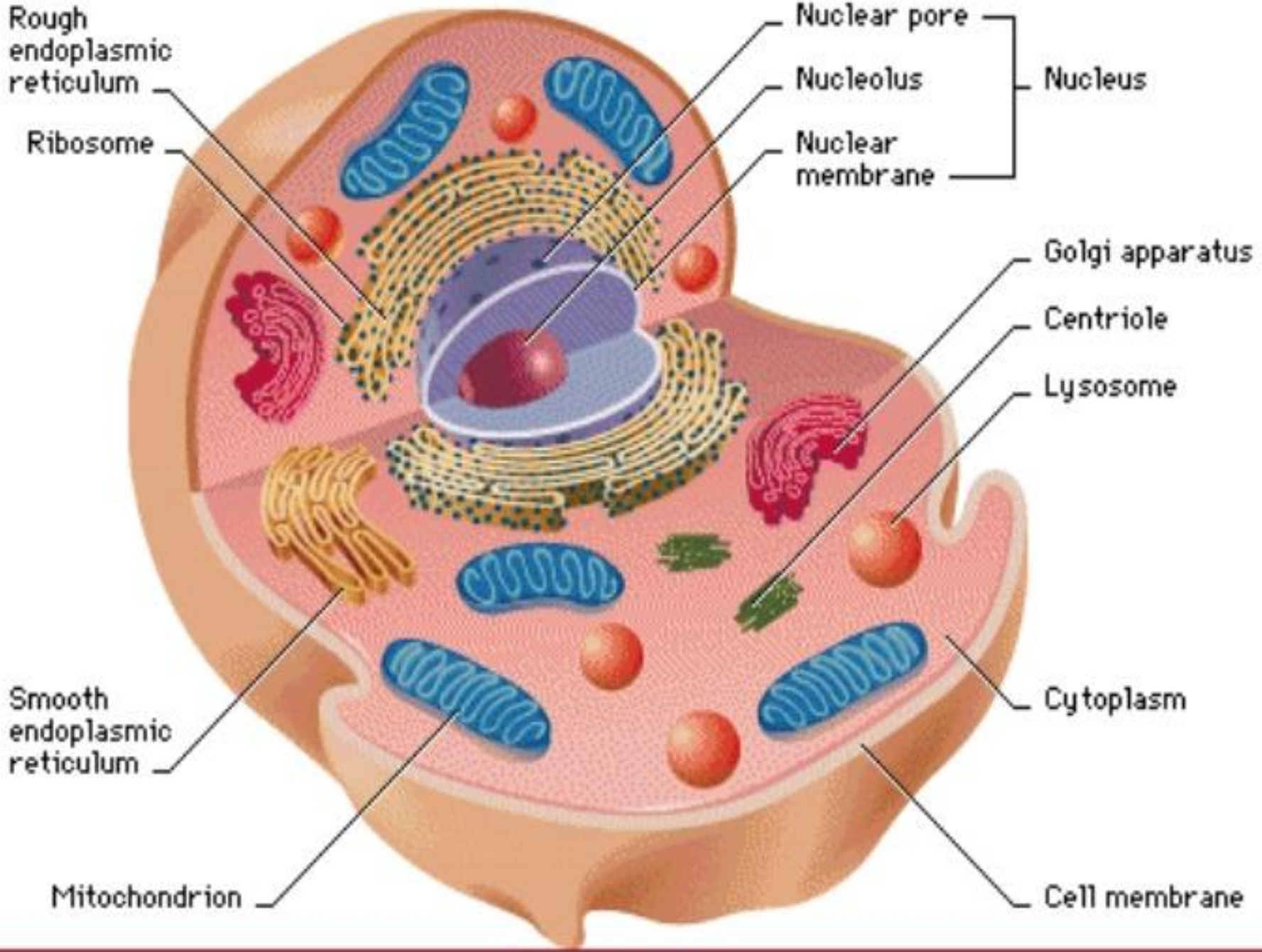
# ANATOMY AND PHYSIOLOGY

**Dr Ashok Kumar Yadav (PhD,MBA(HM),MSc(N),BHMS,BSc)**

**Dean & Principal**
**HOD & Professor Mental Health Nursing**
**Faculty of Nursing**
**Tantia University**
**Sriganganagar**


Rough endoplasmic reticulum
Ribosome
Nuclear pore
Nucleolus
Nuclear membrane
Nucleus
Golgi apparatus
Centriole
Lysosome
Smooth endoplasmic reticulum
Mitochondrion
Cytoplasm
Cell membrane

# INTRODUCTION

The cell is the basic unit of structure and function in living things. Cells vary in their shape size, and arrangements but all cells have similar components, each with a particular function.

Some of the 100 trillion of cells make up human body.

All human cell are microscopic in size, shape and function.

The diameter range from 7.5 micrometer (RBC) to 150 mm (ovum).

# Discovery of Cells

Robert Hooke (mid-1600s)

Observed sliver of cork

Saw “row of eboxes”

Coined the term cell

# Principles of Cell Theory

All living things are made of cells

Smallest living unit of structure and function of all organisms is the cell

All cells arise from preexisting cells (this principle discarded the idea of spontaneous generation)

# Characteristics of Cell

A surrounding membrane

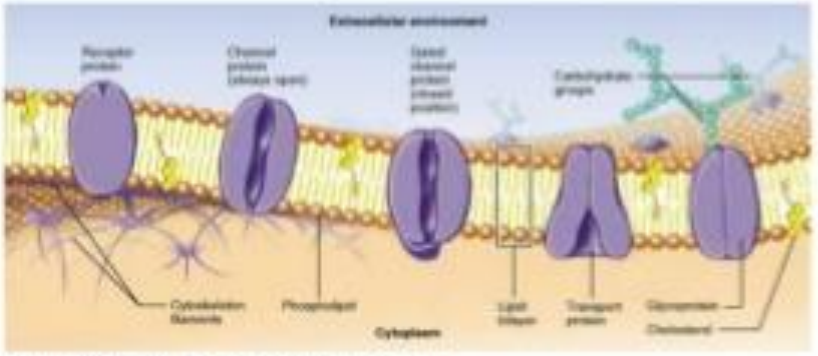
Protoplasm – cell contents in thick fluid

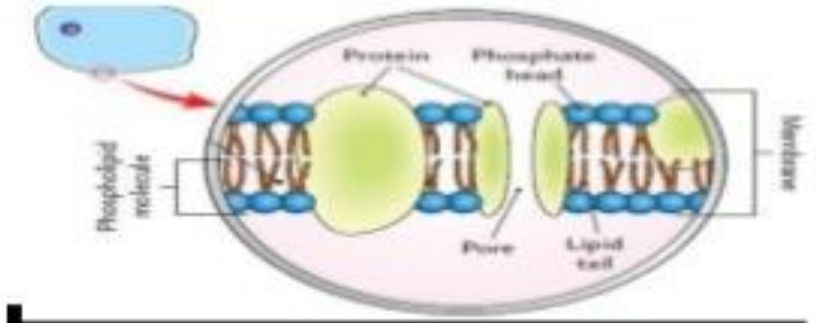
Organelles – structures for cell function

Control center with DNA

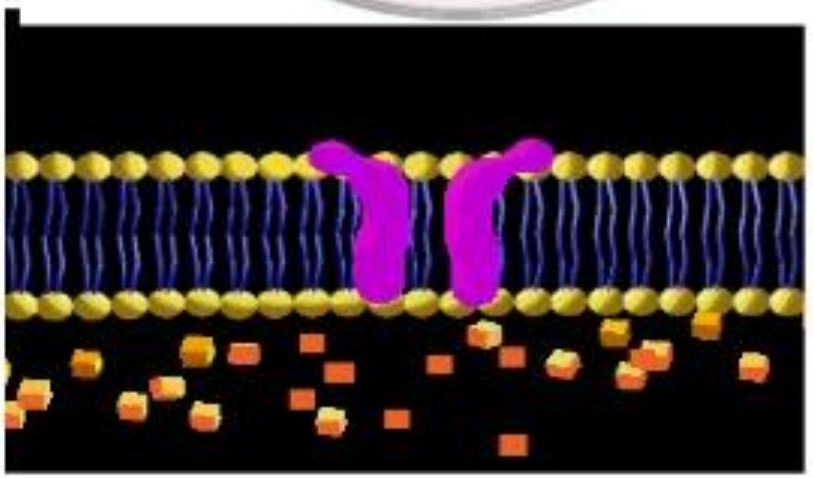
# Plasma Membrane

- The plasma membrane (cell membrane) has several functions.
- Selective access
- Separation of internal and external environments
- Means of waste removal
- Environmental interactions



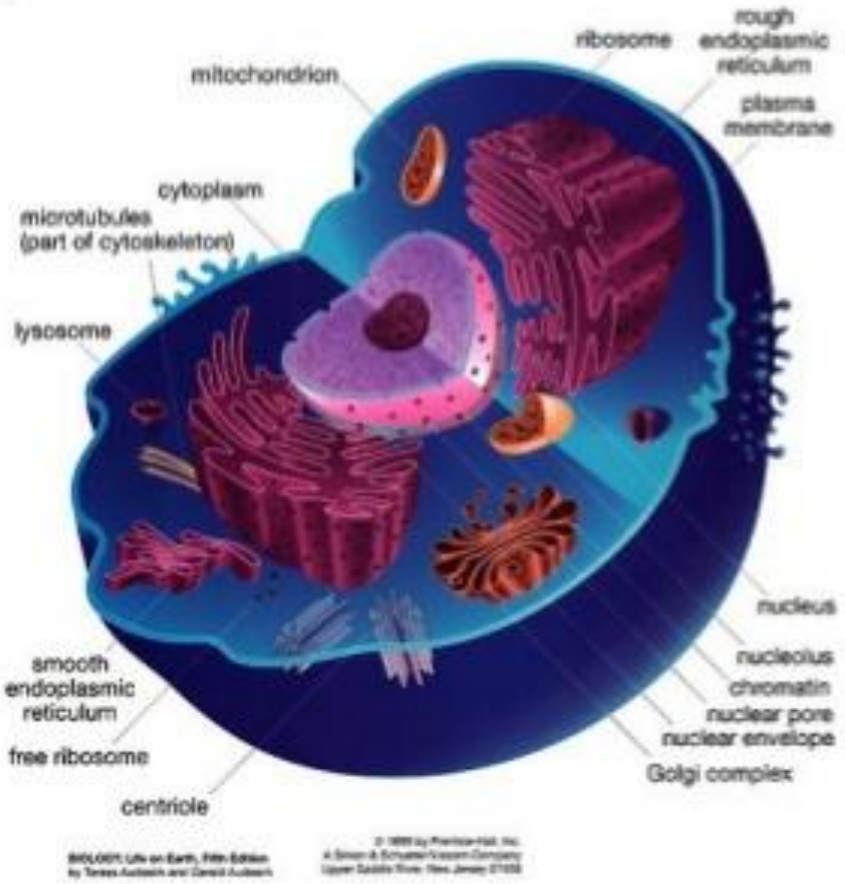




- Fluid Mosaic Model – The membrane behaves more like a liquid than a solid.
- It is a pattern (mosaic) of lipids and proteins.



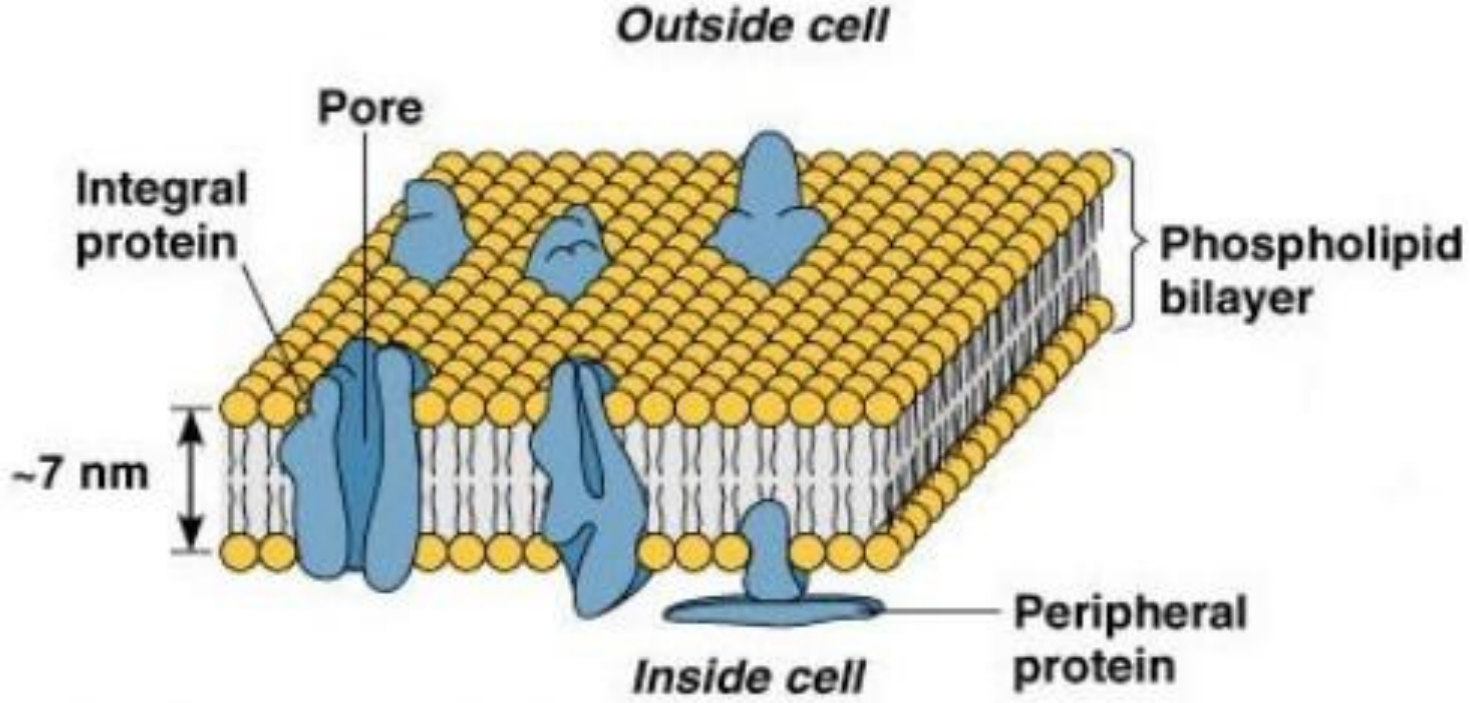
# Cell Organelles

- Organelle= "little organ"
- Found only inside **eukaryotic cells**
- **Organelles are structures that have specific jobs within cells**
- All the stuff in between the organelles is cytosol
- Everything in a cell except the nucleus is cytoplasm



# Cell Membrane

- Boundary of the cell
- Made of a phospholipid bilayer




**(b)** Phospholipid bilayer of membrane

# Nucleus

- Control center of the cell
- Contains **DNA**
- Surrounded by a double membrane
- Usually the easiest organelle to see under a microscope
- Usually one per cell

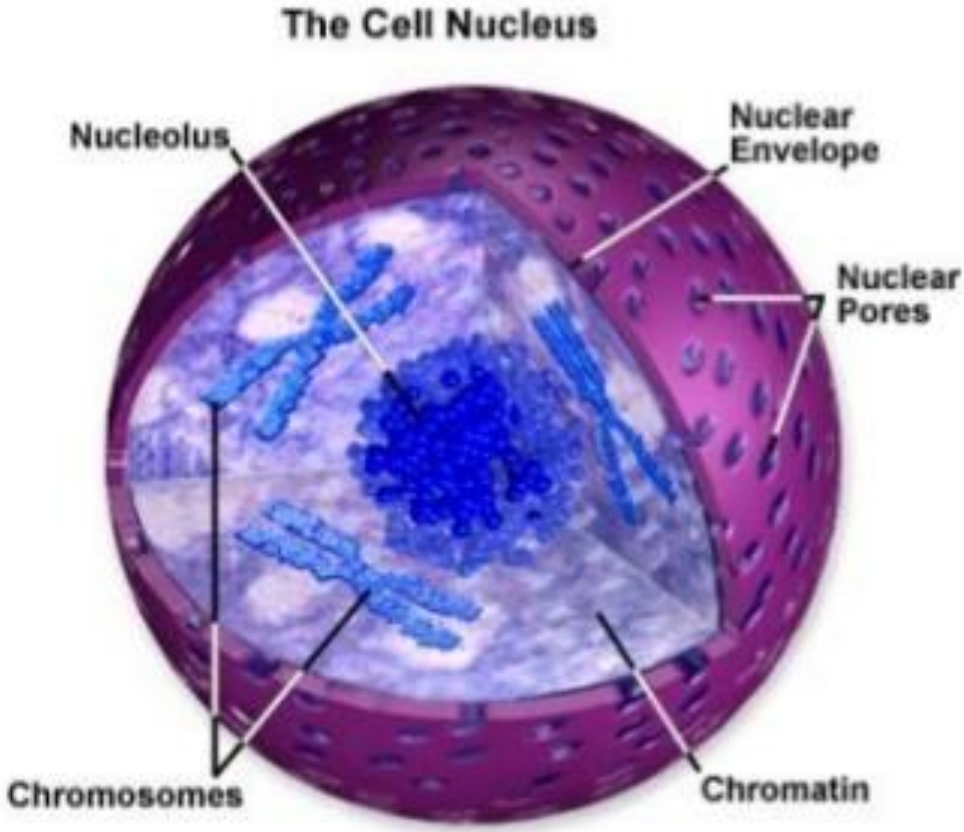
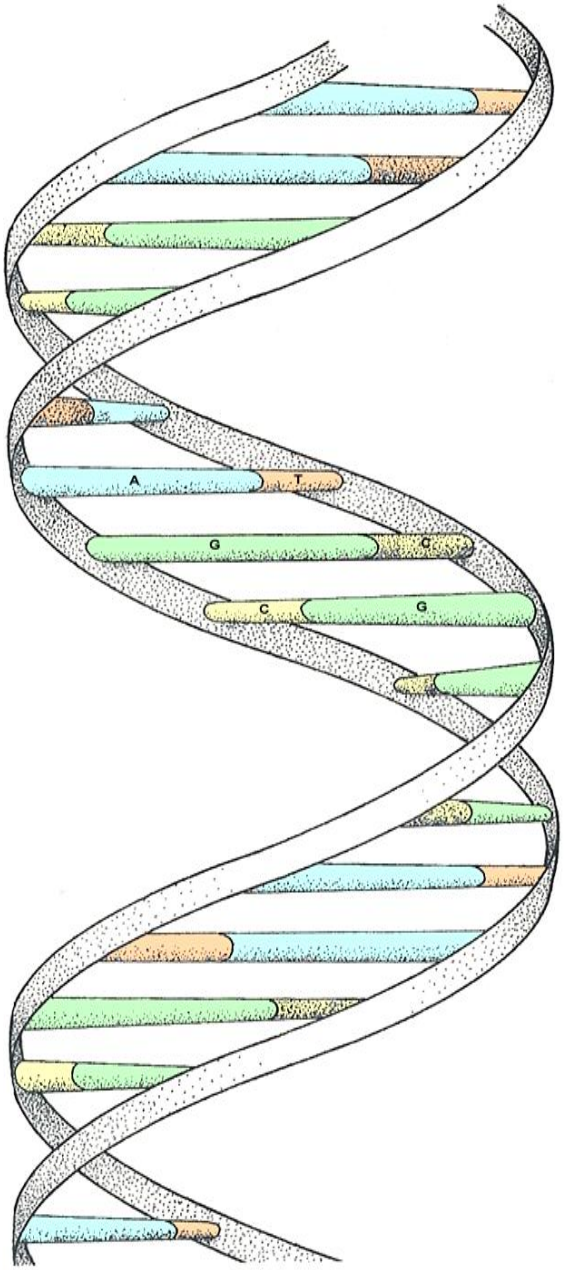



Figure 1

# DNA



**DNA** stands for **deoxyribose nucleic acid.**

This chemical substance is present in the nucleus of all cells in all living organisms

DNA controls all the chemical changes which take place in cells.

