Chapter 4

A Tour of the Cell

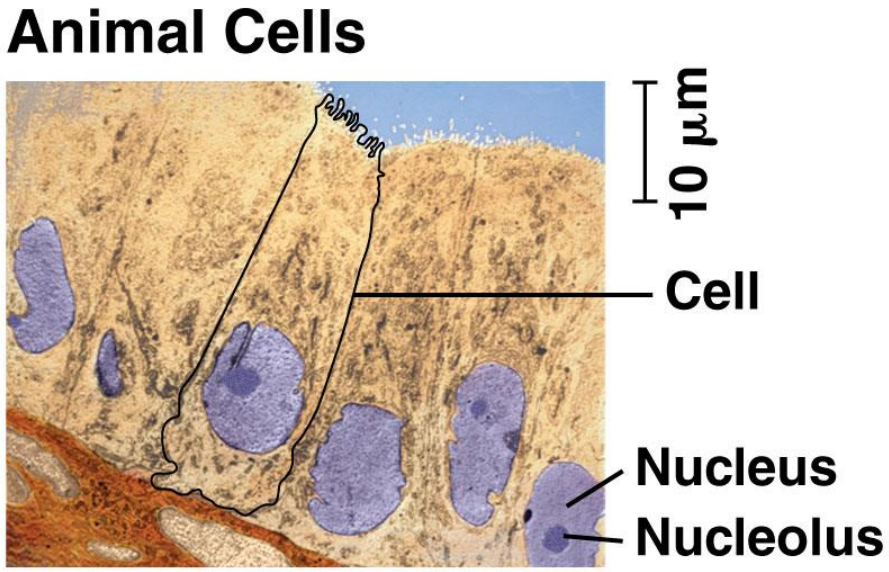
You must know:

- Three differences between prokaryotic and eukaryotic cells.
- The structure and function of organelles common to plant and animal cells.
- The structure and function of organelles found only in plant cells or only in animal cells.
- How different cell types show differences in subcellular components.
- How internal membranes and organelles contribute to cell functions.
- How cell size and shape affect the overall rate of nutrient intake and waste elimination.

2 Types of Cells:

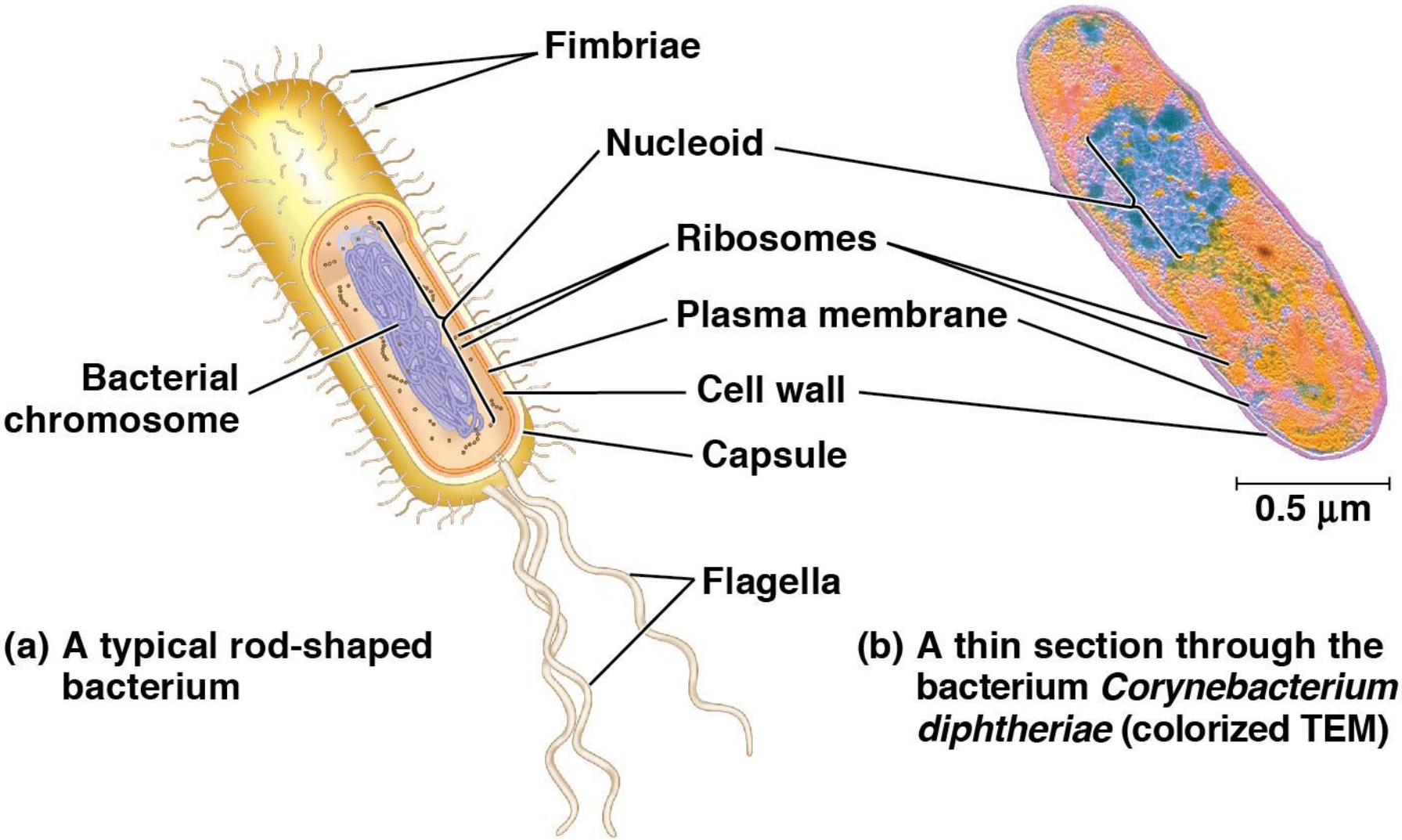
1. <u>Prokaryotes</u>: Domain Bacteria & Archaea
2. <u>Eukaryotes</u> (Domain Eukarya): Protists, Fungi, Plants, Animals

