Cell Biology course
For Clinical Pharmacy Students
Lecture 3

II

Cell Components

Dr. Tito Habib

Professor of Genetics& Molecular Biology

Objectives

By the end of this lecture you should be familiar with:

The following components of the cell:

1- Cytoplasm
2- Organelles
3- Cytoskeleton
4- Surface appendages

PARTS OF EUKARYOTIC CELL

INTRACELLULAR COMPONENTS

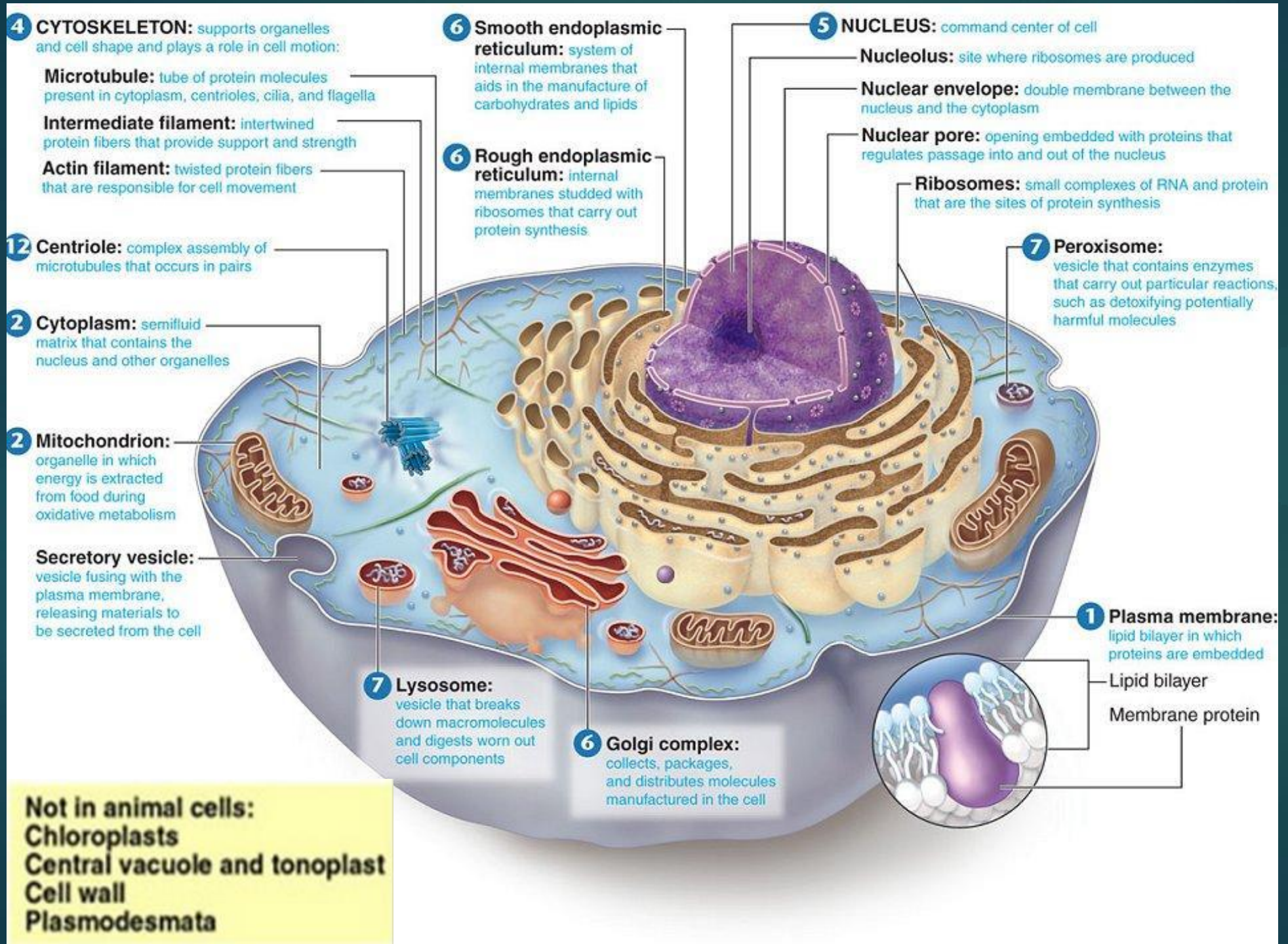
- CYTOPLASM
- ORGANELLES

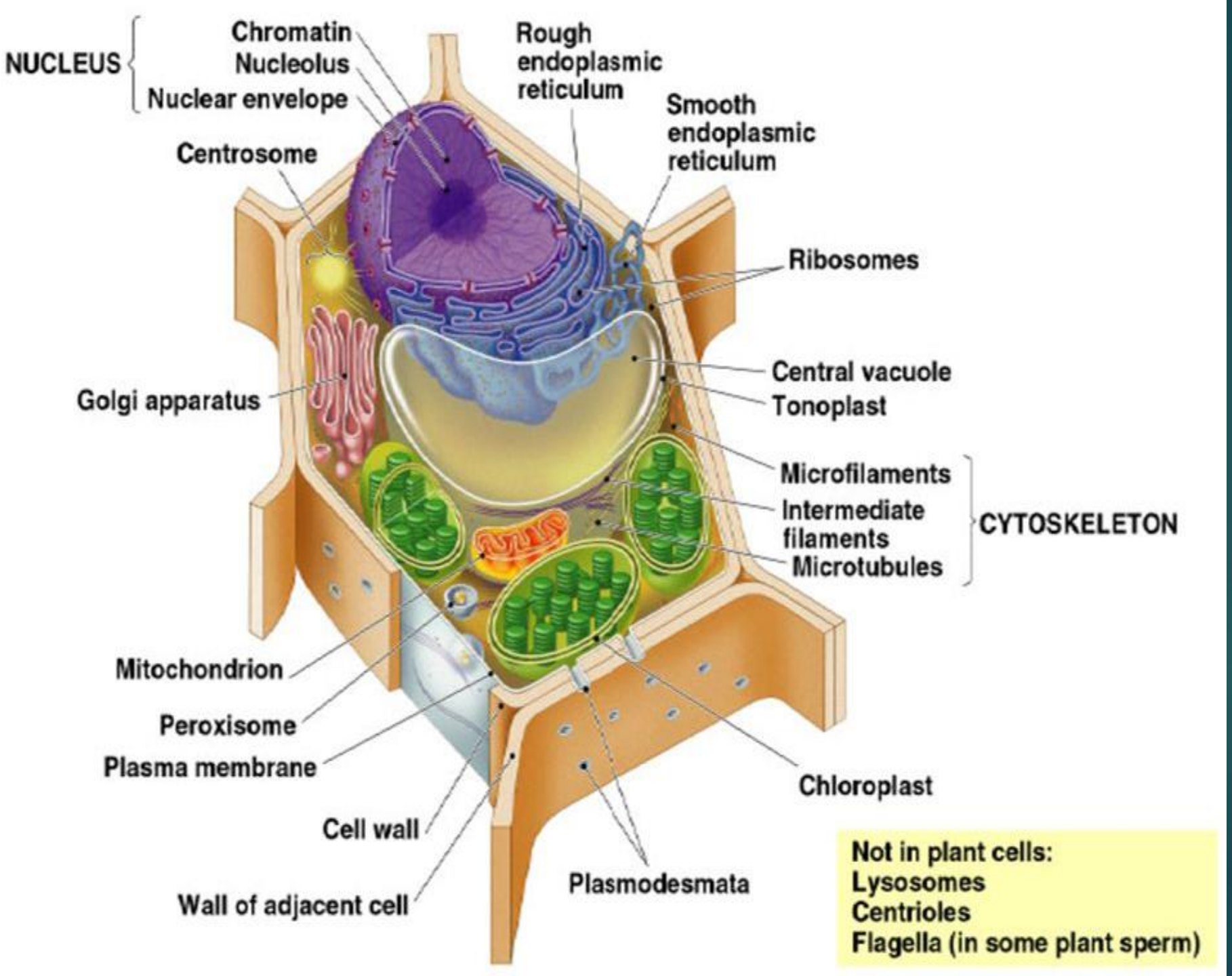
CYTOSKELETON

SURFACE APPENDAGES

- CELL WALL
- FLAGELLA
- CILLIA

CELL MEMBRANE


4 CYTOSKELETON: supports organelles and cell shape and plays a role in cell motion:
Microtubule: tube of protein molecules present in cytoplasm, centrioles, cilia, and flagella
Intermediate filament: intertwined protein fibers that provide support and strength
Actin filament: twisted protein fibers that are responsible for cell movement
12 Centriole: complex assembly of microtubules that occurs in pairs
2 Cytoplasm: semifluid matrix that contains the nucleus and other organelles
2 Mitochondrion: organelle in which energy is extracted from food during oxidative metabolism
Secretory vesicle: vesicle fusing with the plasma membrane, releasing materials to be secreted from the cell
6 Smooth endoplasmic reticulum: system of internal membranes that aids in the manufacture of carbohydrates and lipids
6 Rough endoplasmic reticulum: internal membranes studded with ribosomes that carry out protein synthesis
5 NUCLEUS: command center of cell
Nucleolus: site where ribosomes are produced
Nuclear envelope: double membrane between the nucleus and the cytoplasm
Nuclear pore: opening embedded with proteins that regulates passage into and out of the nucleus
Ribosomes: small complexes of RNA and protein that are the sites of protein synthesis
7 Peroxisome: vesicle that contains enzymes that carry out particular reactions, such as detoxifying potentially harmful molecules
7 Lysosome: vesicle that breaks down macromolecules and digests worn out cell components
6 Golgi complex: collects, packages, and distributes molecules manufactured in the cell