**DNA** is a very large molecule made up of a long chain of sub-units.

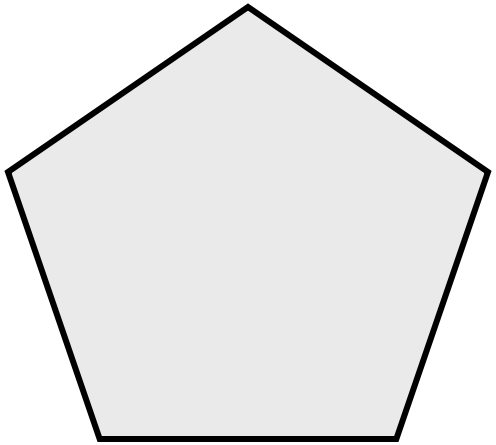
The sub-units are called **nucleotides.**
Each nucleotide is made up of
a sugar called **deoxyribose**
a phosphate group **-$PO_4$** and
an **organic base**

# Ribose & deoxyribose

**Ribose** is a sugar, like glucose, but with only five carbon atoms in its molecule.

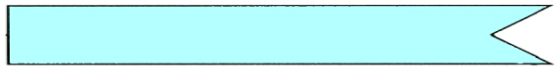
**Deoxyribose** is almost the same but lacks one oxygen atom .

Both molecules may be represented by the symbol

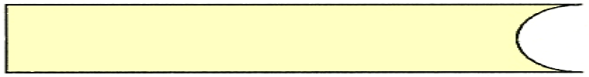


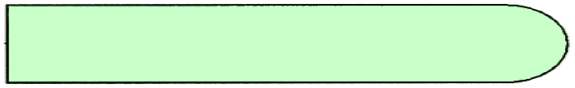
# The bases

The most common organic bases are

Adenine  (A)

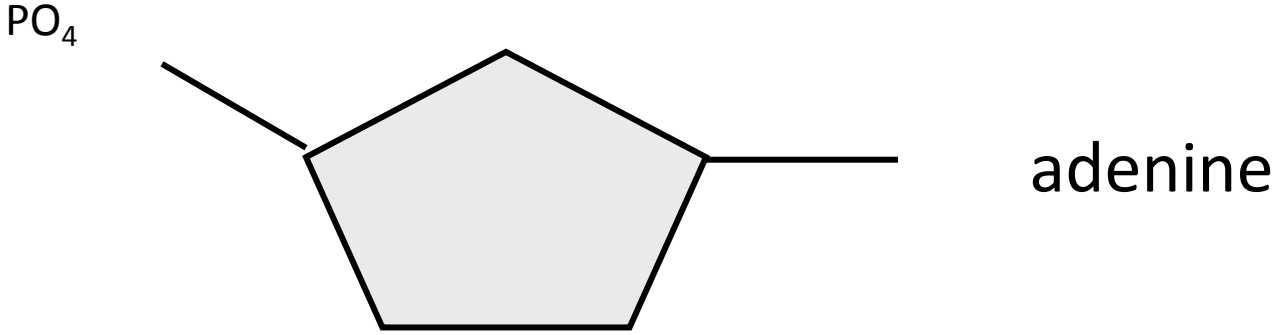
Thymine  (T)

Cytosine  (C)

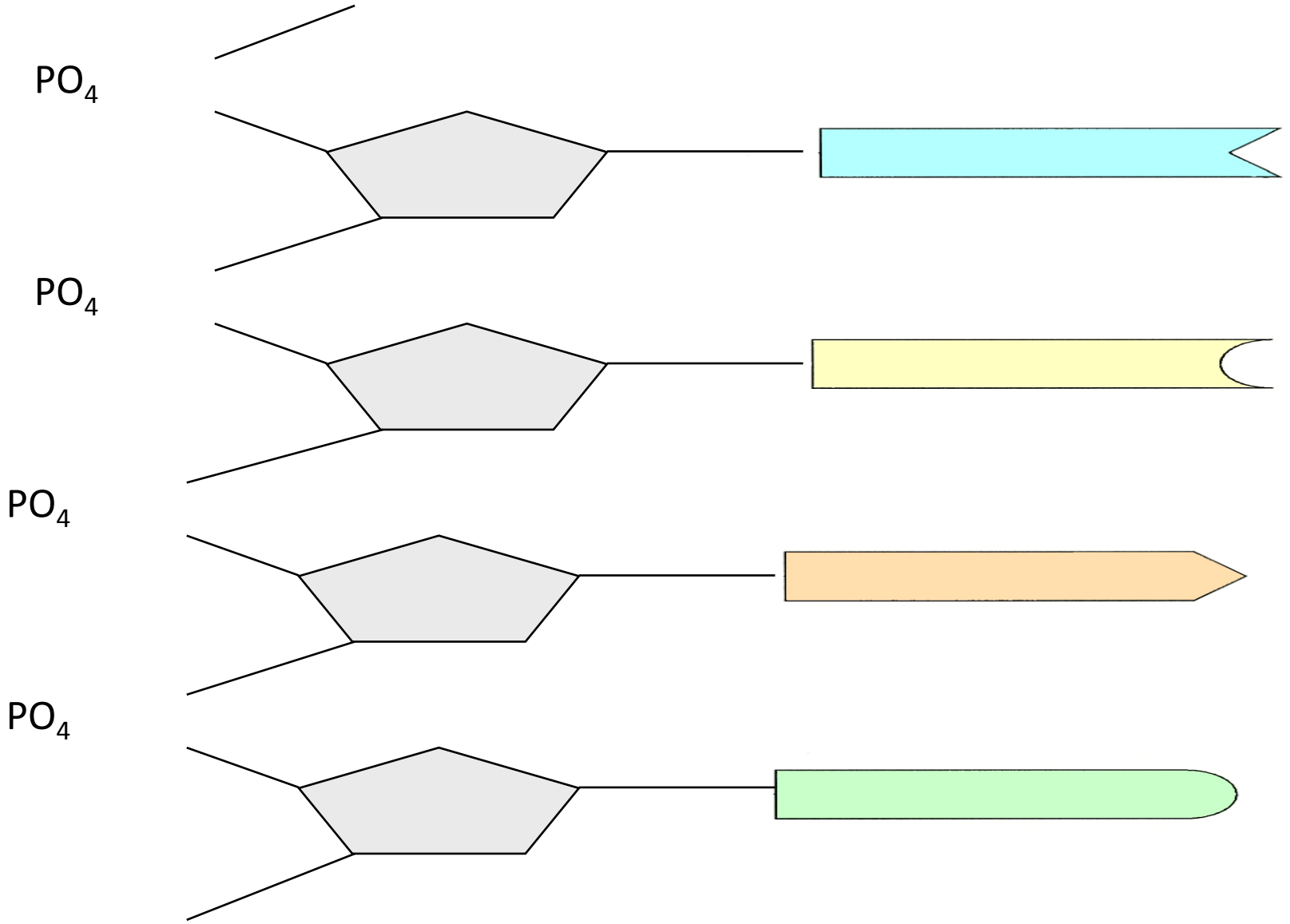
Guanine  (G)

# Nucleotides

The deoxyribose, the phosphate and one of the bases combine to form a nucleotide.



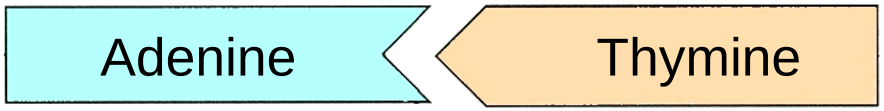
A molecule of DNA is formed by millions of nucleotides joined together in a long chain.



