BCH 211/201

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Prokaryotic and Eukaryotic cells

There are two types of cells: prokaryotic and eukaryotic.

Comparing Prokaryotic and Eukaryotic Cells

- Cells fall into one of two broad categories: prokaryotic and eukaryotic. The single-celled organisms of the domains Bacteria and Archaea are classified as prokaryotes (*pro* = before; *karyon*– = nucleus). Animal cells, plant cells, fungi, and protists are eukaryotes (*eu* = true).

Components of Prokaryotic Cells

All cells share four common components:

(1) a plasma membrane, an outer covering that separates the cell's interior from its surrounding environment;

(2) cytoplasm, consisting of a jelly-like region within the cell in which other cellular components are found;

(3) DNA, the genetic material of the cell; and

(4) ribosomes, particles that synthesize proteins. However, prokaryotes differ from eukaryotic cells in several ways.

- A **prokaryotic cell** is a simple, single-celled (unicellular) organism that lacks a nucleus, or any other membrane-bound organelle. We will shortly come to see that this is significantly different in eukaryotes. Prokaryotic DNA is found in the central part of the cell: a darkened region called the nucleoid (Figure 1).

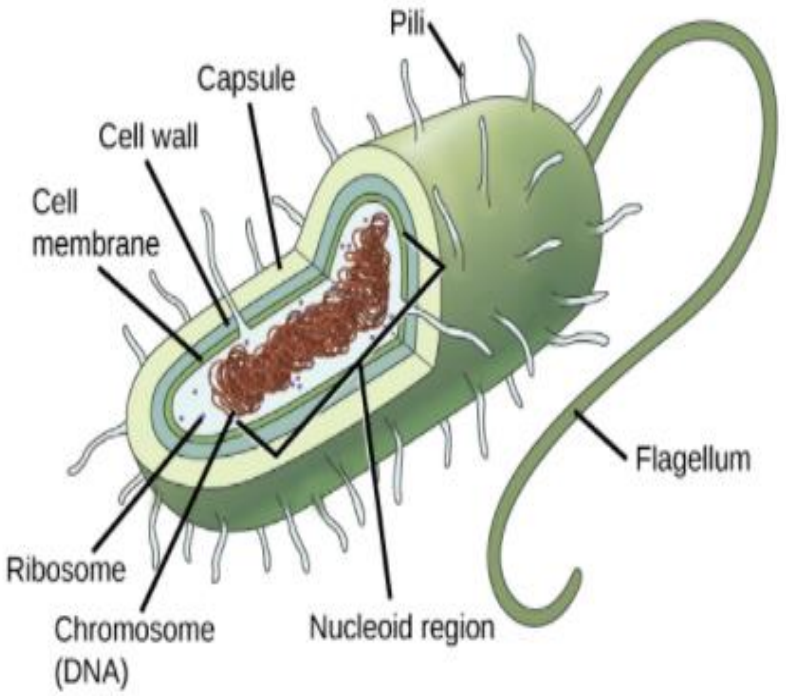


Figure 1. This figure shows the generalized structure of a prokaryotic cell.

- Unlike Archaea and eukaryotes, bacteria have a cell wall made of peptidoglycan, comprised of sugars and amino acids, and many have a polysaccharide capsule (Figure 1).

- The cell wall acts as an extra layer of protection, helps the cell maintain its shape, and prevents dehydration. The capsule enables the cell to attach to surfaces in its environment.

- Some prokaryotes have flagella, pili, or fimbriae. Flagella are used for locomotion, while most pili are used to exchange genetic material during a type of reproduction called conjugation.

Eukaryotic Cells

- In nature, the relationship between form and function is apparent at all levels, including the level of the cell, and this will become clear as we explore eukaryotic cells.
- The principle “form follows function” is found in many contexts. It means that, in general, one can deduce the function of a structure by looking at its form, because the two are matched.
- For example, birds and fish have streamlined bodies that allow them to move quickly through the medium in which they live, be it air or water.

- A **eukaryotic cell** is a cell that has a membrane-bound nucleus and other membrane-bound compartments or sacs, called **organelles**, which have specialized functions.
- The word eukaryotic means “true kernel” or “true nucleus,” alluding to the presence of the membrane-bound nucleus in these cells.

- The word “organelle” means “little organ,” and, as we learned earlier, organelles have specialized cellular functions, just as the organs of your body have specialized functions.

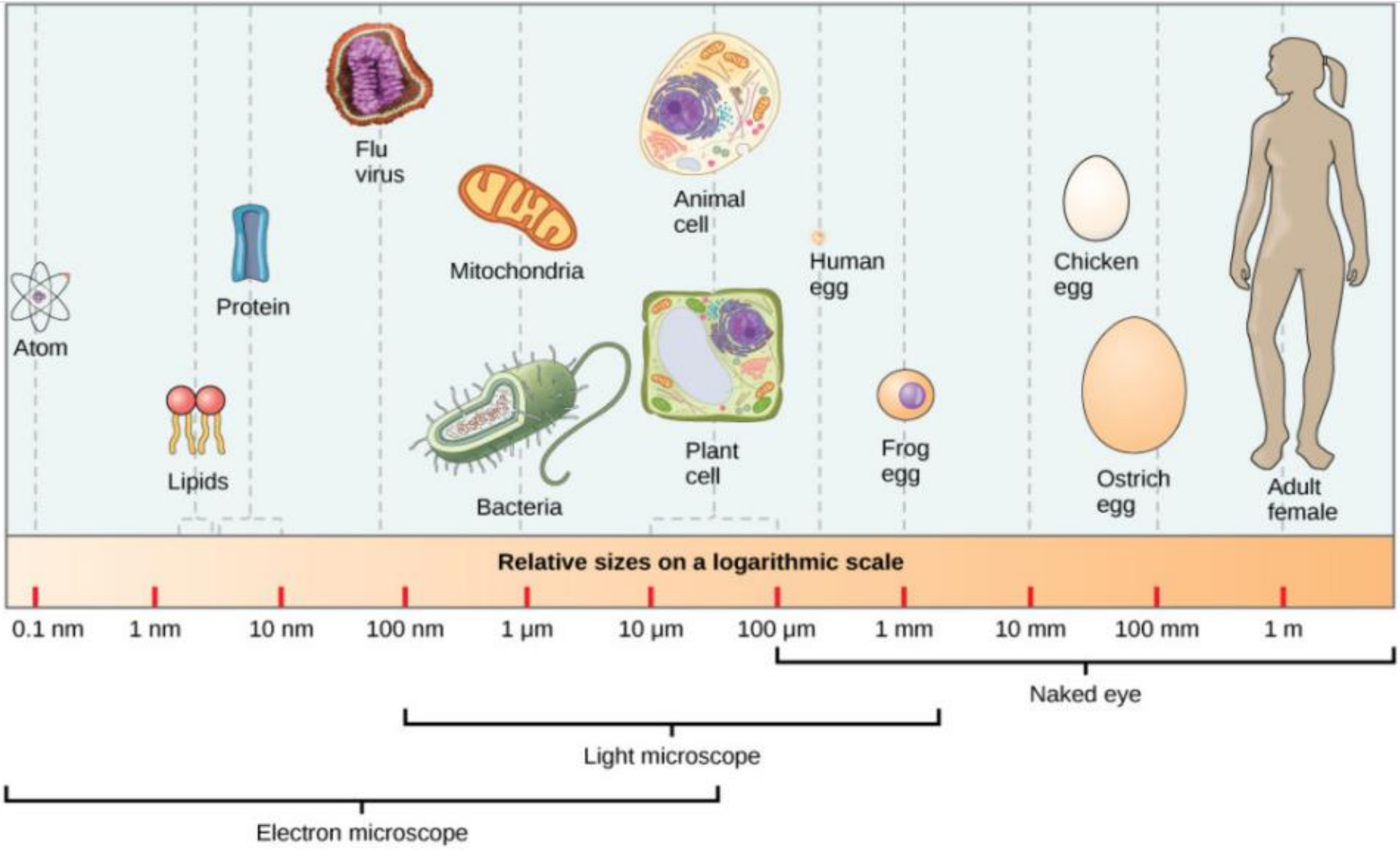


Figure 2. This figure shows the relative sizes of different kinds of cells and cellular components. An adult human is shown for comparison.

Cell Size

- At 0.1–5.0 µm in diameter, prokaryotic cells are significantly smaller than eukaryotic cells, which have diameters ranging from 10–100 µm (Figure 2).

- The small size of prokaryotes allows ions and organic molecules that enter them to quickly spread to other parts of the cell. Similarly, any wastes produced within a prokaryotic cell can quickly move out. However, larger eukaryotic cells have evolved different structural adaptations to enhance cellular transport.

- Indeed, the large size of these cells would not be possible without these adaptations. In general, cell size is limited because volume increases much more quickly than does cell surface area.

- As a cell becomes larger, it becomes more and more difficult for the cell to acquire sufficient materials to support the processes inside the cell, because the relative size of the surface area across which materials must be transported declines.

1. Eukaryotic and Prokaryotic cells share what component?

A. Cell wall

B. Flagellum

C. DNA

2. Many bacterial cells are roughly the same size as

A. Some eukaryotic organelles

B. Most animal cells

C. The smallest plant cells

3. Which of the following is not a uniform feature of life?

A. Nucleus
B. Cell membrane
C. Ribosomes

4. Overall cell size is restricted by the need to;

A. Find enough nutrients to survive
B. Hide from predators
C. Transport materials inside the cell

Summary

- Prokaryotes are single-celled organisms of the domains Bacteria and Archaea. All prokaryotes have plasma membranes, cytoplasm, ribosomes, a cell wall, DNA, and lack membrane-bound organelles. Many also have polysaccharide capsules. Prokaryotic cells range in diameter from 0.1–5.0 μm.

- Like a prokaryotic cell, a eukaryotic cell has a plasma membrane, cytoplasm, and ribosomes, but a eukaryotic cell is typically larger than a prokaryotic cell, has a true nucleus (meaning its DNA is surrounded by a membrane), and has other membrane-bound organelles that allow for compartmentalization of functions. Eukaryotic cells tend to be 10 to 100 times the size of prokaryotic cells.

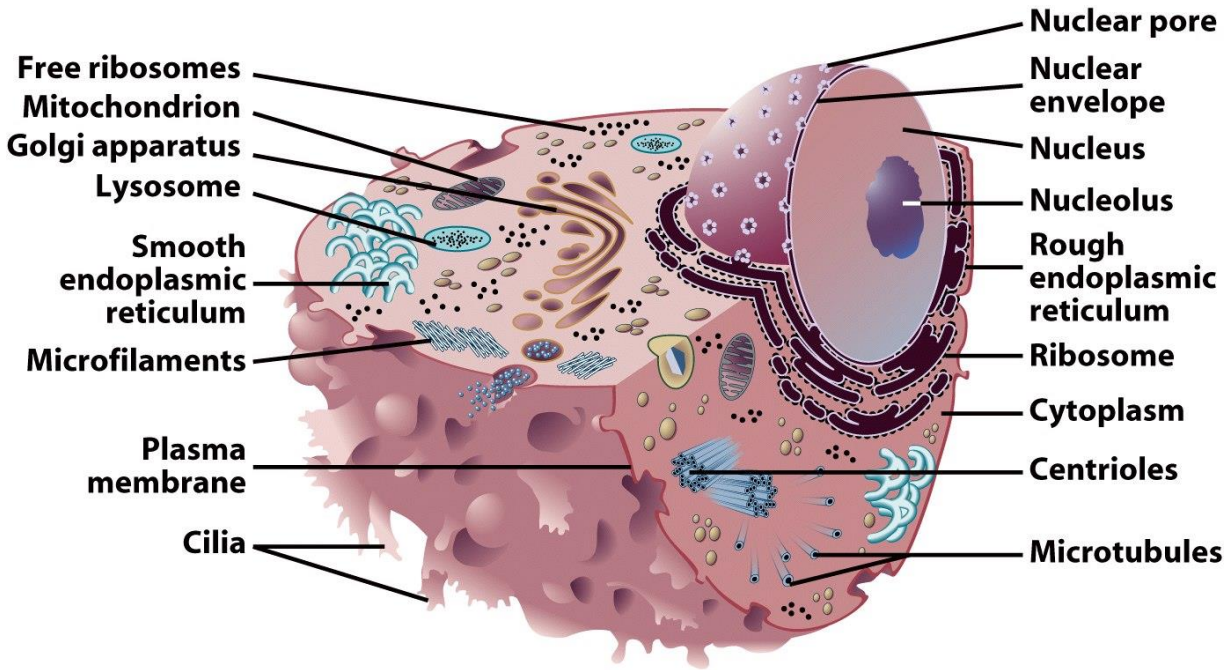
STRUCTURE AND FUNCTION OF CELLULAR ORGANELLES

- We have identified the cell as the basic structural and functional unit of life.
- We also agreed that living organisms are made up of cells.
- Biochemistry studies the biochemical reactions necessary to sustain life.
- Hence, Biochemistry studies the reactions and transformations that occurs within cells.