(b) A thin section through the bacterium *Bacillus coagulans* (TEM)



Human cells from lining of uterus (colorized TEM)

A Prokaryotic Cell (bacteria)



Prokaryote Vs. Eukaryote

- "before" "kernel"
- No nucleus
- DNA in a nucleoid
- Cytosol
- No organelles other than ribosomes
- Small size
- Primitive
- i.e. Bacteria & Archaea

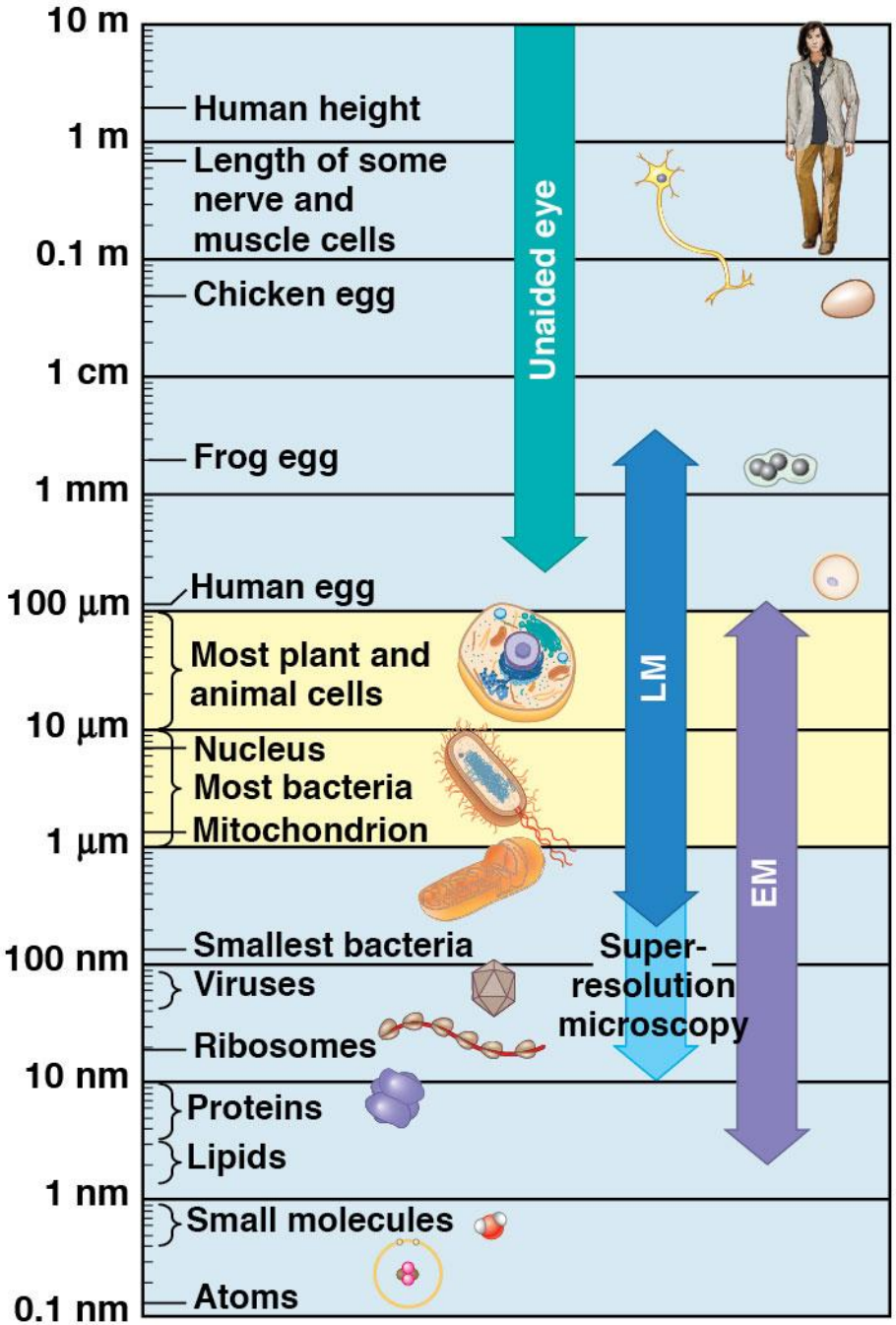
- "true" "kernel"
- Has nucleus and nuclear envelope
- Cytosol
- Membrane-bound organelles with specialized structure/function
- Much larger in size
- More complex
- i.e. plant/animal cell