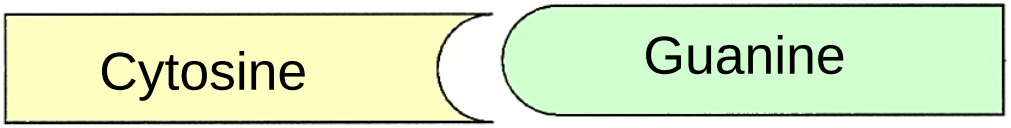

sugar-phosphate backbone

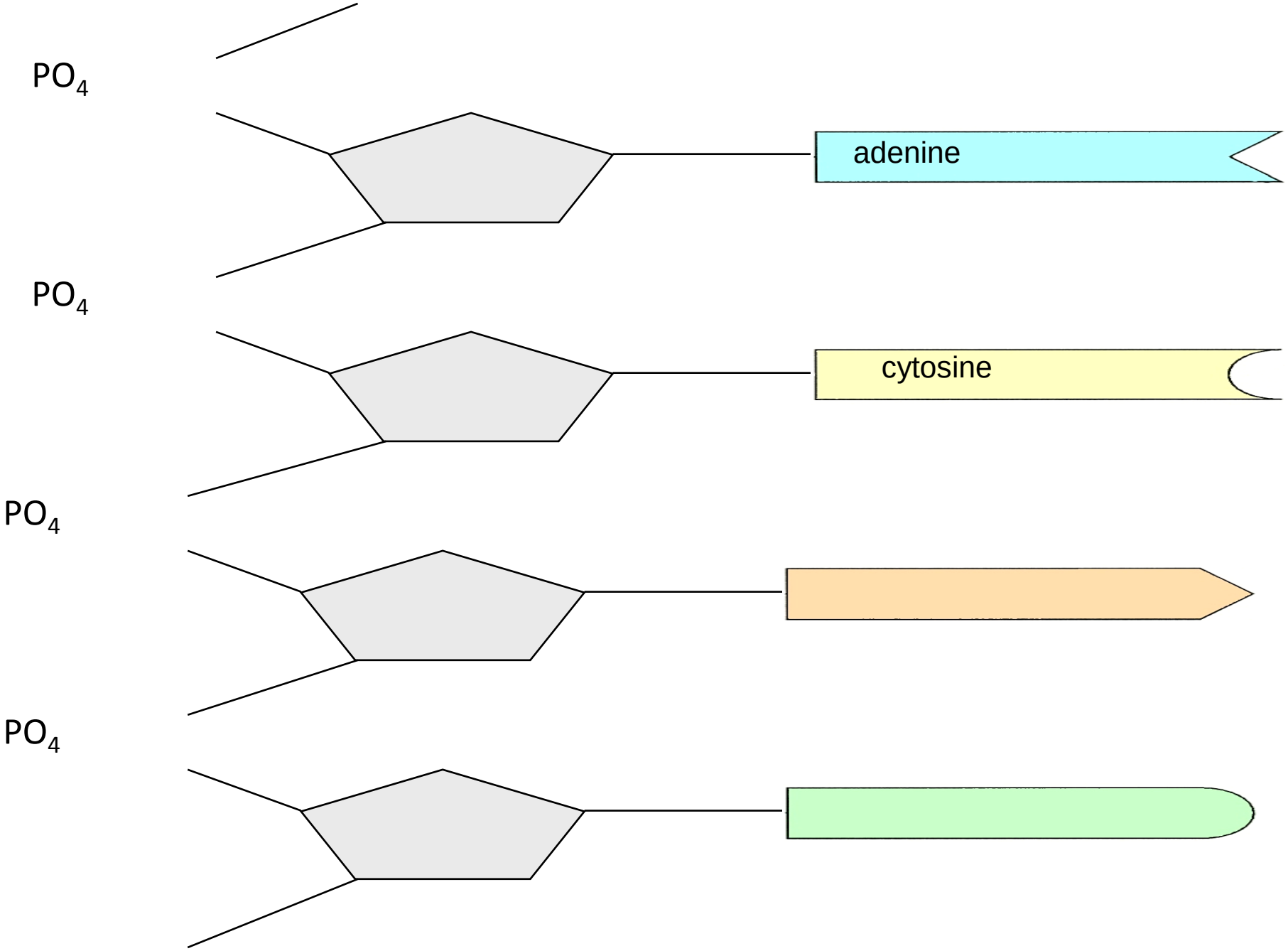
+ bases

The bases always pair up in the same way.
Adenine forms a bond with Thymine

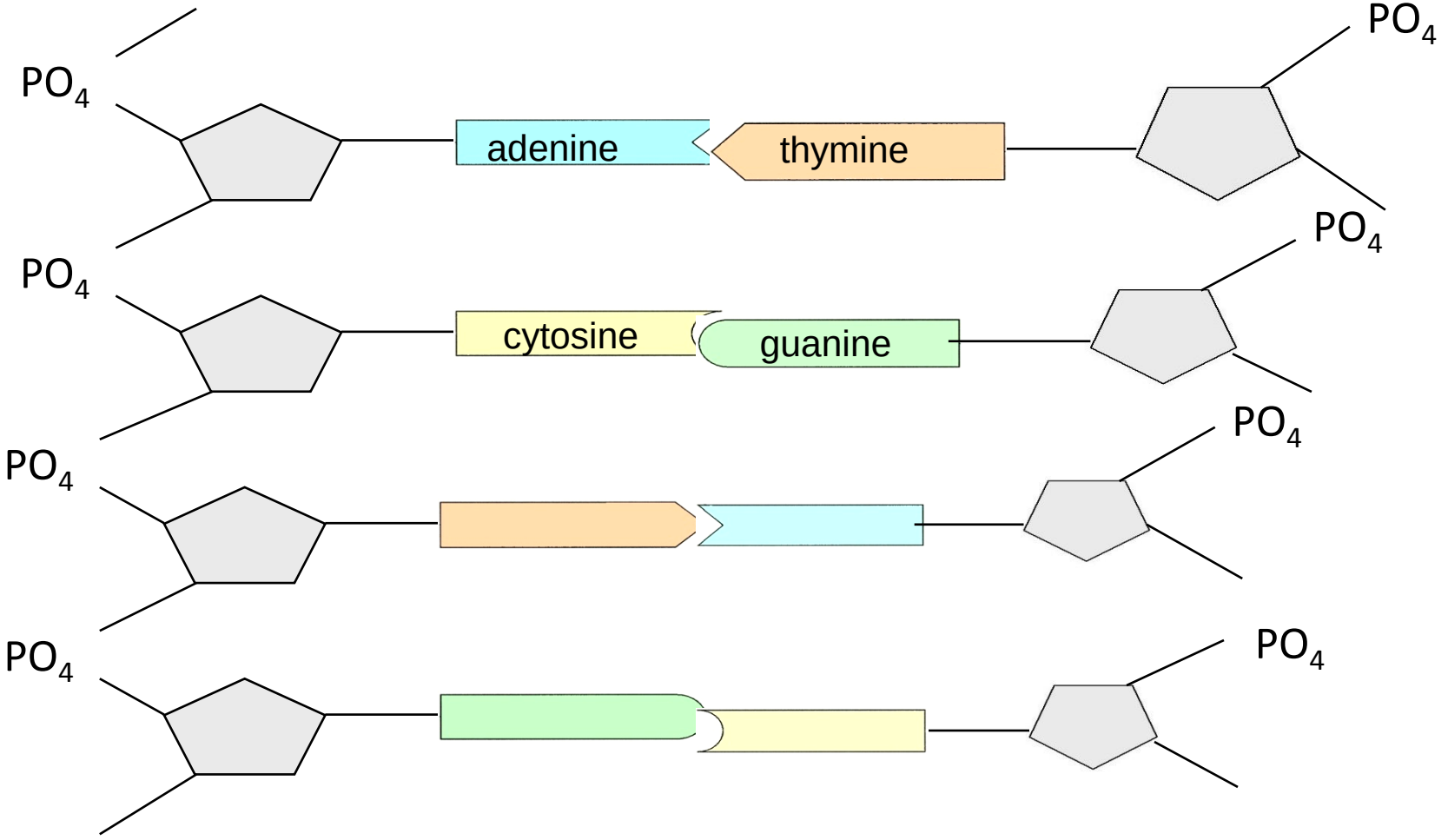



and Cytosine bonds with Guanine

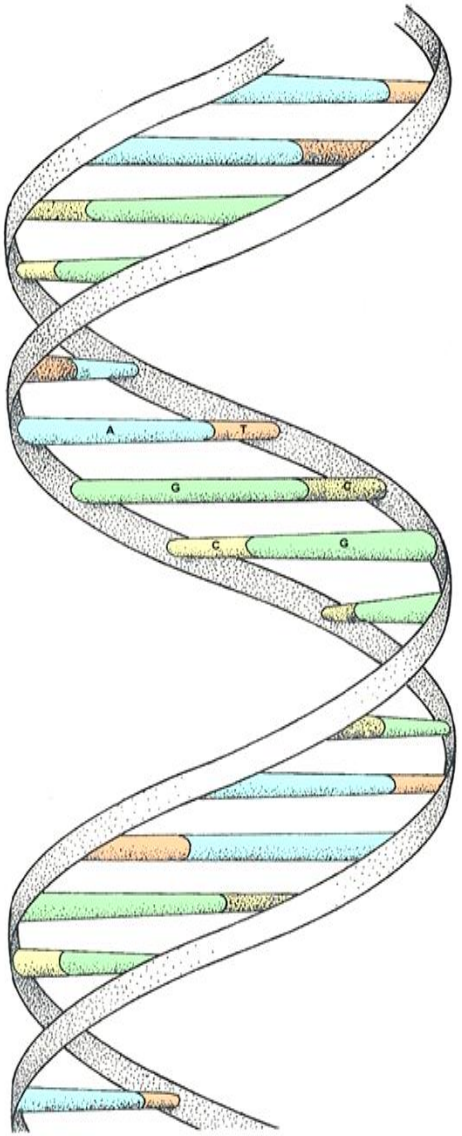



$PO_4$
adenine
$PO_4$
cytosine
$PO_4$
$PO_4$

# Bonding

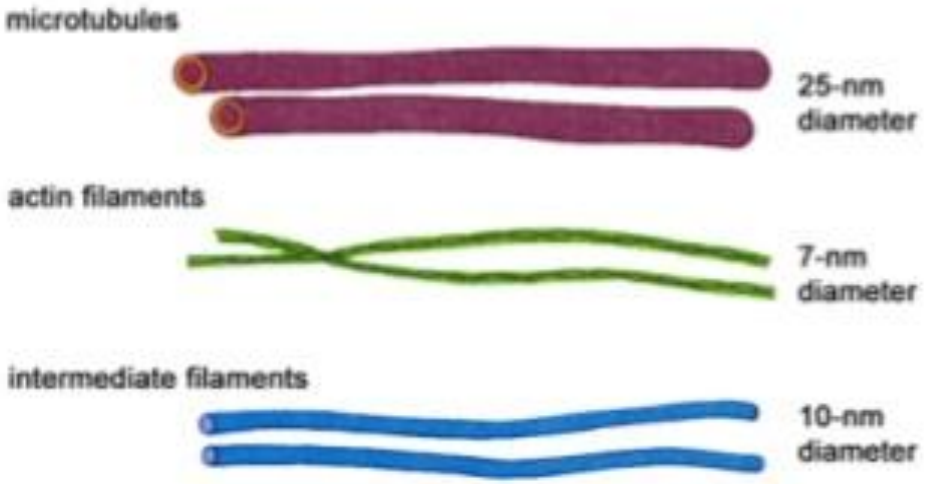

PO4
PO4
adenine
thymine
PO4
PO4
cytosine
guanine
PO4
PO4
PO4

# THE DOUBLE HELIX (DNA)



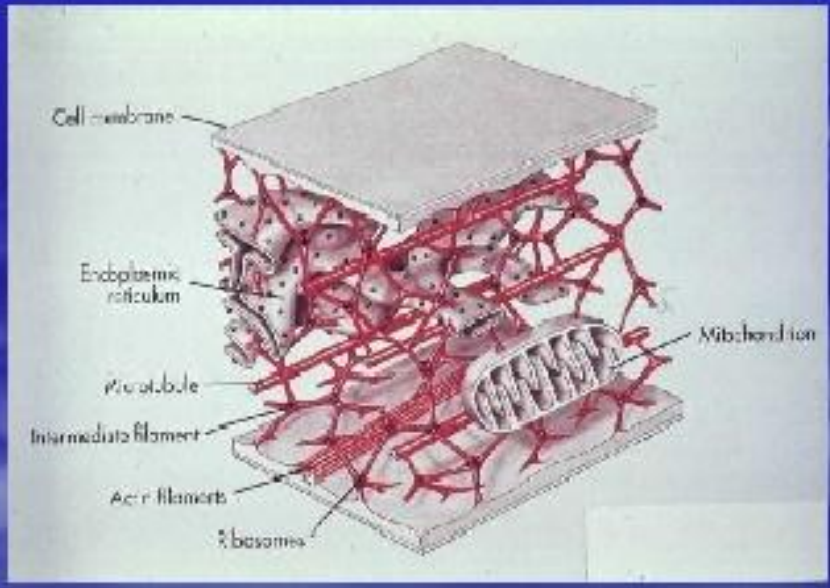
# Cytoskeleton

- Acts as **skeleton** and **muscle**
- Provides shape and structure
- Helps move organelles around the cell
- Made of three types of filaments



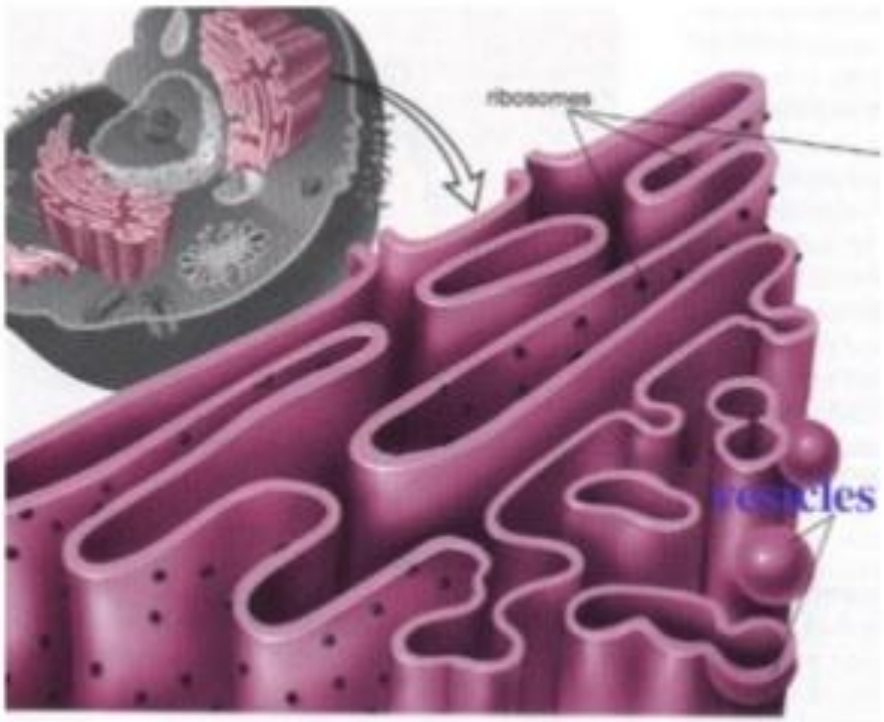
# CYTOSKELETON

- Maintains the shape and size of cell
- Network of long protein strands
- Not surrounded by a membrane
- Participates in the movement of organelles
- 2 major components – microfilaments and microtubules
- Microfilaments – threads made of actin (protein) – smallest strands
- Microtubules – largest strands that are hollow tubes – help the cell divide by forming spindle fibers that extend across the cell



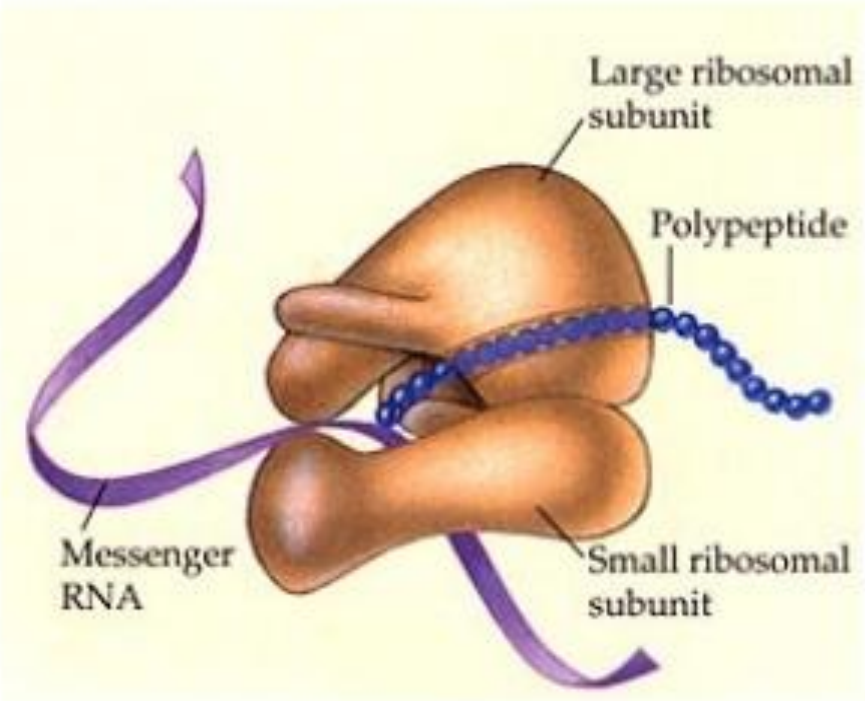
# Endoplasmic Reticulum

- A.k.a. "ER"
- Connected to nuclear membrane
- Highway of the cell
- Rough ER: studded with ribosomes; it makes proteins
- Smooth ER: no ribosomes; it makes lipids



# Ribosome

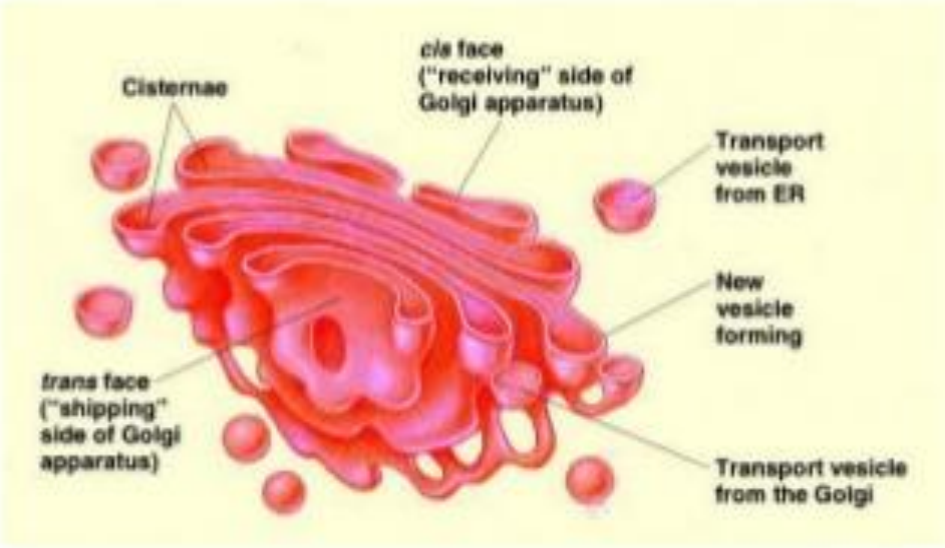
- Site of protein synthesis
- Found attached to rough ER or floating free in cytosol
- Produced in a part of the nucleus called the nucleolus




That looks familiar…what is a **polypeptide**?

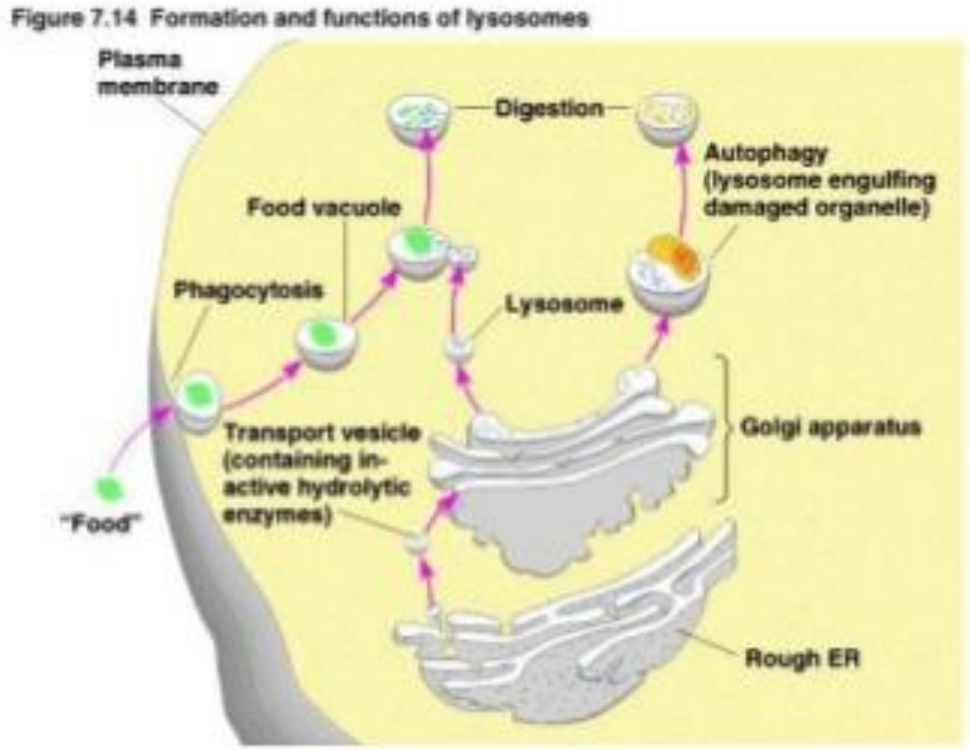
# Golgi Apparatus

- Looks like a stack of plates
- Stores, modifies and packages proteins
- Molecules transported to and from the Golgi by means of vesicles



# Lysosomes

- Garbage disposal of the cell
- Contain digestive enzymes that break down wastes




**Which organelles do lysosomes work with?**

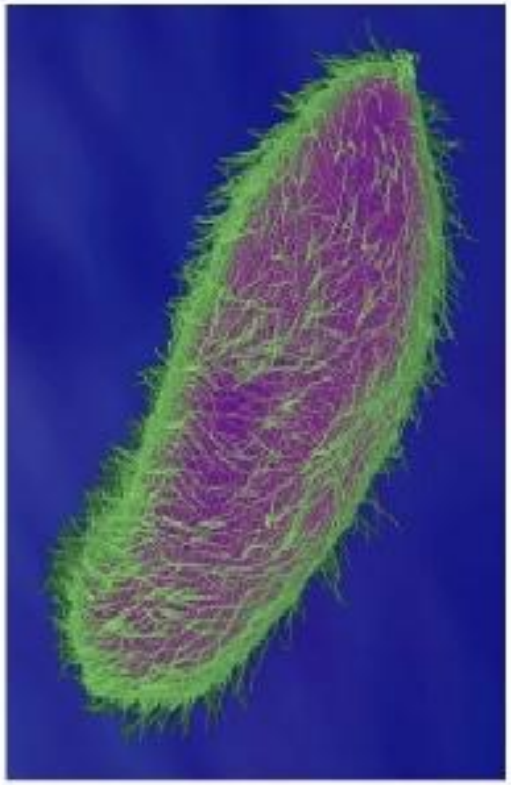
# Mitochondria

- "Powerhouse of the cell"
- Cellular respiration occurs here to release energy for the cell to use
- Bound by a double membrane
- Has its own strand of DNA

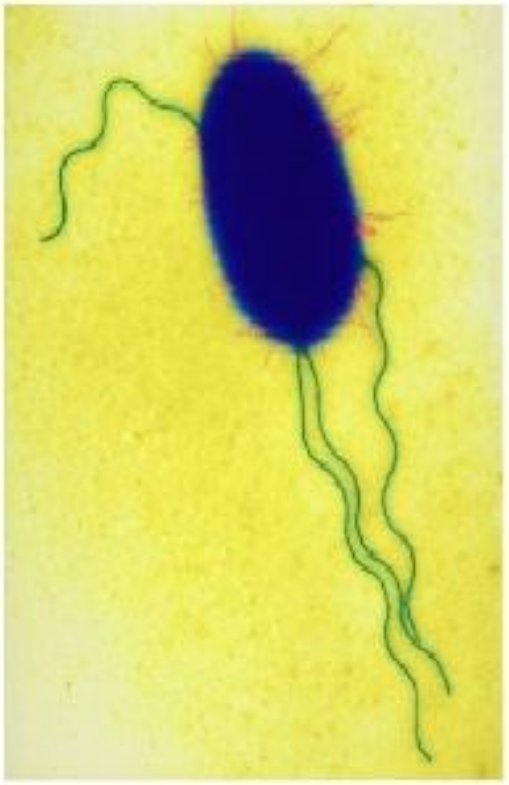
# CILIA AND FLAGELLA

- Hairlike organelles that extend from the surface of the cell
- Assist in movement
- Cilia – short and present in large numbers
- Flagella – long and less numerous