Organelles

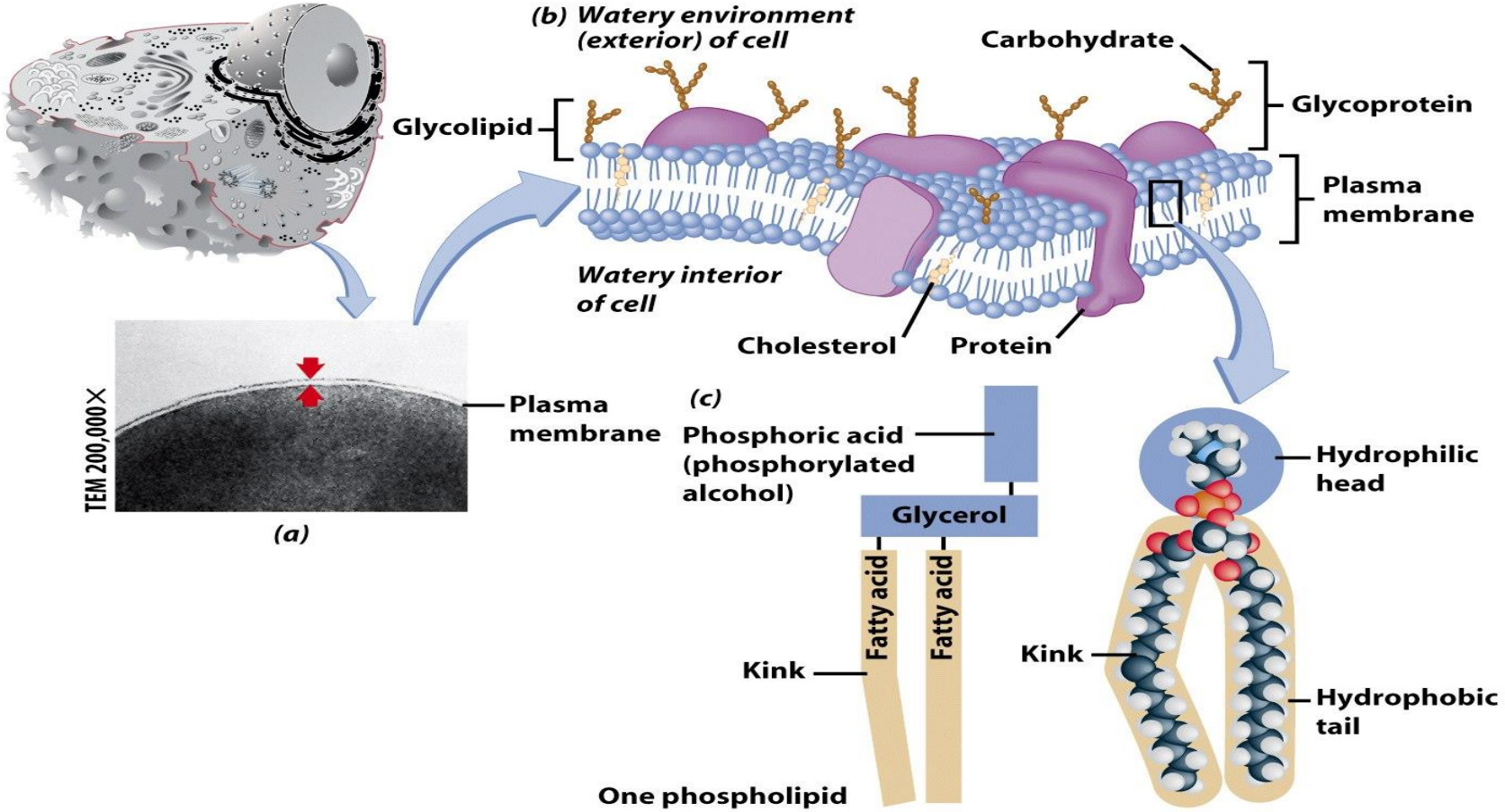
- well developed subcellular compartments.

- found mostly in yeast, fungi, protozoans, plants and animals.



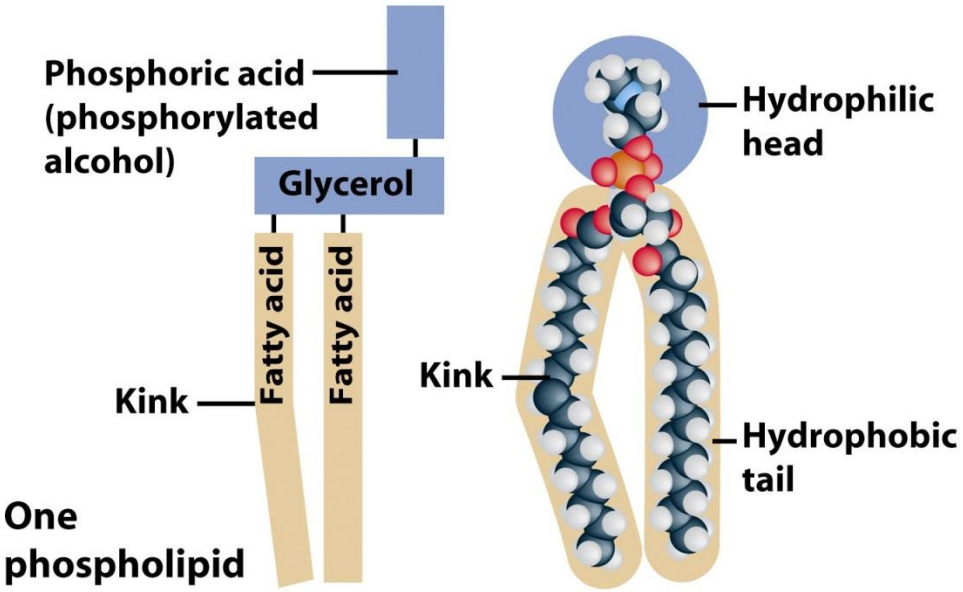
Plasma Membrane

- It is one of the most important part of the cell.
- Double layer of phospholipids embedded with proteins.



Phospholipids

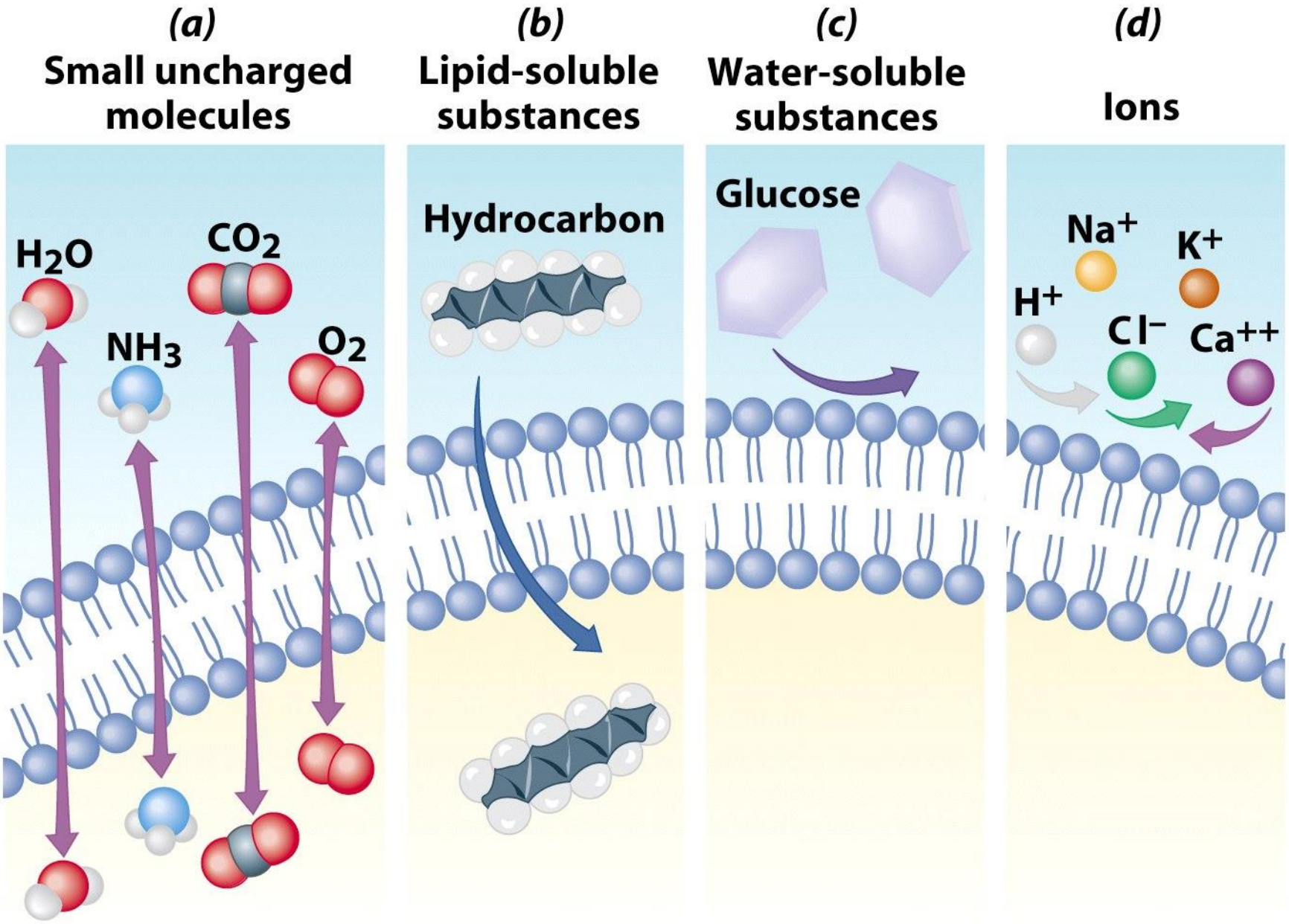
- Polar
  - Hydrophilic head
  - Hydrophobic tail
- Interacts with water



- It defines the boundary of the cell.
- It regulates the movement of molecules into and out of the cytoplasm.
- It offers shape and rigidity to the cell.
- It separates the cells from one another and from the surrounding medium.

Movement Across the Plasma Membrane

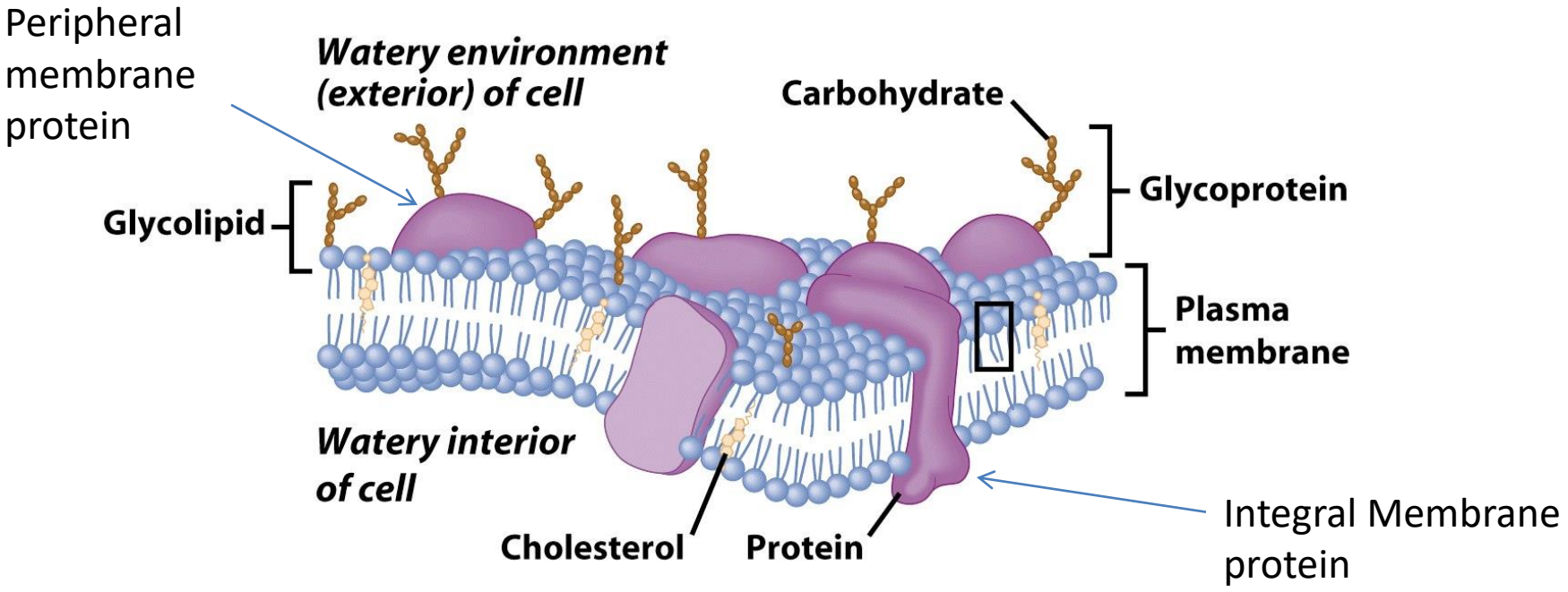
- A few molecules move freely
  - Water, Carbon dioxide, Ammonia, Oxygen
- Carrier proteins transport some molecules
  - Proteins embedded in lipid bilayer
  - Fluid mosaic model – describes fluid nature of a lipid bilayer with proteins