Cell Size and Scale

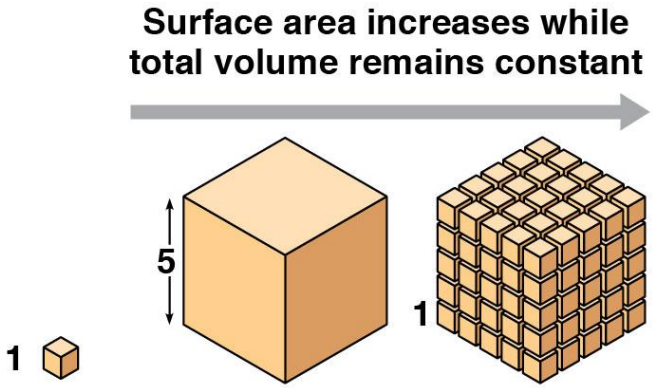
http://learn.genetics.utah.edu/content/begin/cells/scale/

Scale of the Universe:

http://www.onemorelevel.com/game/scale_of_the_universe_2012



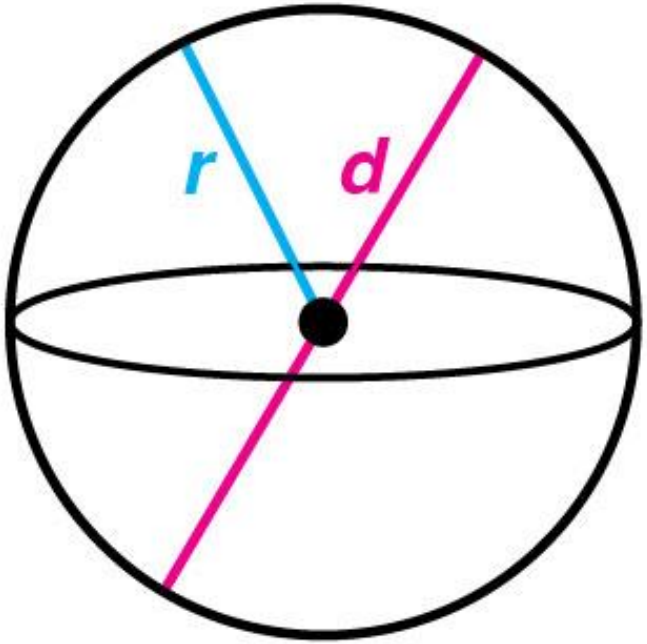
- Cells must be small to maintain a large surface area to volume ratio
- Large S.A. allows ↑ rates of chemical exchange between cell and environment



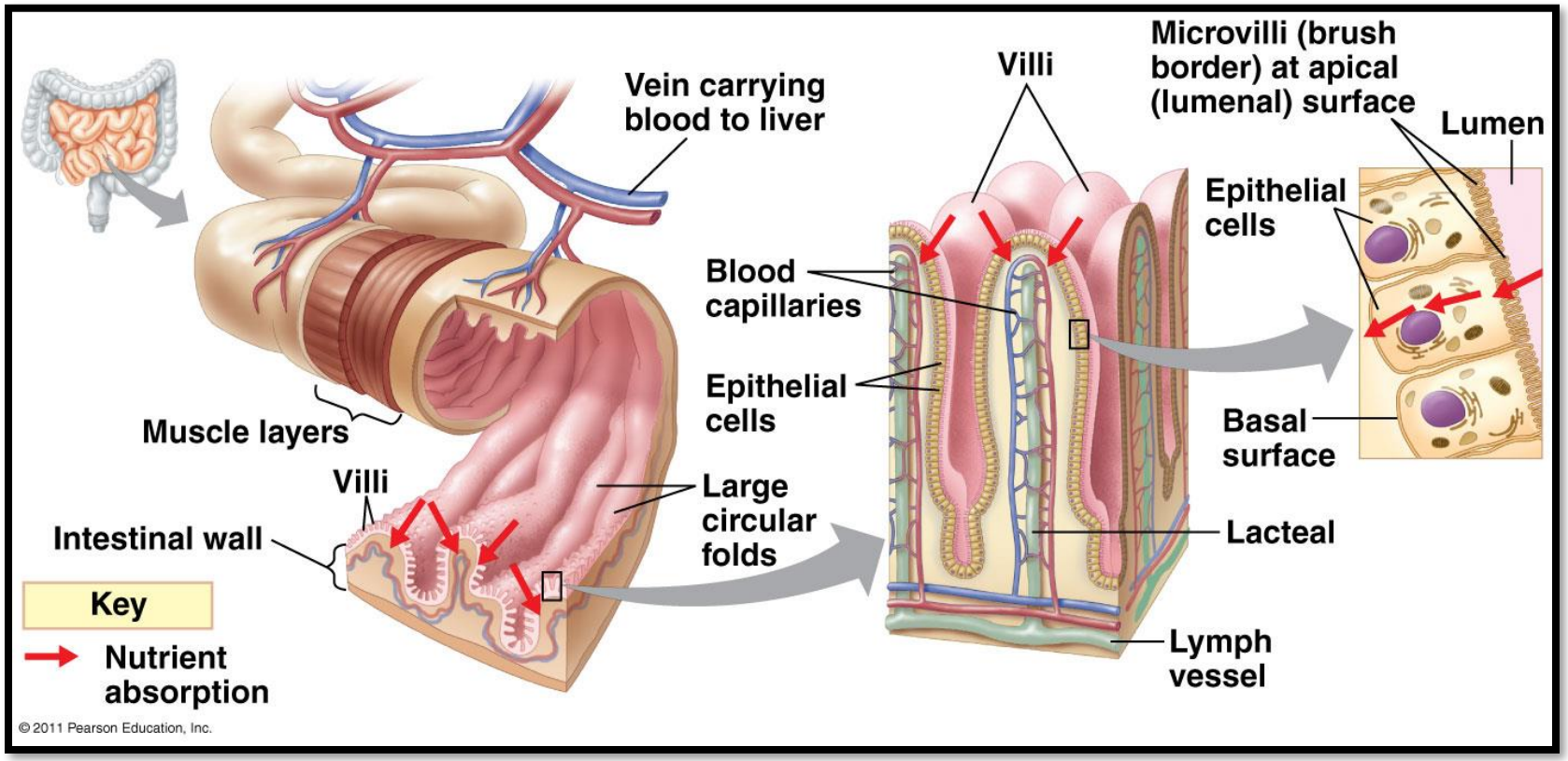
Total surface area [sum of the surface areas (height × width) of all box sides × number of boxes]	6	150	750
Total volume [height × width × length × number of boxes]	1	125	125
Surface-to-volume (S-to-V) ratio [surface area ÷ volume]	6	1.2	6