1 Plasma membrane: lipid bilayer in which proteins are embedded
Lipid bilayer
Membrane protein
Not in animal cells:
Chloroplasts
Central vacuole and tonoplast
Cell wall
Plasmodesmata


NUCLEUS
Chromatin
Nucleolus
Nuclear envelope
Centrosome
Rough endoplasmic reticulum
Smooth endoplasmic reticulum
Ribosomes
Golgi apparatus
Central vacuole
Tonoplast
Microfilaments
Intermediate filaments
Microtubules
CYTOSKELETON
Mitochondrion
Peroxisome
Plasma membrane
Cell wall
Wall of adjacent cell
Plasmodesmata
Chloroplast
Not in plant cells:
Lysosomes
Centrioles
Flagella (in some plant sperm)

CYTOSOL

- The **cytosol** is the ***internal fluid*** of the cell.
- ***In prokaryotes*** , all chemical reactions take place in the cytosol.
- ***In eukaryotes*** , the cytosol contains the cell organelles ; this is collectively called cytoplasm.
- ***In plants*** , the amount of cytosol can be reduced due to the large central vacuole.

Cell organelles

- Structurally ***discrete*** components of a cell.
- An organelle is one of several structures with ***specialized functions*** , suspended in the cytoplasm of a eukaryotic cell.
- In the organelle, the cell maintains ***specific environment*** for the biochemical reactions.

ORGANELLES

I-Membranous organelles

- Endomembrane system (nuclear envelope, endoplasmic reticulum, Golgi apparatus, lysosomes, and vesicles).
- Nucleus (separate lecture).
- Other membranous organelles.

II-Energy related organelles

Endomembrane System

1-Endoplasmic Reticulum (ER)

- Endoplasmic "within the cytoplasm" Reticulum "network"; network of membranous tubules and sacs called ***CISTERNAE.***
- ER membrane is **continuous** with the nuclear envelope.
- It ***separates*** its internal space from the cytosol.
- It accounts for ***more than half*** the total membrane in many eukaryotic cells.

Endoplasmic Reticulum (ER)

1. ***Rough ER***: studded with ***ribosomes***

Functions:

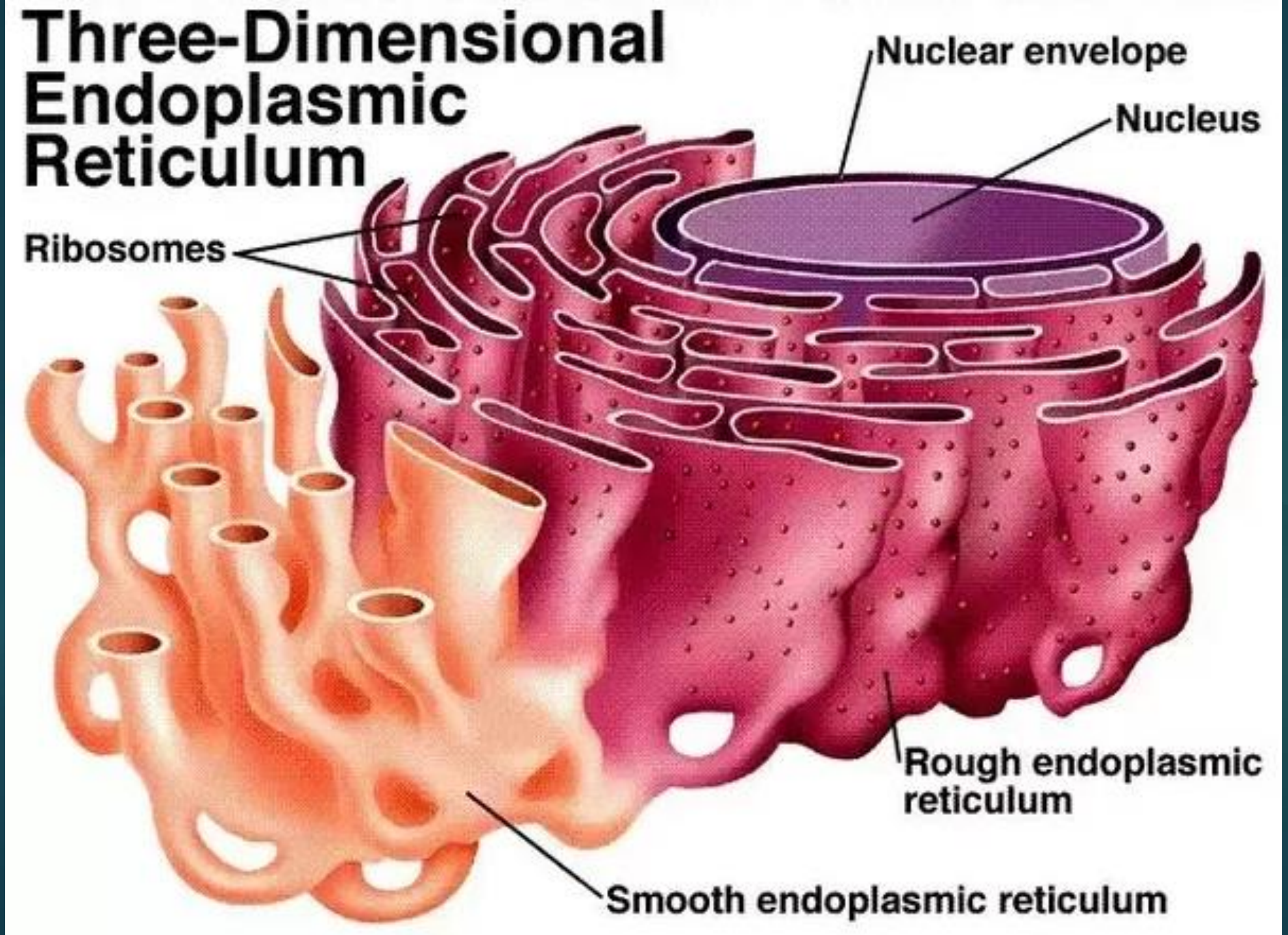
- Processing and modification of newly formed proteins (addition of sugar chain).
- Make proteins for export from cell (e.g. secreted enzymes)
- Intracellular transport
- Temporary storage