(a)
Small uncharged molecules
(b)
Lipid-soluble substances
(c)
Water-soluble substances
(d)
Ions
H2O
CO2
NH3
O2
Hydrocarbon
Glucose
Na+
K+
H+
Cl−
Ca++

Membrane Proteins

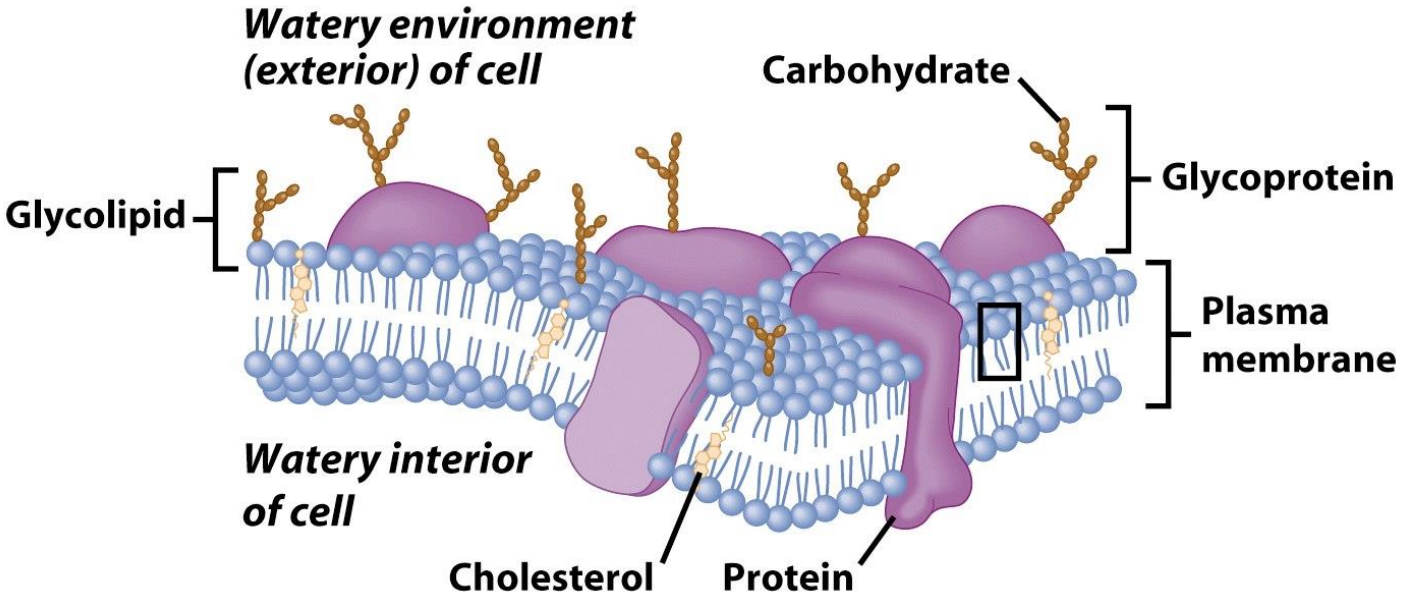
- Peripheral membrane proteins e.g Phospholipase C, Cholesterol oxidase etc

- Integral membrane proteins e.g rhodopsin, integrins, Band 3 protein, glycophorin, ion channels, Gap junction.



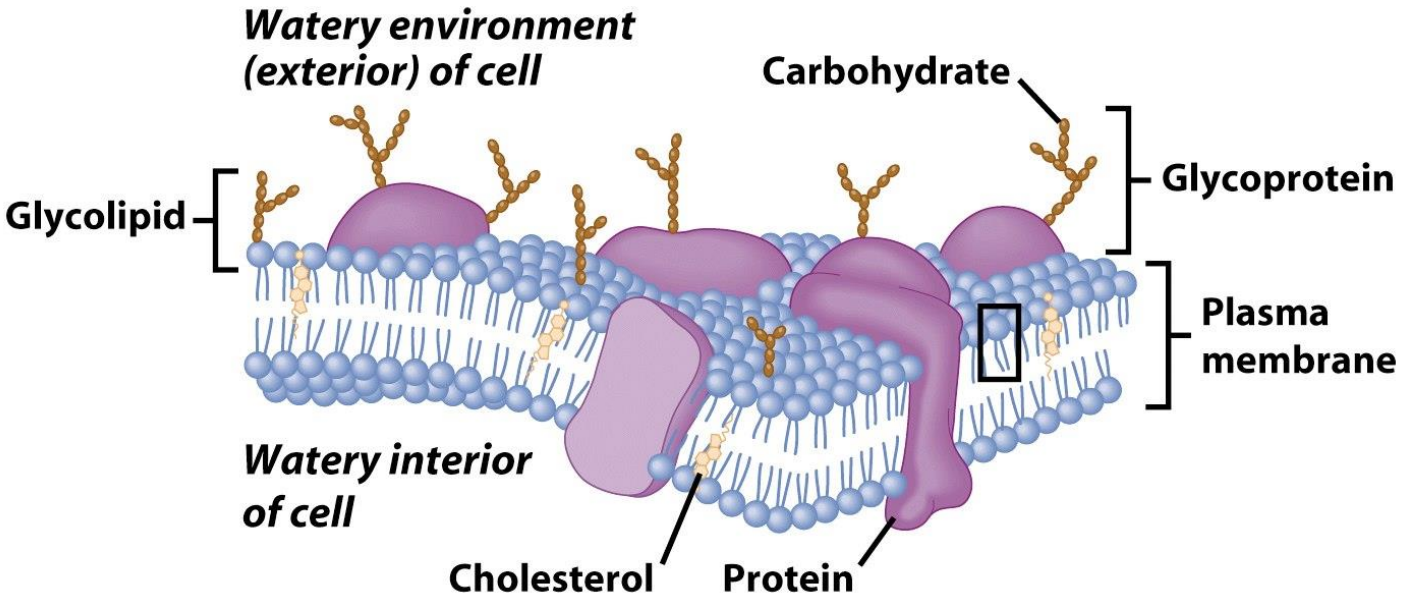
Membrane Proteins

1. Channels or transporters
   - Move molecules in one direction
2. Receptors
   - Recognize certain chemicals



Membrane Proteins

3. Glycoproteins
   - Identify cell type
4. Enzymes
   - Catalyze production of substances



Cell Walls

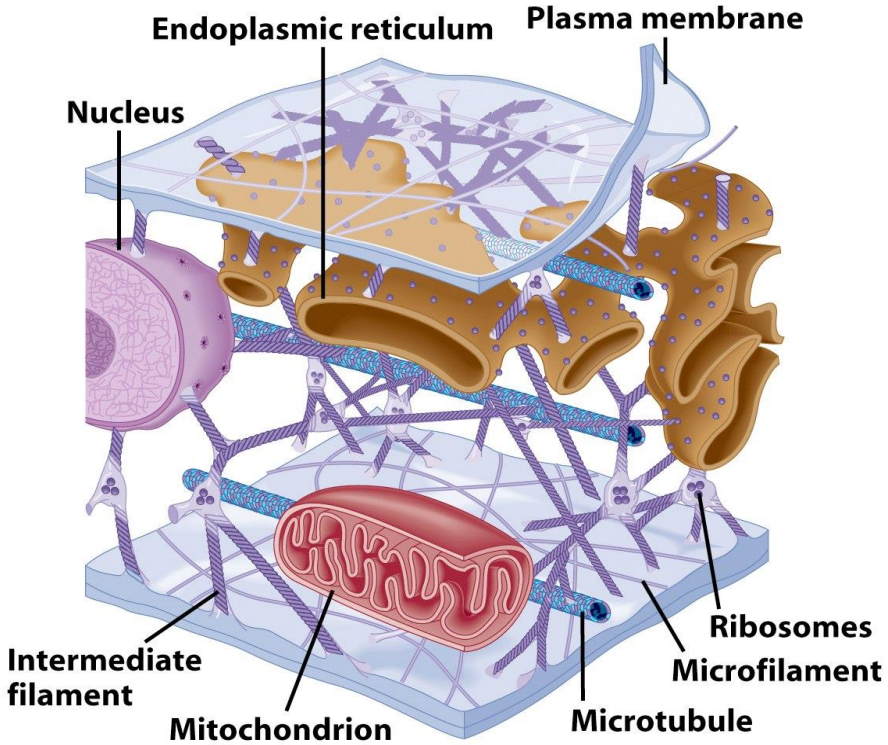
- Found in plants, fungi, & many protists
- Surrounds plasma membrane

Cell Wall Differences

- Plants – mostly cellulose
- Fungi – contain chitin

Cytoplasm

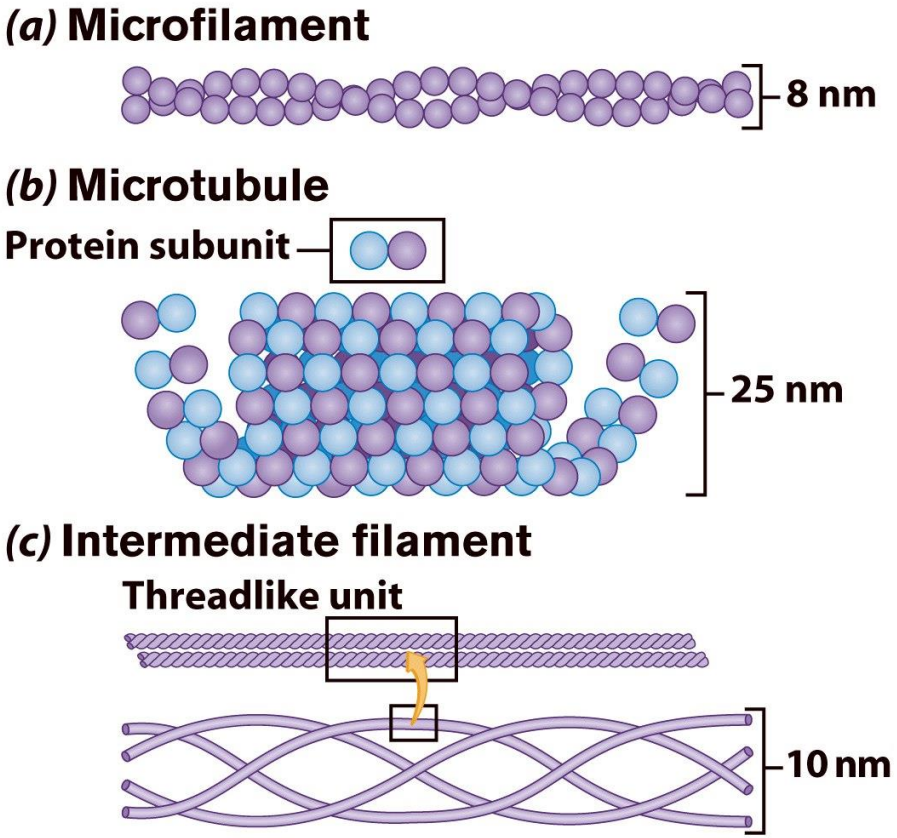
- Viscous (jelly-like) fluid containing organelles
- components of cytoplasm
  - Interconnected filaments & fibers
  - Fluid = cytosol
  - Organelles (not nucleus)
  - storage substances like starch, glycogen, oxalates