Cilia



Flagella



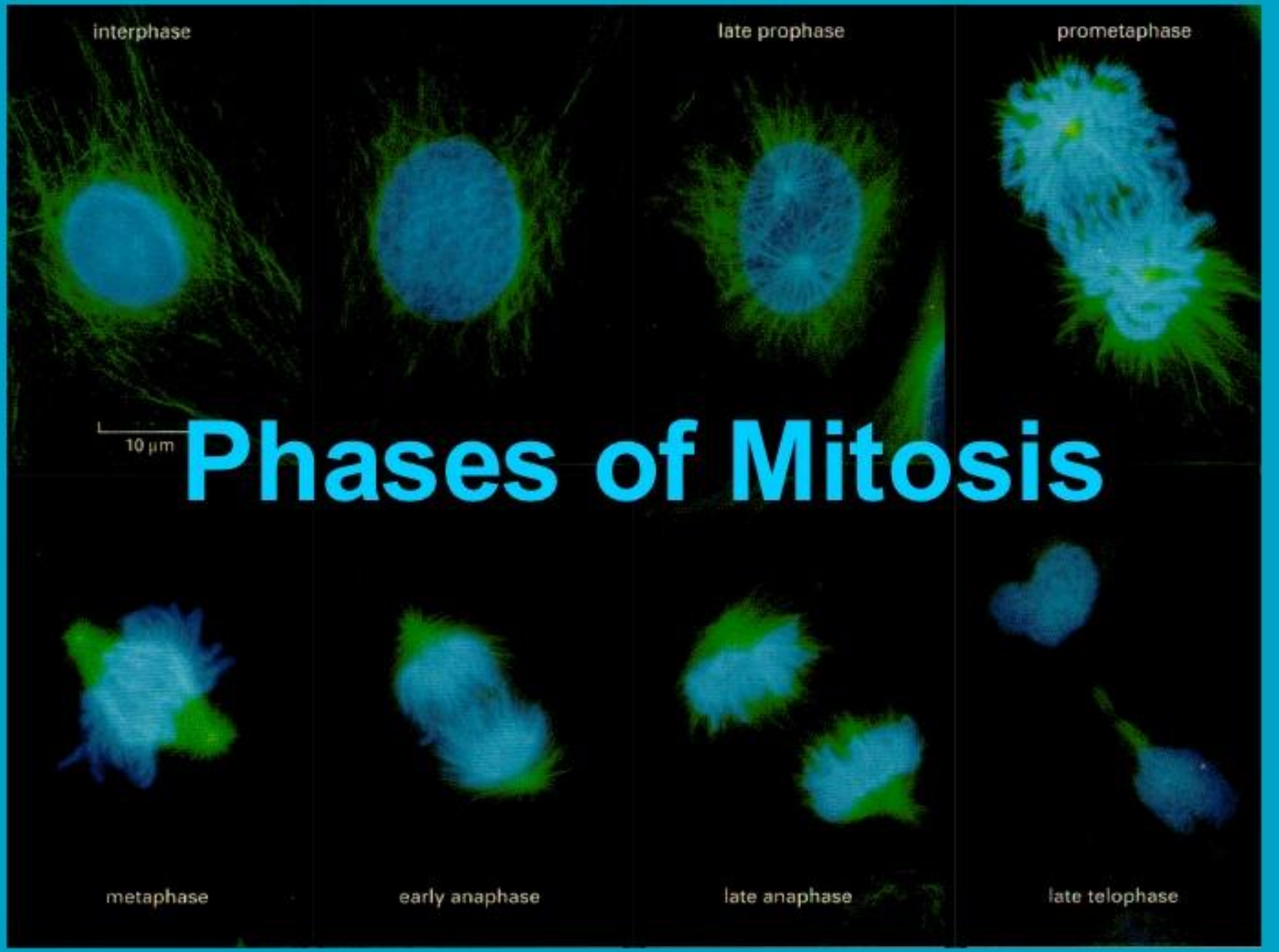
# Cell Division

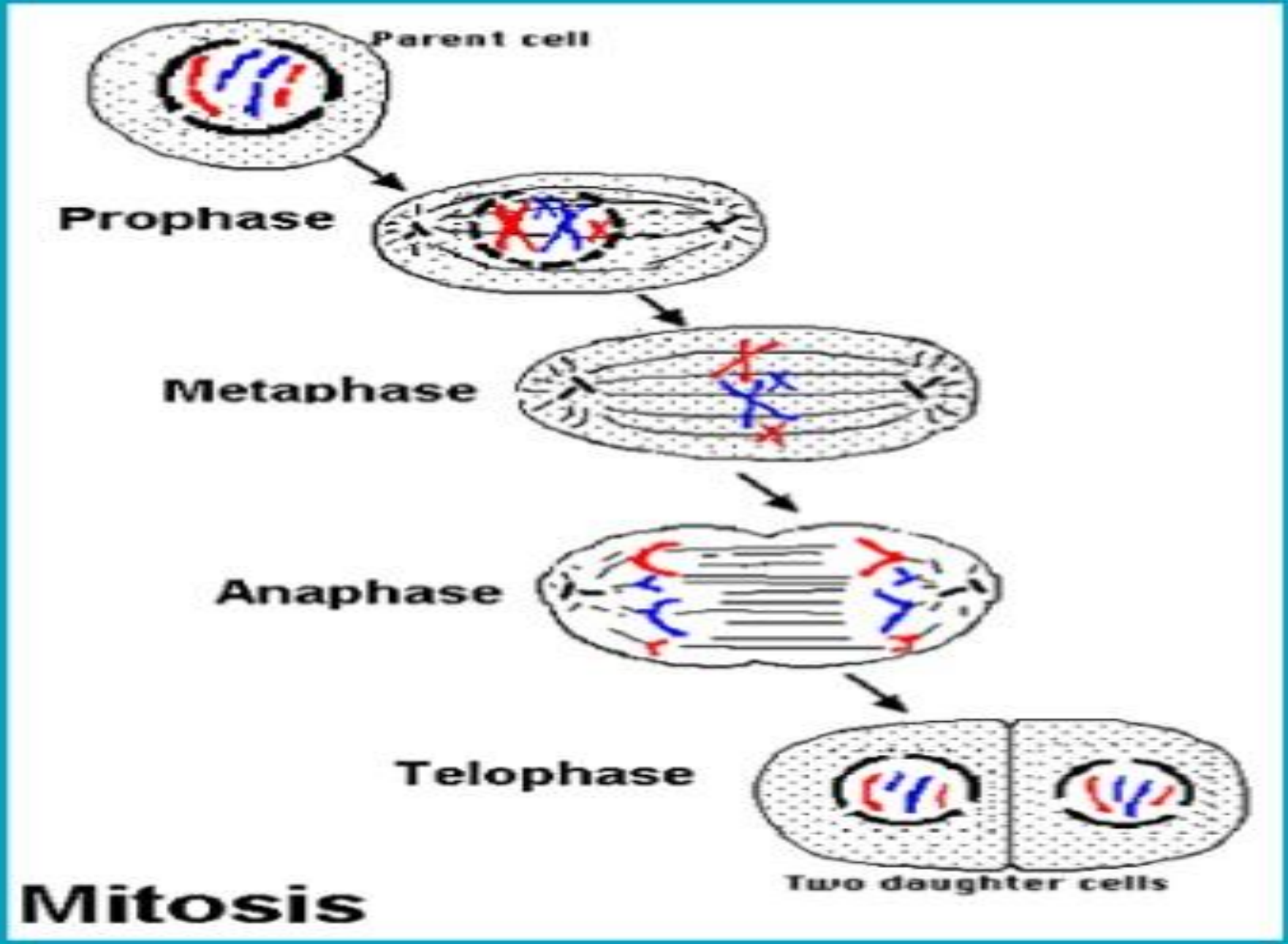
# Mitosis and Meiosis

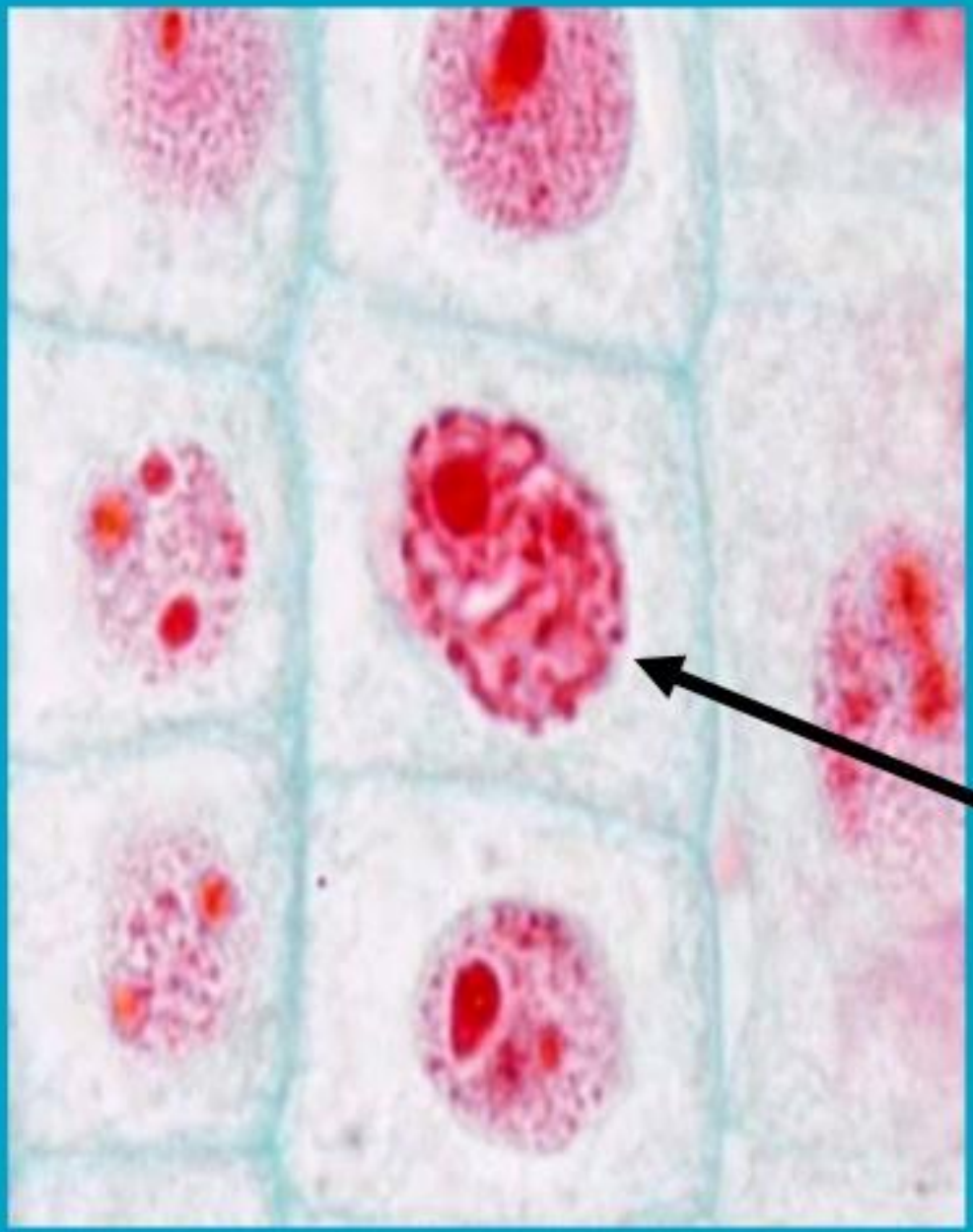
# *Why Do Cells Divide?*

For growth, repair, and reproduction

# Mitosis


interphase
late prophase
prometaphase
10 µm
Phases of Mitosis
metaphase
early anaphase
late anaphase
late telophase