Calculate Volume of a Sphere:

$$V = \frac{4}{3}\pi r^3$$



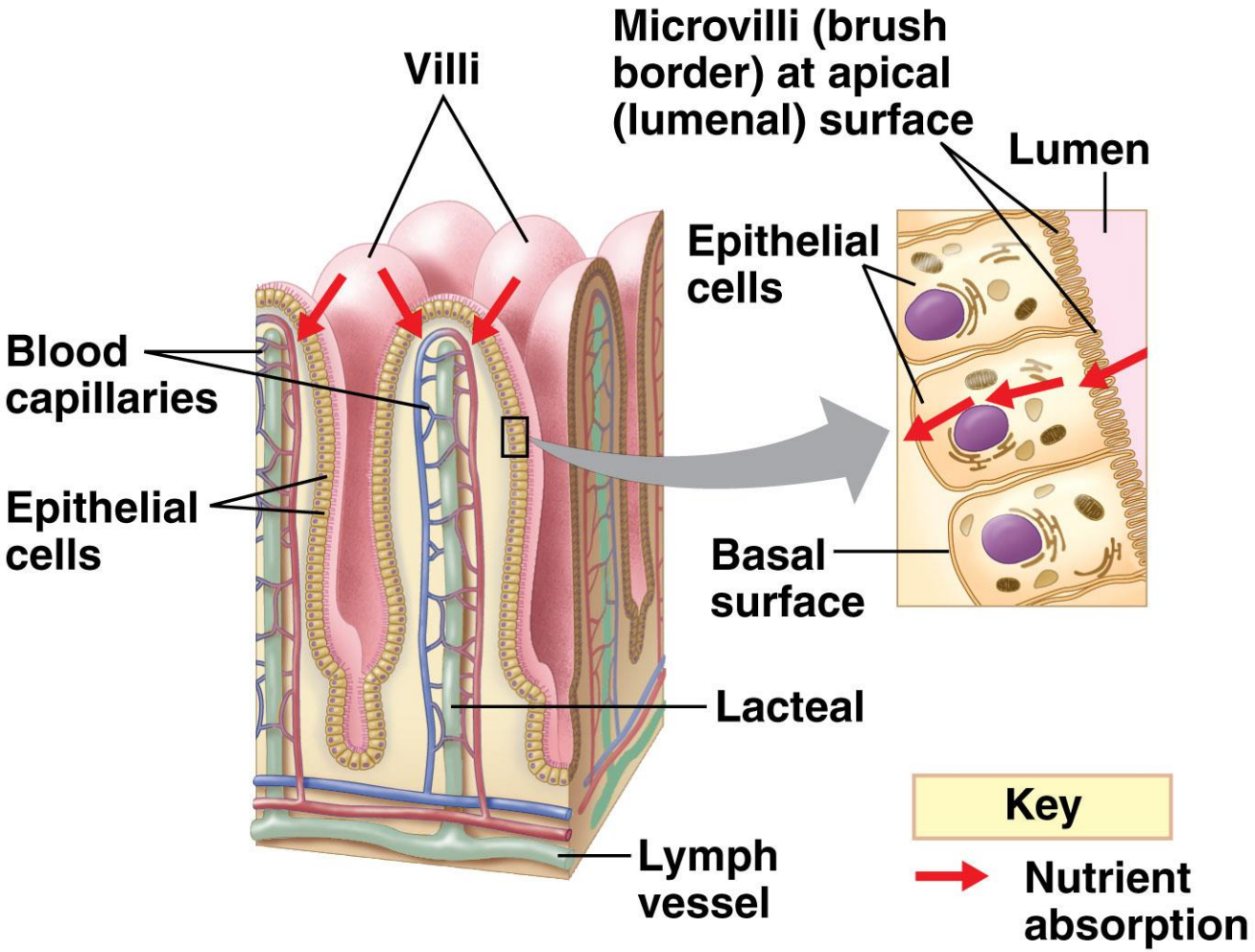
Surface Area Example (Animal):