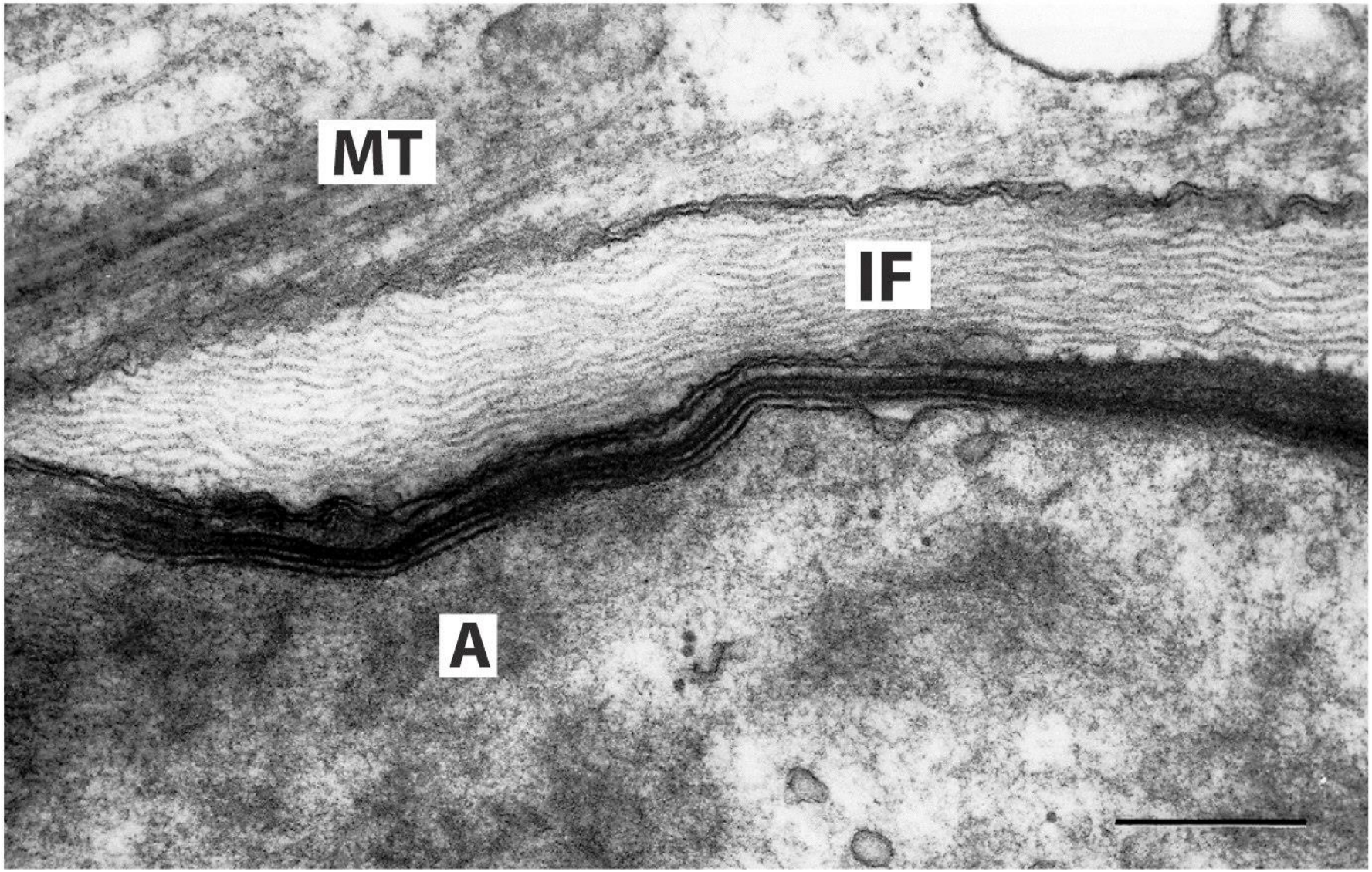


Cytoskeleton

- Filaments & fibers

- Made of 3 fiber types
  - Microfilaments
  - Microtubules
  - Intermediate filaments
- 3 functions:
  - mechanical support
  - anchor organelles
  - help move substances





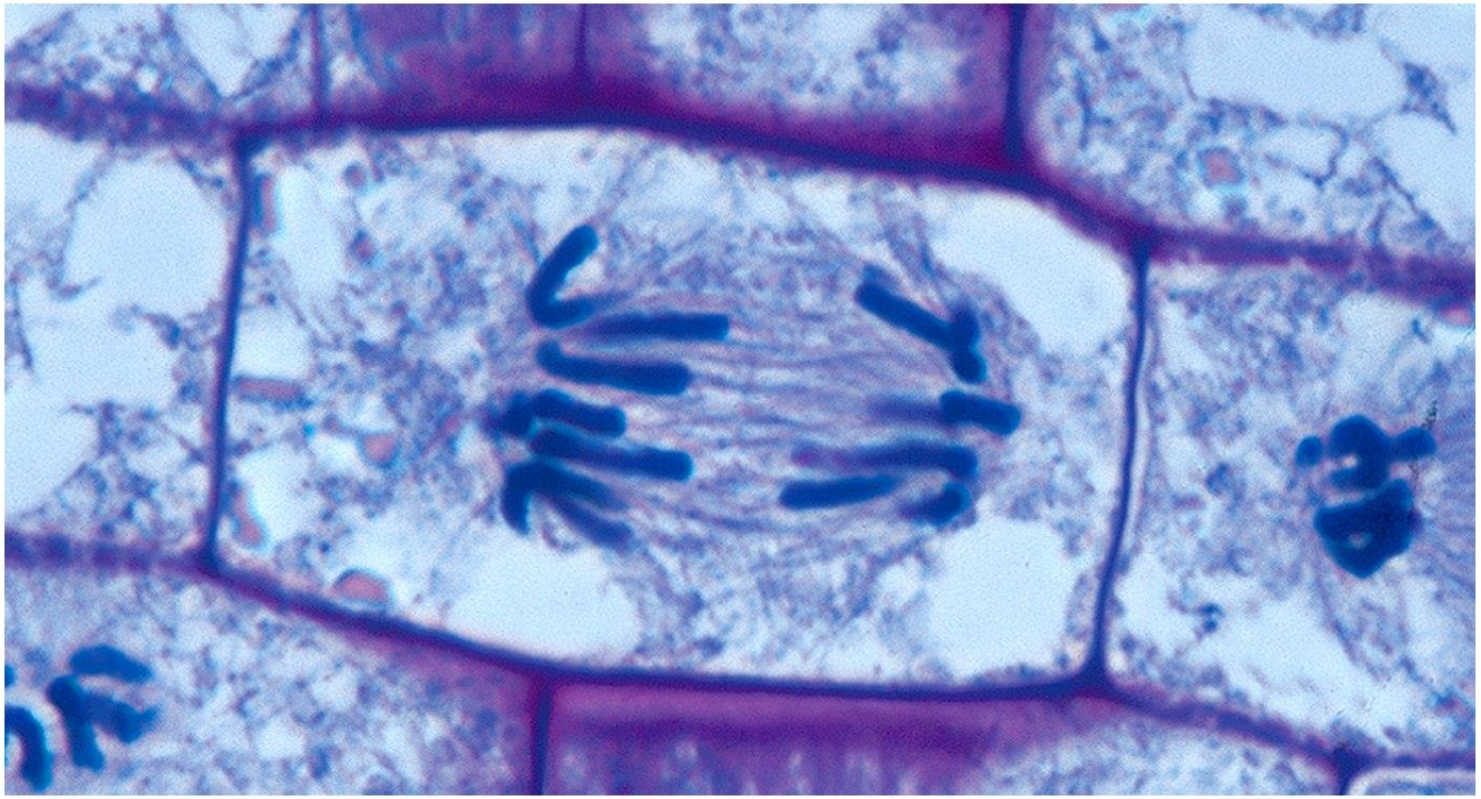
A = actin, IF = intermediate filament, MT = microtubule

Cilia & Flagella

- Provide motility
- Cilia
  - Short
  - Used to move substances outside human cells
- Flagella
  - Whip-like extensions
  - Found on sperm cells
- Basal bodies like centrioles