Endoplasmic Reticulum (ER)

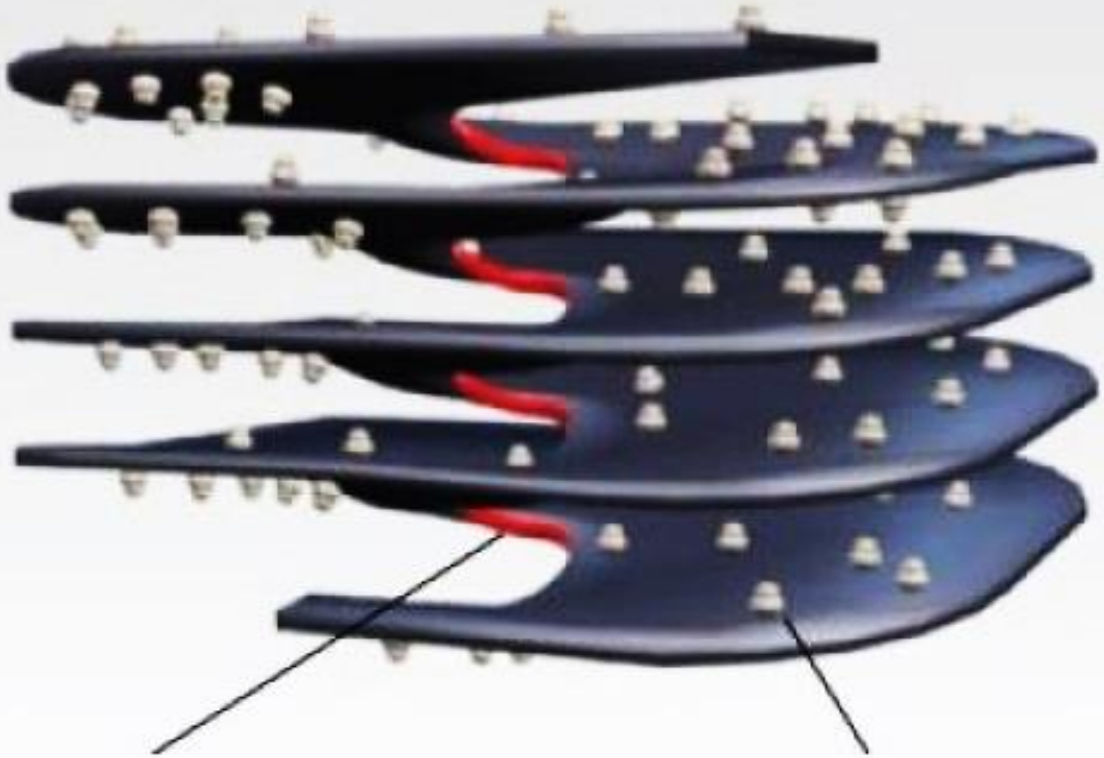
2. Smooth ER: no attached ribosomes

Functions:

- Lipid synthesis (phospholipids).
- Vesicles transport new proteins to Golgi apparatus
- Storage area for Ca^{2+}
- Surface area for enzymatic reactions
- Detoxification reactions


Three-Dimensional Endoplasmic Reticulum
Nuclear envelope
Nucleus
Ribosomes
Rough endoplasmic reticulum
Smooth endoplasmic reticulum

"Parking garage" model of stacked ER sheets



helicoidal ramp

membrane-bound ribosome

2-Golgi apparatus

- Golgi bodies are ***flattened stack of membranes*** that are scattered throughout the cytoplasm.

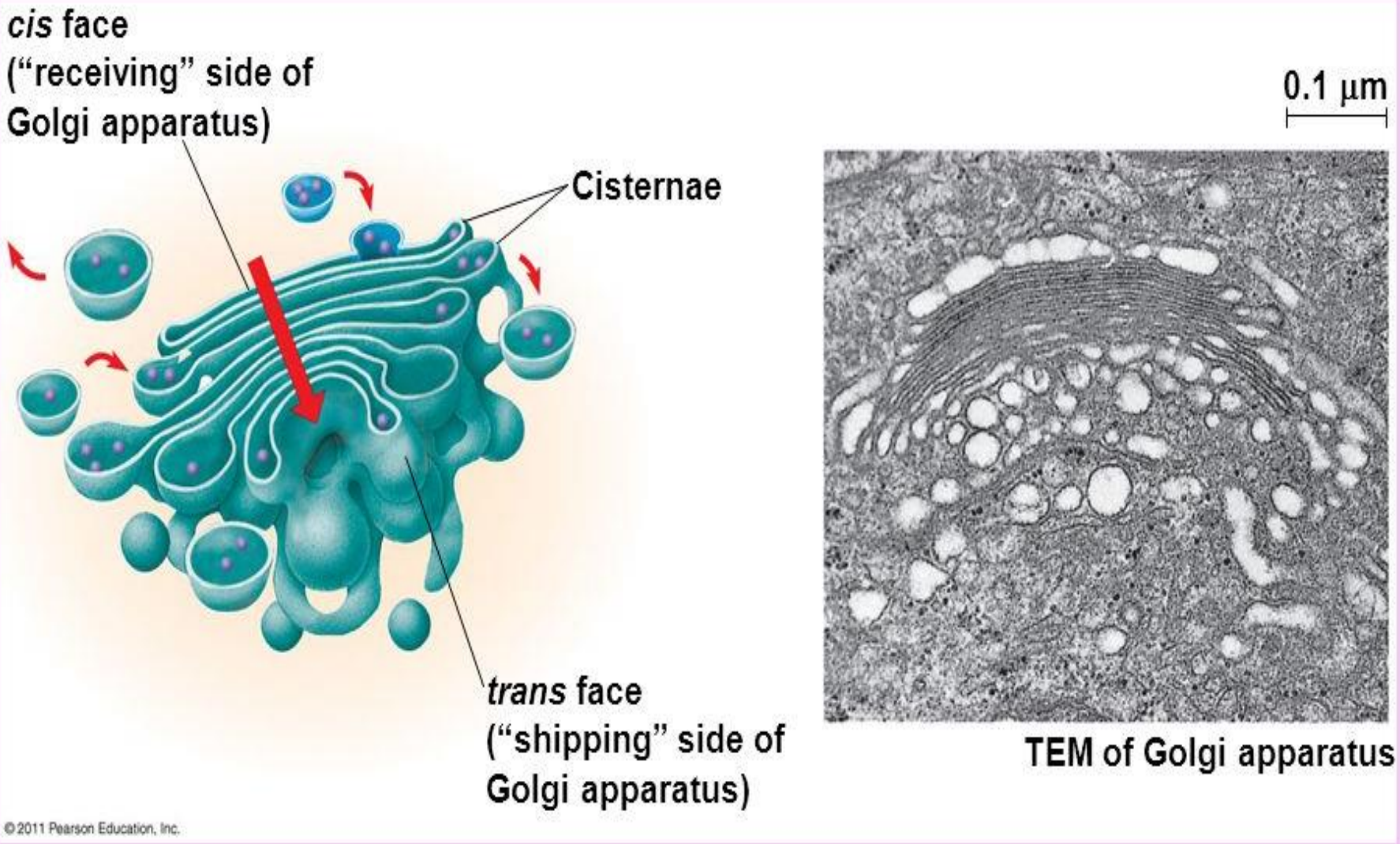
- Its ***cis*** face is the side facing the ER, while the ***trans*** face is directed towards the plasma membrane.