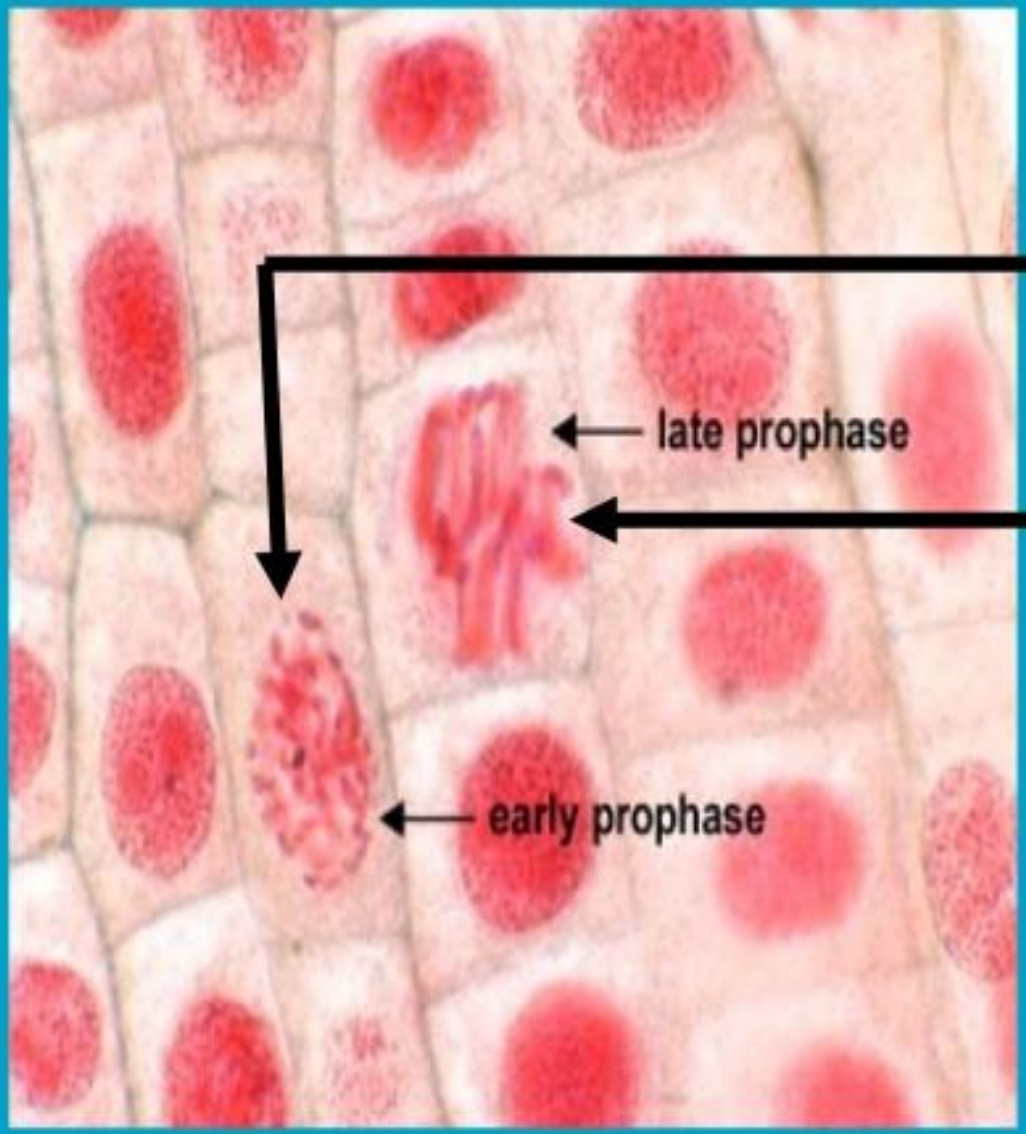

Parent cell
Prophase
Metaphase
Anaphase
Telophase
Two daughter cells
Mitosis



# Prophase

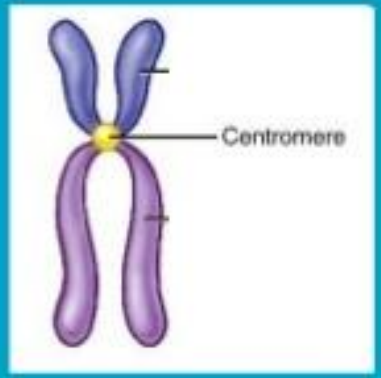
The Cell begins the division process

4. The nucleolus disappears,
5. The nuclear membrane breaks apart

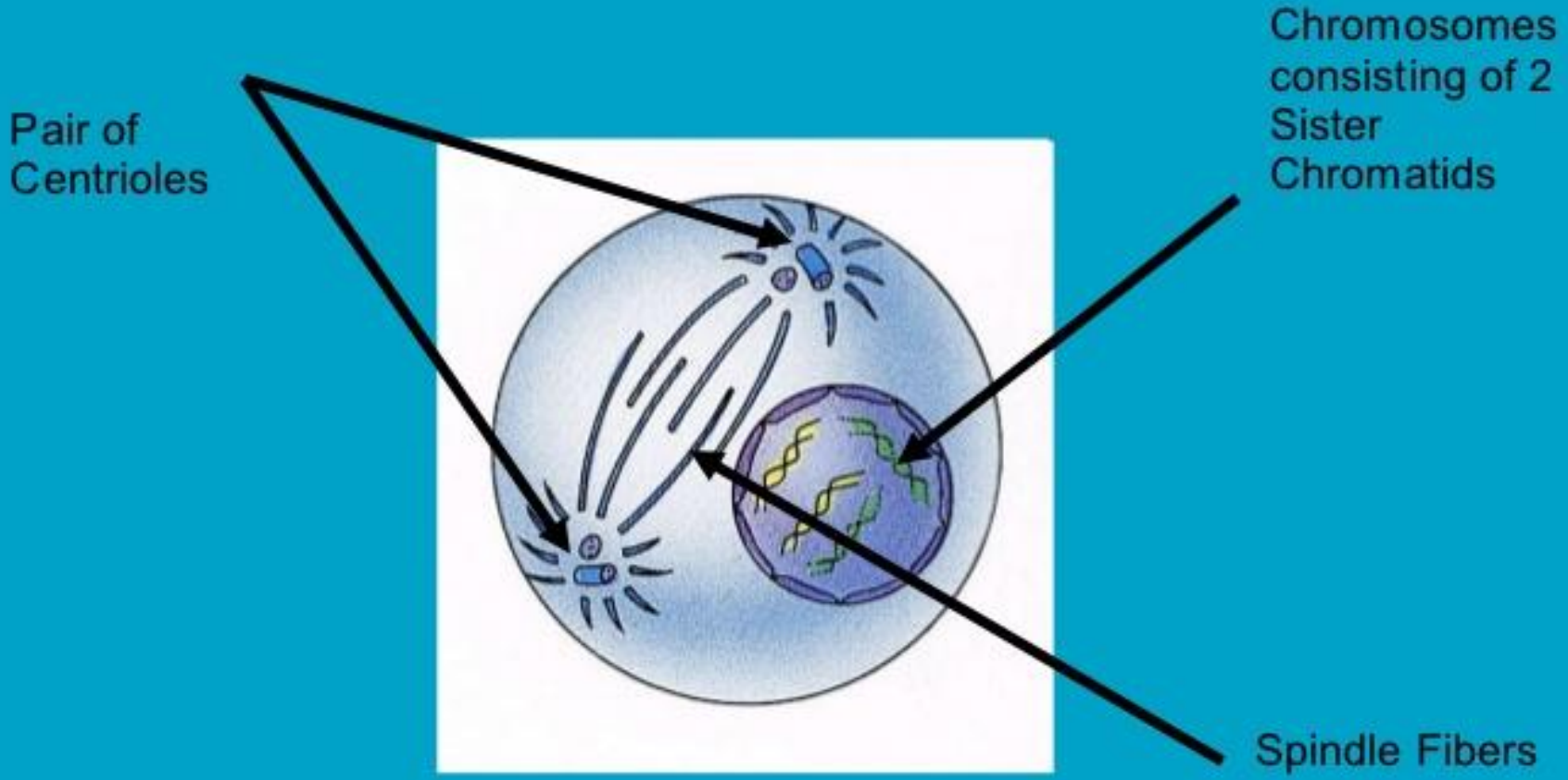



3. The chromosomes become visible

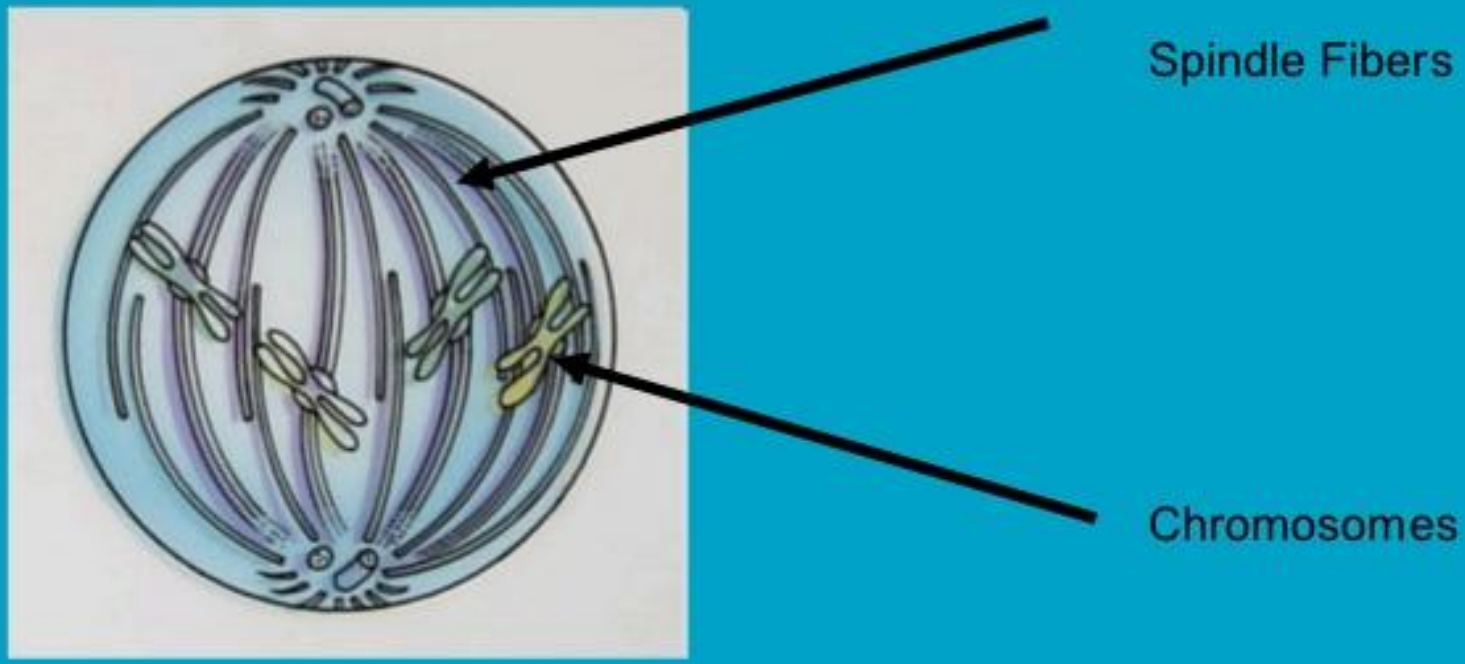
4. The spindle apparatus forms and attaches to the centromeres of the chromosomes

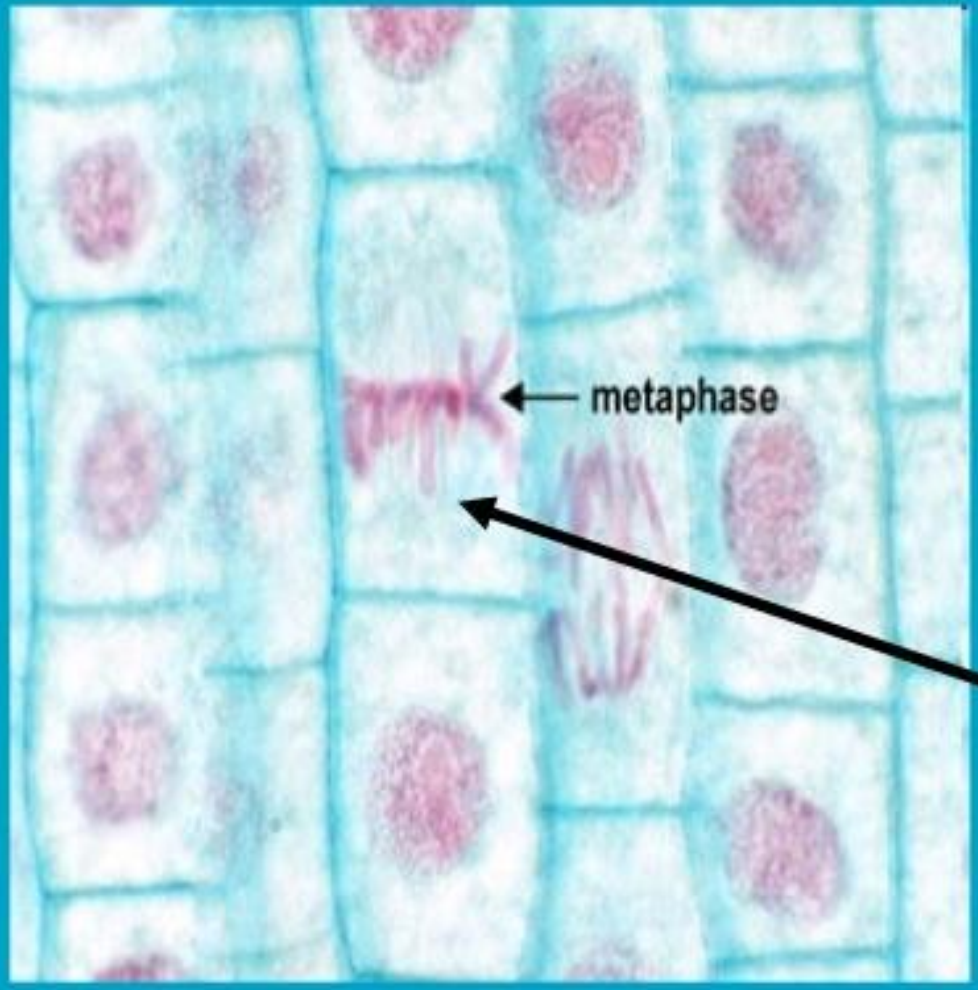


In Early Prophase of Mitosis the Chromosomes get small, centrioles move to the poles of the nucleus, and spindle fibers develop



Late Prophase happens when the Nuclear Envelope disintegrates and spindle fibers begin to move Chromosomes toward the center of cell.



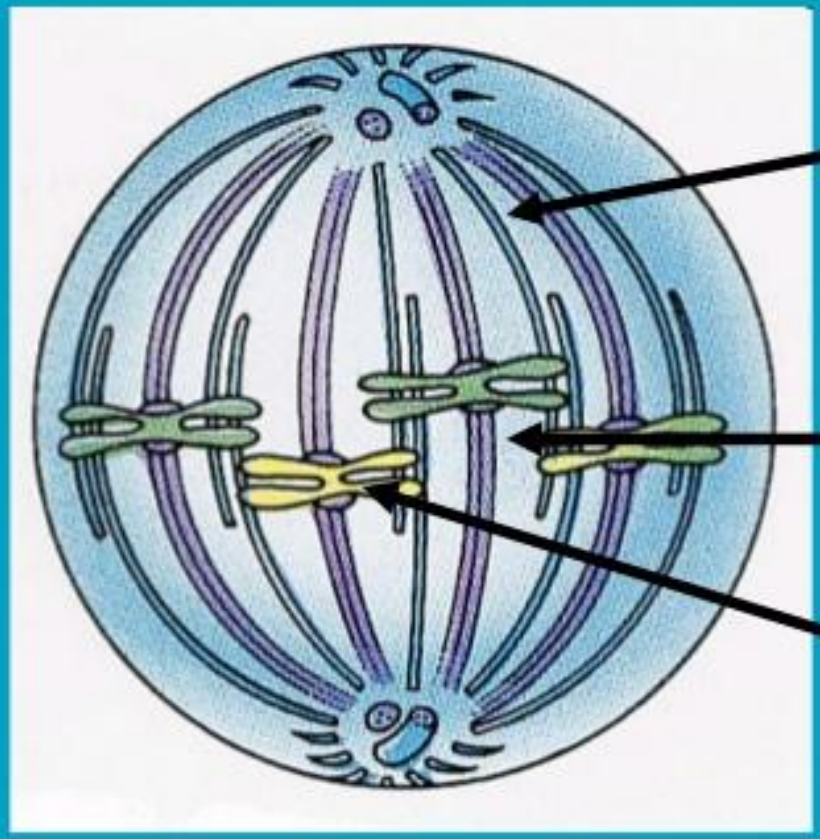


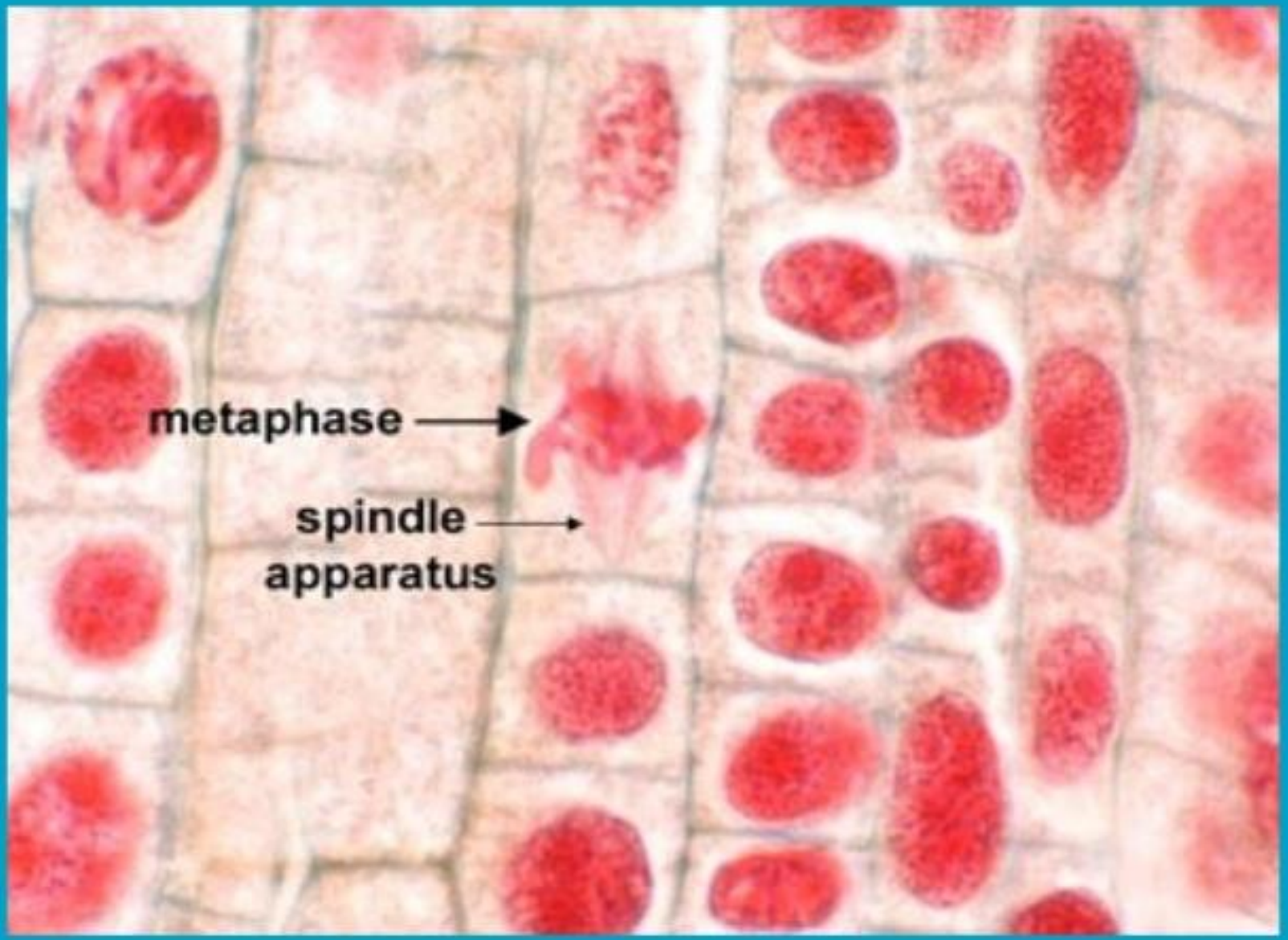

# Metaphase

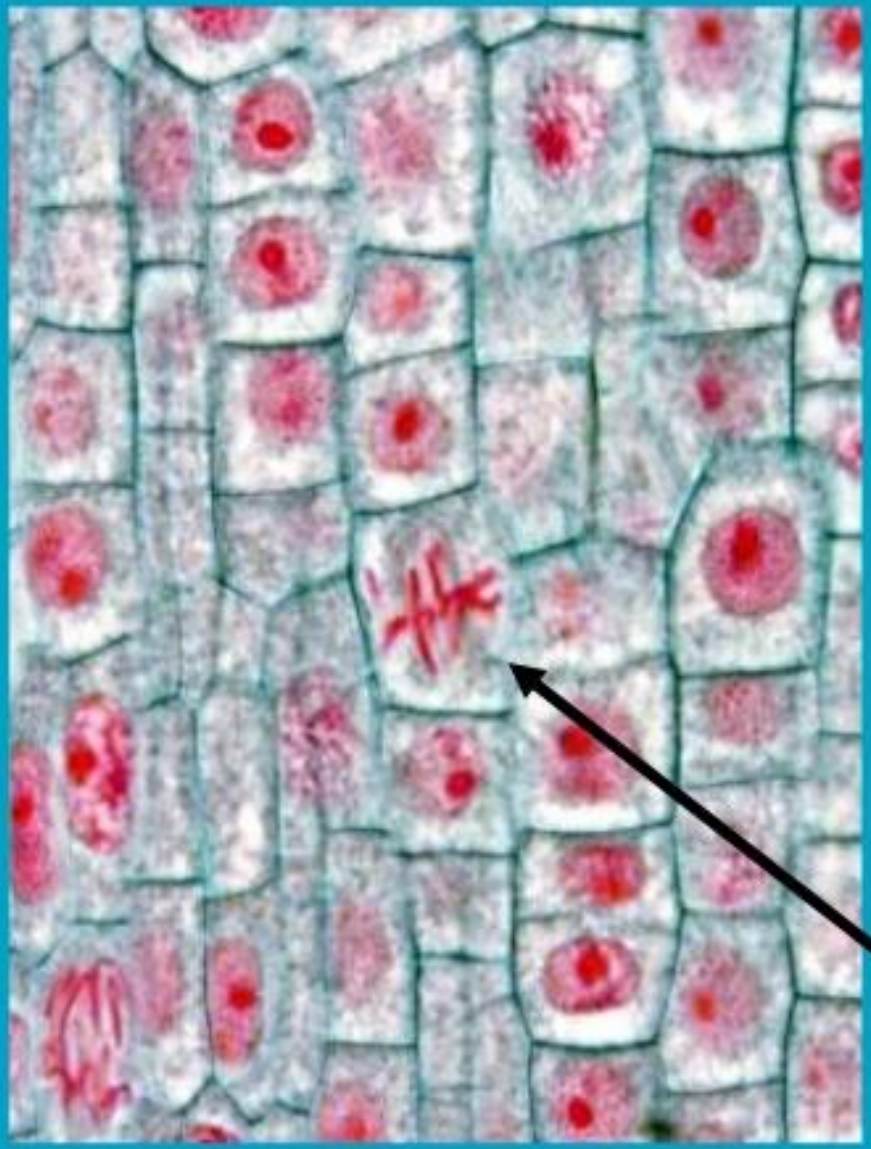
## The Second Phase of Mitosis

4. The Nuclear Membrane is completely gone
2. The duplicated chromosomes line up along the cell's equator.

During Metaphase the Chromosomes line up across center of the cell, also called the equator, or Metaphase plate.