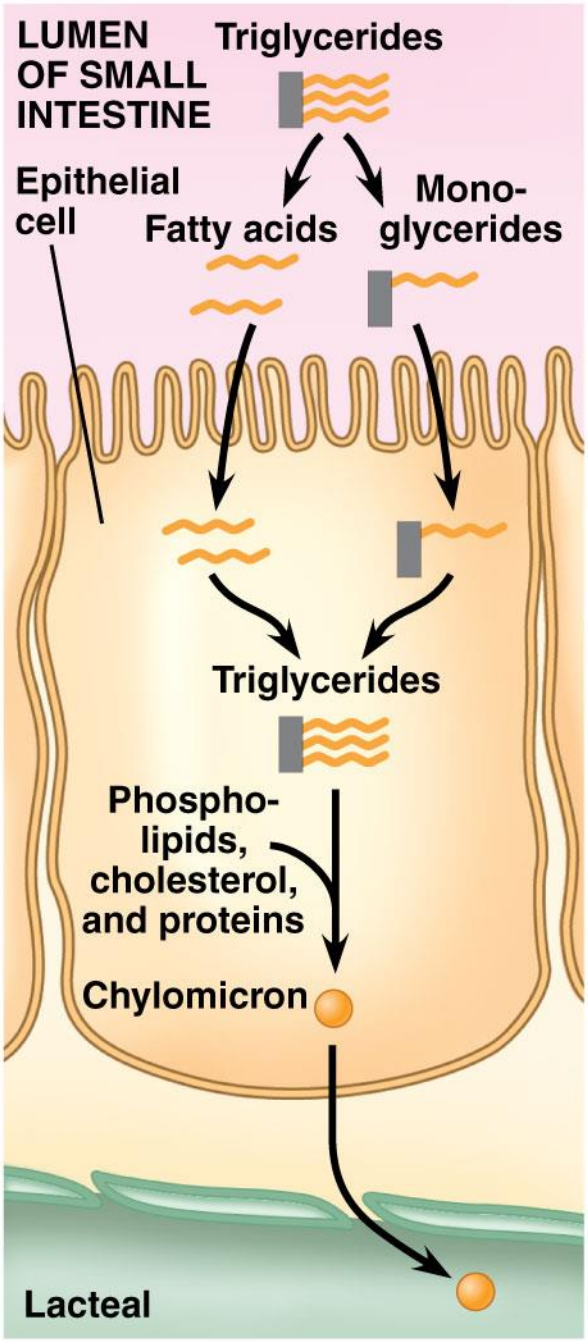


Small Intestine: *highly folded surface* to increase absorption of nutrients

- Villi: finger-like projections on SI wall
- Microvilli: projections on each cell

Folds → Villi → Microvilli

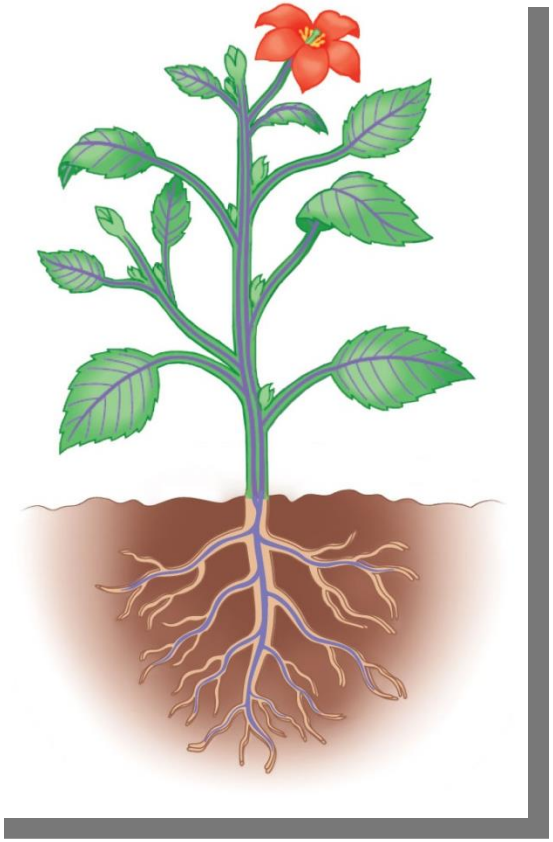




Surface Area Example (Plant):

Root hairs: extensions of root epidermal cells;

