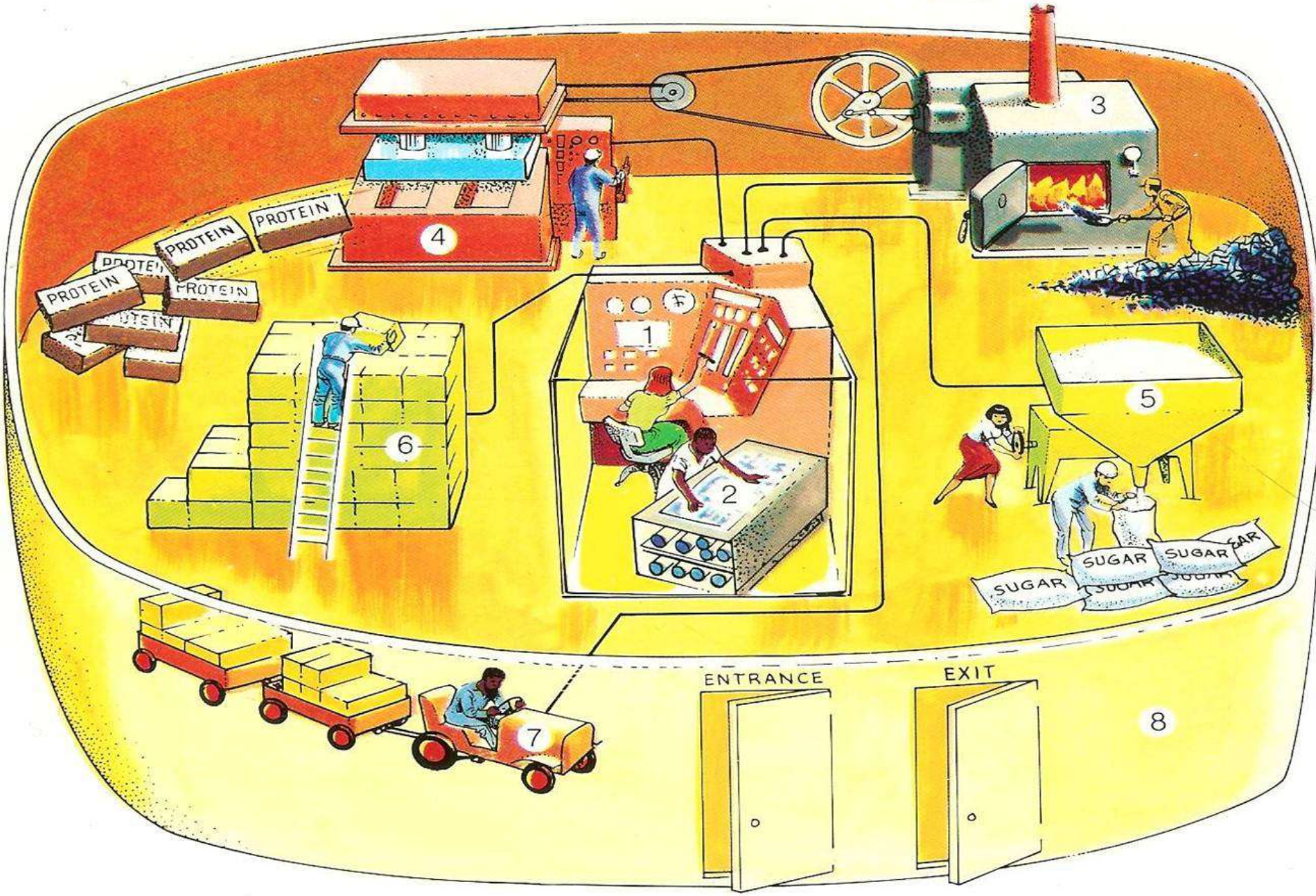
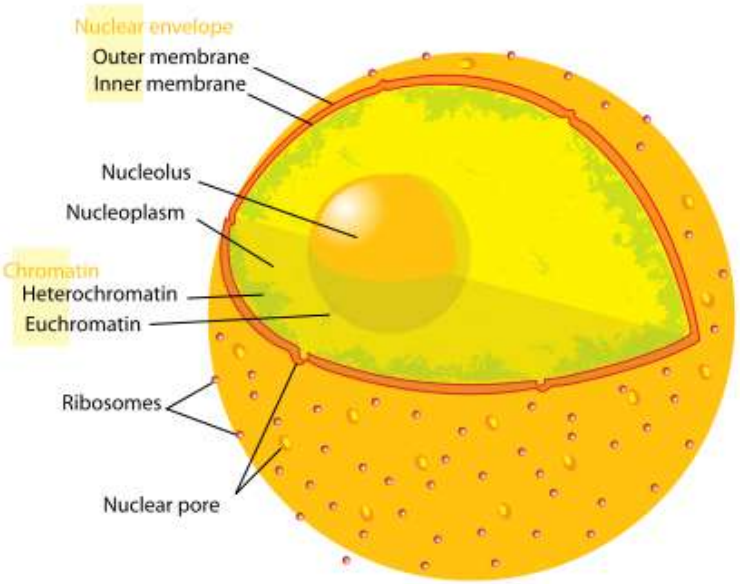
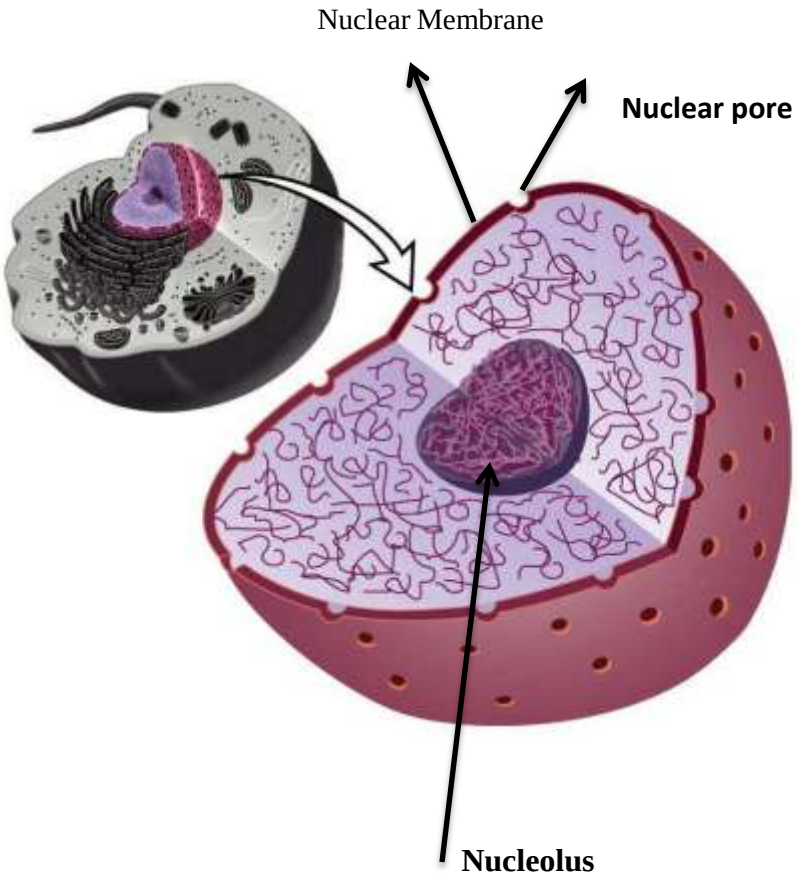
THE NUCLEUS


PROTEIN
PROTEIN
PROTEIN
PROTEIN
PROTEIN
SUGAR
SUGAR
SUGAR
ENTRANCE
EXIT
1
2
3
4
5
6
7
8

NUCLEUS


Nuclear envelope
Outer membrane
Inner membrane
Nucleolus
Nucleoplasm
Chromatin
Heterochromatin
Euchromatin
Ribosomes
Nuclear pore


Nuclear Membrane
Nuclear pore
Nucleolus

What is Nucleus ?

- Nucleus” is a Latin word meaning Kernel. It is the “CONTROL CENTER” of the cell. It was First cell organelle to be discovered It is membrane bound organelle found in eukaryotic cells. Main functions are - to maintain the integrity of genes - to control the activities of the cell by regulating gene expression .

THE NUCLEUS:FUNCTIONS

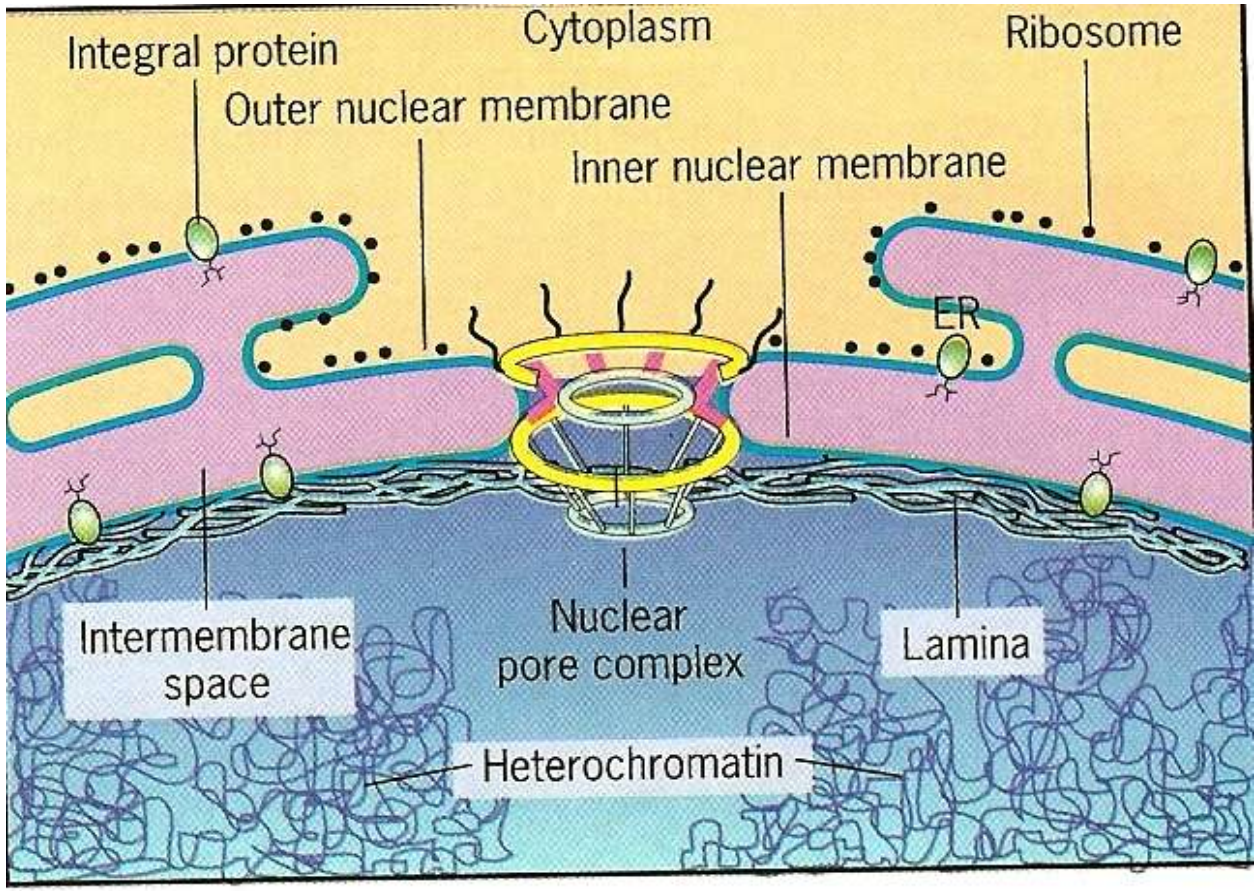
- It stores the cell's hereditary material, or DNA.
- Site of DNA replication
- Site of DNA transcription to mRNA
- Ribosomal formation
- -Nucleolus: RNA & protein required for ribosomal synthesis
- It coordinates the cell's activities, which include growth, intermediary metabolism, protein synthesis, and reproduction (cell division) by regulating gene expression.