- The Golgi complex is like a post office collects, packages, modifies and distributes molecules.

Functions:

- Receives proteins from rough ER and puts finishing touches on them
- Involved in secretion of protein out of cell by forming **secretory vesicles.**
- Forms new membrane components
- Packages lysosomes.

Golgi Apparatus (Golgi Complex)



TEM of Golgi apparatus

3-Lysosomes

- Arise from the Golgi complex
- They contain enzymes that break down macromolecules.
- Function in intracellular digestion of:
  -Worn-out cellular components (autophagy).
  -Substances taken into cells.
  The resulting material is then recycled.

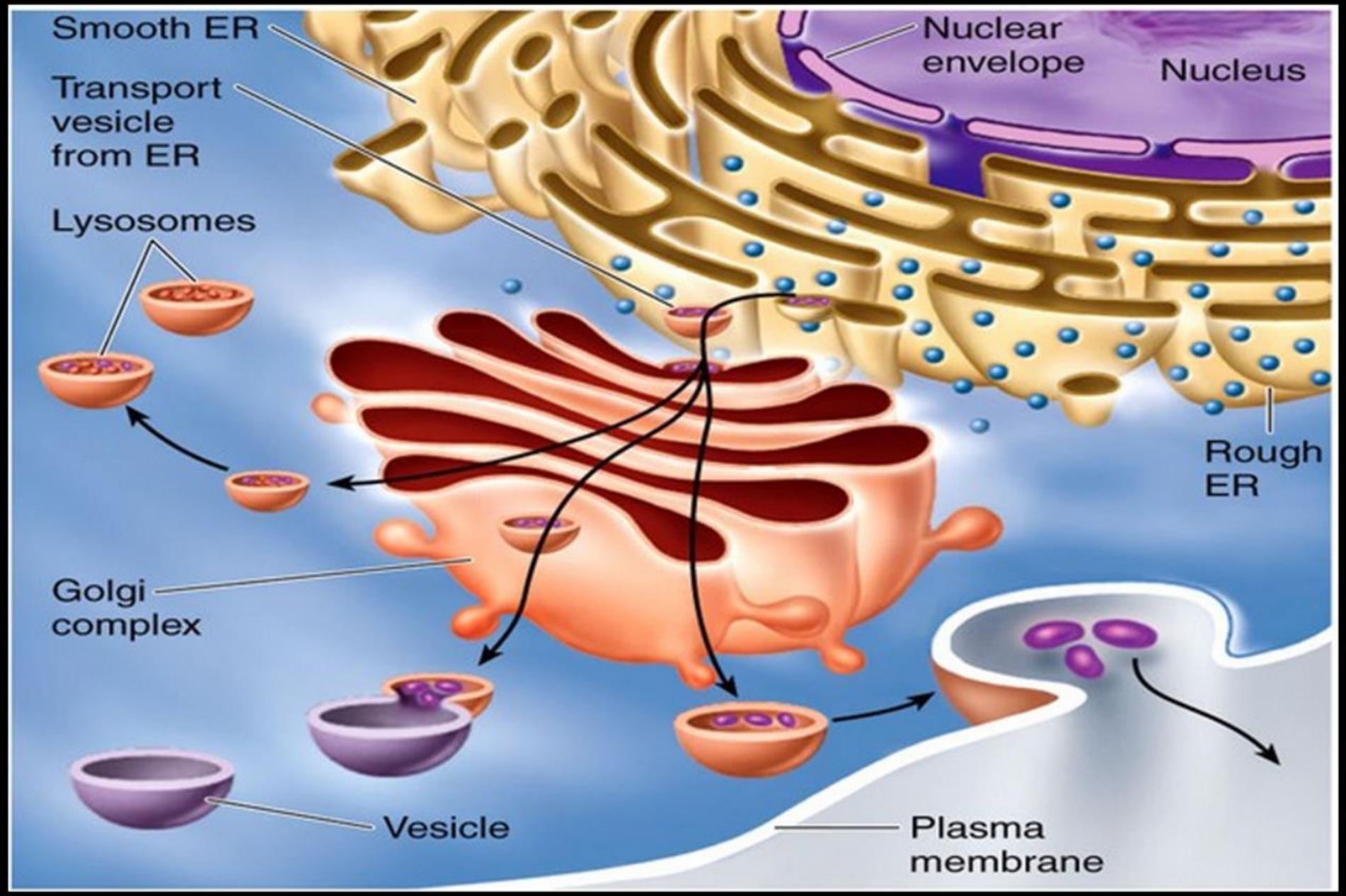
4-Vesicles

- Relatively small and enclosed compartment, separated from the cytosol by at least one lipid bilayer ***(unilamellar)*** vesicles; or multiple bilayers ***(multilamellar).***

- Vesicles store, transport, or digest cellular products and wastes.

- Many of them are made in the ***Golgi*** apparatus, but also in the ***ER***, or are made from parts of the ***plasma membrane*** .

How the Endomembrane System Works



Other membranous organelles

1-Peroxisomes (microbodies)

- They resemble a lysosome, however, they are ***not formed in the Golgi*** complex.
- They contain ***enzymes*** that breakdown lipids, and hydrogen peroxide and function to ***rid the body of toxic substances.***
- They are a major site of ***oxygen utilization*** and are numerous in ***the liver*** where toxic byproducts are going to accumulate.