increase surface area for absorbing water and minerals



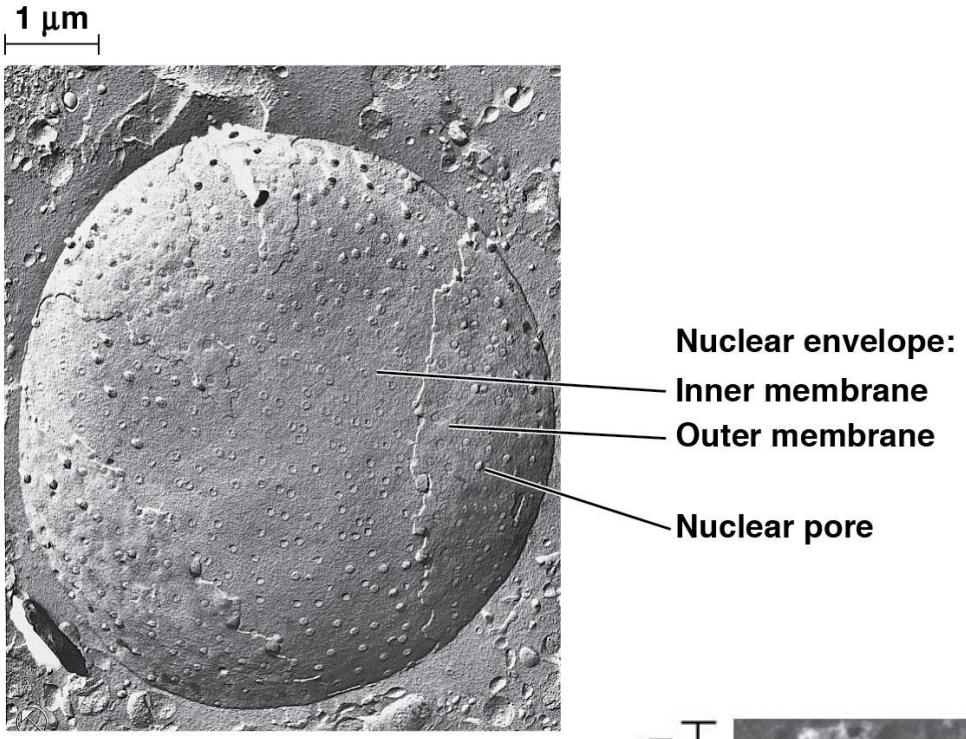
Nucleus

Function:

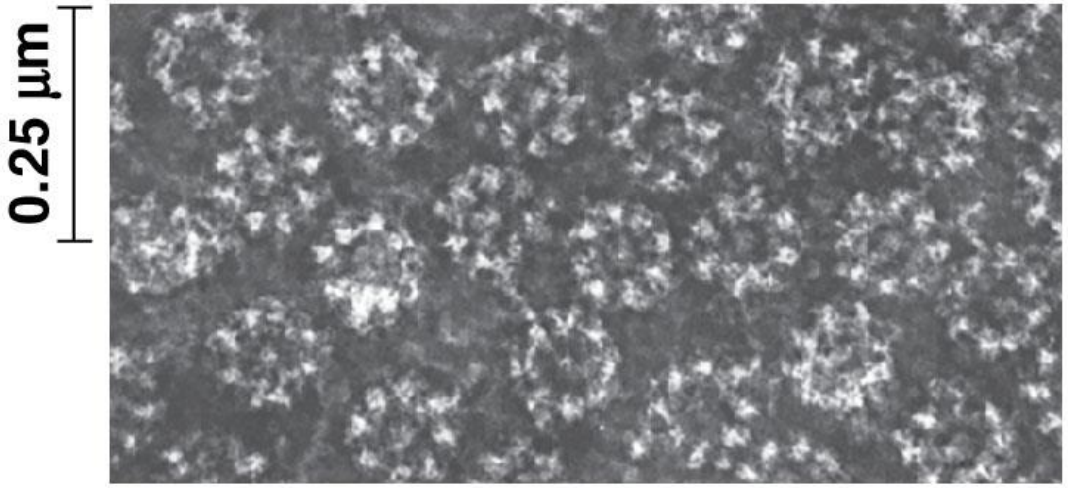
- "Command center" of cell – controls cell's growth & reproduction

Structure:

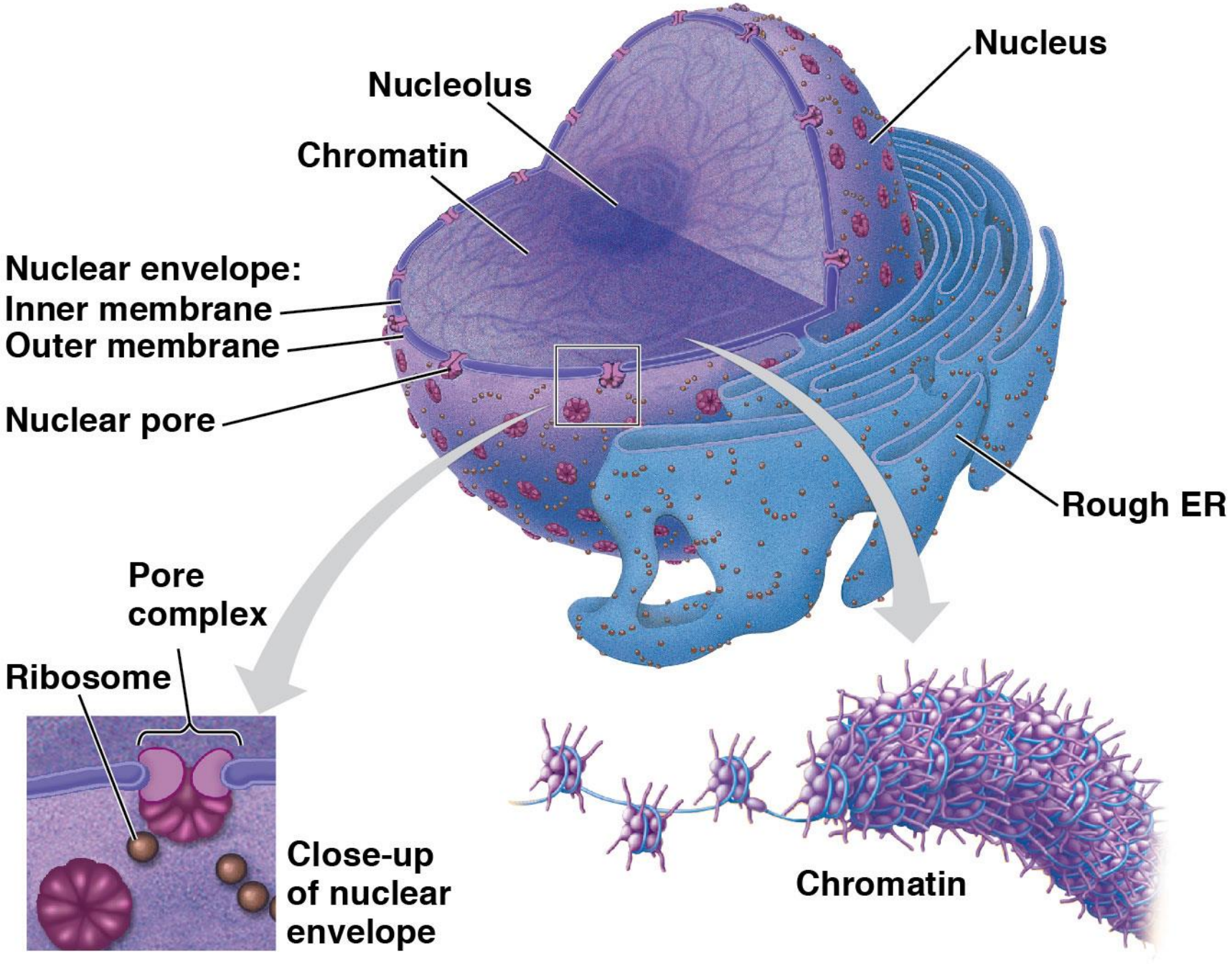
- Surrounded by double membrane (**nuclear envelope**)
  - Continuous with the rough ER
- Contains DNA (& mRNA)
- Nuclear pores: control what enters/leaves nucleus
- Chromatin: complex of DNA + proteins; makes up chromosomes
- Nucleolus: region where ribosomal subunits (rRNA + proteins) are formed