THE NUCLEUS:STRUCTURE

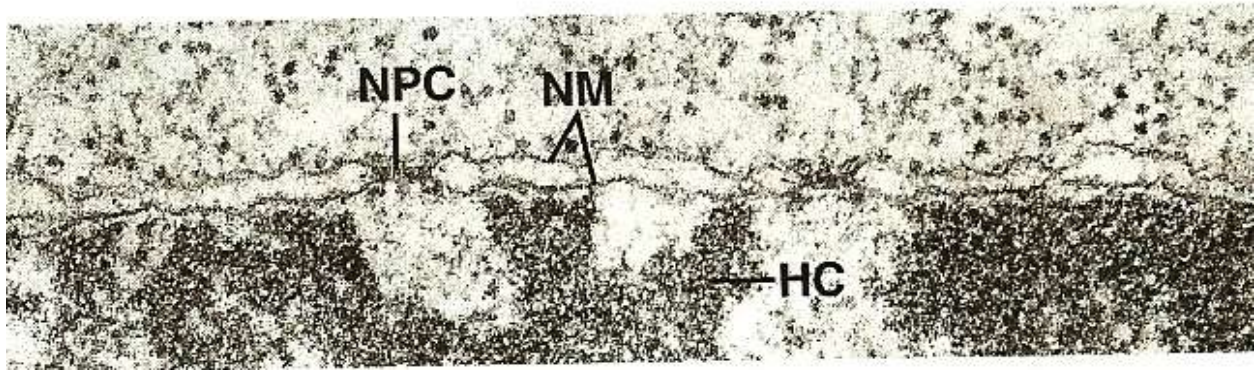
- Average diameter of nucleus is 6um, which occupies around 10% of cell volume
- The contents of the nucleus are enclosed by a complex ***nuclear envelope.***
- Included within the nucleus are:
- ***1- Chromatin***
- ***2- Nucleoplasm***
- ***3- Nucleolus (concentrated area of chromatin, RNA and proteins)***

The NUCLEAR ENVELOPE (NE)

- The nuclear envelope completely encloses the nucleus and separates the cell's genetic material from the surrounding cytoplasm, serving as a barrier to prevent macromolecules from diffusing freely between the nucleoplasm and the cytoplasm.
- Also known as perinuclear envelope, nuclear membrane or karyotheca Encloses the nucleus and separates the cell's genetic material from the surrounding cytoplasm.
- The space between the membranes is called the perinuclear space and is continuous with the RER lumen.


Integral protein
Cytoplasm
Ribosome
Outer nuclear membrane
Inner nuclear membrane
ER
Intermembrane space
Nuclear pore complex
Lamina
Heterochromatin

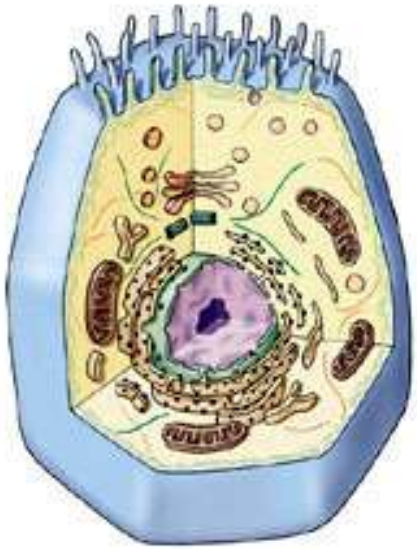
(a)

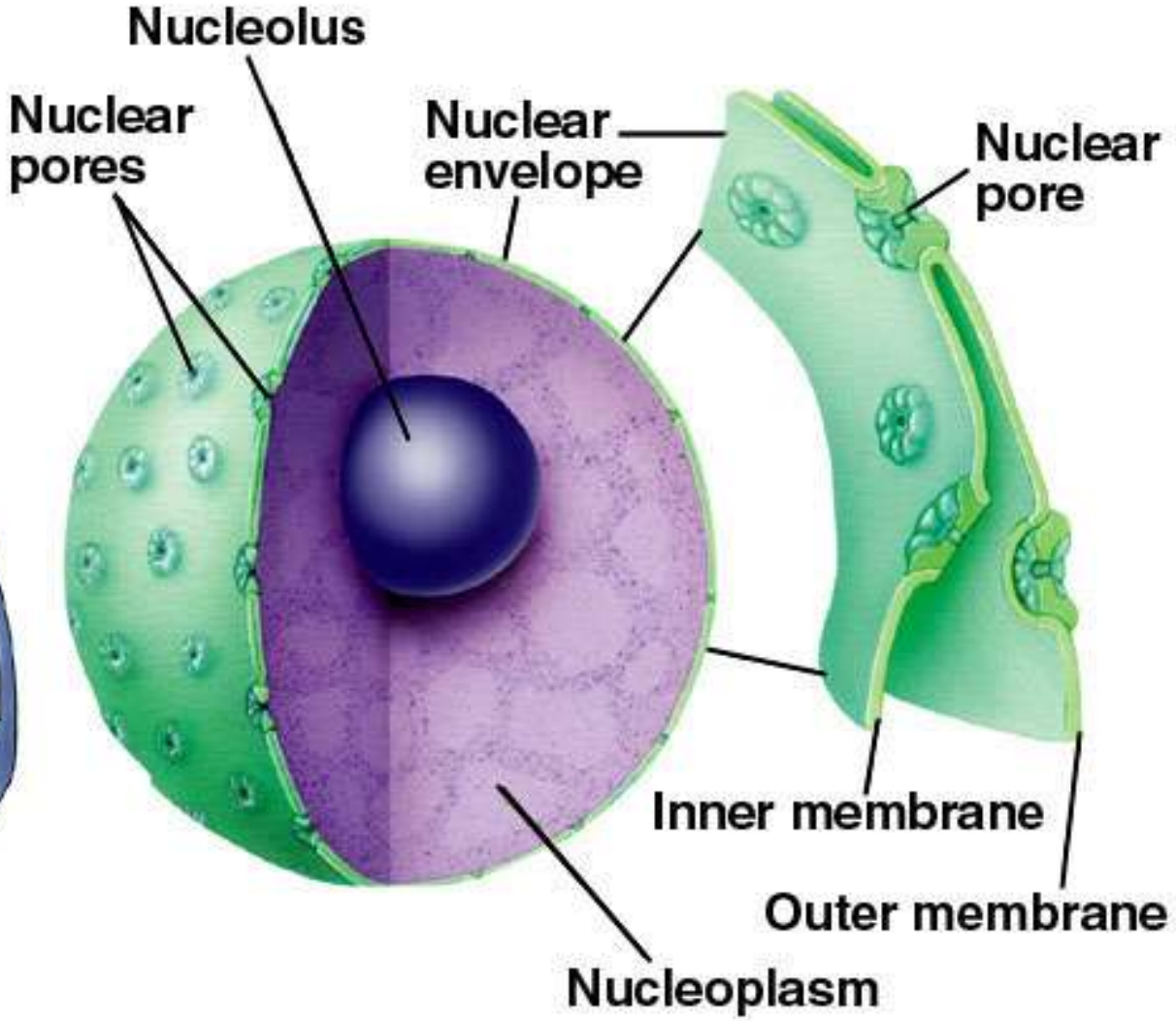

NPC
NM
HC

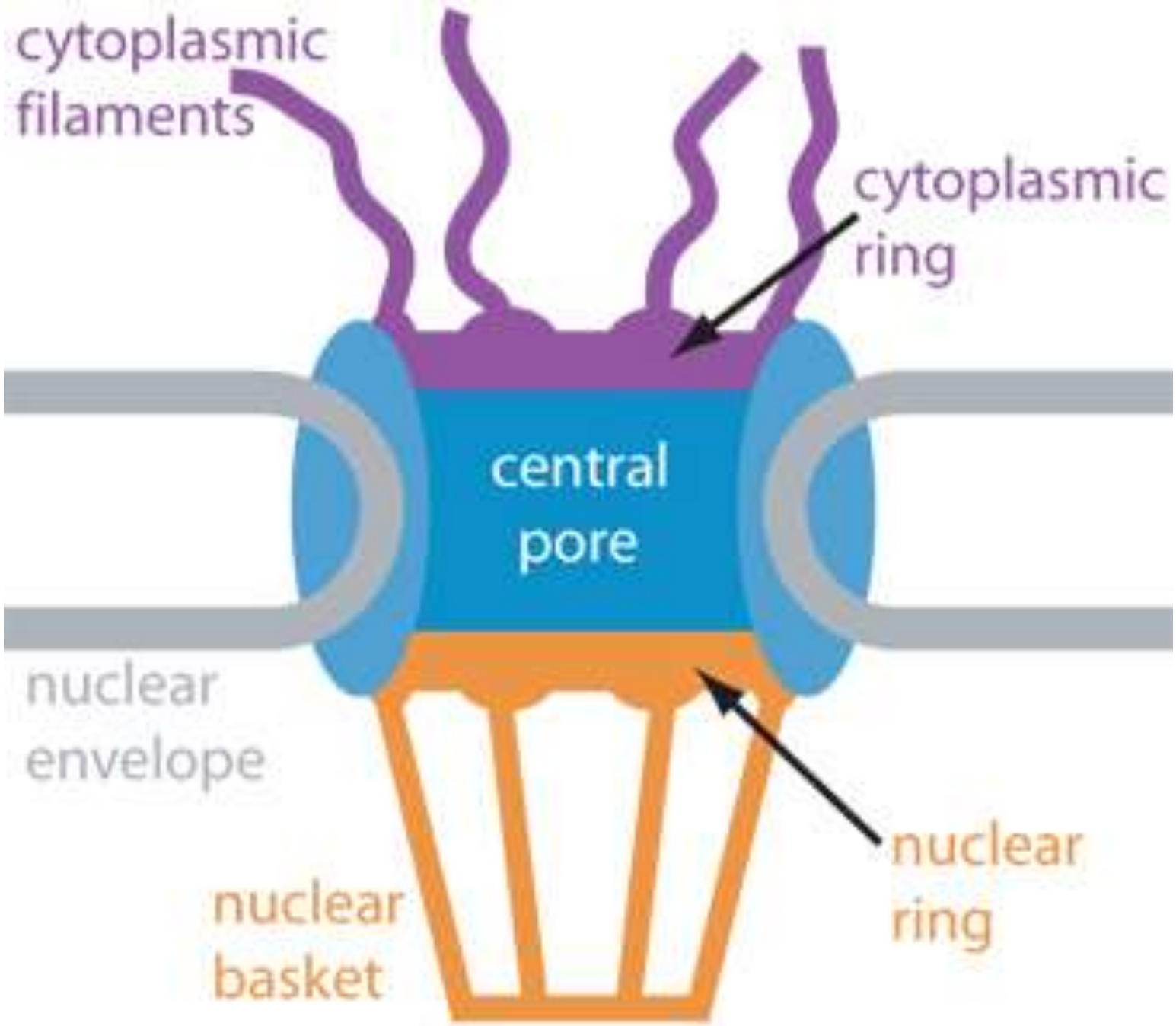
NUCLEAR PORE COMPLEX

- It is a complex in the nuclear membrane that enables the trafficking of molecules between the nucleus and cytoplasm.