2-Vacuoles

- Vacuoles are bounded by a ***single*** membrane.
- Young plant cells often contain many small vacuoles, but as the cells mature, these unite to form a large **central vacuole.**

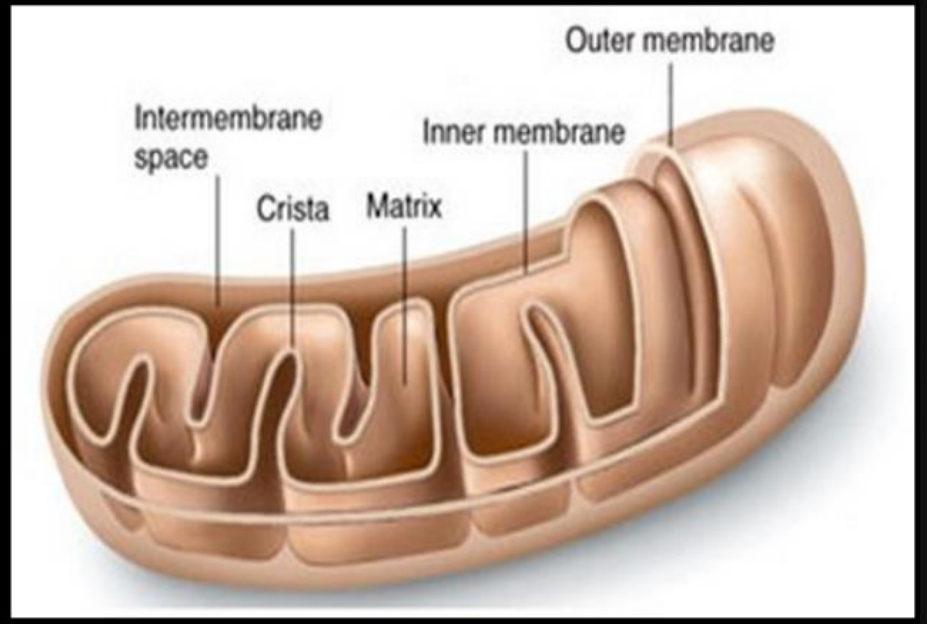
Functions:

- Storing foods (e.g., proteins in seeds)
- Storing wastes, pigments
- Repository of inorganic ions –potassium, chloride
- Protection of plants

Energy Related Organelles

1-Mitochondria

- Consists of double membrane: Outer and inner membrane.
- Inner membrane contains foldings called ***cristae.***
- Inner fluid-filled space is mitochondrial ***matrix.***



Mitochondrial matrix contains DNA (circular), RNA, ribosomes, proteins.

Mitochondria

- Functions in ***ATP production*** ("energy factory" of cell).
- Enzymes for ATP production are located on **inner membrane,** ATP produced in matrix, must be transported across double-membrane for use in cellular activities.
- **General Rule** = mitochondria are located near where ATP is most needed. Cells active in metabolism (energy usage) have many mitochondria (e.g., muscle), inactive cells don't (e.g., adipose).

2-Chloroplasts

- The chloroplast is made up of *3 types of membrane*:

  1- A smooth ***outer membrane*** which is freely permeable to molecules.

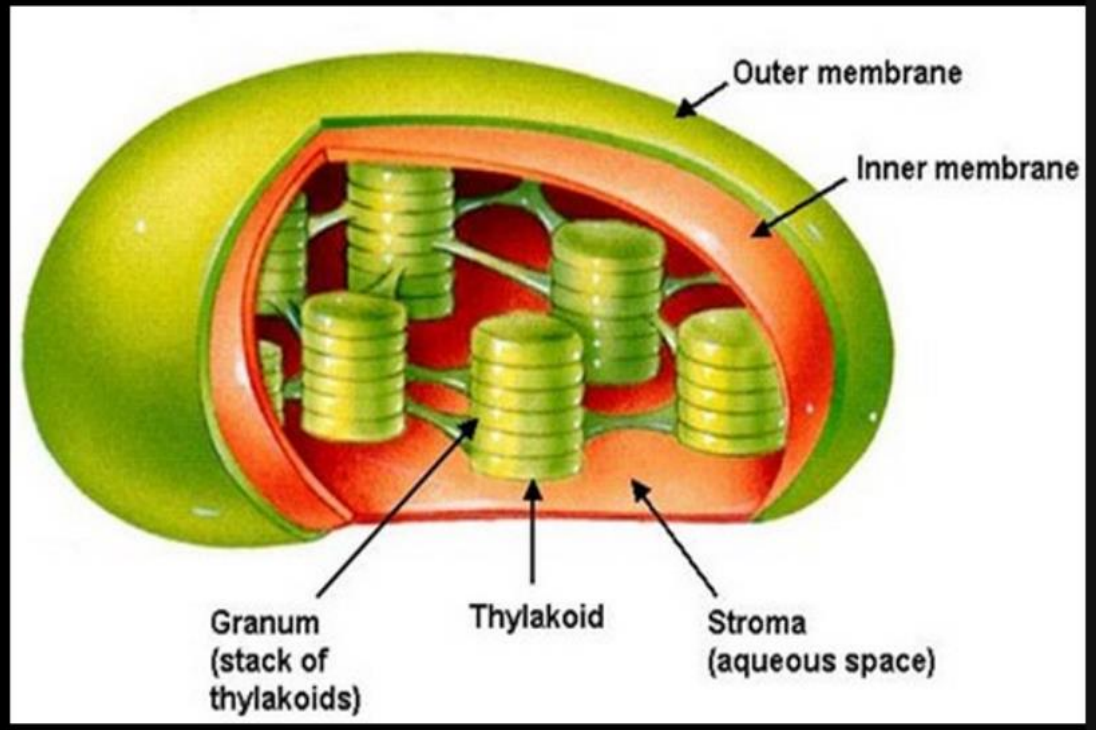
  2- A smooth ***inner membrane*** which contains many transporters: that regulate the passage in an out of the chloroplast of:

  - small molecules like sugars
  - proteins synthesized in the cytoplasm of the cell but used within the chloroplast

- 3- A system of ***thylakoid membranes*** .

Chloroplasts

- The thylakoid membranes enclose a system of vesicles (that may all be interconnected).



- At various places within the chloroplast these are stacked in arrays called ***grana*** (resembling a stack of coins).

- The thylakoid membranes are surrounded by a fluid ***stroma.***

Chloroplasts

- Site of photosynthesis.
- Use solar energy to produce food (carbohydrates).
- Have their own DNA and ribosomes to make their own enzymes.

The Cytoskeleton

A network of fibers extending throughout the cytoplasm

Functions:

- Maintain cell shape and movement
- Providing mechanical strength
- Intracellular transport of organelles
- Chromosome separation in cell division

The Cytoskeleton

Contains three types of elements:

1. Microfilaments - Actin filaments

-support cell shape

2. Microtubules - tubulin

-Movement.