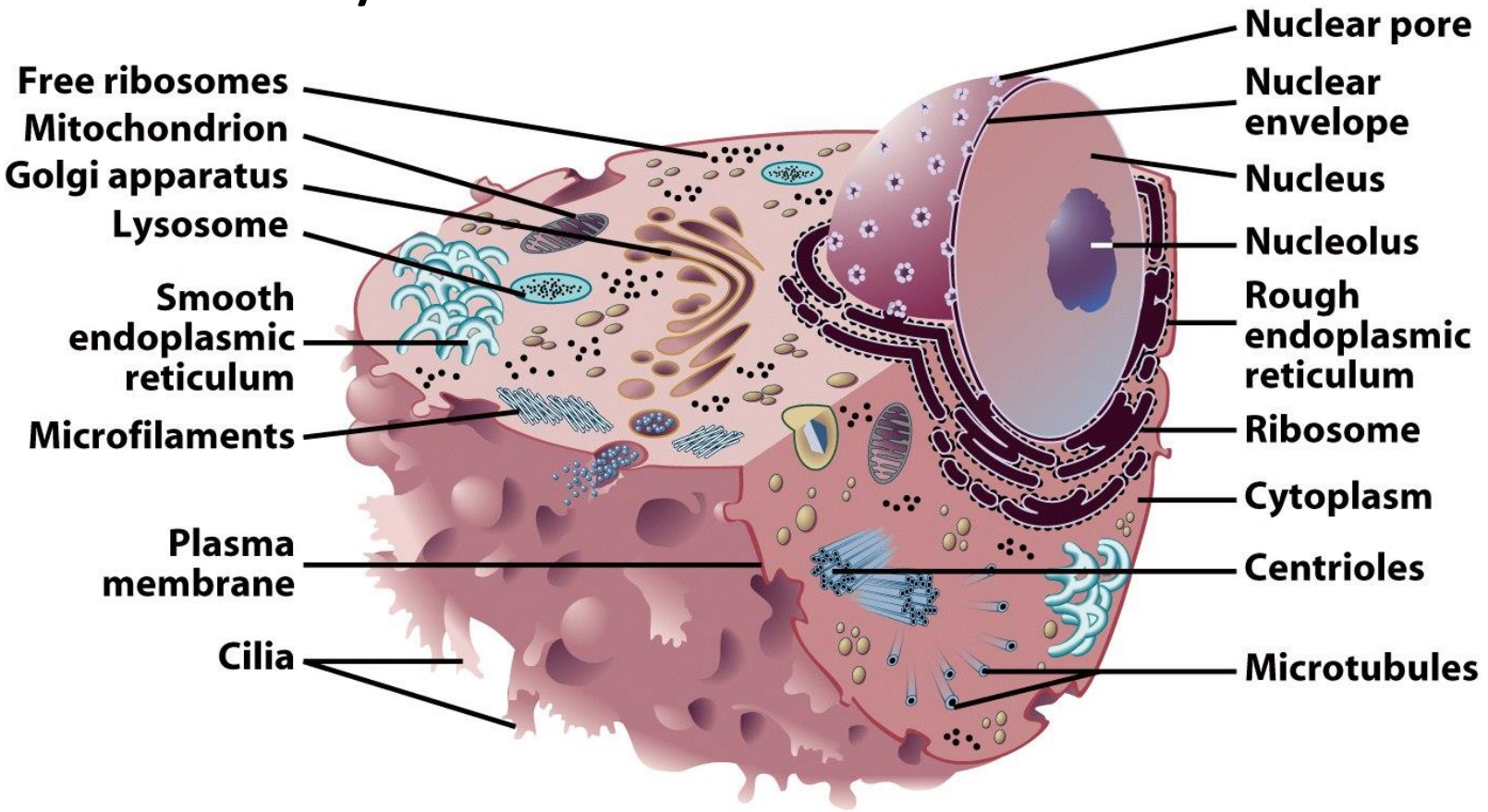
Centrioles

- Pairs of microtubular structures
- Play a role in cell division



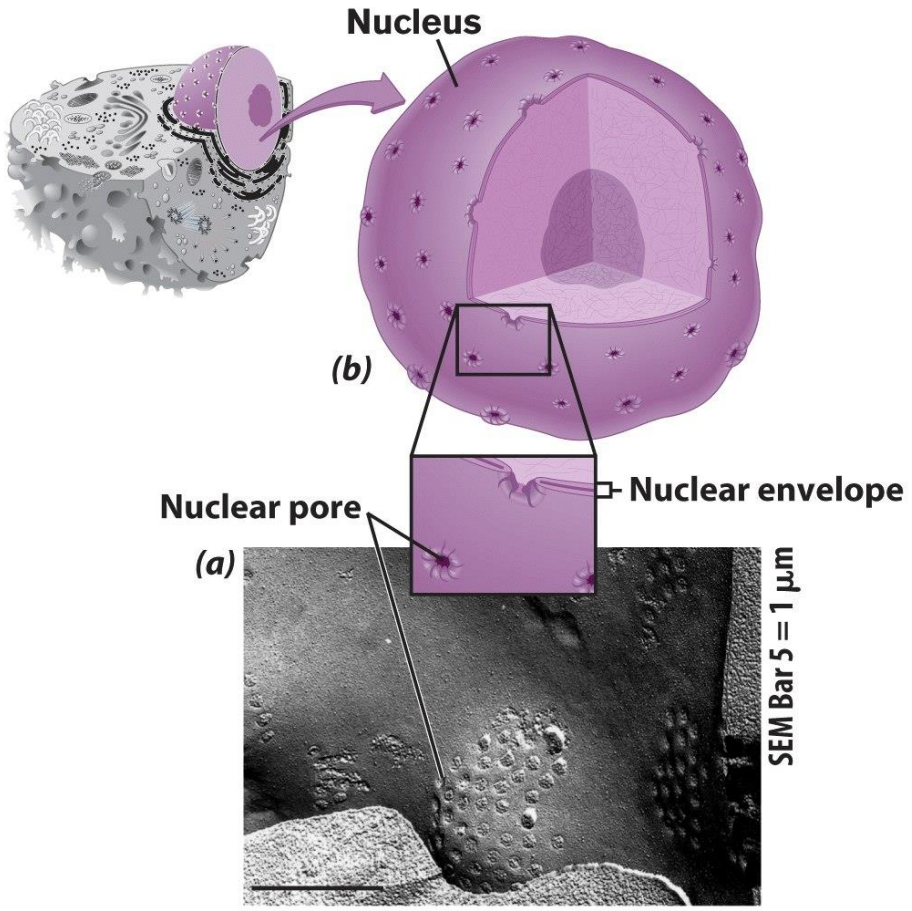
Membranous Organelles

- Functional components within cytoplasm
- Bound by membranes



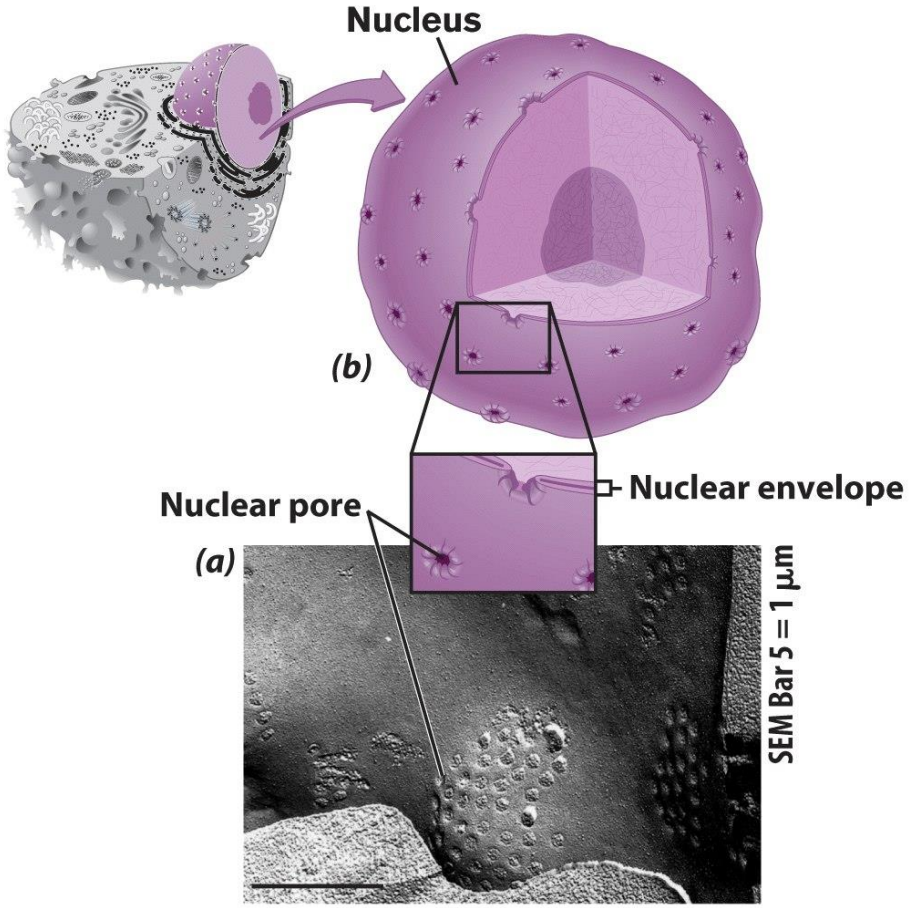
Nucleus

- Stores the genetic material.
- Control center of cell
- Double membrane i.e nuclear envelope
- Contains
  - Chromosomes
  - Nucleolus



Nuclear Envelope

- Separates nucleus from rest of cell
- Double membrane
- Has pores

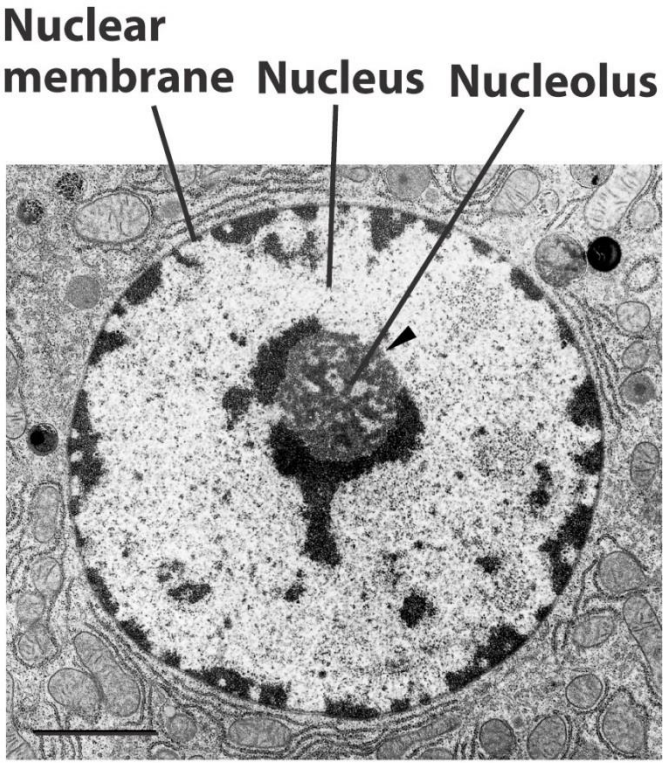


DNA

- Hereditary material
- Chromosomes
  - DNA
  - Proteins
  - Form for cell division
- Chromatin

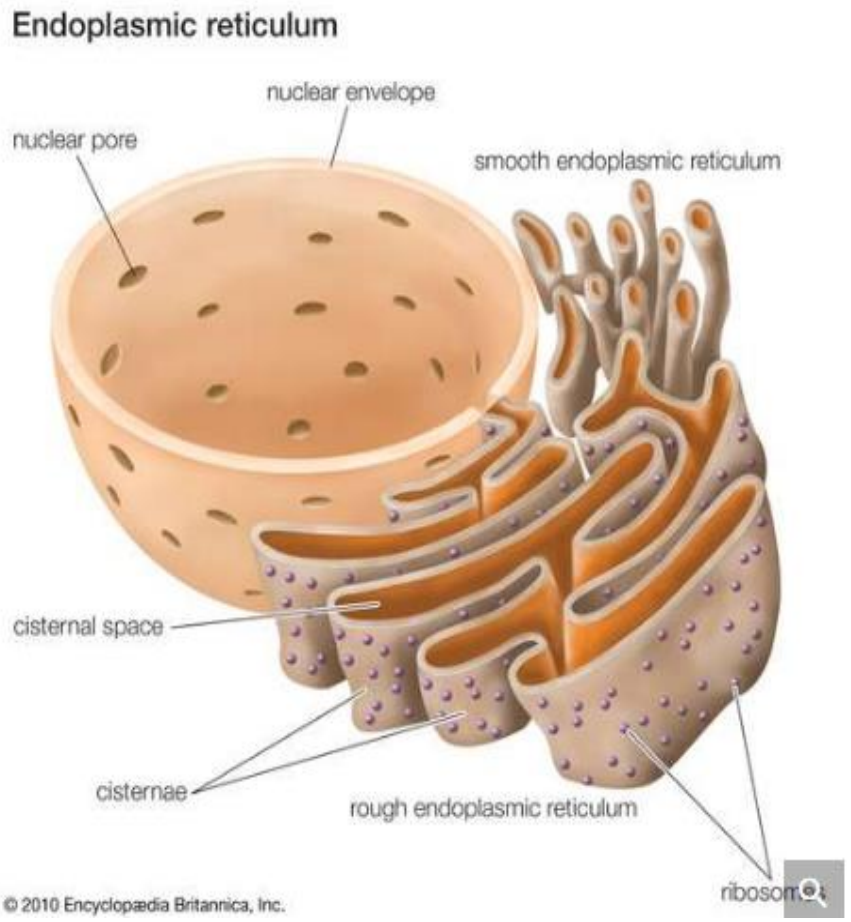
Nucleolus

- Most cells have 2 or more.
- Directs synthesis of RNA
- Takes up 25% volume of the nucleus.
- Forms ribosomes from the component RNA and proteins



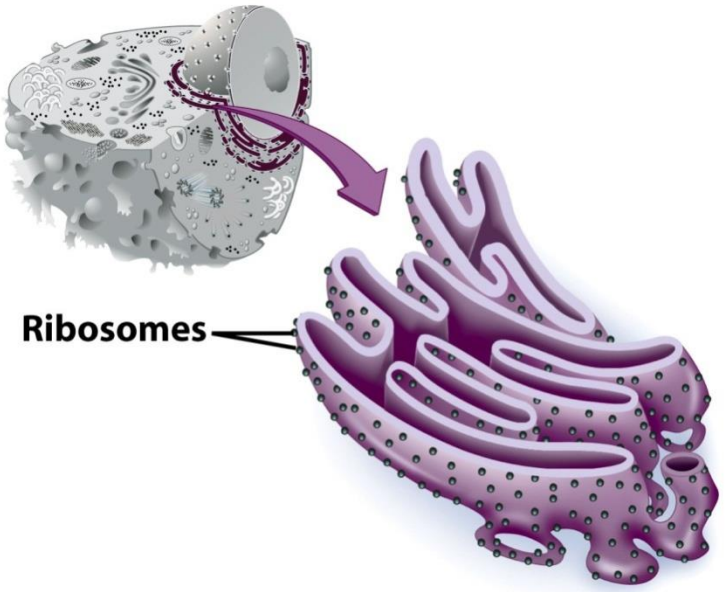
Endoplasmic Reticulum

- Network of interconnected membranes.
- Helps move substances within cells
- Two types,
  - RER- Rough endoplasmic reticulum
  - SER- Smooth endoplasmic reticulum