Nucleus



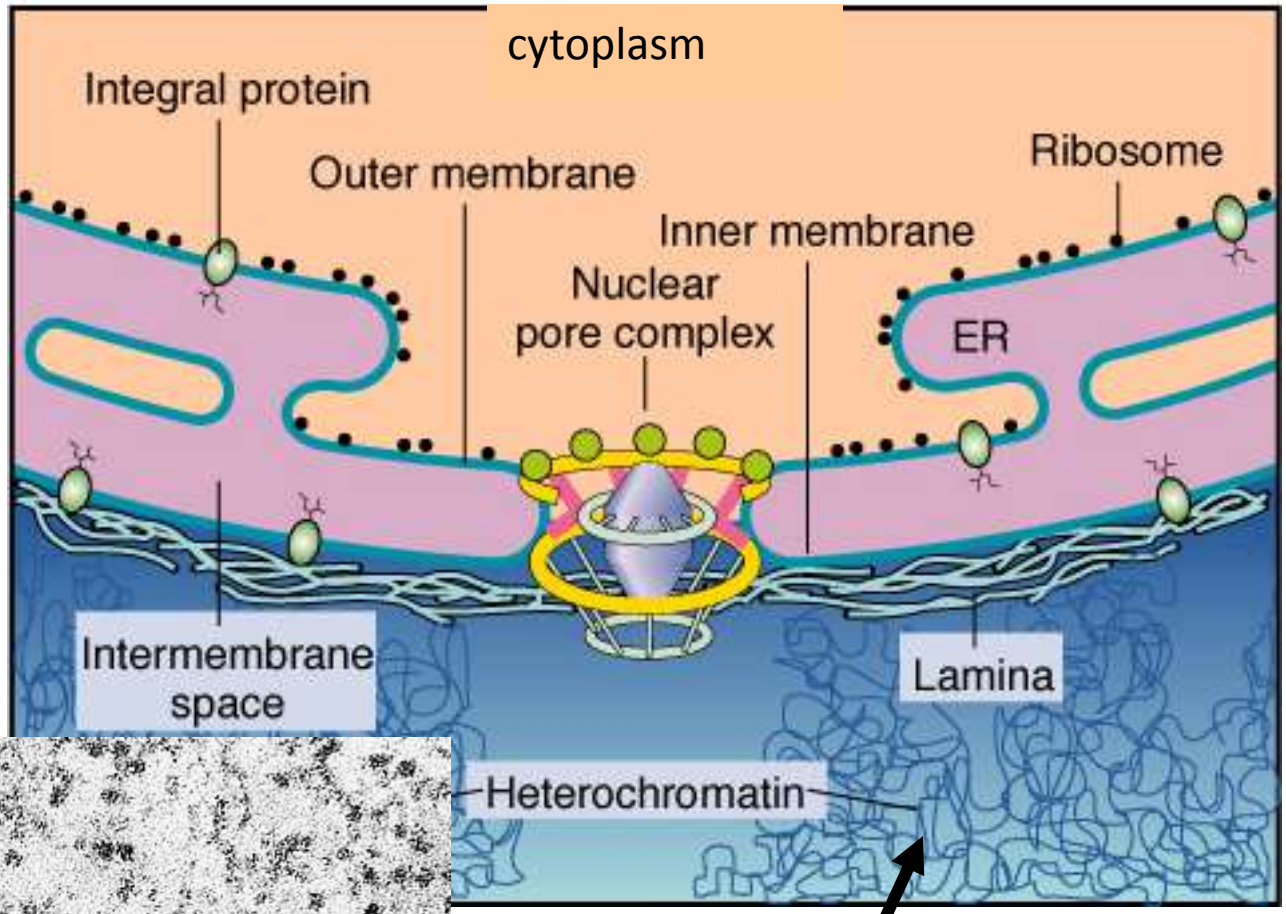


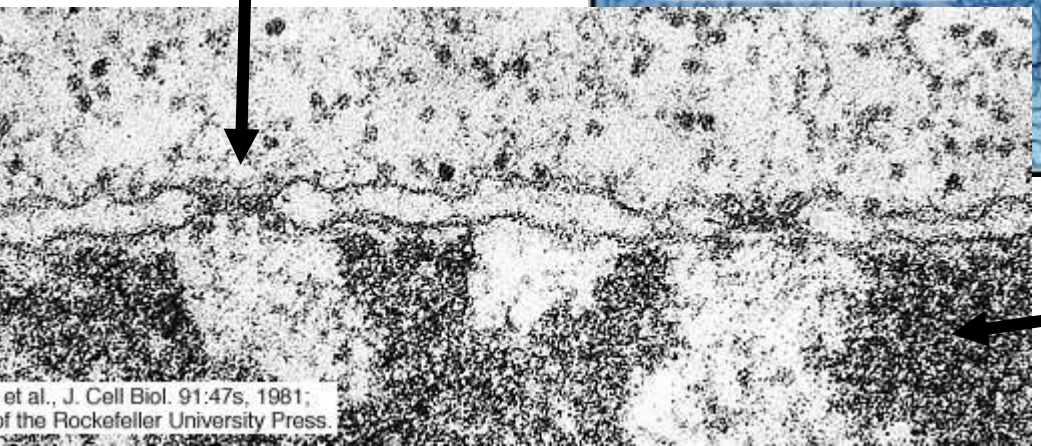

cytoplasmic filaments
cytoplasmic ring
central pore
nuclear envelope
nuclear ring
nuclear basket

Nuclear envelope and lamina

N. lamina

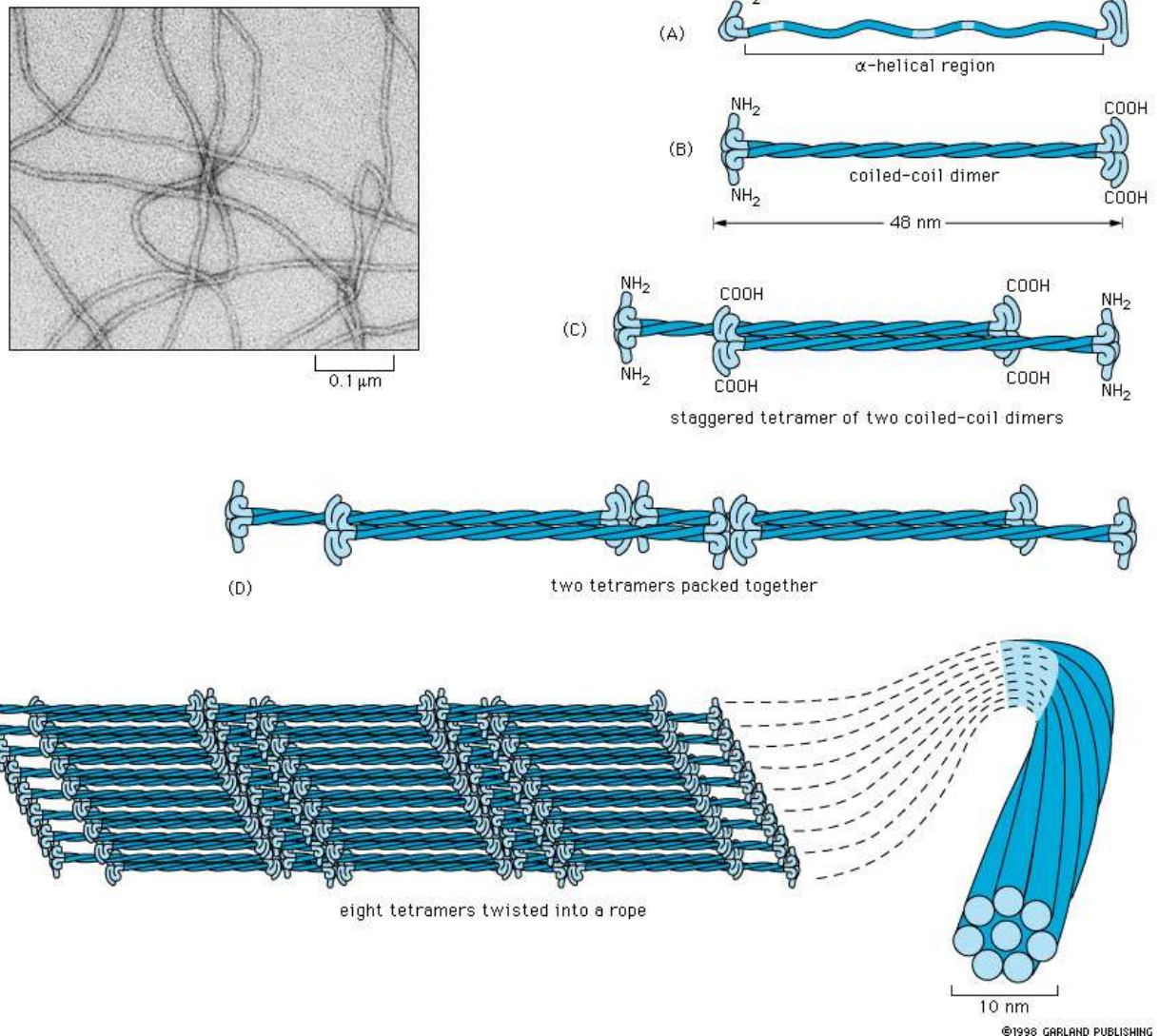
Nuclear pore





heterochromatin

Lamins are filamentous proteins in the intermediate filament family



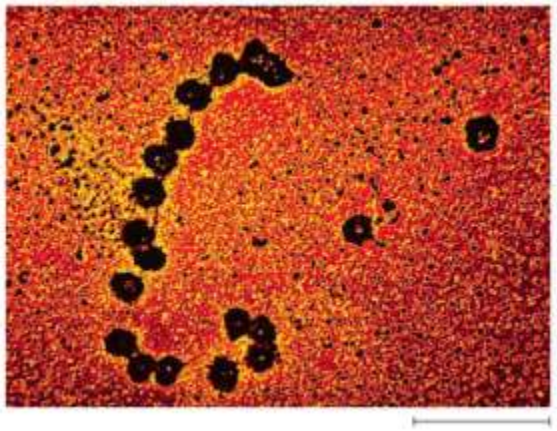
Lamin phosphorylation in prophase disassembles the nuclear lamina & allows for nuc. envel. breakdown

Laminins are extracellular proteins, unrelated

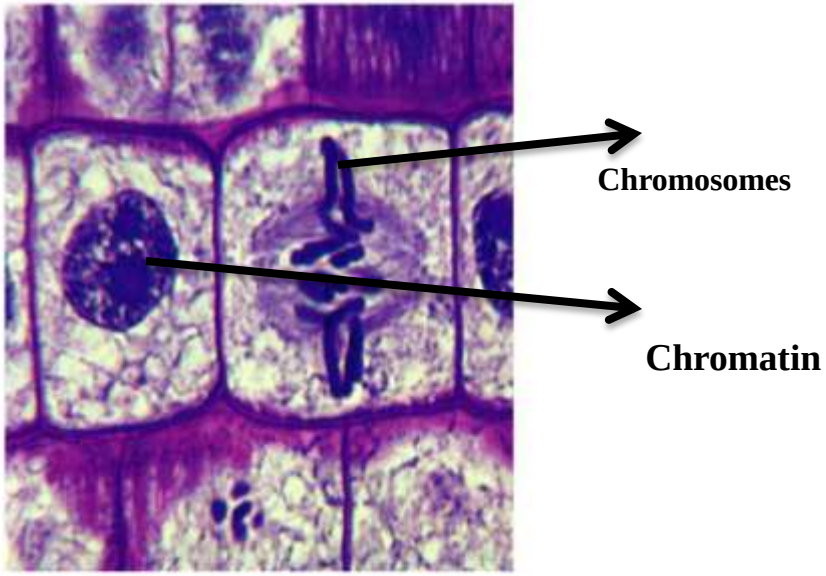
CHROMATIN

The interphase chromosomes is present in a highly extended nucleoprotein fibers called chromatin.

- Chromatin is the complex of DNA and protein ***(Histones)*** that makes up chromosomes.
- Each unreplicated chromosome contains a single continuous DNA molecule.
- ***The mitotic chromosome*** represents a higlhy condensed structure (10000:1)