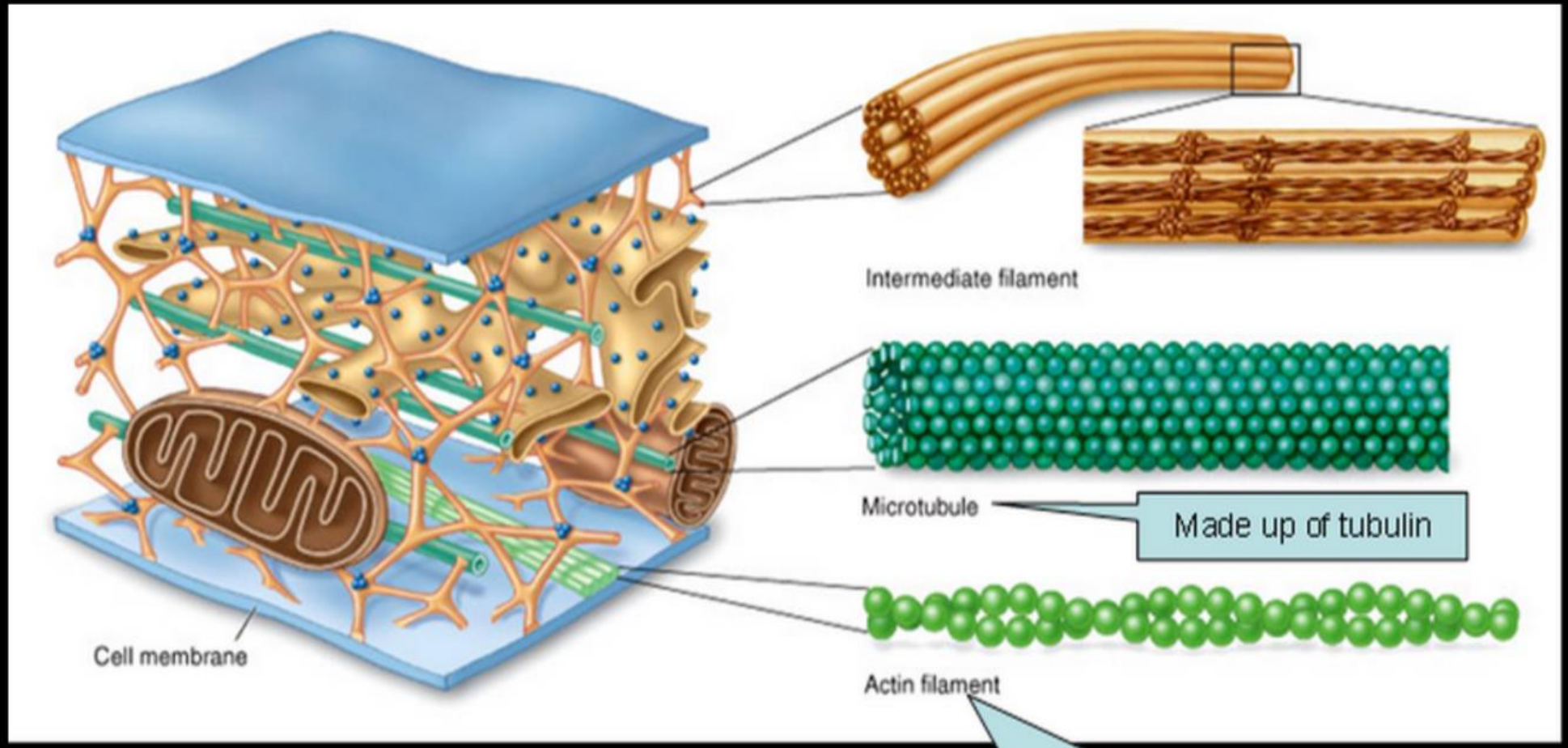
-Serve as tracks along which organelles can move such as vesicles.

-Include centrioles (involved in cell division).

3. Intermediate filaments

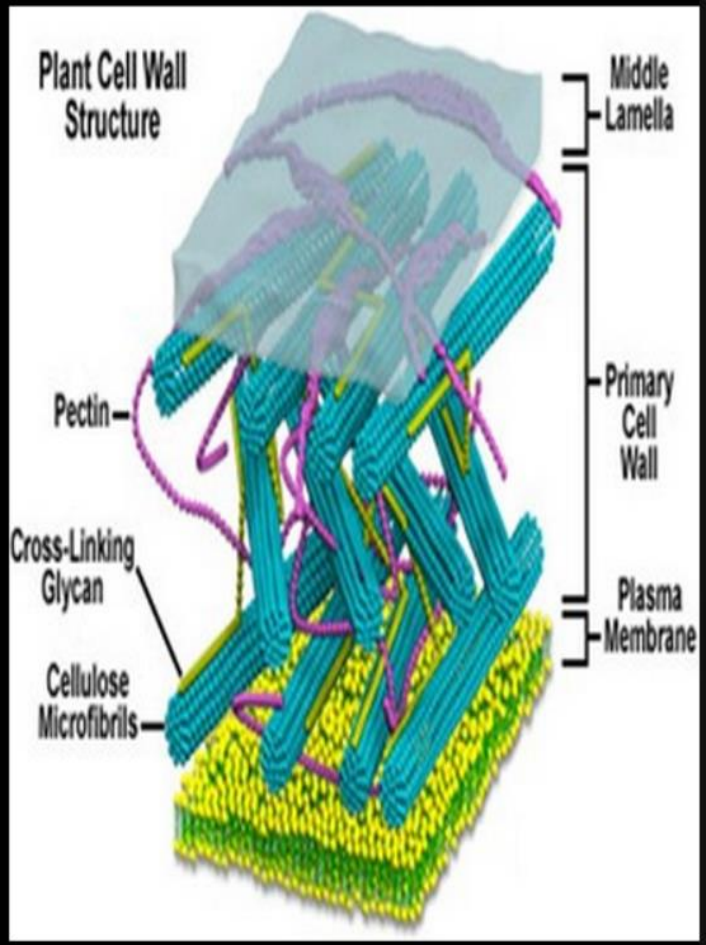
permanent fixtures, keep organelles in place (nucleus).