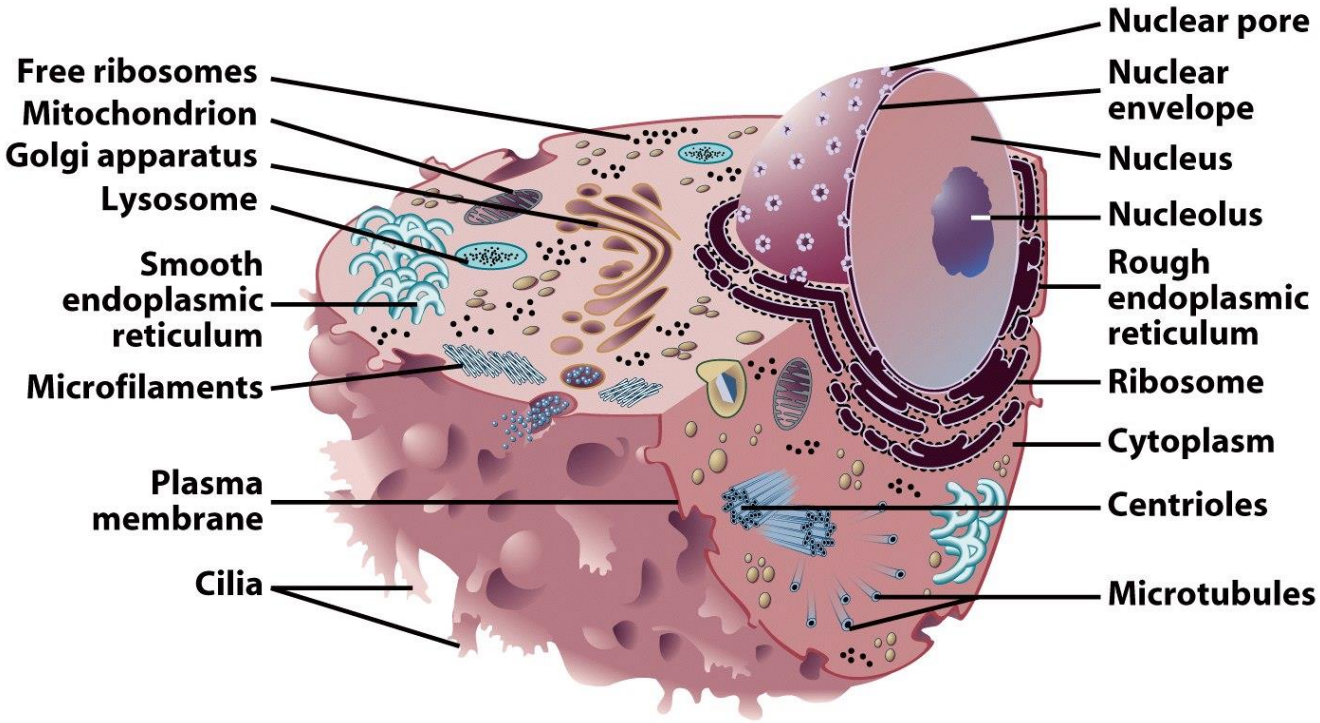
Rough Endoplasmic Reticulum

- Ribosomes attached to surface
  - Manufacture proteins, glycoproteins
  - Not all ribosomes attached to rough ER
- May modify proteins from ribosomes



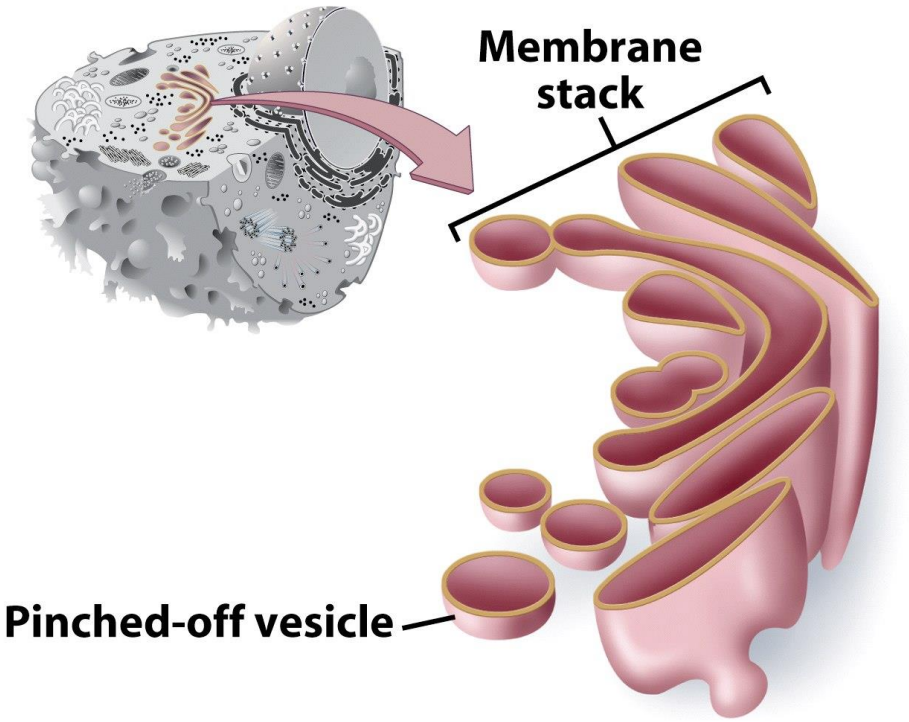
Smooth Endoplasmic Reticulum

- No attached ribosomes
- Has enzymes that help build molecules
  - Carbohydrates
  - Lipids (phospholipids, cholesterol)



Golgi Apparatus

- Involved in synthesis of plant cell wall
- Packaging & shipping station of cell



Golgi Apparatus Function

1. Molecules come in vesicles

2. Vesicles fuse with Golgi membrane

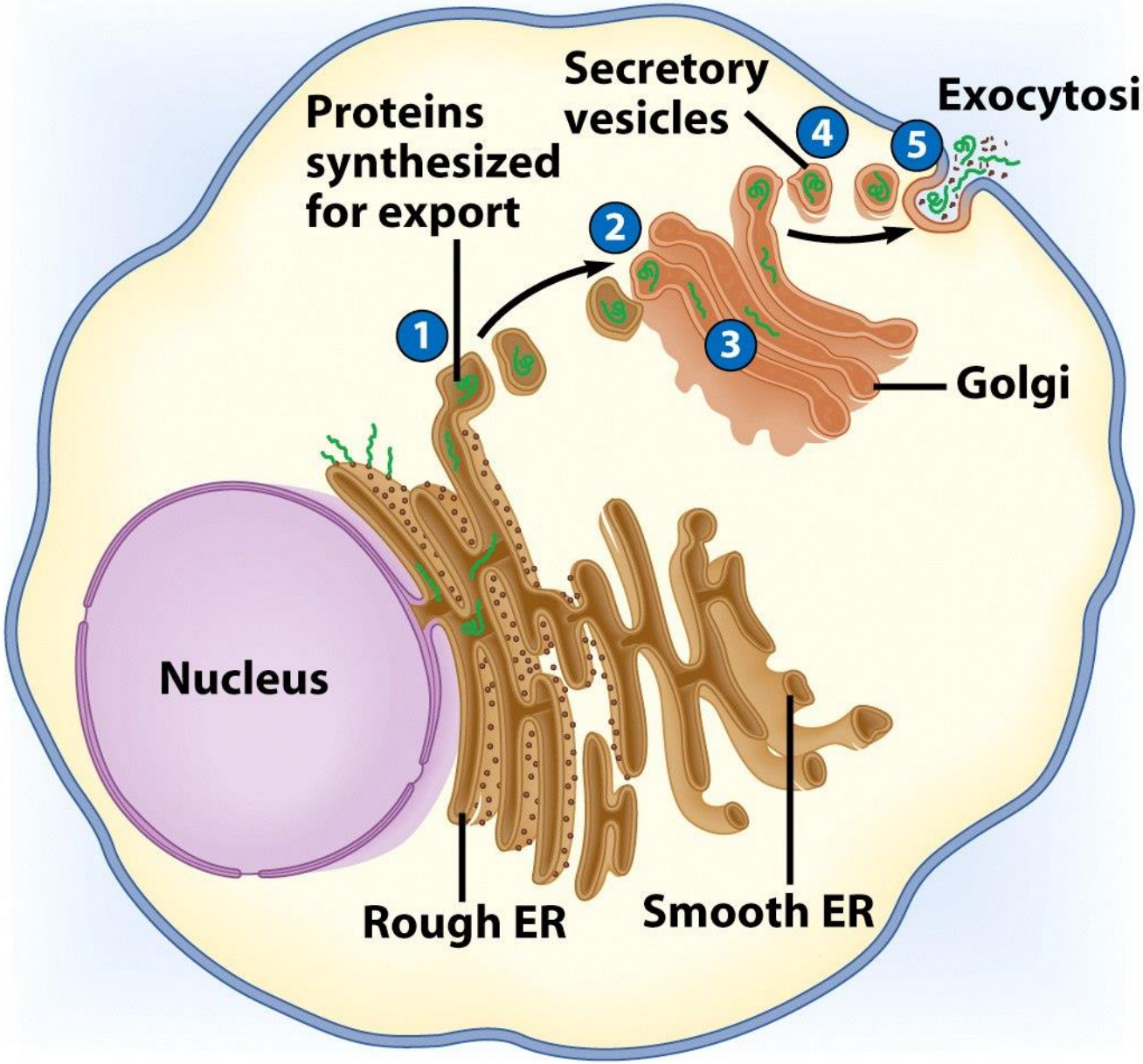
3. Molecules may be modified by Golgi

Golgi Apparatus Function (Continued)

4. Molecules pinched-off in separate vesicle

5. Vesicle leaves Golgi apparatus

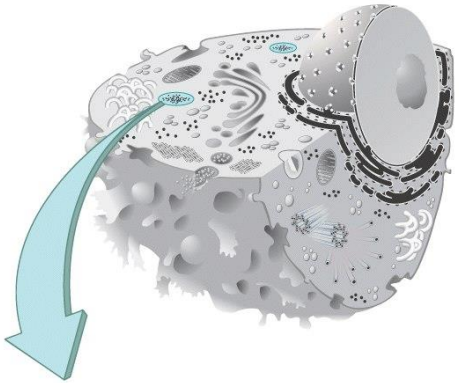
6. Vesicles may combine with plasma membrane to secrete contents

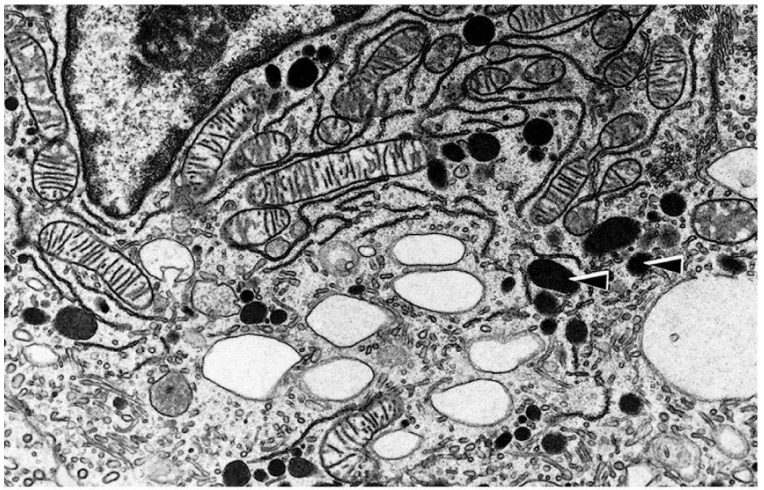

Proteins synthesized for export
Secretory vesicles
Exocytosis
1
2
3
4
5
Golgi
Nucleus
Rough ER
Smooth ER

Lysosomes

- Lysosomes are membrane bound vesicles.

- Contain hydrolytic, digestive enzymes such as acid phosphatase, lysozyme, phosphodiesterase, hyaluronidase, esterase, nuclease, protease.





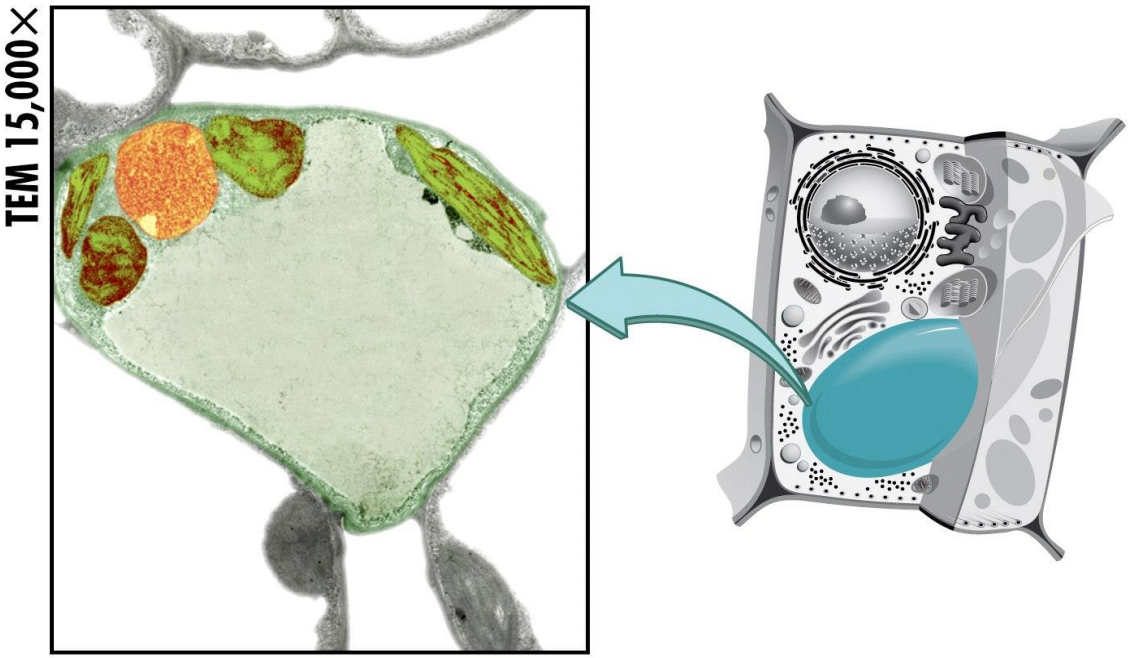
- Functions
  - Aid in cell renewal.
  - Break down old cell parts
  - Digests invaders – breaks biomolecules

Peroxisomes

- Oxidative membrane-bound organelles found in most eukaryotic cells.
- They hold 10% of the activity of two Pentose phosphate pathway enzymes; Glucose 6-phosphate dehydrogenase, 6-phosphogluconate dehydrogenase.
- It contains enzymes involved in beta oxidation of long chain fatty acids.
- Oxidative enzymes (peroxidases) which produce peroxides and catalase which breaks down peroxides.