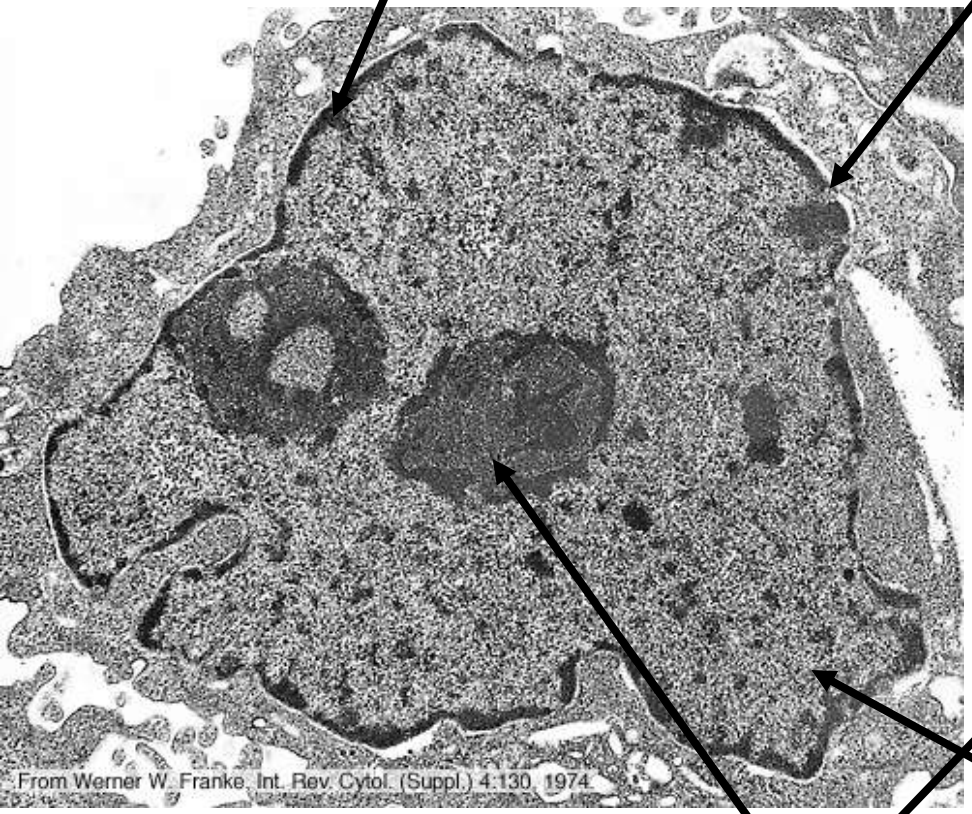


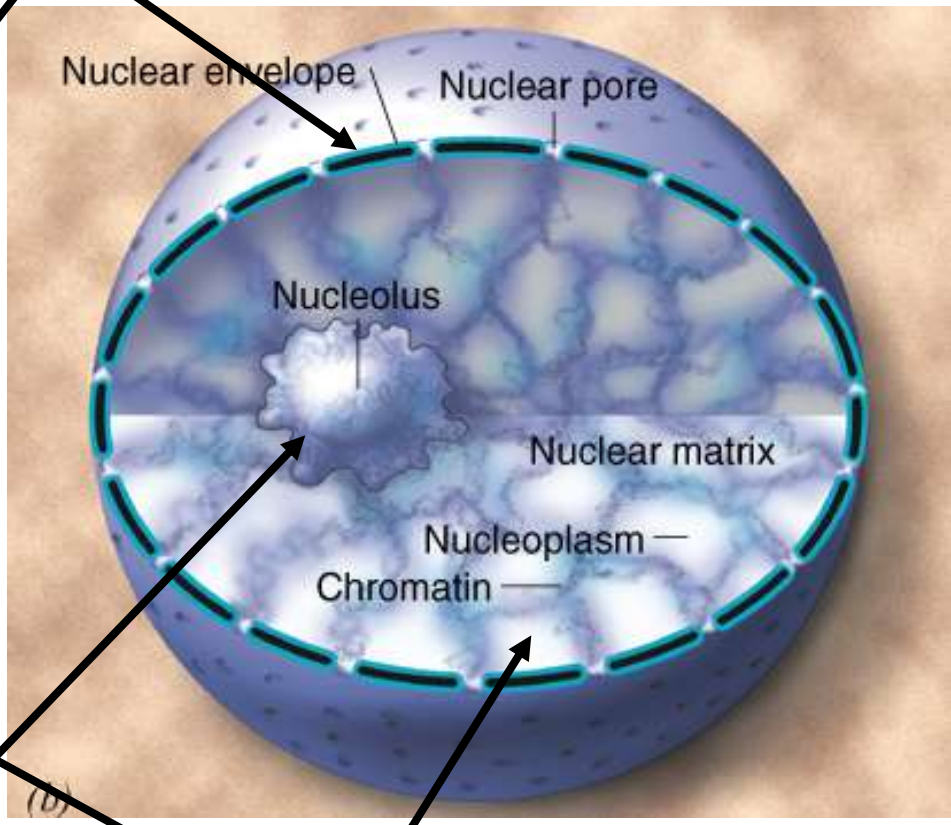
Nucleosomes particles connected by short strands of linker DNA



Heterochromatin = too compacted, transcriptionally inactive

nuclear envelope





Nucleolus

Nucleoplasm

Euchromatin = can be transcriptionally active

LETZ STUDY THIS PART ON BOARD.

Nucleolus :

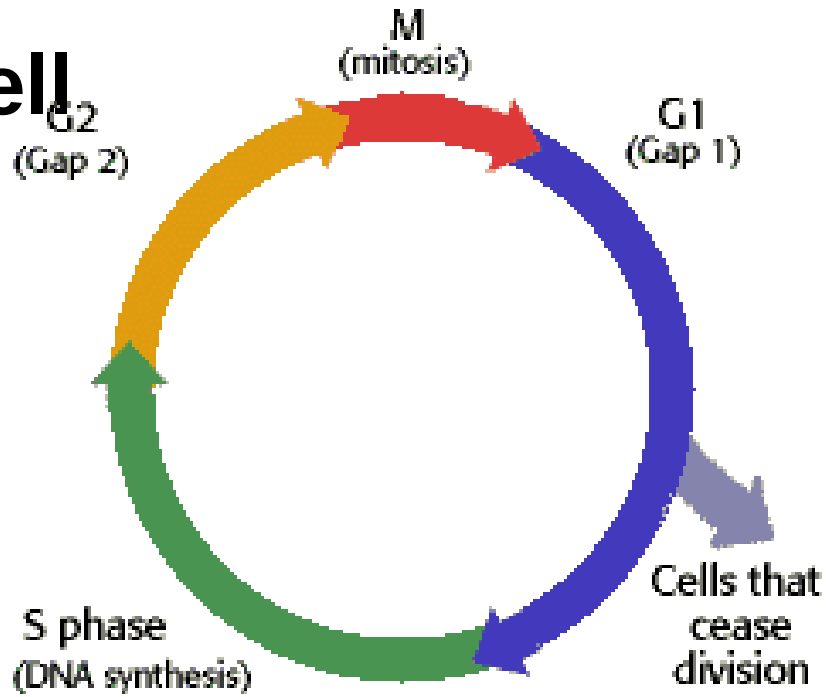
- Nucleolus is the discrete densely stained structure found in nucleus It is a nuclear inclusion that is not surrounded by a membrane Present in cells that are actively synthesizing proteins Its size depends on metabolic activity of cell Average size .5-5um in dia Nucleolus .
- It is mainly associated with synthesis of rRNA

Nucleoplasm :

- Nucleoplasm is the protoplasm within the nuclear envelope It consists of a nuclear matrix and various types of particles Highly viscous liquid which scaffolds chromosomes, nucleolus and various granules like heterochromatin, perichromatin granules Many substances like nucleotides and certain enzymes are also dissolved in it Nucleoplasm.

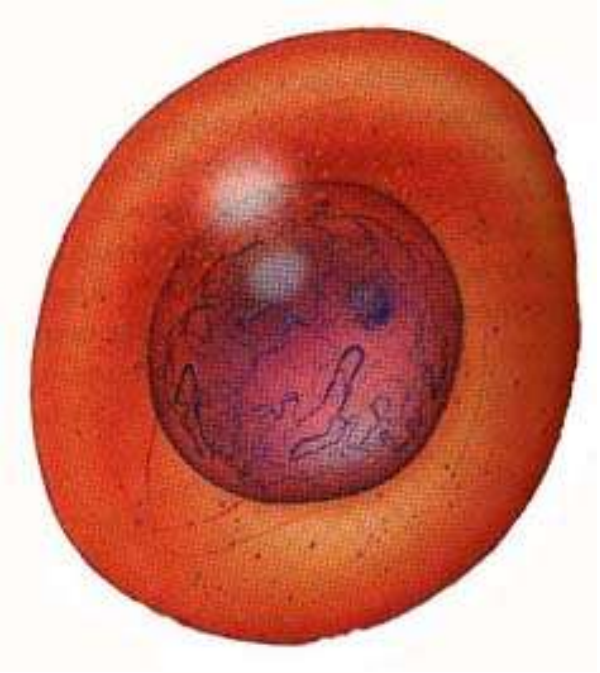
Cell Cycle

- **Four stages to the cell cycle**
  - **Growth period - Interphase includes:**
    - **G1**
    - **S Stage**
    - **G2**
  - **Division period - Includes:**
    - **Mitosis**



G1
Stage #1

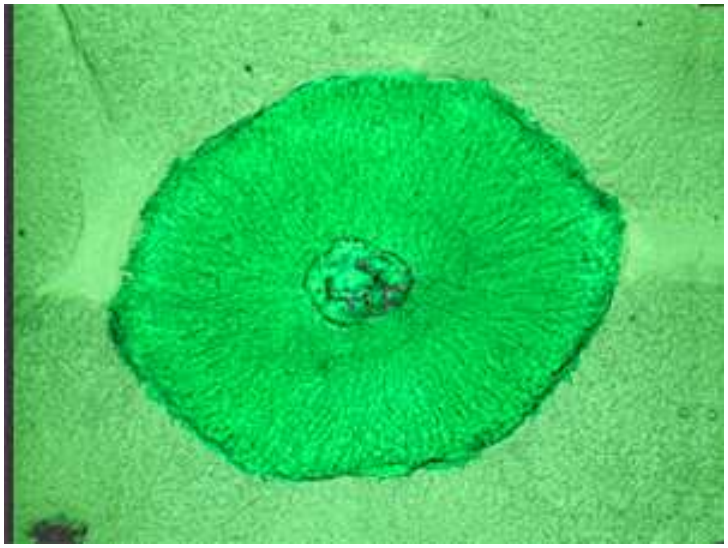
- **Chromosomes are not visible under a microscope - because they are uncoiled, therefore called <u>chromatin</u>**



- **Proteins are quickly made**

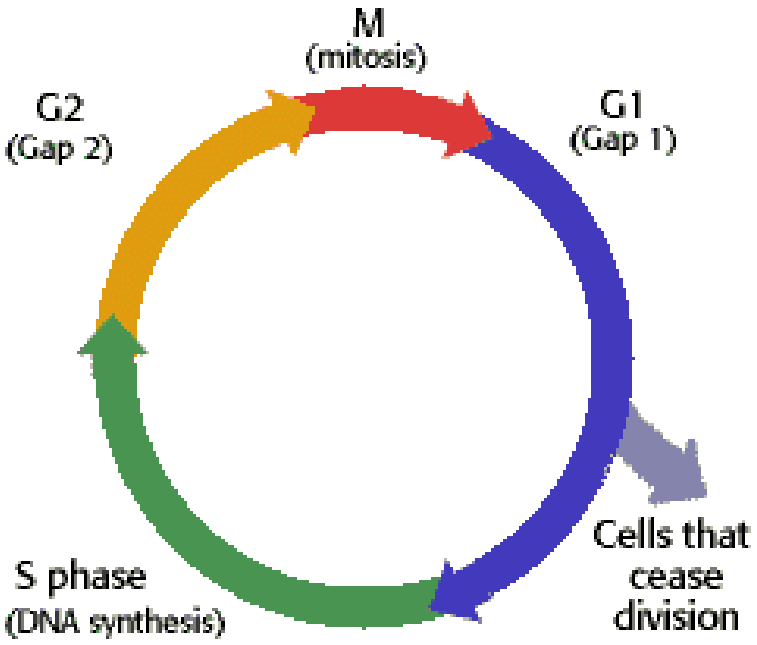
S Stage
Stage #2

- **Chromatin is replicated in the nucleus**
- **Chromatin divides to form sister chromatids which are connected by centromeres**



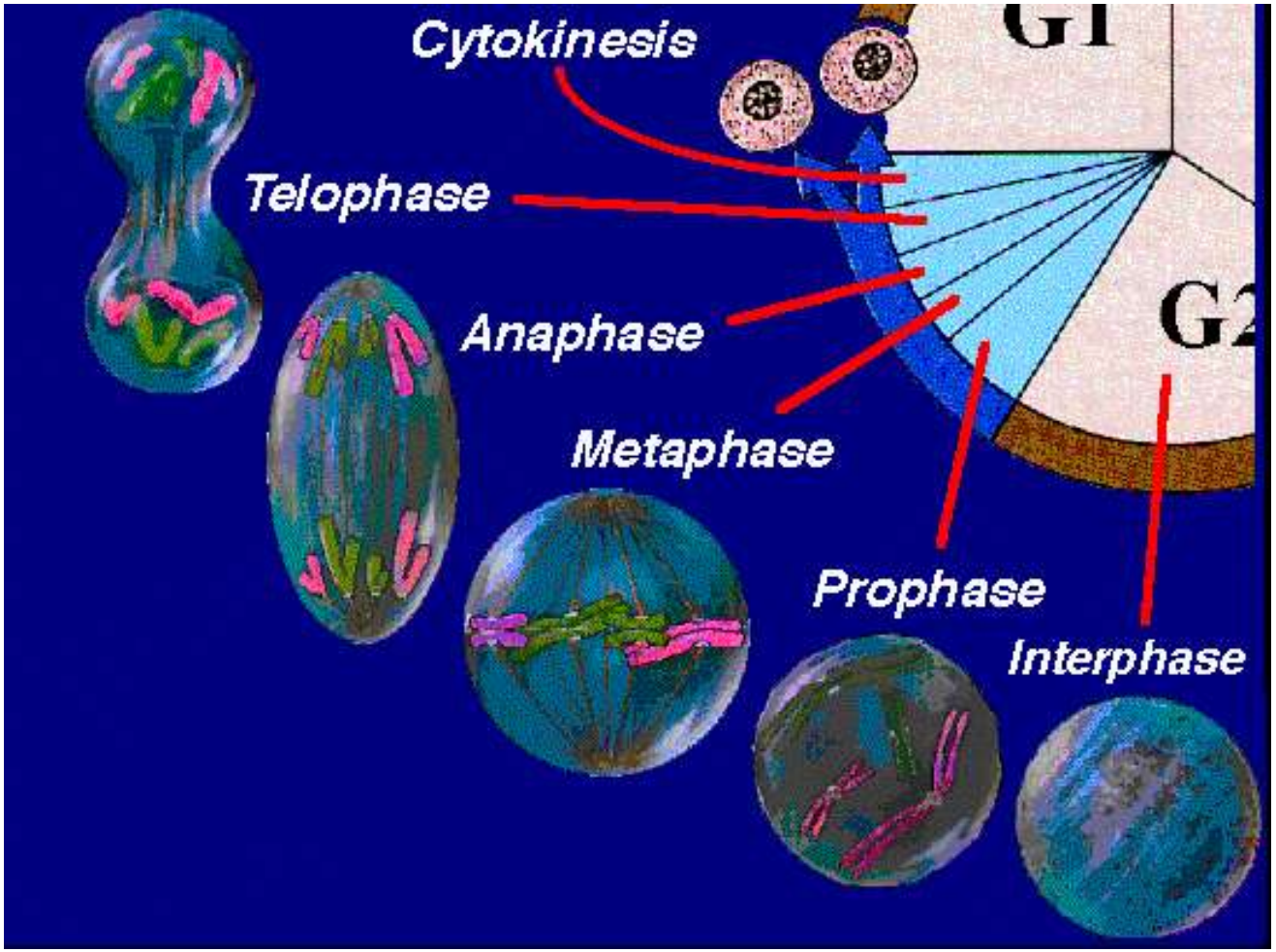
G2
Stage #3

- **Chromatin shortens and coils**
- **Organelles are made**
- **Most proteins made are for mitosis**
- **Animals - centriole pair replicates and prepares to form spindle fibers.**