metaphase
spindle
apparatus



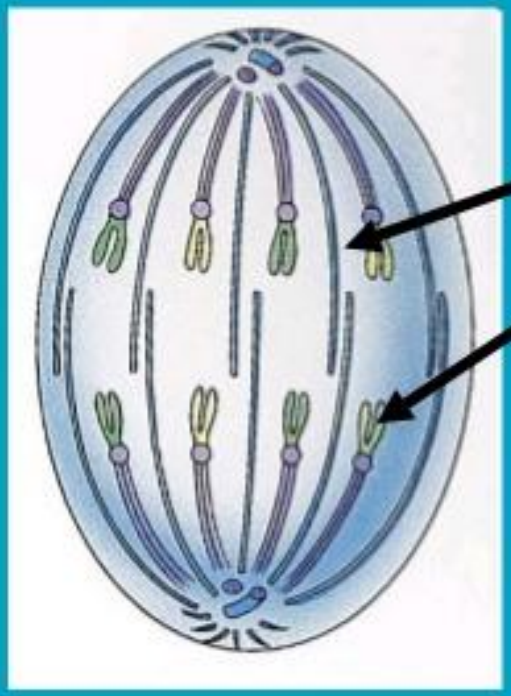
# Anaphase

The third phase of Mitosis

Diploid sets of daughter chromosomes separate

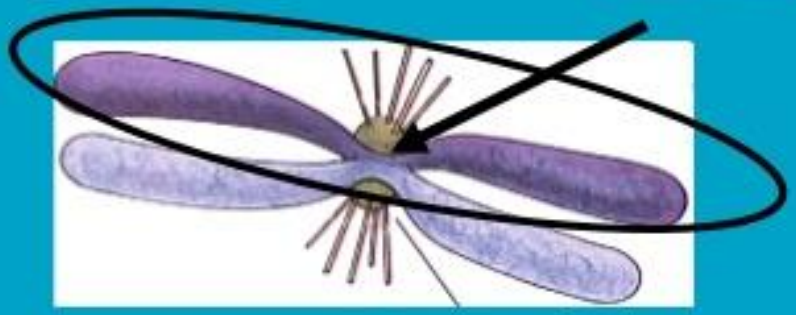
They are pushed and pulled toward opposite poles of the cell by the spindle fibers

In Anaphase the Chromatids that make up each Chromosome move apart and travel to opposite ends of cellular spindle

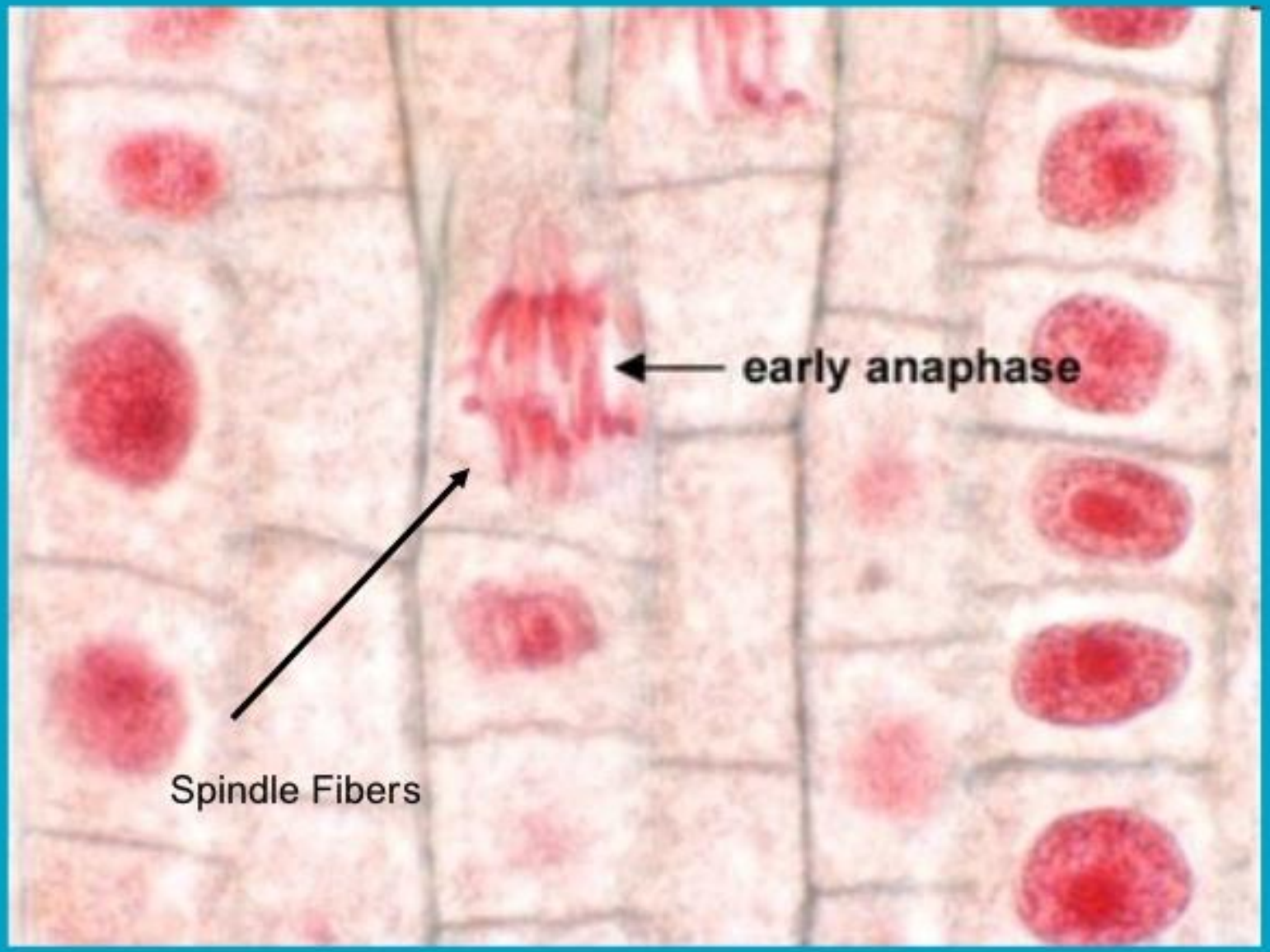


Daughter Chromosomes

Chromatid



Chromosome

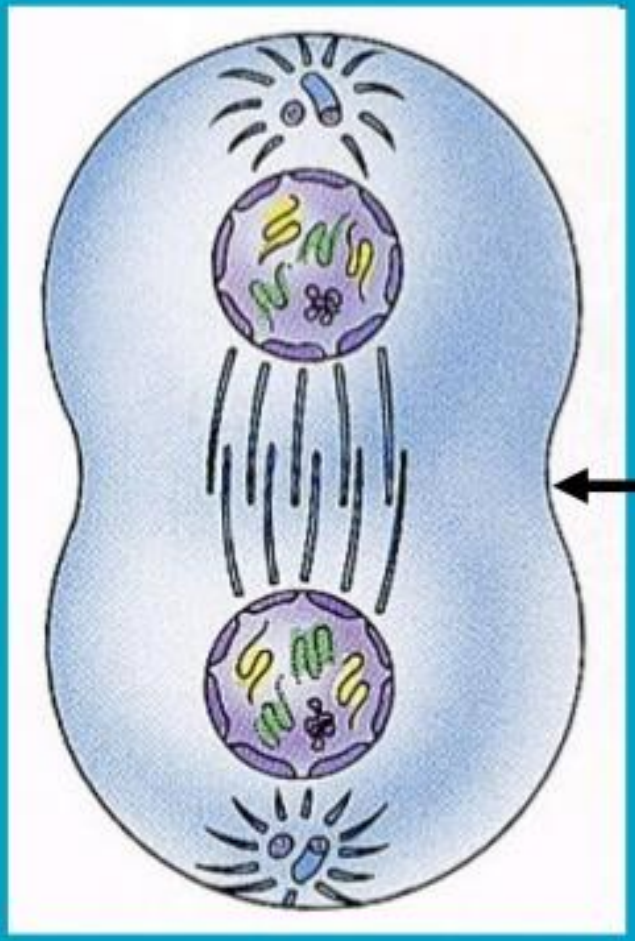

early anaphase
Spindle Fibers

# Telophase

The nuclear membrane and nucleoli (nucleus) reform.

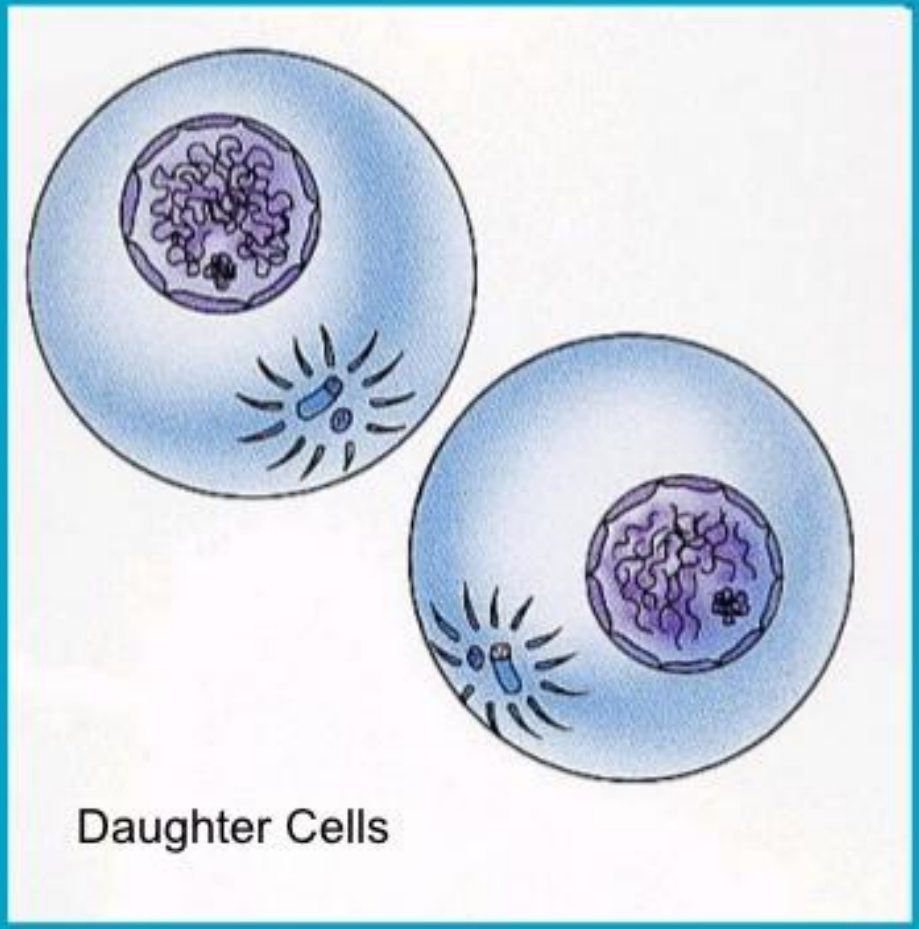
Cytokinesis is nearly complete,

In Telophase an envelope surrounds each set of Chromatids to form new Nucleus and the Cytoplasm starts to divide



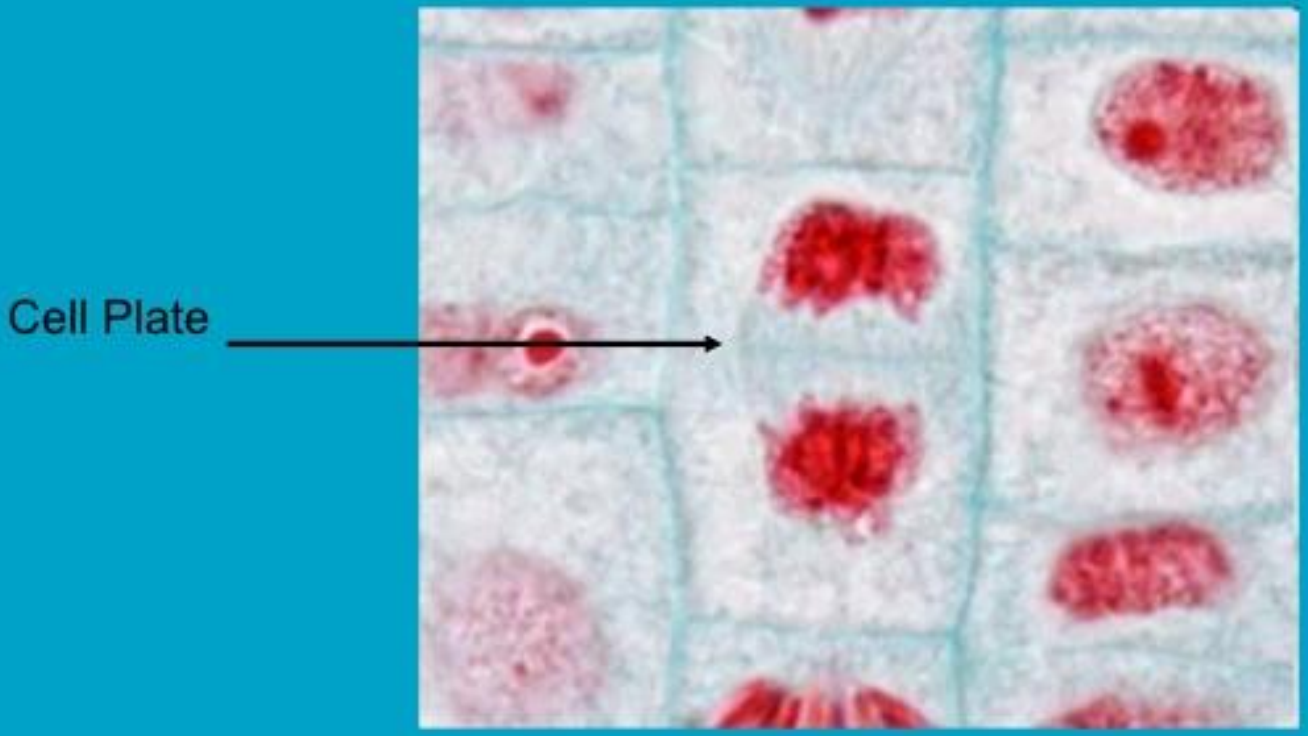
Cleavage Furrow

Cytokinesis takes place when the Cytoplasm divides and two cells with identical genetic material are formed