The Cytoskeleton



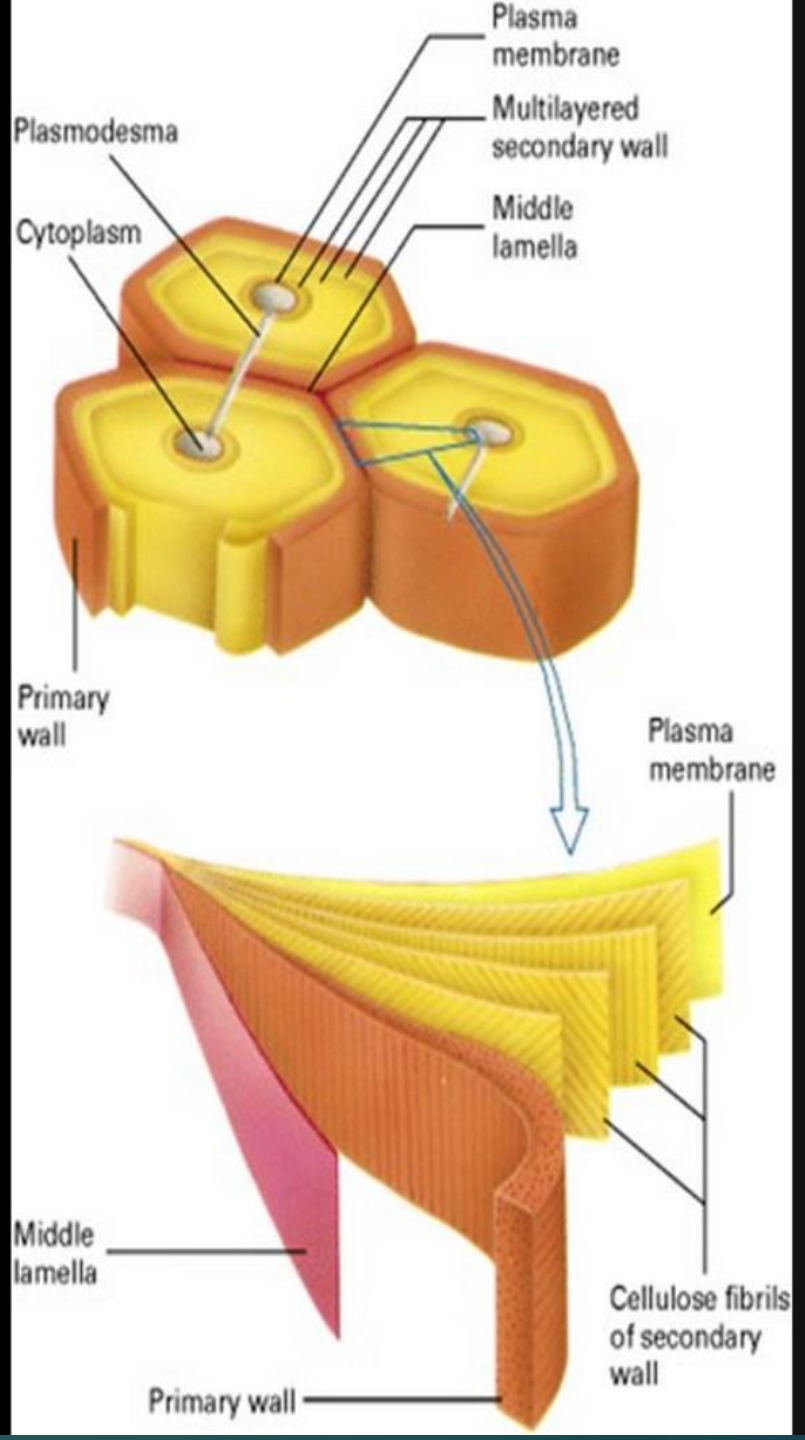
Cell Wall

- Cell walls are carbohydrate frameworks for mechanical support in plants; ***cell walls are not found in animals*** .
- In growing plant parts, bundles of **cellulose** strands form a primary cell wall that is elastic enough to allow enlargement under pressure.

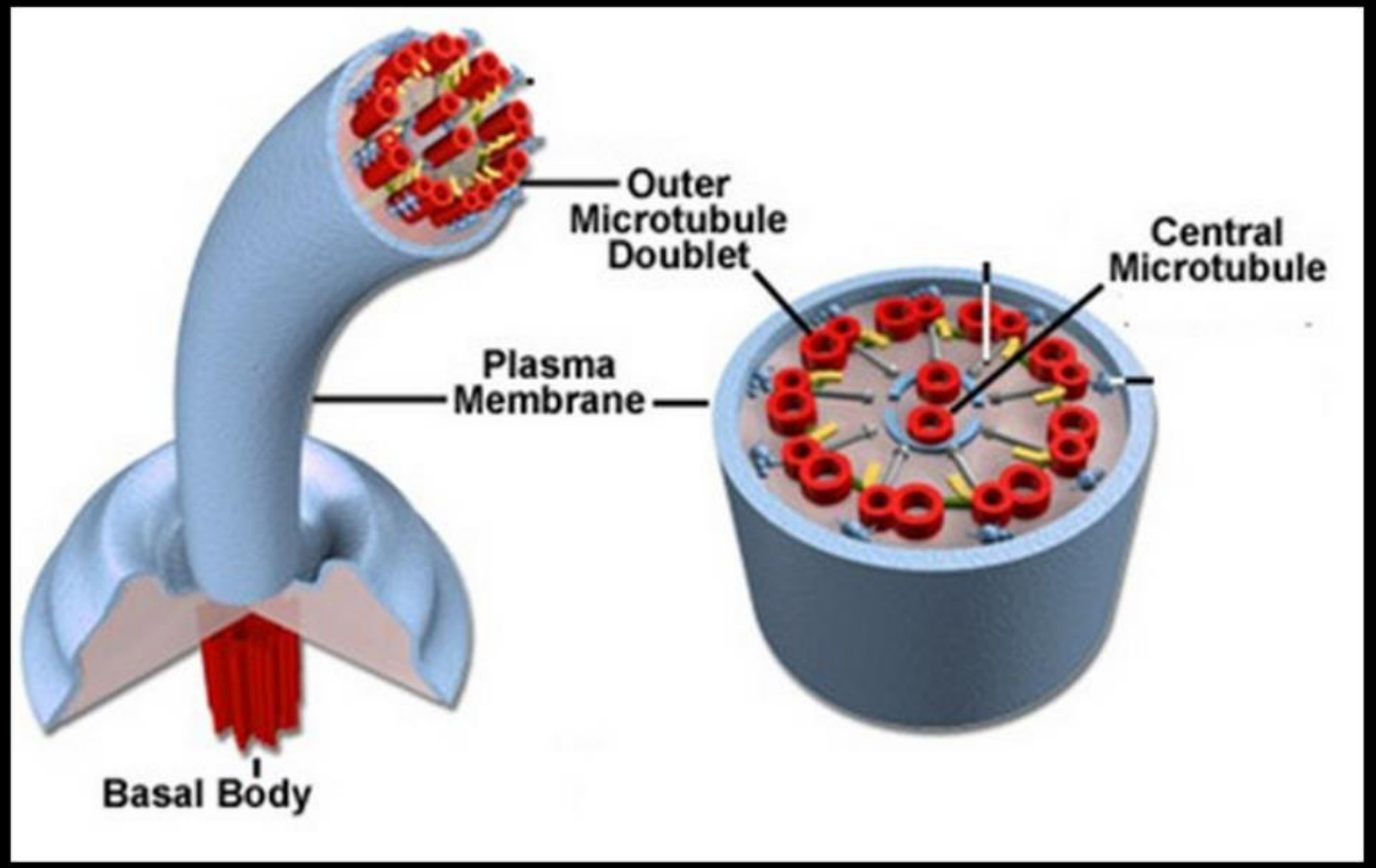


- Later, more layers are deposited on the ***inside*** of the primary wall to for the secondary wall.

- ***Lignin*** composes up to 25 percent of the secondary wall in woody plants; it makes plant parts stronger, more waterproof, and less inviting to insects.



Flagella and Celia



- Consist of a ***9 + 2*** arrangement of ***microtubules***
- Anchored in the cell by a ***basal body***
- In the basal body, there is no central microtubule and each of the nine pairs has an additional microtubule fused with it, making nine triplets