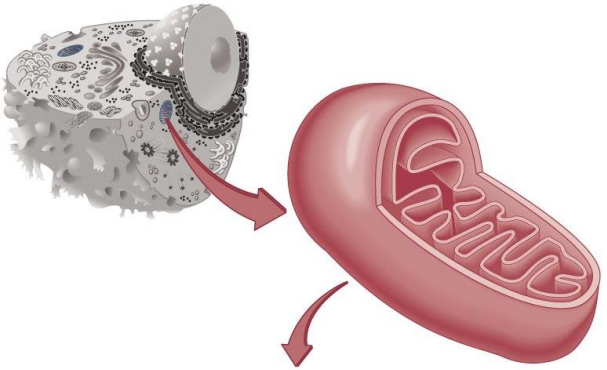
Vacuoles

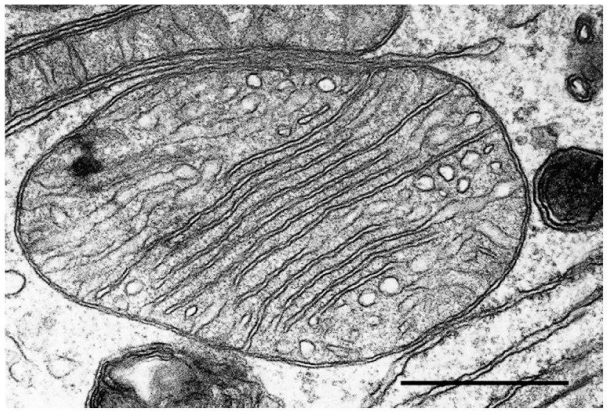
- Membrane-bound storage sacs
- More common in plants than animals.
- Contents
  - Water
  - Food i.e sugars, salts, pigments, toxic molecules.
  - wastes



Mitochondria

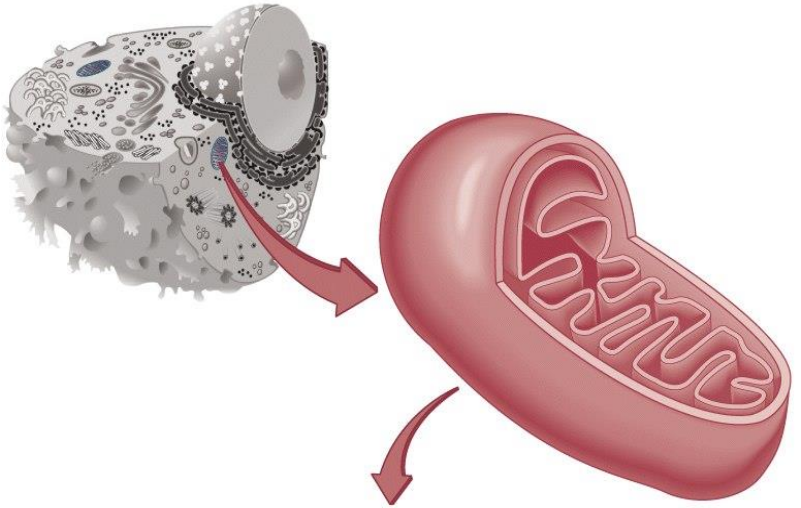
- Have their own DNA
- Bound by double membrane





Mitochondria

- Break down fuel molecules (cellular respiration)
  - Glucose
  - Fatty acids



- Release energy
  - ATP

- Contains TCA cycle enzymes

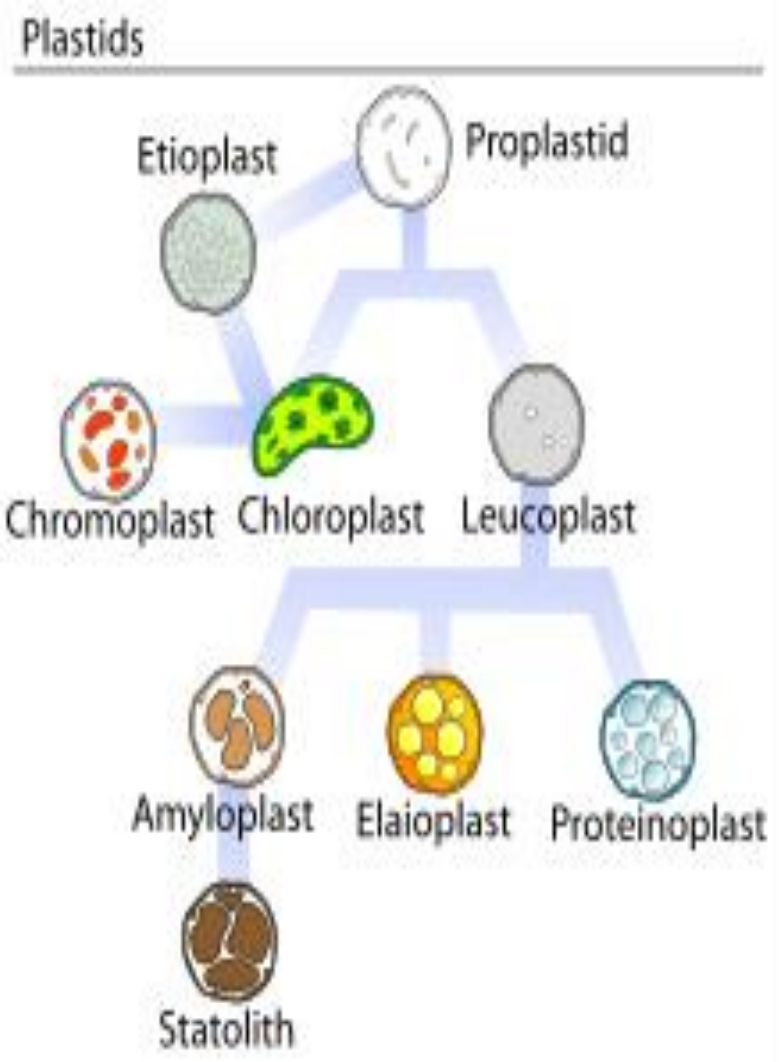
e.g α-ketoglutarate dehydrogenase

Plastids

- Plastids are a characteristic component of plant cells
- Plastids are classified and named based on the kinds of pigments they contain
- Each plastid is surrounded by two membranes and internally the plastid has a system of membranes which form flattened sacs called thylakoids and a ground (fluid) substance called stroma

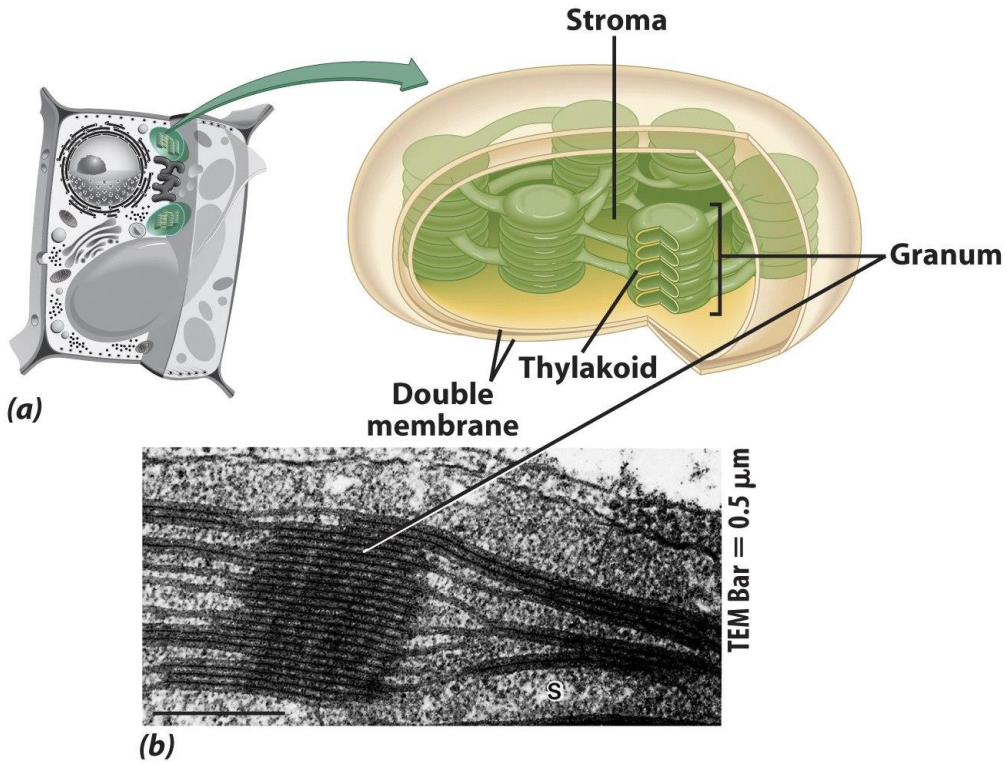
Proplastids

- Proplastids are small, colorless or pale green undifferentiated plastids that occur in meristematic cells of roots and shoots - they will eventually develop into other, differentiated plastids such as the chloroplasts, chromoplasts or leucoplasts.