Mitosis

- **Four Phases of mitosis**
  - **Prophase**
  - **Metaphase**
  - **Anaphase**
  - **Telophase**



Prophase
first phase of mitosis

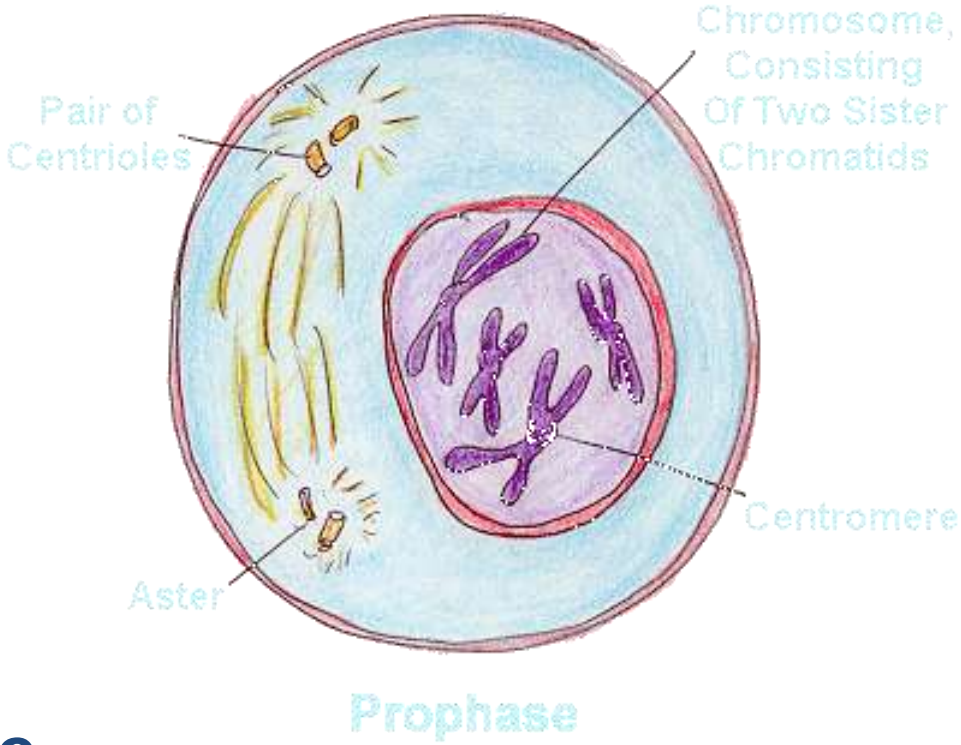
- **Longest Phase**
- **Chromatin coils up into visible chromosomes**
- **Chromosomes look hairy**
- **Each chromosome now has two halves**

Prophase
first phase of mitosis

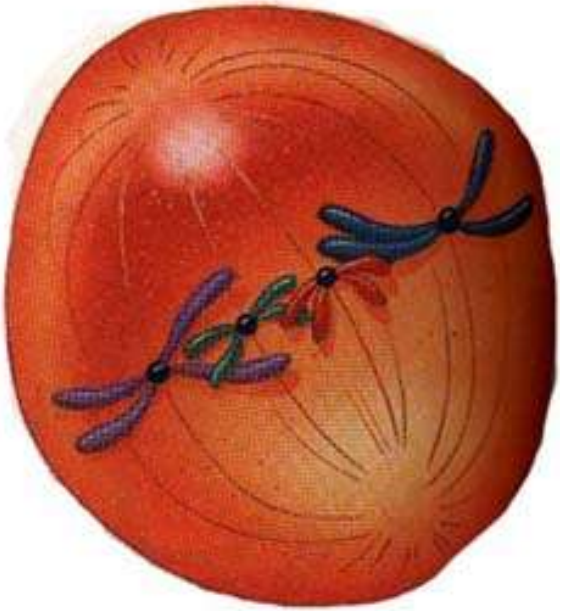
- **Chromosomes**
  - **are also called sister chromatids**
  - **Two sister chromatids can be called a diploid chromosome**
  - **One sister chromatid can also be called a haploid chromosome**
  - **DNA in sister chromatids are alike**
  - **Sister chromatids are held together by a centromere**

Prophase
first phase of mitosis

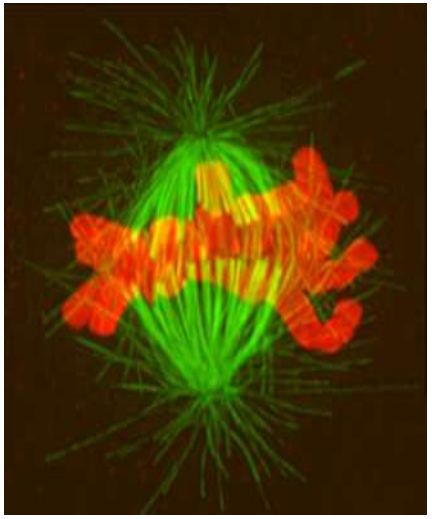
- **Nucleus disappears**
- **Nuclear envelope disintigrates**
- **Nucleolus disintigrates**
- **Completely absent by the end of prophase**



Metaphase
second stage of mitosi



- Short stage
- Sister chromatids (SC)line up at the equator
- Sister chromatids are attached by their centromeres to the spindle fibers



Anaphase
third stage of mitosis

- **SC are pulled apart at the centromere to opposite ends of the cell**
- **This ensures that each new cell gets one set of the information needed**
- **SC are pulled apart because the spindle fiber shortens**

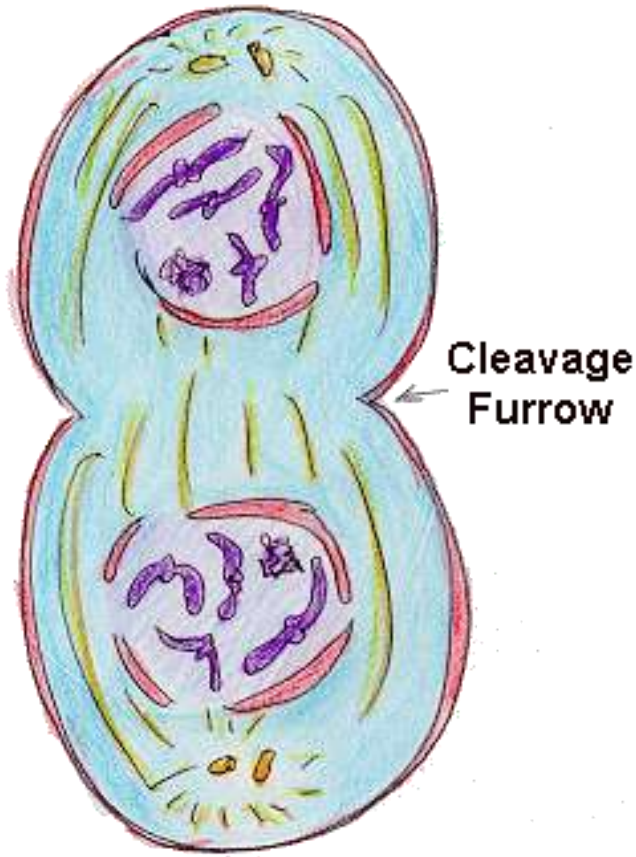
Telophase
fourth stage of mitosis

- **Chromatids reach opposite poles of cell**
- **Chromosomes unwind**
- **Spindle breaks down**
- **Nucleolus reappears**
- **New nuclear envelope forms around each set of chromosomes**
- **New double membrane begins to form between the two new nuclei.**

Cytokinesis
end of telophase

- **The dividing of the cytoplasm**

- **ANIMALS**
  - **Plasma membrane pinches along the equator**
  - **Two new cells are separated**



Telophase and Cytokinesis

MEIOSIS

Meiosis

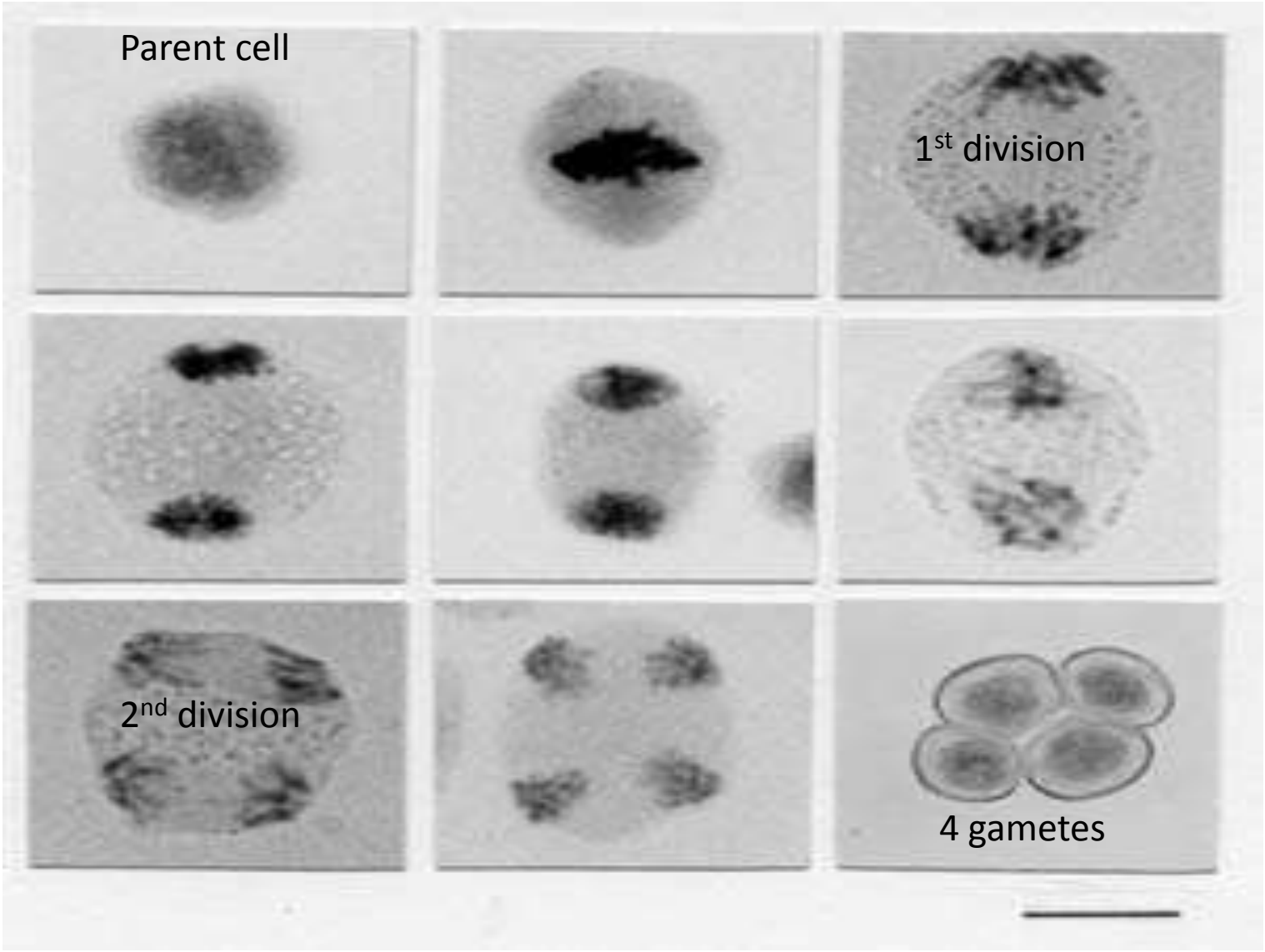
- **Sex cells** divide to produce **gametes (sperm or egg)**.
- **Gametes** have **half** the # of **chromosomes**.
- **Occurs only in gonads (testes or ovaries).**

Male: spermatogenesis

Female: oogenesis

- **Meiosis** is similar to **mitosis** with some chromosomal differences.