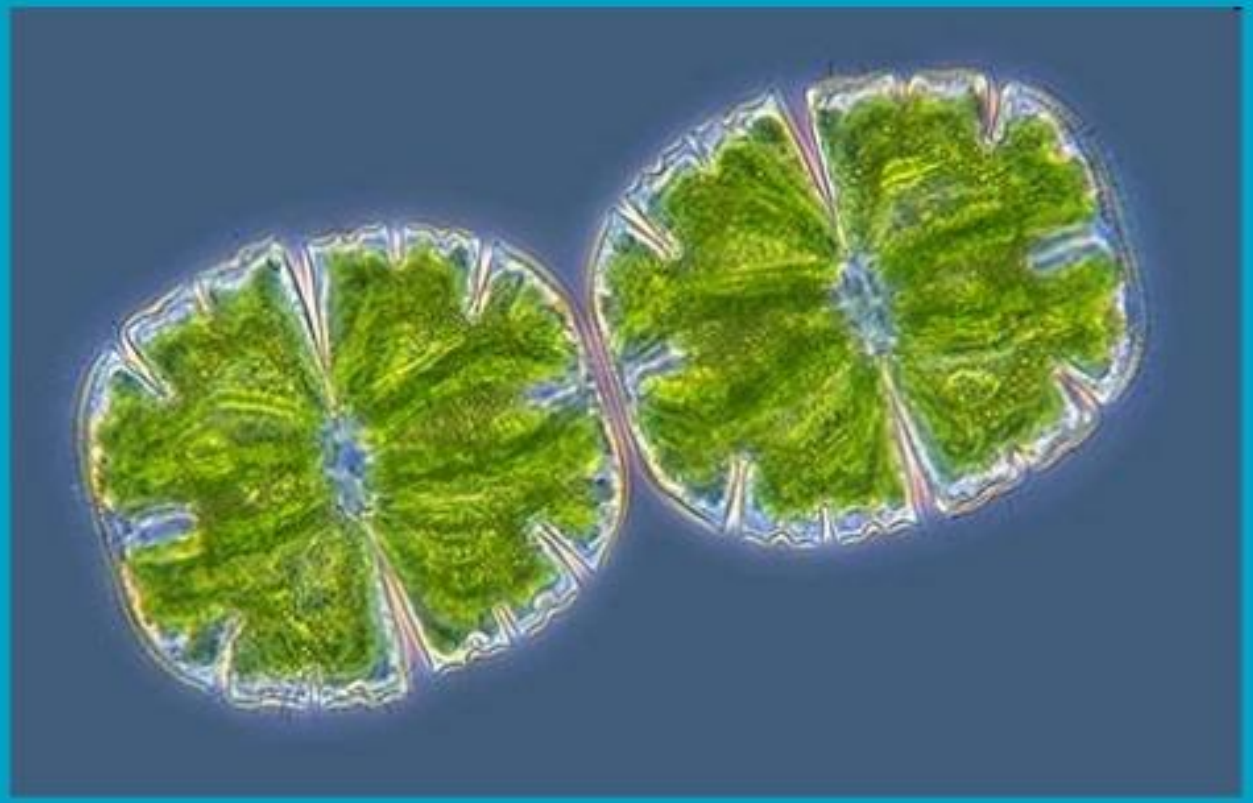


## Cytokinesis – The final stage of Mitosis

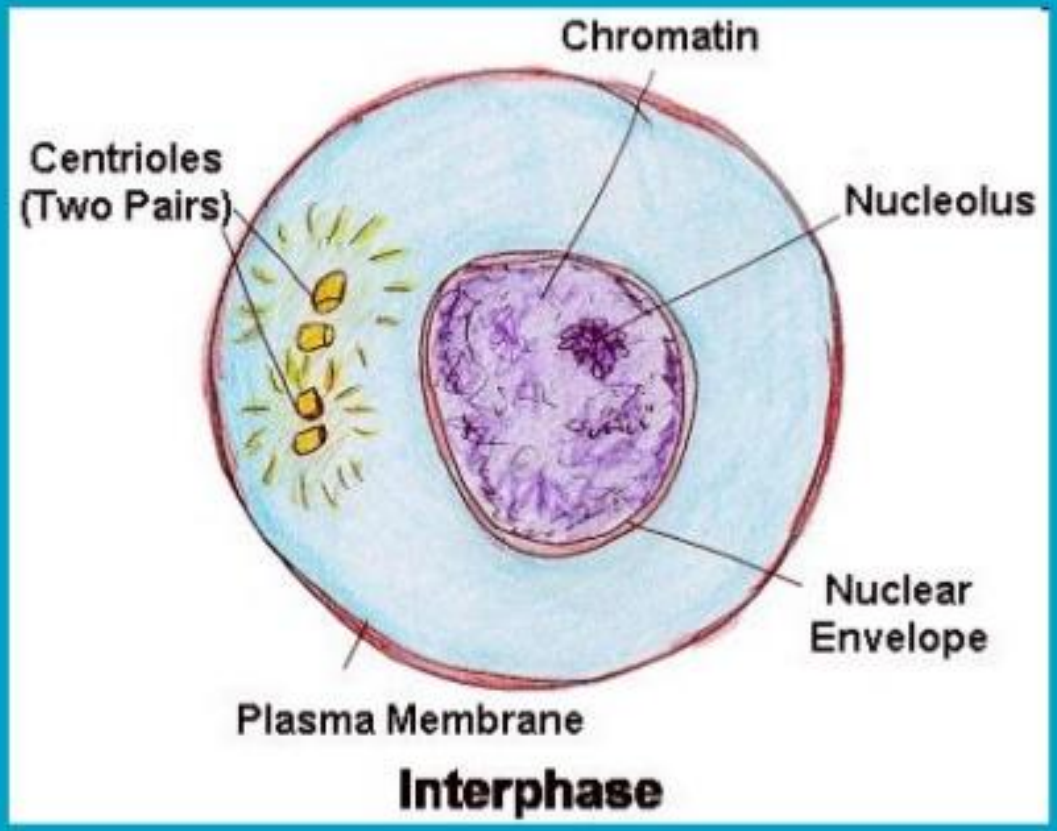
The cytoplasm, organelles, and nuclear material are evenly split and two new cells are formed.



The two new cells – each exactly like the other – are called Daughter Cells



Interphase – The Cell spends the majority of its life here, growing and functioning. During the S Phase of the Cell Cycle, the DNA replicates, in anticipation of Mitosis



# Meiosis

Takes place in the Gametes of an organism

People have a Chromosome count of 46

When an egg joins a sperm the count must stay at 46 to remain human

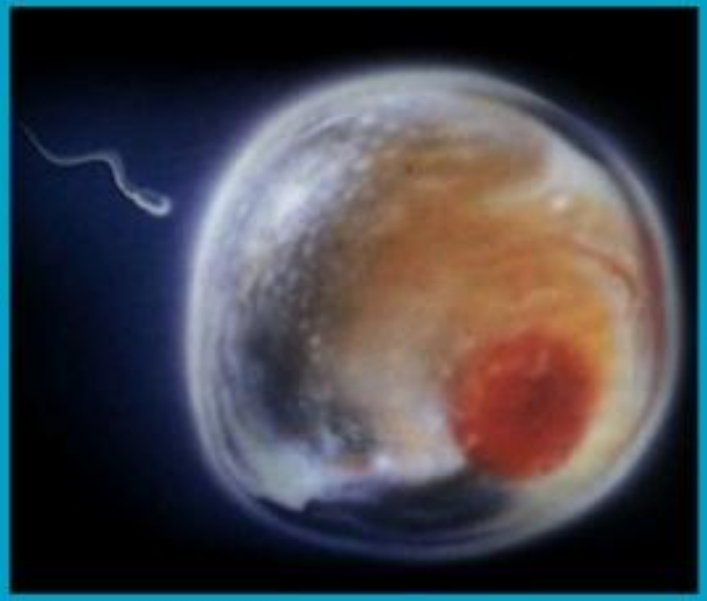
So, the egg can only have 23 chromosomes, and the sperm can only have 23 chromosomes

But, the integrity of the organism must be ma

How does this happen?

During Meiosis gamete (sex) cells undergo a "double division", maintaining the DNA, but reducing the chromosomal count to 23

+



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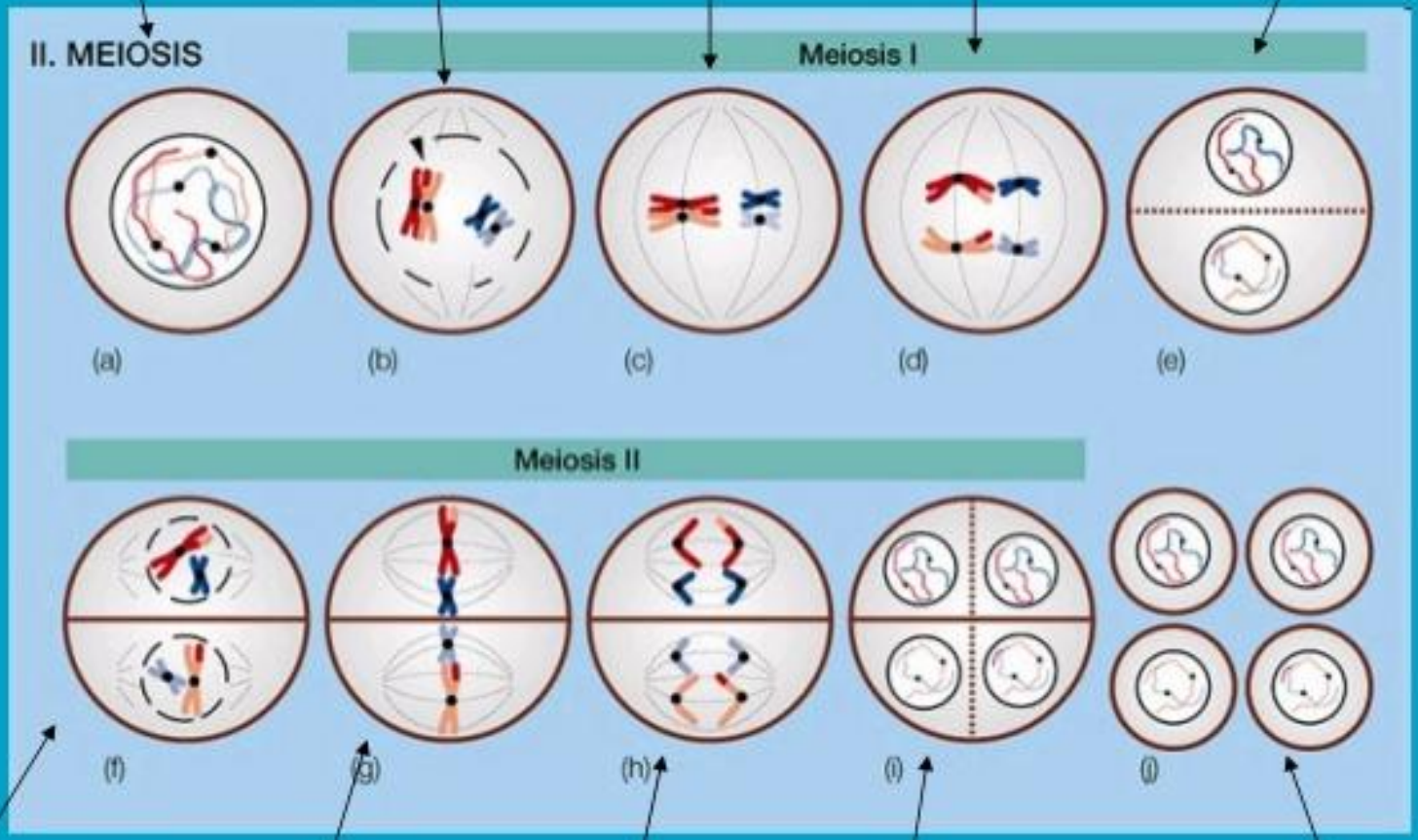
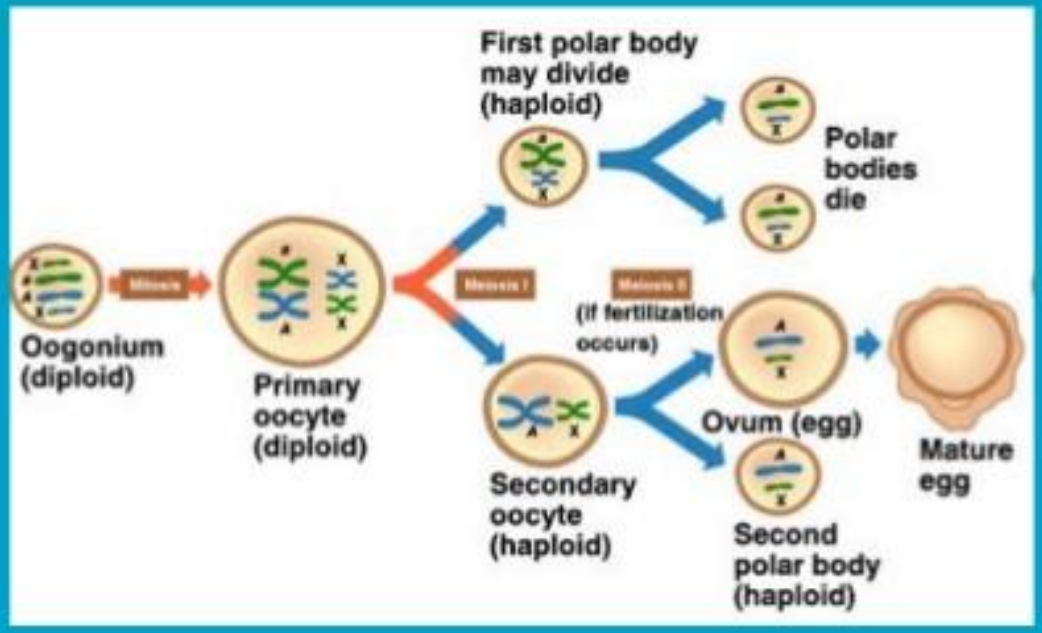
Sperm (23) + Egg (23) = Fertilized Cell (46)

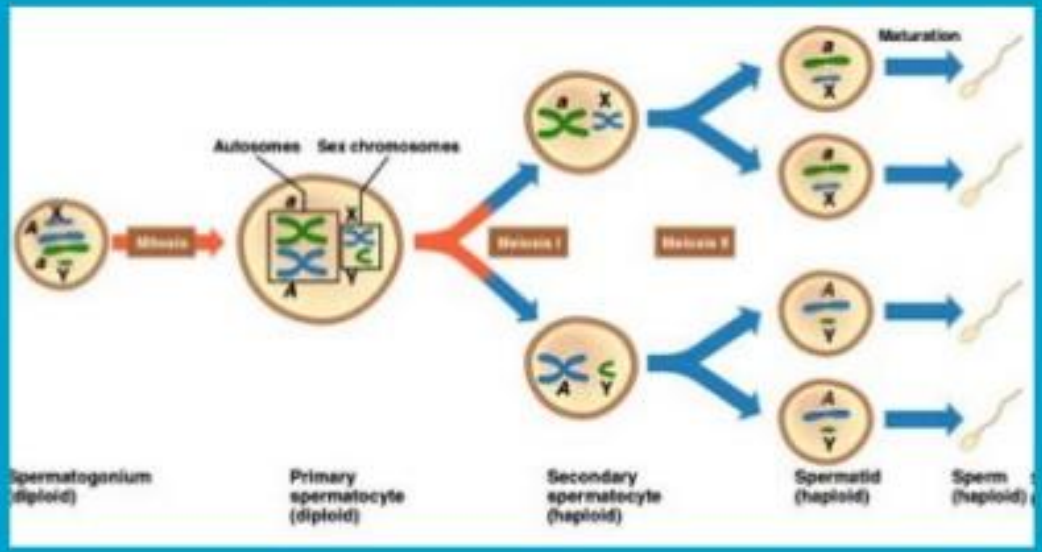
Original Gamete Metaphase Anaphase Telophase Cytokinesis




2 Daughter Cells Metaphase 2 Anaphase 2 Telophase 2 Cytokinesis – 4 Gametes




***OOGENESIS***




***SPERMATOGENESIS***

# Cellular Physiology:
## Membrane Transport

- Membrane Transport – movement of substance in and out of the cells
- Transport is by 2 basic methods:
  - Passive transport: No energy is required
  - Active transport: Metabolic energy required

# Selective Permeability

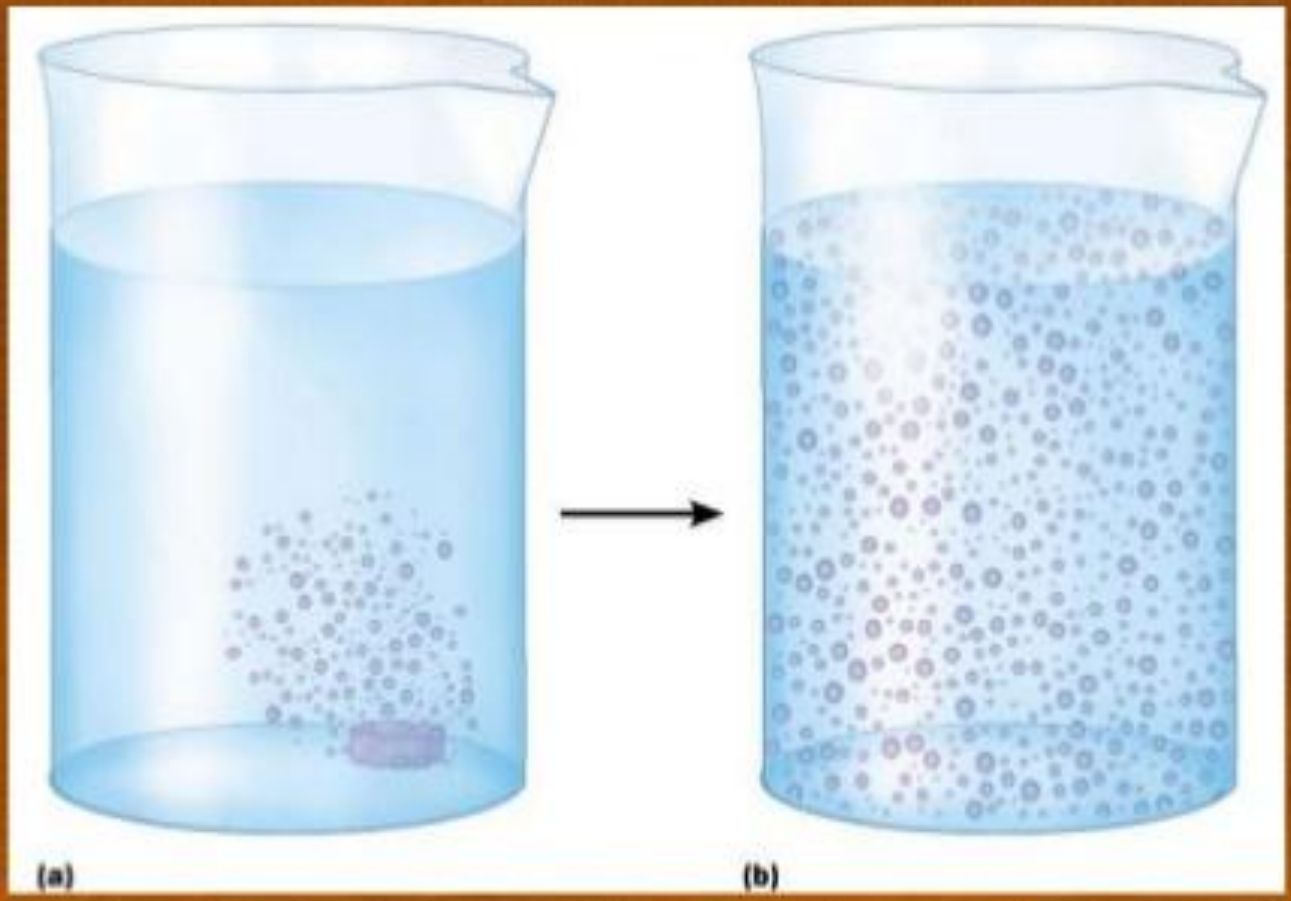
- The plasma membrane allows some materials to pass while excluding others