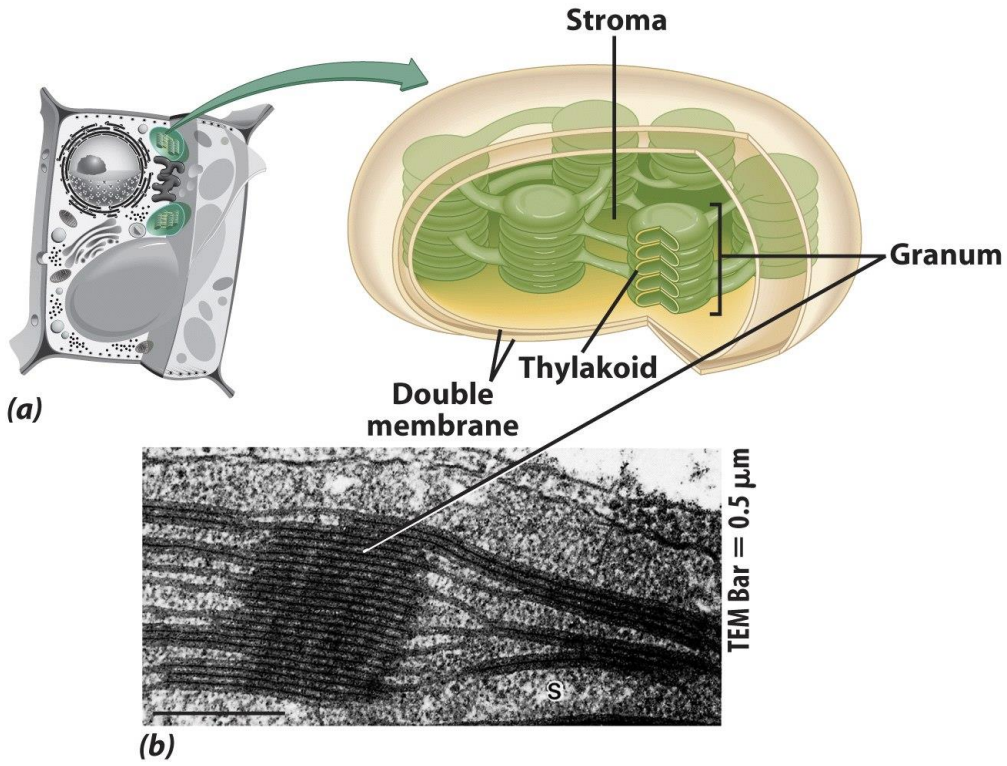
Chloroplasts

- Derived form photosynthetic bacteria
- Solar energy capturing organelle



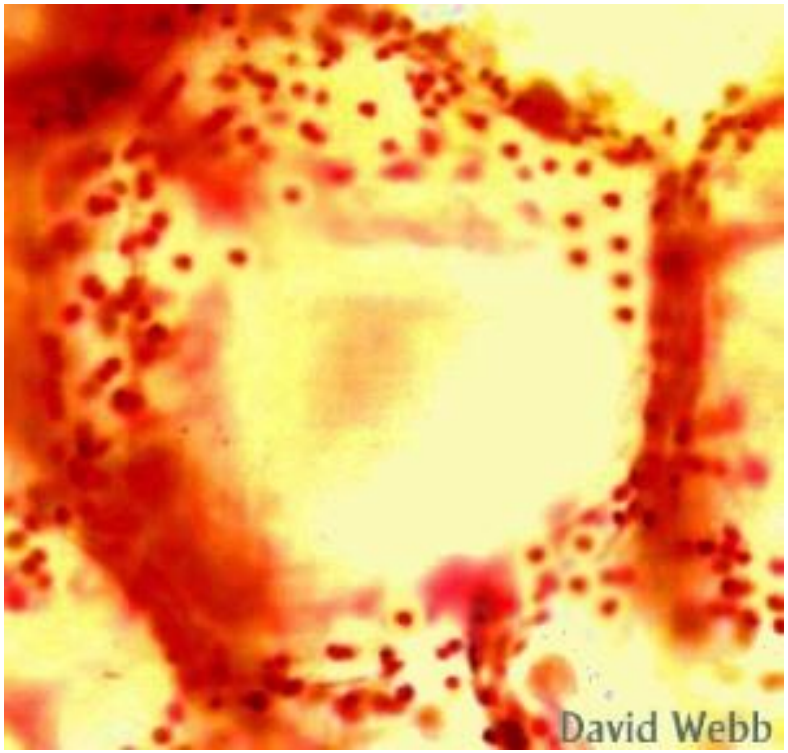
Photosynthesis

- Takes place in the chloroplast
- Makes cellular food – glucose



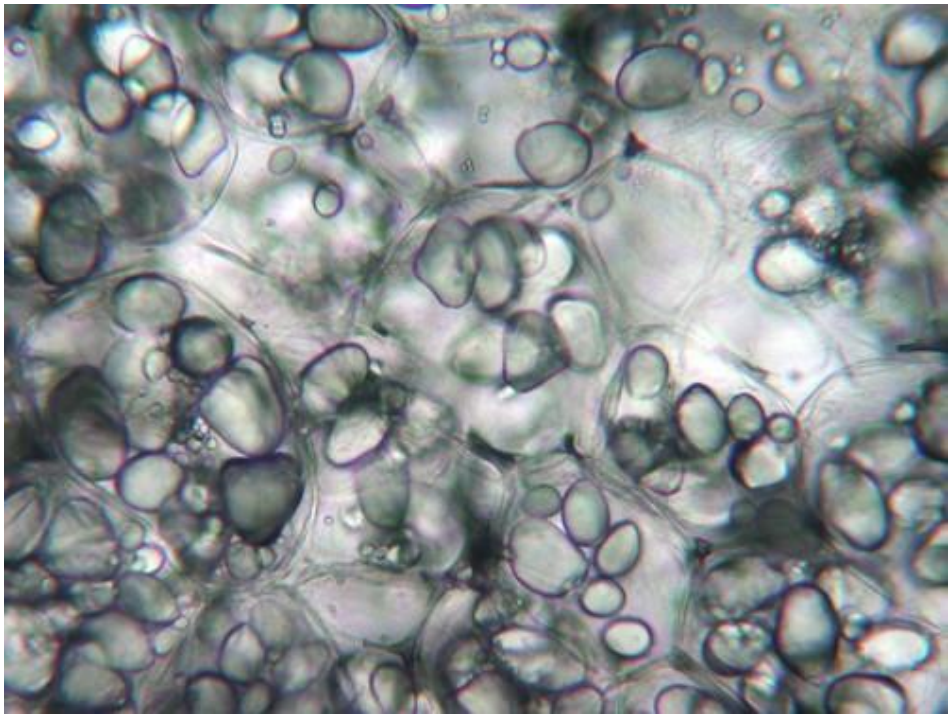
Chromoplasts

Chromoplasts lack chlorophyll but synthesize and retain carotenoid pigments which are responsible for the yellow, orange or red colors of many flowers, old leaves, some fruits and some roots

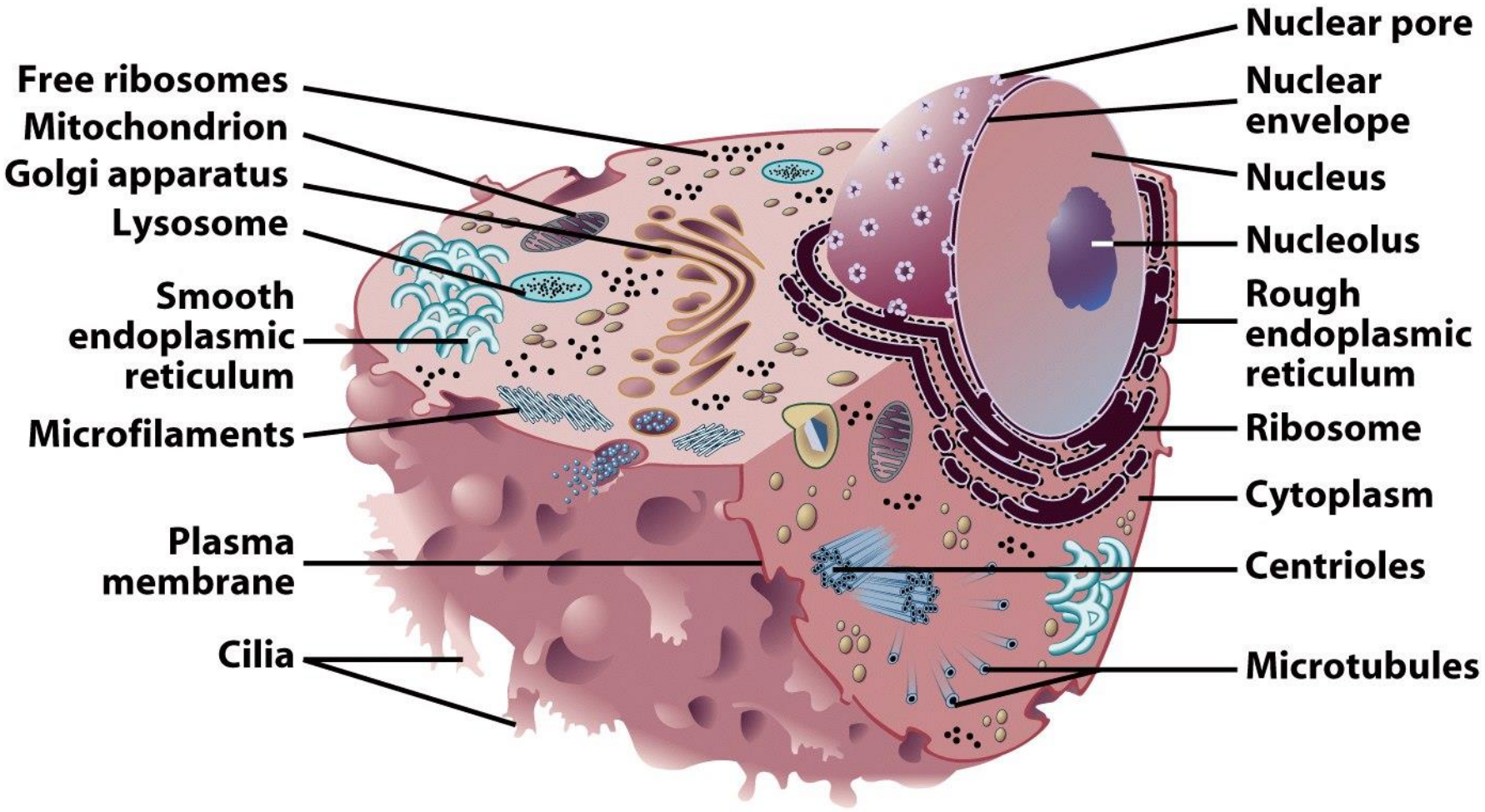


Leucoplasts

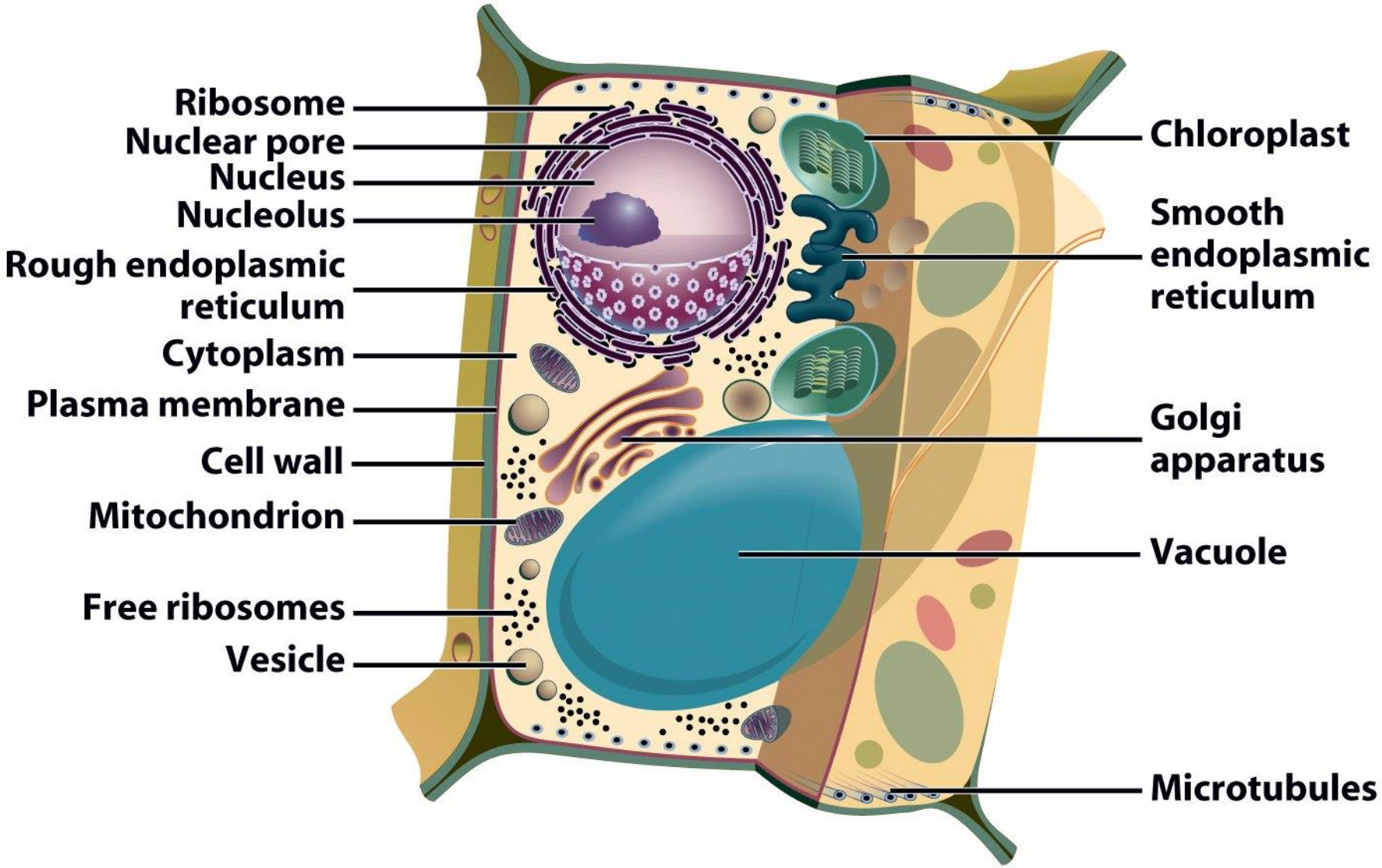
- Leucoplasts are nonpigmented plastids some of which synthesize starch while others produce oils or proteins
- Upon exposure to light they may develop into chloroplasts



Representative Animal Cell



Representative Plant Cell



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