Meiosis – mouse testes



Meiosis I (four phases)

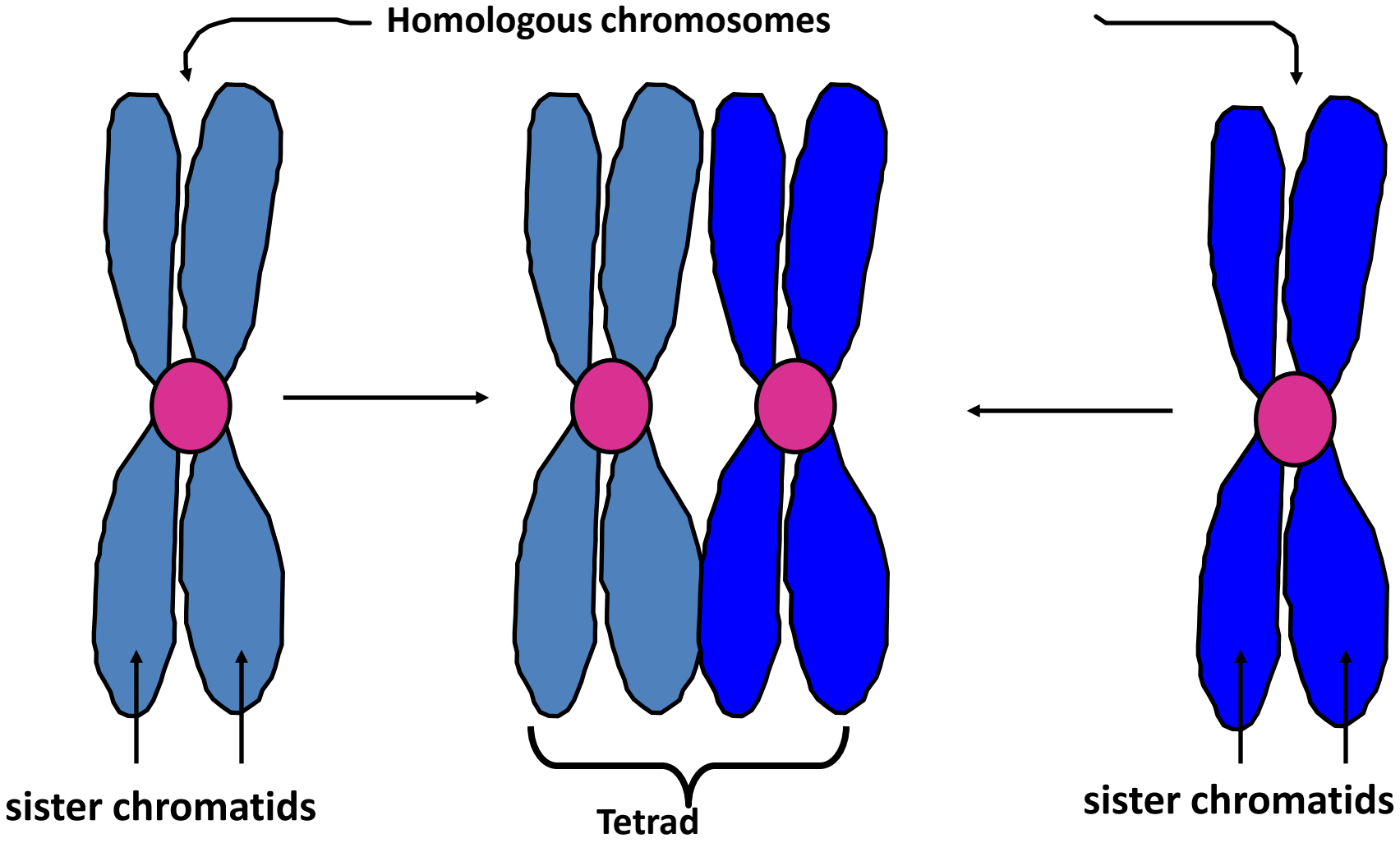
- **Cell division** that reduces the **chromosome** number by **one-half.**

- **four phases**:
  a. **prophase I**
  b. **metaphase I**
  c. **anaphase I**
  d. **telophase I**

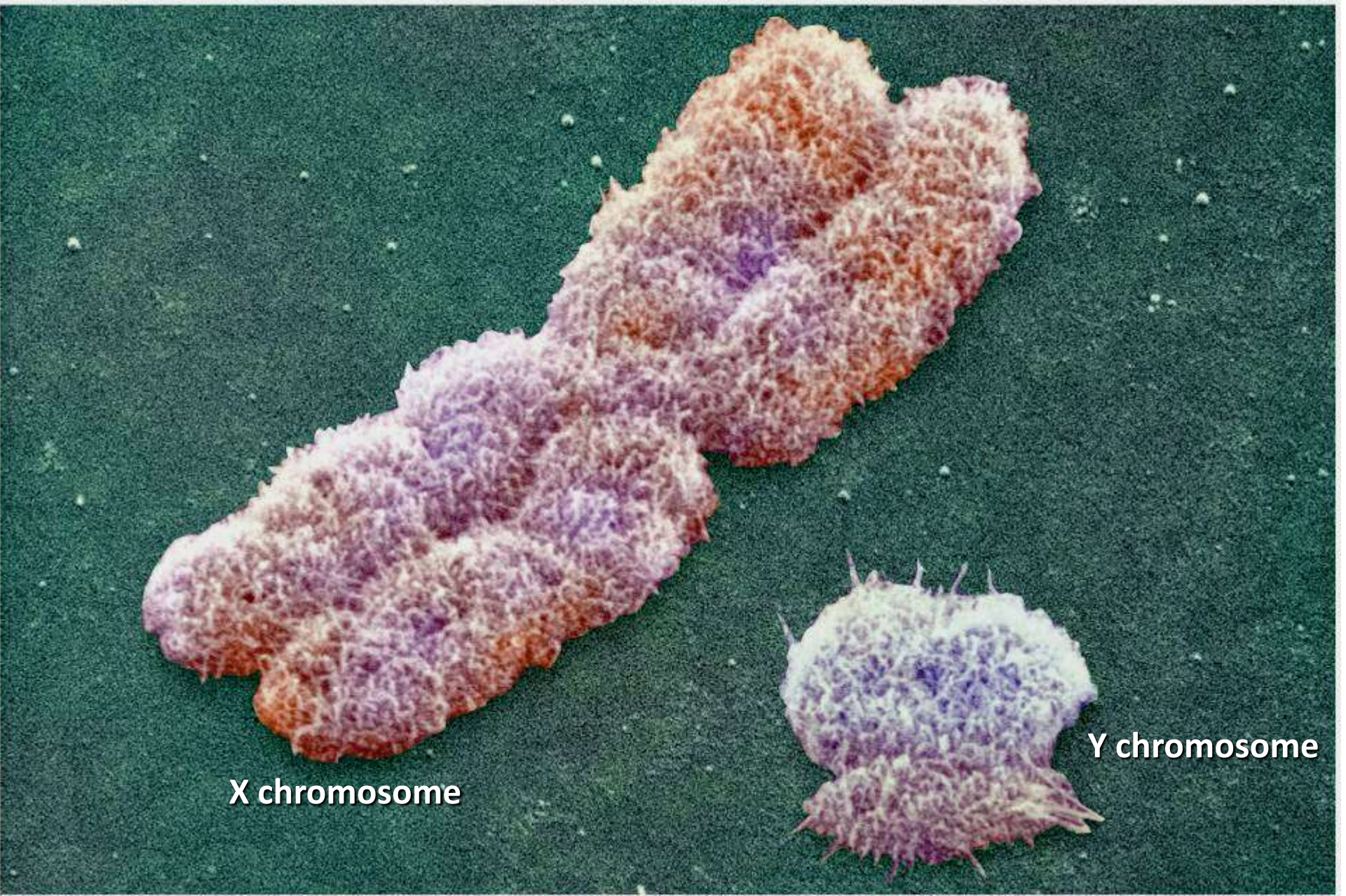
Prophase I

- **Longest and most complex phase (90%).**
- **Chromosomes** condense.
- **Synapsis** occurs: **homologous chromosomes** come together to form a **tetrad**.
- **Tetrad** is two **chromosomes** or four **chromatids** (sister and nonsister chromatids).

Prophase I - Synapsis



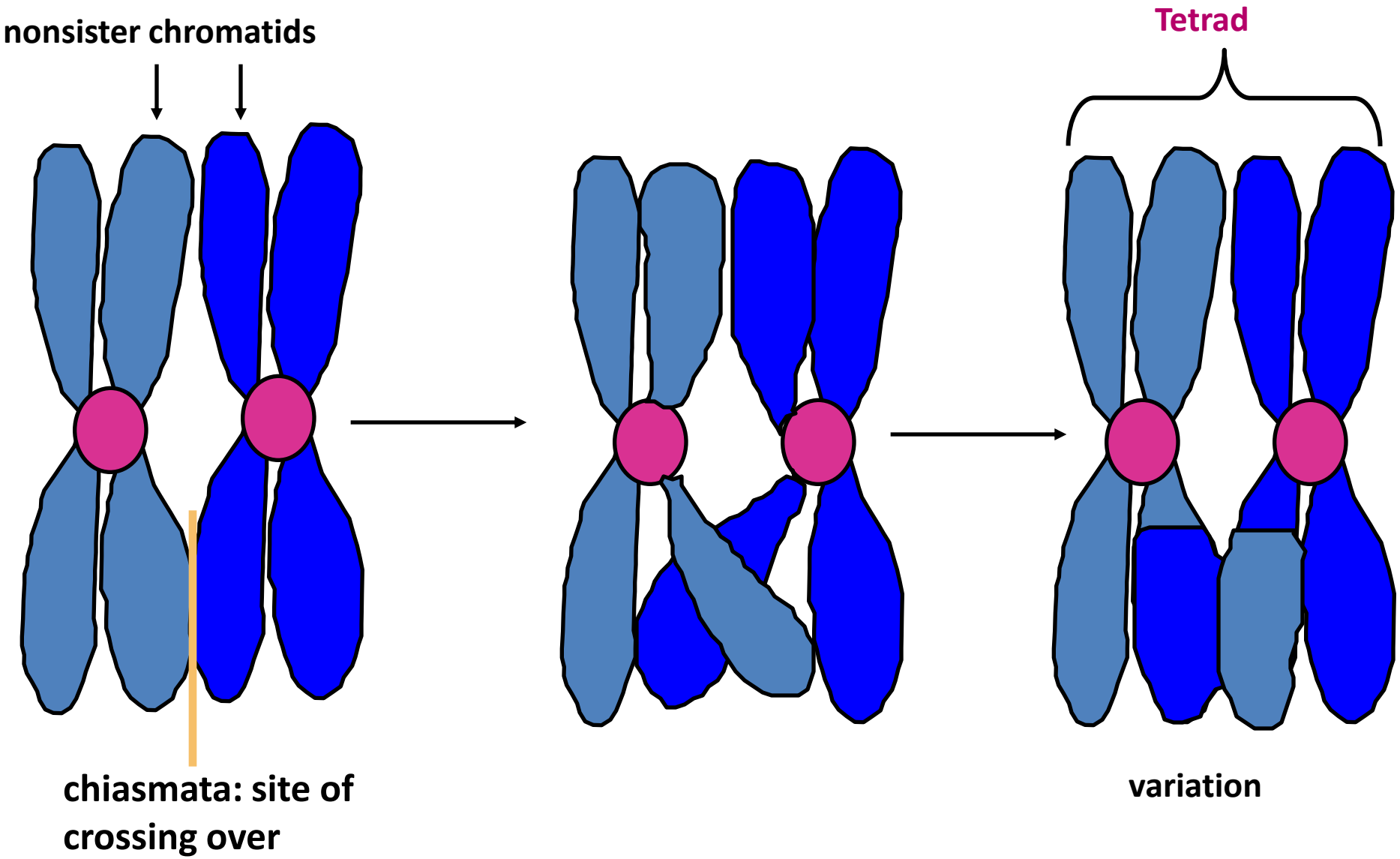
Boy or Girl? The Y Chromosome "Decides"