Flagella and Celia

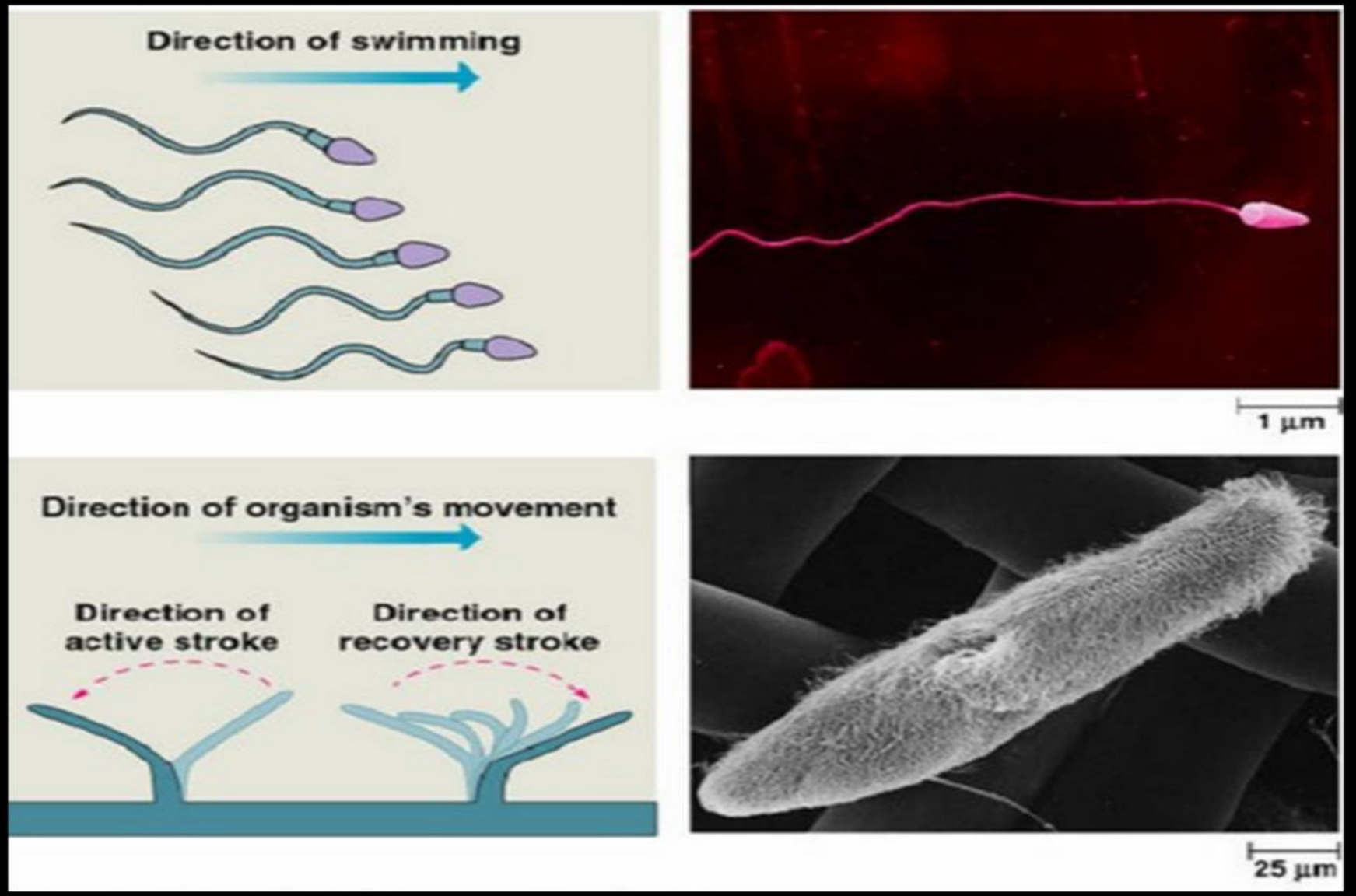
Flagella

- Long and few in number.
- Rolling motion that generates force in the same direction as the flagellum's axis.

Cilia

- Short and numerous.
- Alternating power and recovery strokes generating force in a direction perpendicular to the cilium's axis.

Flagella and Celia



Extracellular matrix (ECM)

- In **plants** , the ECM is primarily composed of ***cellulose*** .
- In **arthropods** and fungi, the ECM is largely composed of ***chitin*** .
- In **vertebrates** , the ECM is made of a complex mixture of carbohydrates and proteins (plus minerals in the case of bone).

Extracellular matrix (ECM)

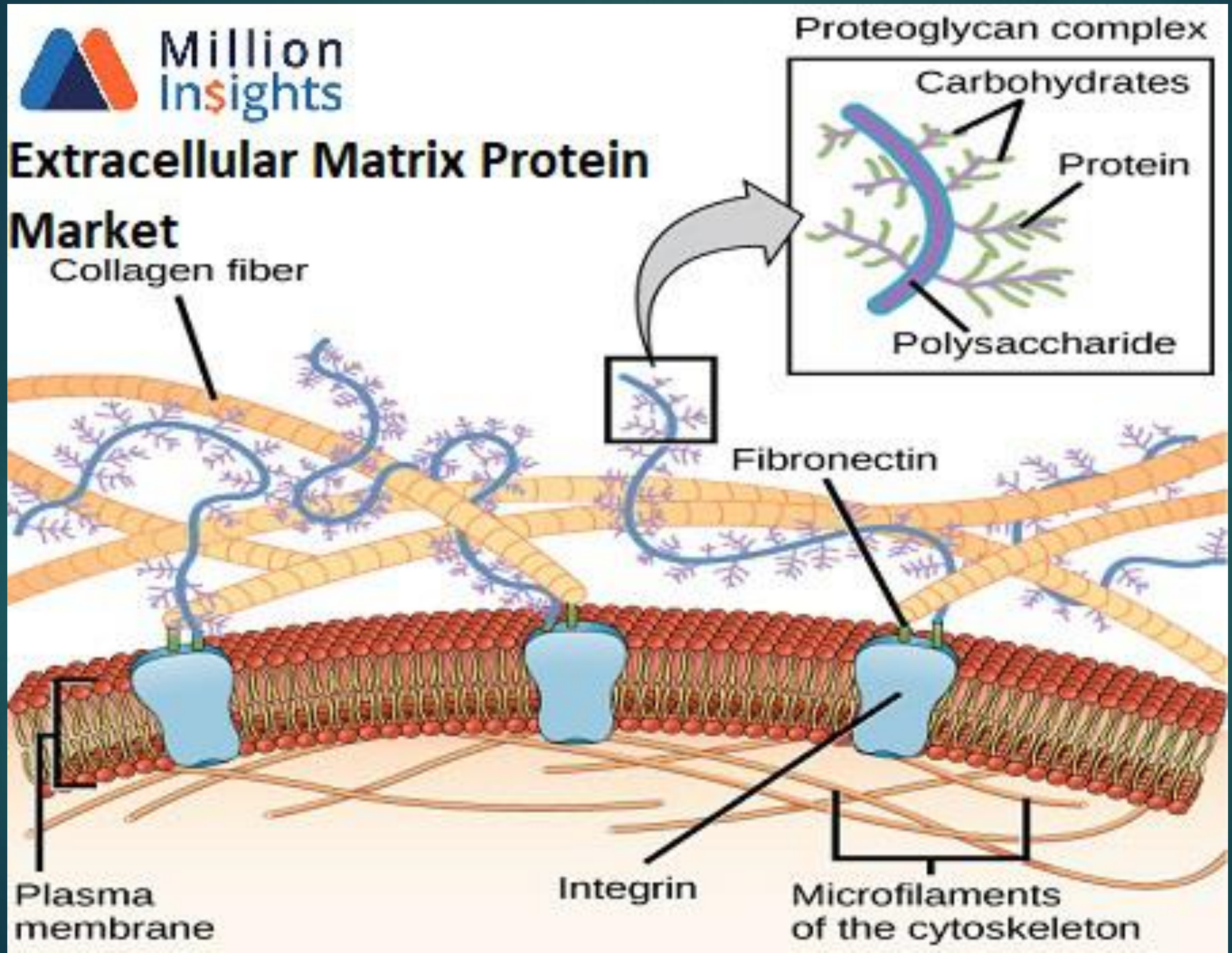
- Cells attach to the ECM by means of transmembrane glycoproteins called ***integrins*** .
- The extracellular portion of integrins binds to various types of ECM proteins:

  Collagens
  Laminins
  Fibronectin

- The intracellular portion binds to the actin filaments of the cytoskeleton.

Million Insights

Extracellular Matrix Protein Market



Summary

Internal components of the cell:

- Cytosol
- Organelles:
  - Membranous
  - Energy related

Other cell components:

Cytoskeleton

Surface appendages