- This permeability includes movement in and out of the cells

# Passive Transport Processes

- Diffusion
  - Particles tend to distribute themselves evenly within a solution
  - Movement is from high concentration to low concentration, or down a concentration gradient

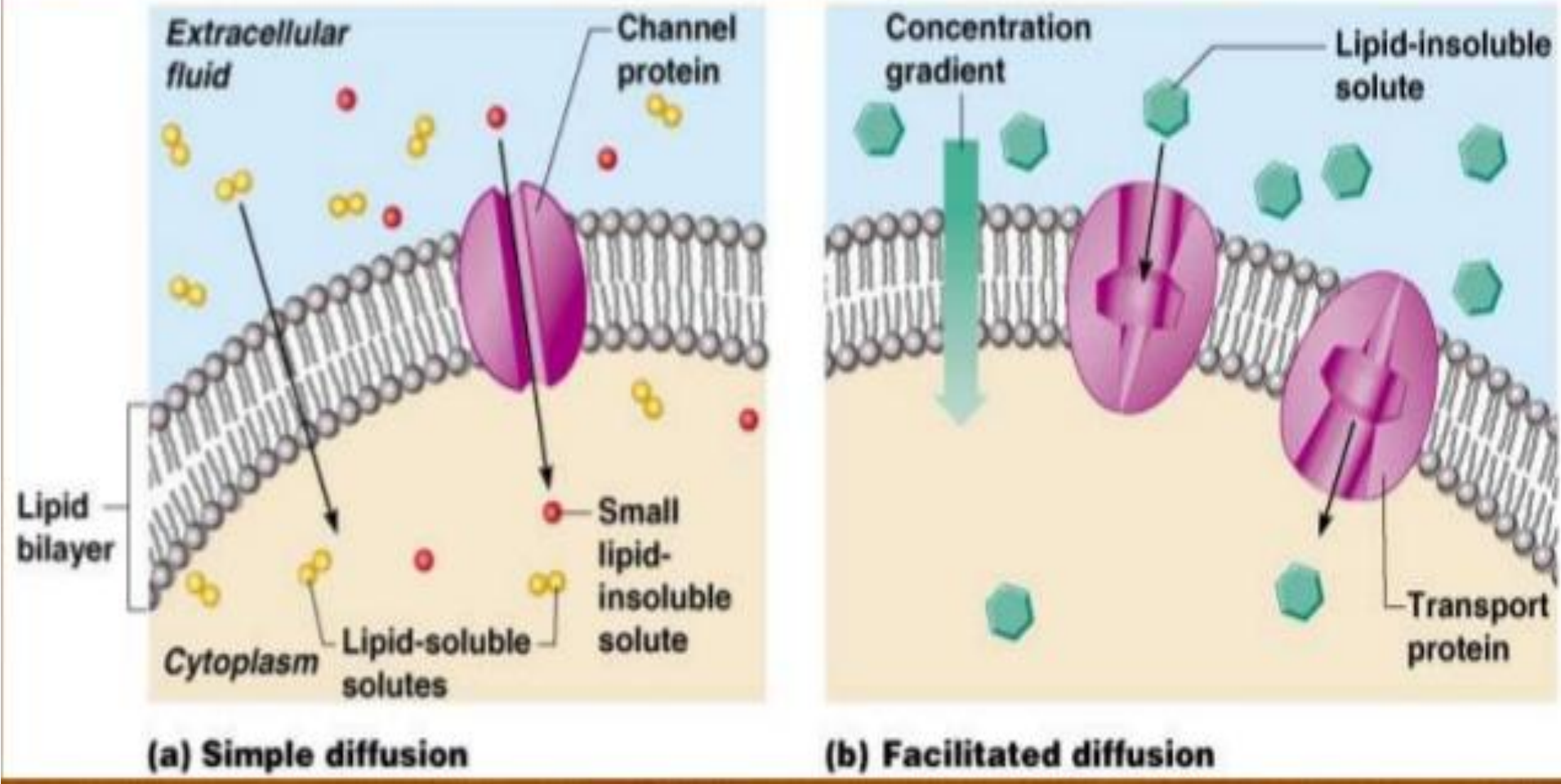
# Passive Transport Processes




Diffusion.

# Passive Transport Processes

- **Types of diffusion**
  - *Simple diffusion:* Unassisted process. Solutes are lipid-soluble materials or small enough to pass through membrane pores.
  - *Osmosis – simple diffusion of water:* Highly polar water easily crosses the plasma membrane.
  - *Facilitated diffusion:* Substances require a protein carrier for passive transport.




# Diffusion through Plasma Membrane

# Passive Transport Processes

- **Filtration:** Water and solutes are forced through a membrane by fluid, or hydrostatic pressure.
  - A pressure gradient must exist
  - Solute-containing fluid is pushed from high pressure area to lower pressure one

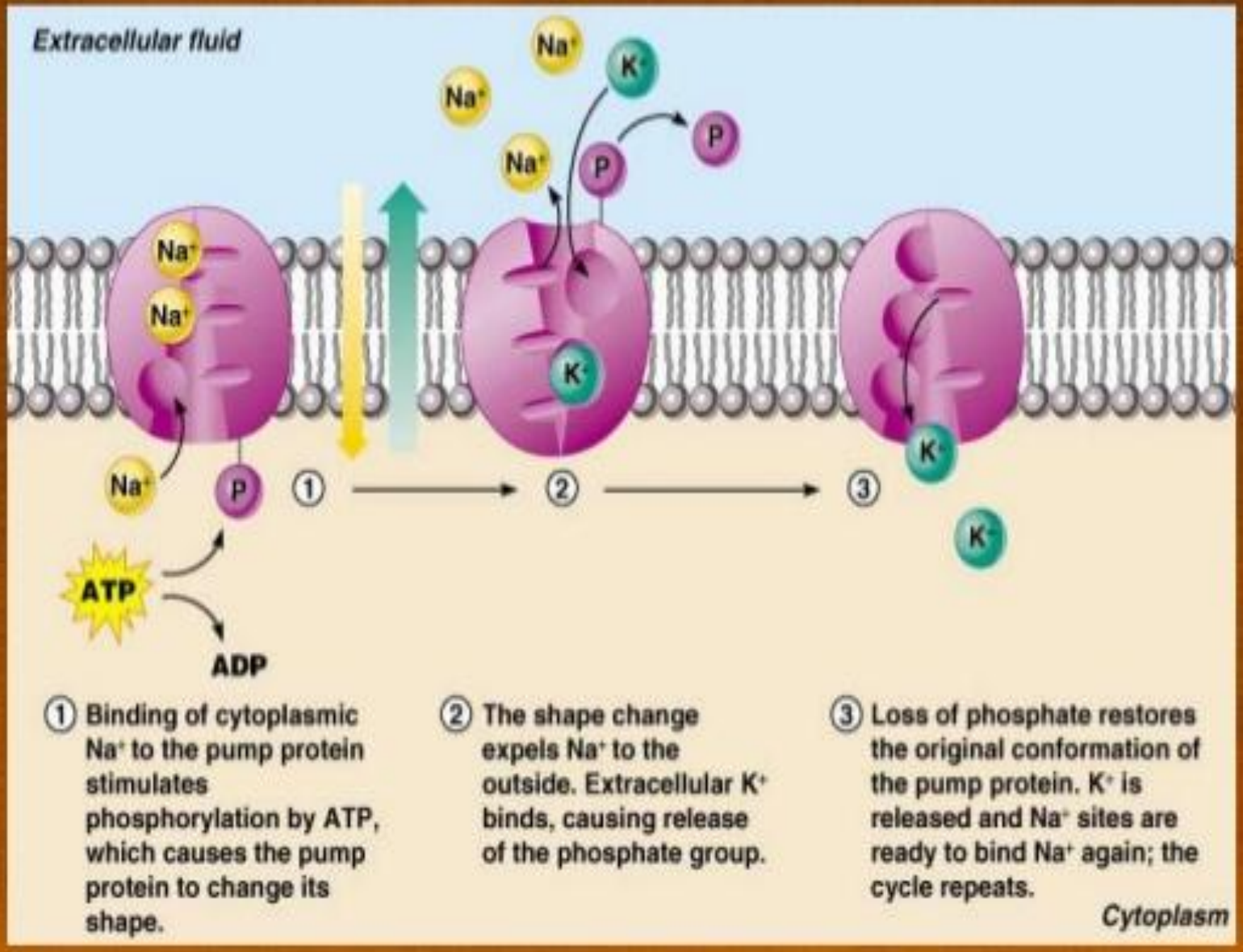
# Active Transport Processes

**Transport of substances that are not able to pass by diffusion because they:**

- May be too large
- May be unable to dissolve in the fat of membranes
- May have to move against a concentration gradient

**2 common forms of active transport:**

**Solute pumping & Bulk transport**



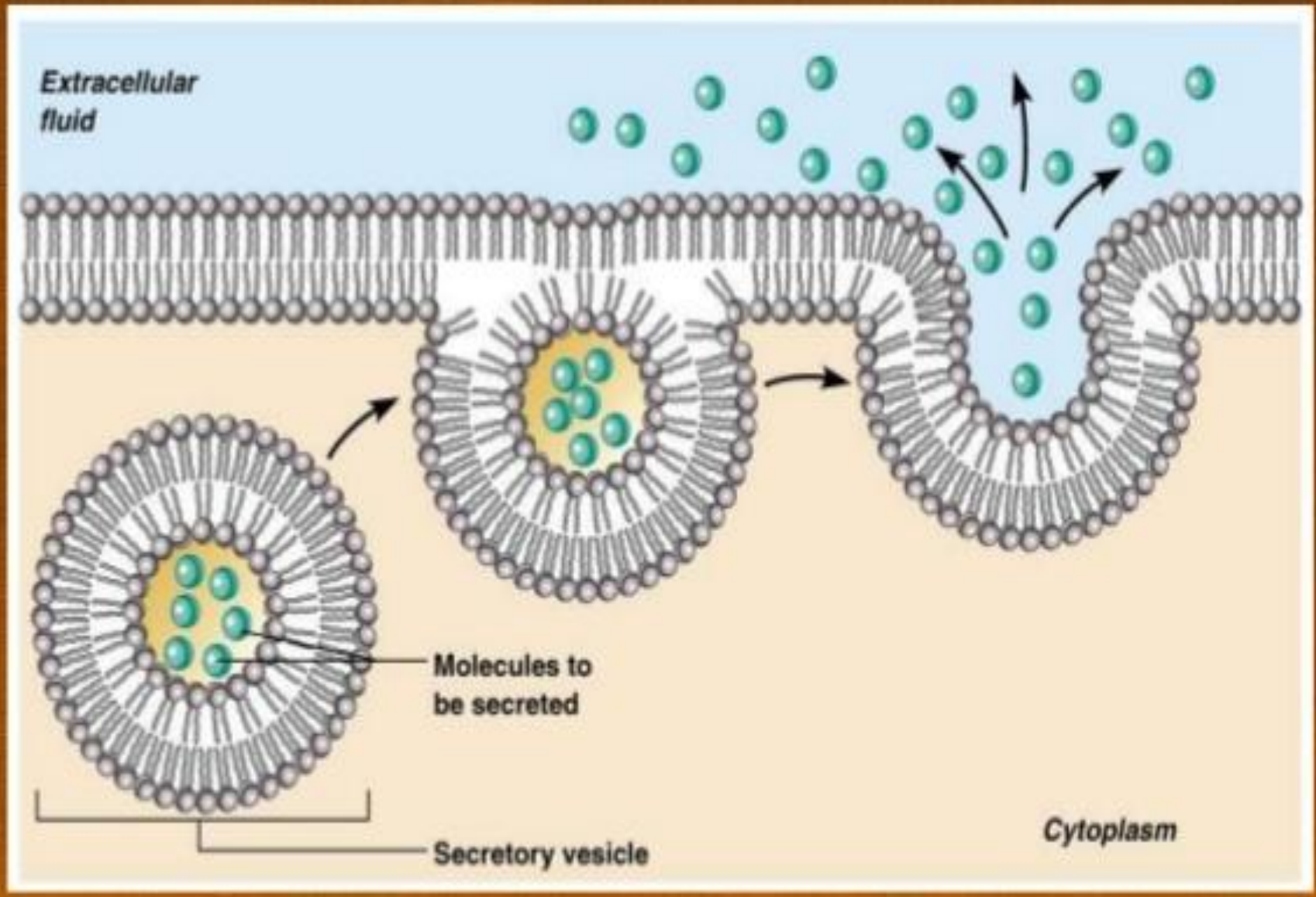

1. Binding of cytoplasmic $Na^+$ to the pump protein stimulates phosphorylation by ATP, which causes the pump protein to change its shape.
2. The shape change expels $Na^+$ to the outside. Extracellular $K^+$ binds, causing release of the phosphate group.
3. Loss of phosphate restores the original conformation of the pump protein. $K^+$ is released and $Na^+$ sites are ready to bind $Na^+$ again; the cycle repeats.

# Solute Pumping

# Active Transport Processes

- **Bulk transport**
  - **Exocytosis:** Moves materials out of the cell. Material is carried in a membranous vesicle.

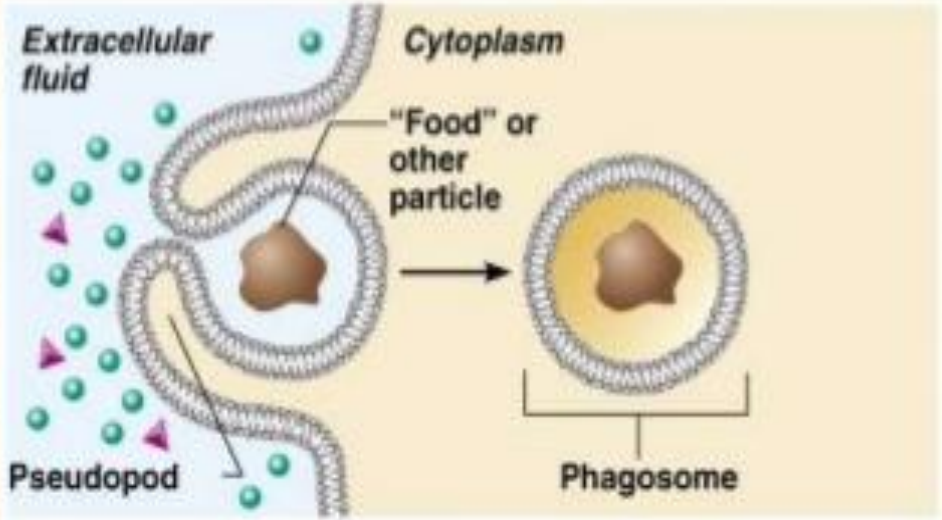
    *STEPS:*
    - Vesicle migrates to plasma membrane
    - Vesicle combines with plasma membrane
    - Material is emptied to the outside


Extracellular fluid
Molecules to be secreted
Secretory vesicle
Cytoplasm

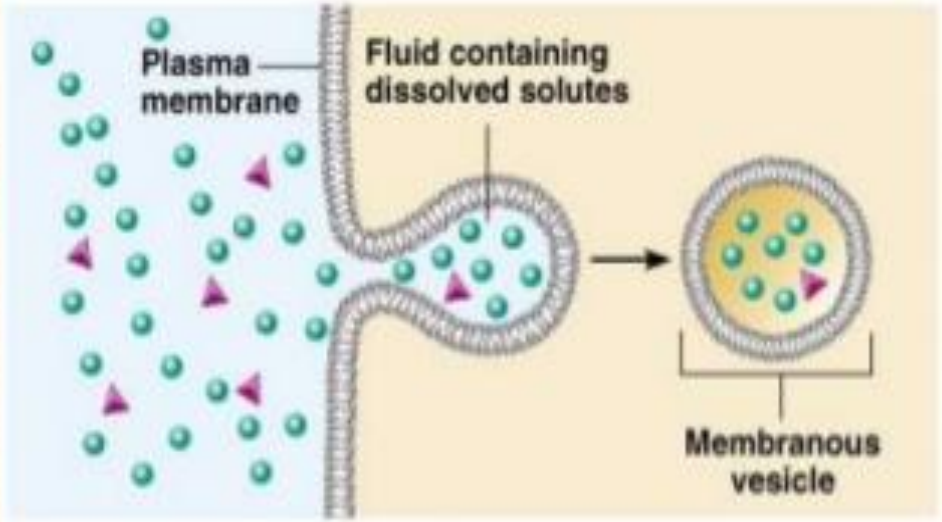
# Exocytosis

# Active Transport Processes

- **Bulk transport**
  - **Endocytosis:** Extracellular substances are engulfed by being enclosed in a membrane vesicle.
  - *TYPES OF ENDOCYTOSIS:*
    - Phagocytosis: cell eating
    - Pinocytosis: cell drinking




(a) Phagocytosis




(b) Bulk-phase endocytosis

# Endocytosis