Crossing Over

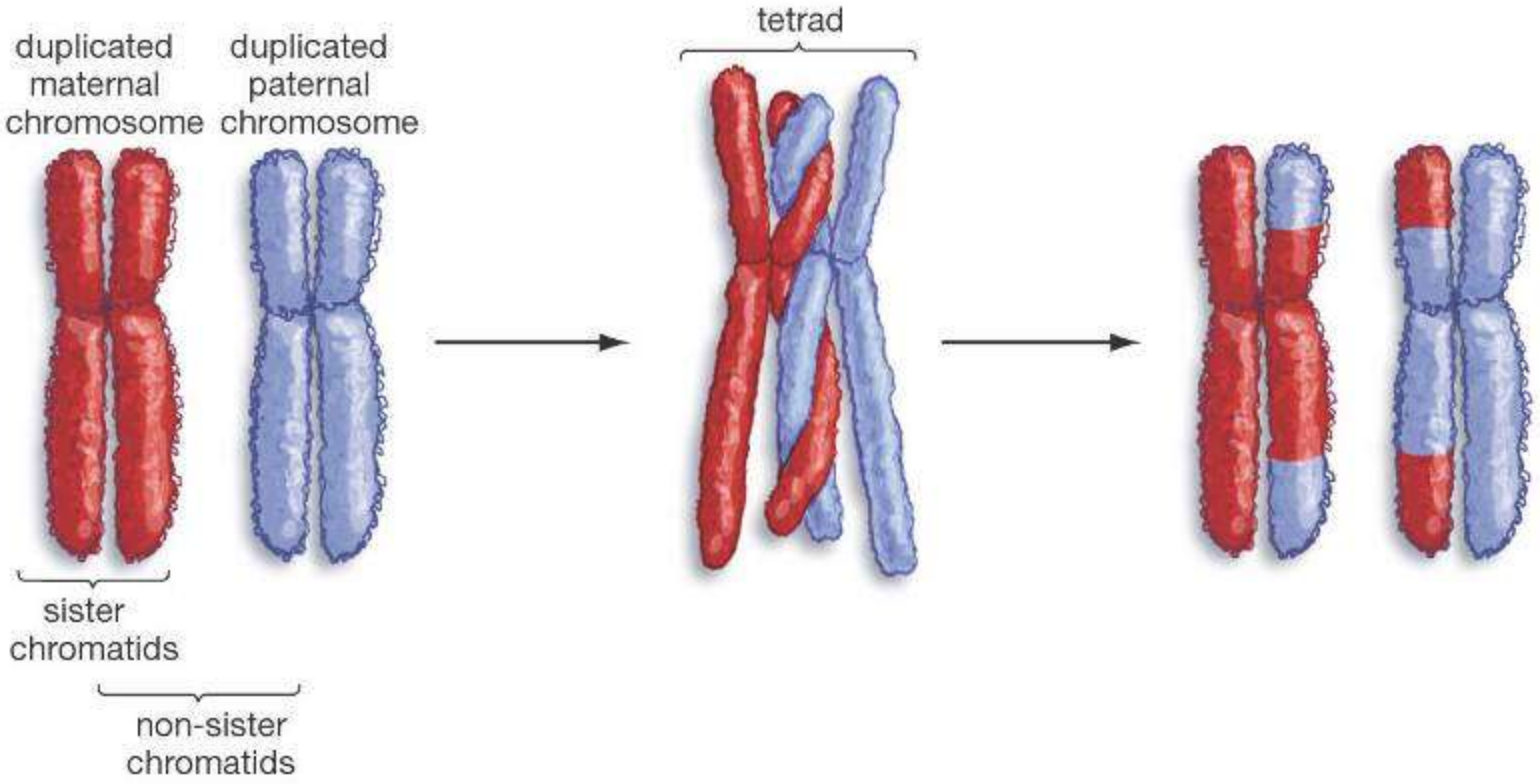
- **Crossing over (variation)** may occur between nonsister **chromatids** at the **chiasmata**.
- **Crossing over**: segments of nonsister **chromatids** break and reattach to the other **chromatid**.
- **Chiasmata (chiasma)** are the sites of **crossing over**.

Crossing Over - variation



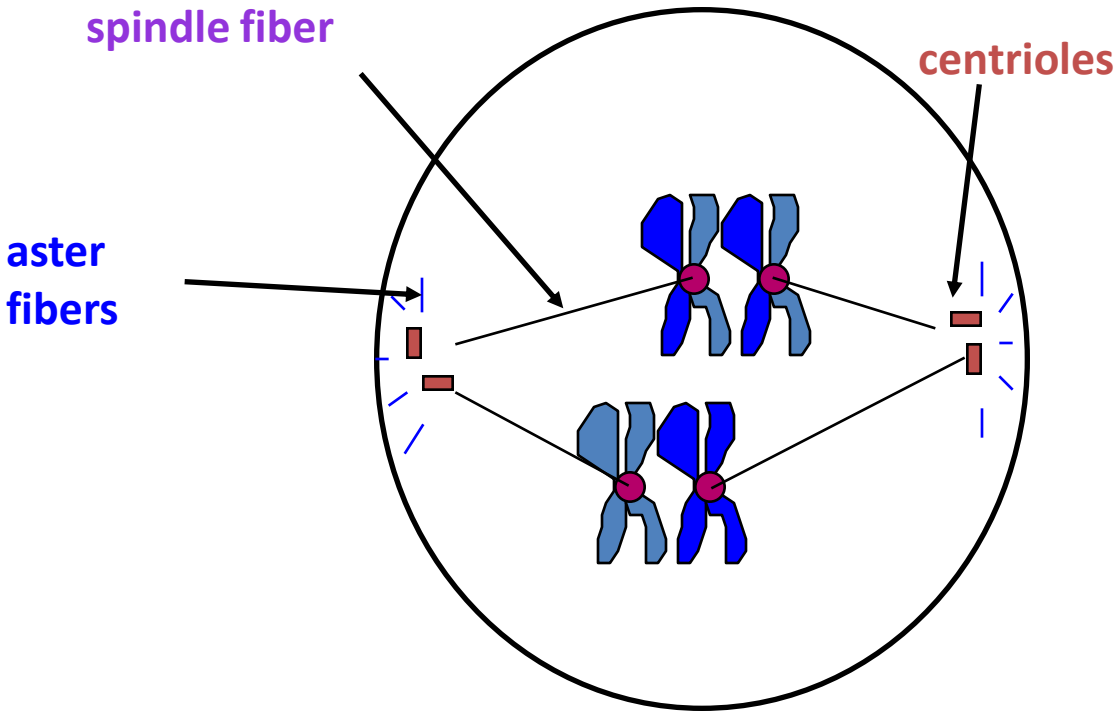
Another Way Meiosis Makes Lots of Different Sex Cells – Crossing-Over

Exchange of parts of non-sister chromatids.



Crossing-over multiplies the already huge number of different gamete types produced by independent assortment.

Prophase I



Metaphase I

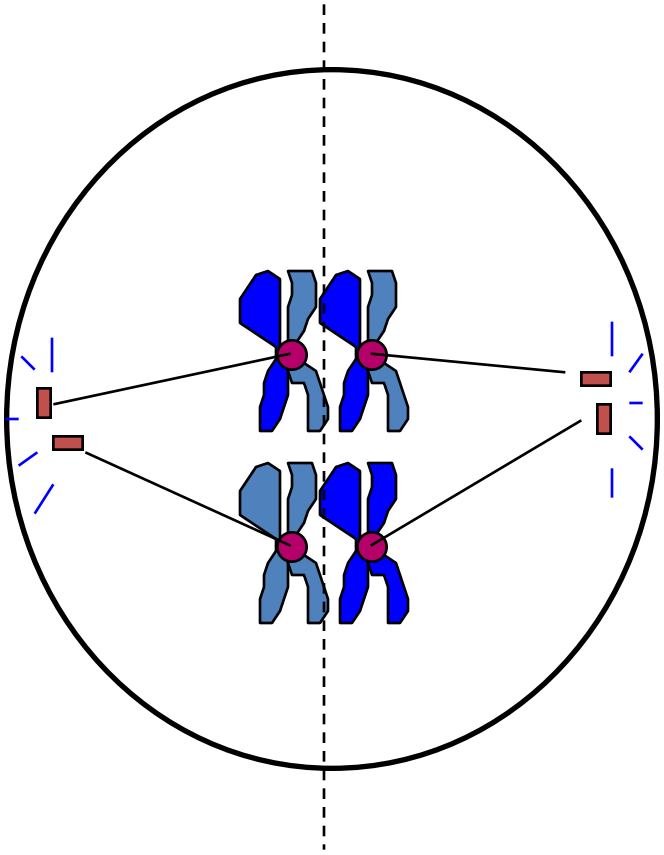
- **Shortest phase**
- **Tetrads** align on the **metaphase plate**.
- **INDEPENDENT ASSORTMENT OCCURS:**
  1. Orientation of homologous pair to poles is random.
  2. Variation
  3. **Formula: 2^n**

Example: 2n = 4

then n = 2

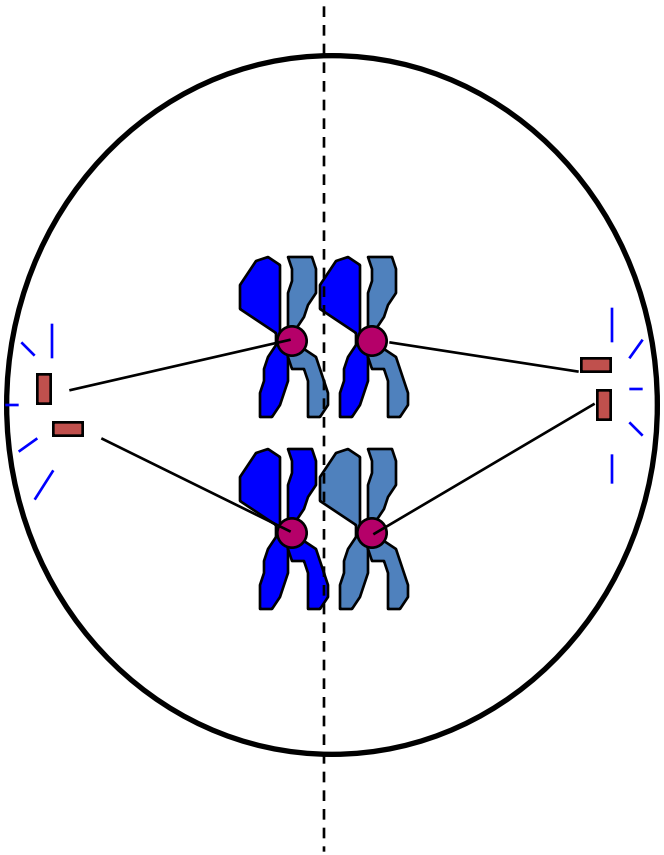
thus 2^2 = 4 combinations

Metaphase I



metaphase plate

OR

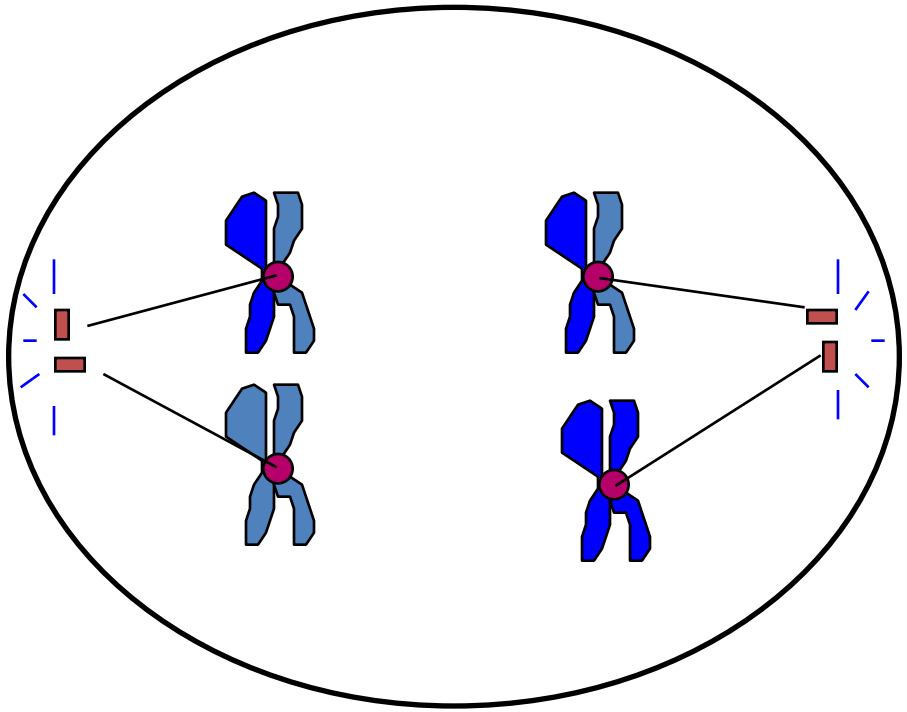


metaphase plate

Anaphase I

- **Homologous chromosomes** separate and move towards the poles.

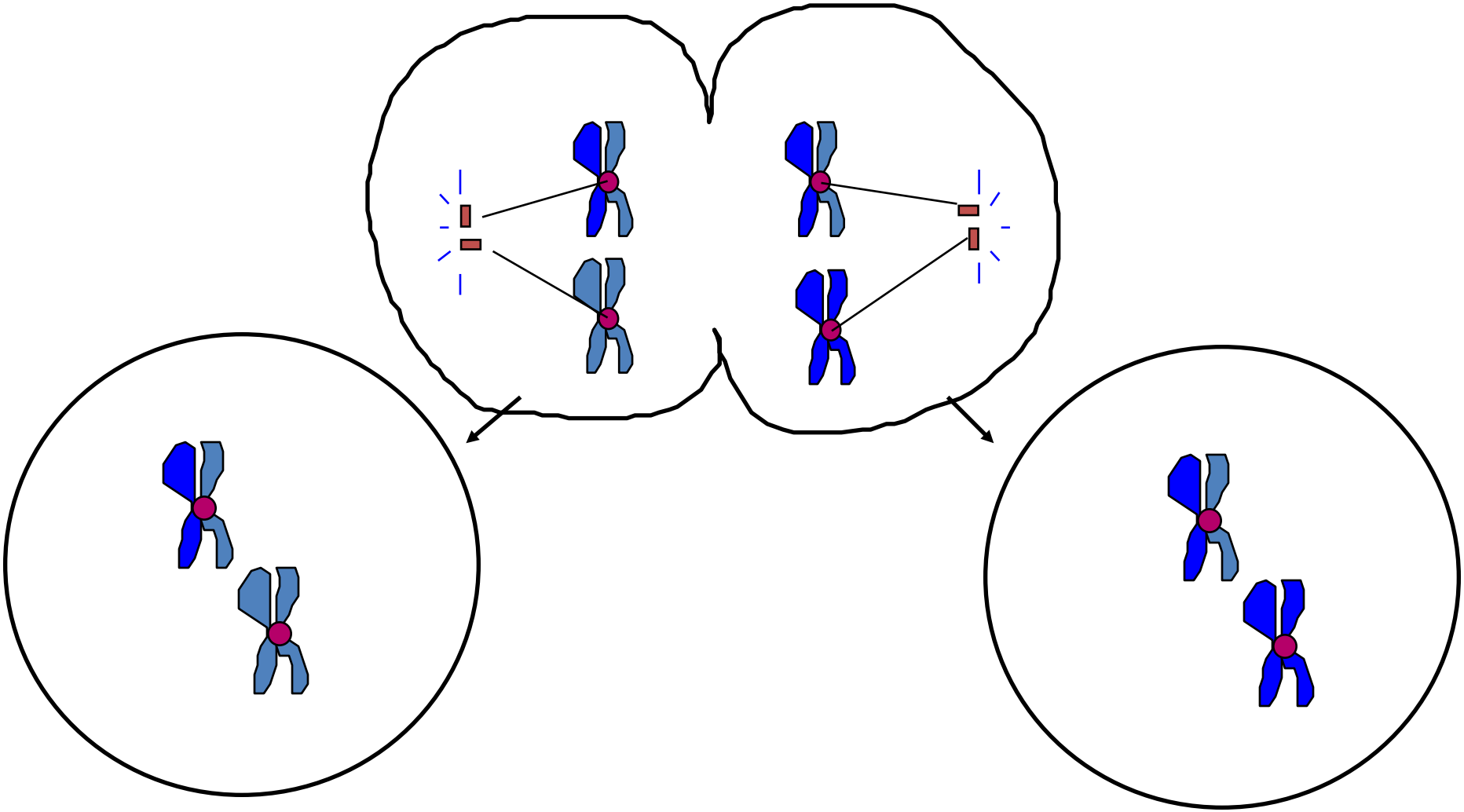
- **Sister chromatids** remain attached at their **centromeres**.



Telophase I

- Each pole now has **haploid** set of **chromosomes**.

- **Cytokinesis** occurs and two haploid daughter cells are formed.



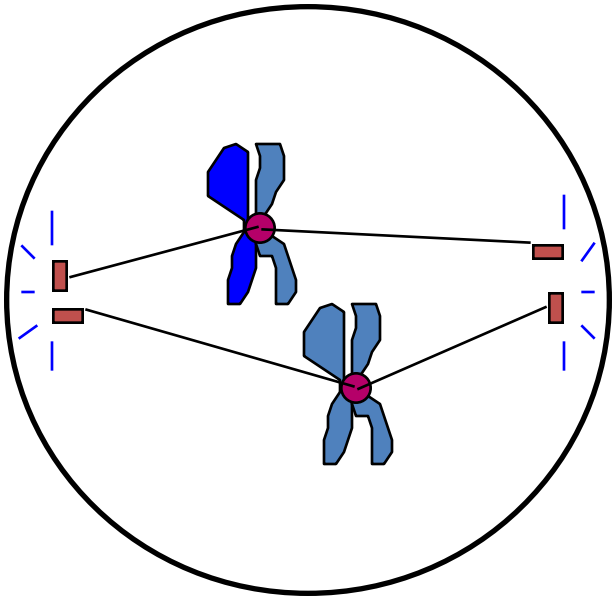
Meiosis II

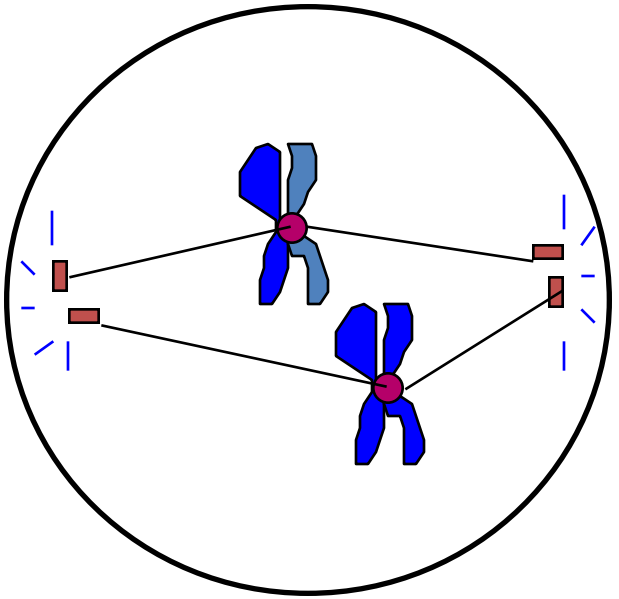
- **No interphase II**
  (or very short - no more **DNA replication**)

- **Remember:** **Meiosis II** is similar to **mitosis**

Prophase II

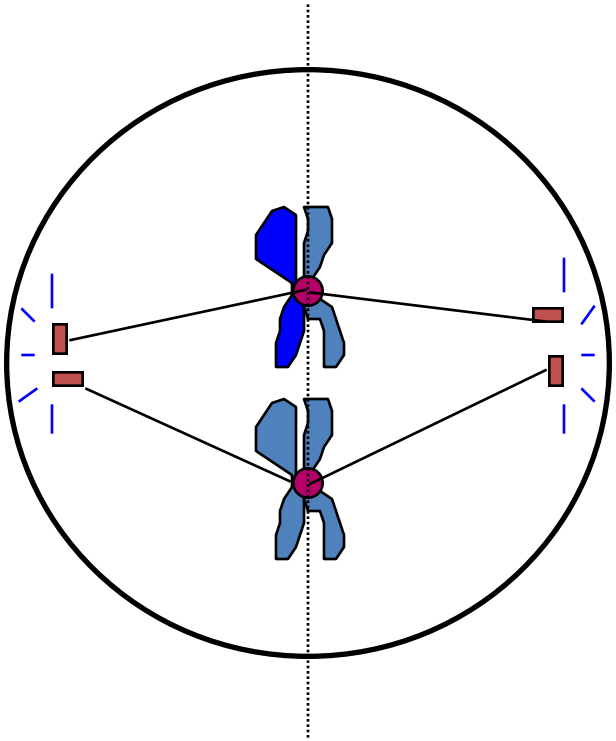
- same as **prophase** in **mitosis**



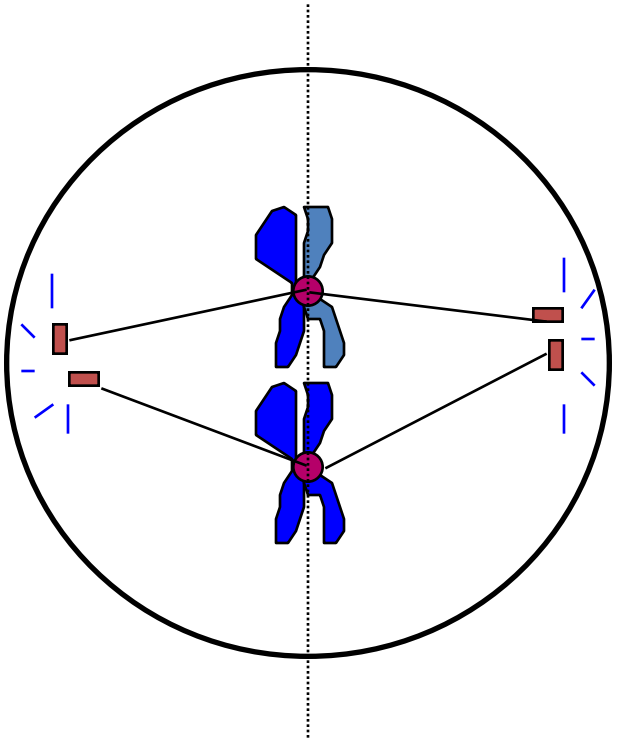


Metaphase II

- same as **metaphase** in **mitosis**



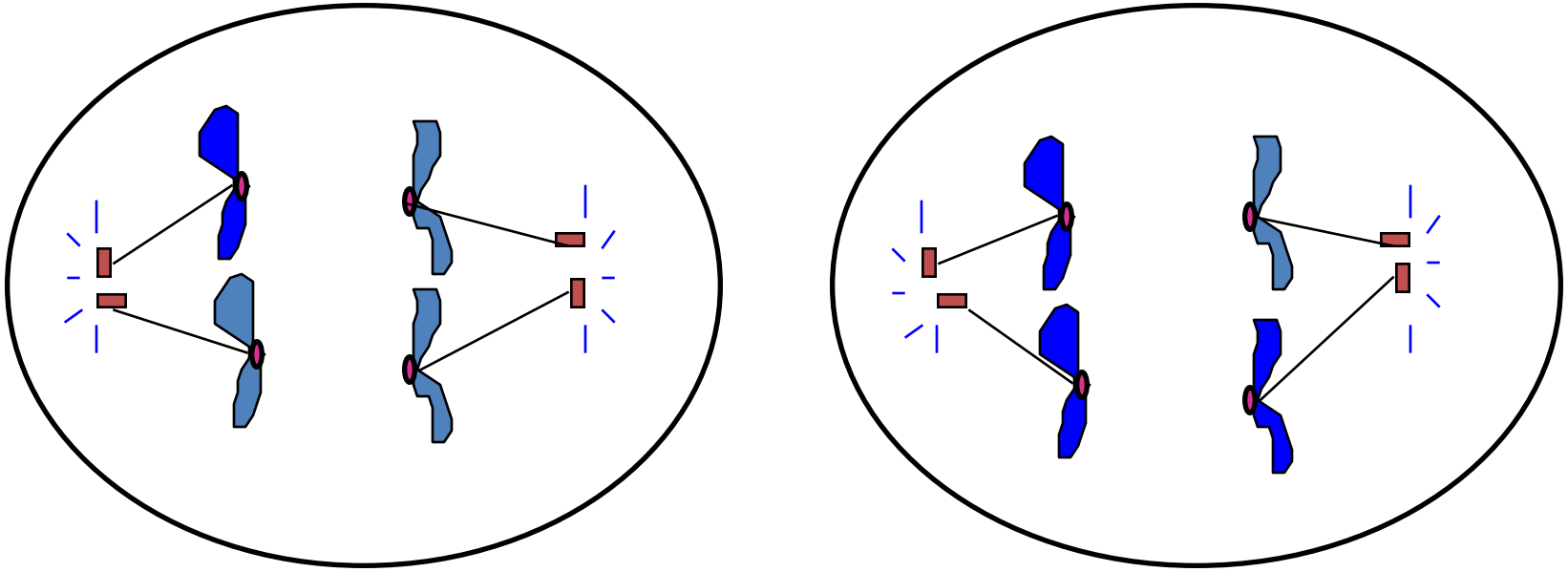
metaphase plate



metaphase plate

Anaphase II

- same as **anaphase** in **mitosis**
- **sister chromatids separate**



Telophase II

- Same as **telophase** in **mitosis**.
- Nuclei form.
- **Cytokinesis** occurs.
- **Remember: four haploid daughter cells produced.**

  gametes = sperm or egg

Telophase II