Surface of nuclear envelope (TEM)



Pore complexes (TEM)



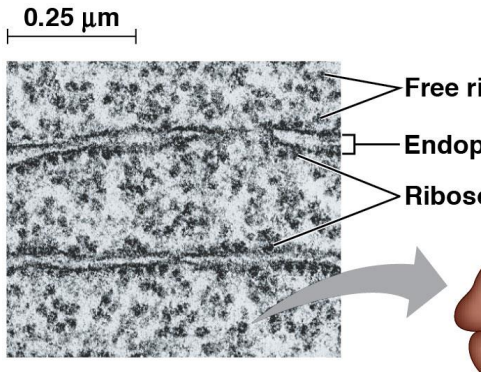
Ribosomes

Function:

- protein synthesis

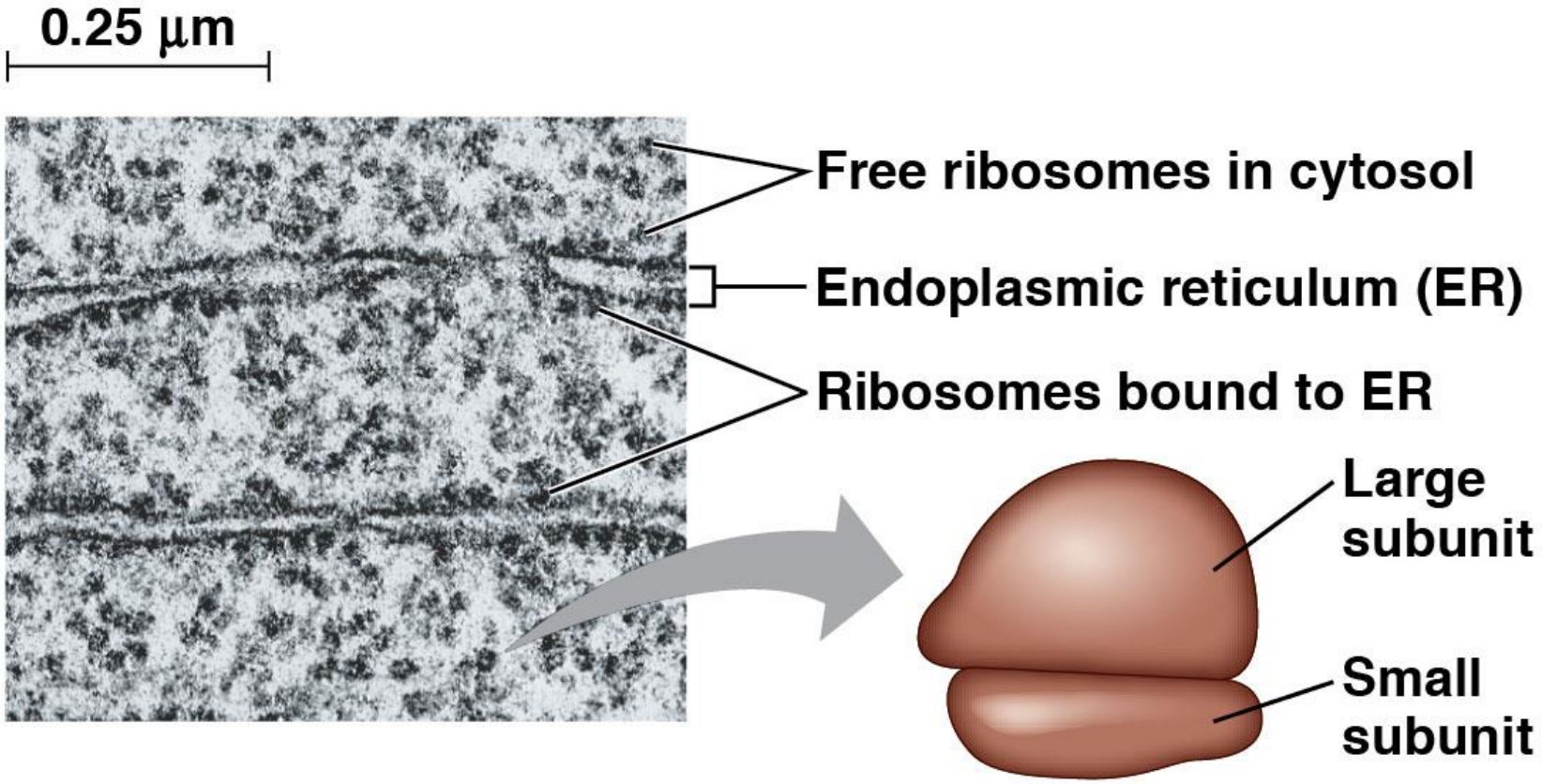
Structure:

- Composed of rRNA + protein
- Large subunit + small subunit
- Types:
  1. Free ribosomes: float in cytosol, produce proteins used within cell
  2. Bound ribosomes: attached to ER, make proteins for export from cell



TEM showing ER and ribosomes

Diagram of a ribosome



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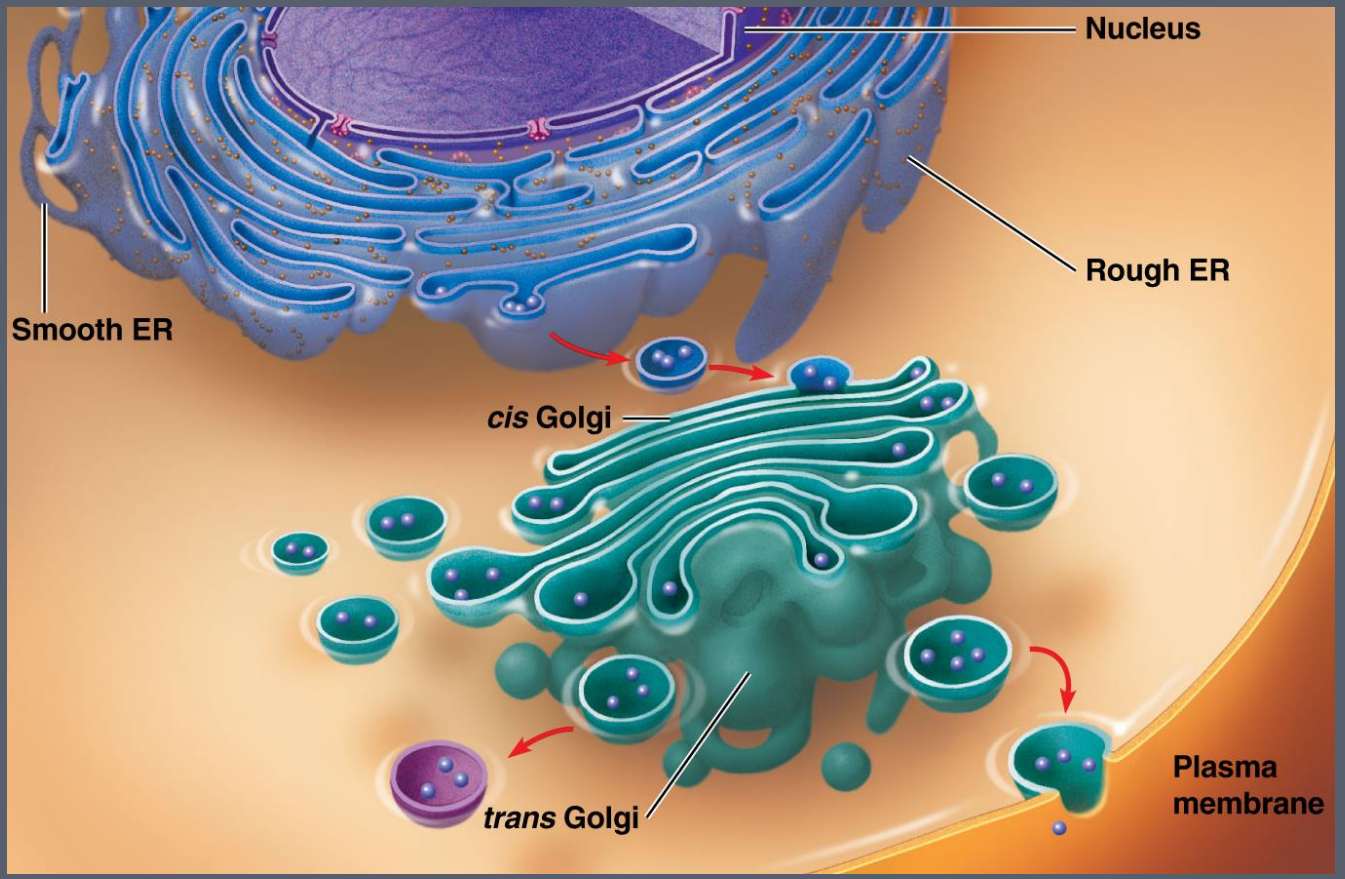


Endomembrane System:

Regulates protein traffic & performs metabolic functions

Endoplasmic Reticulum (ER)

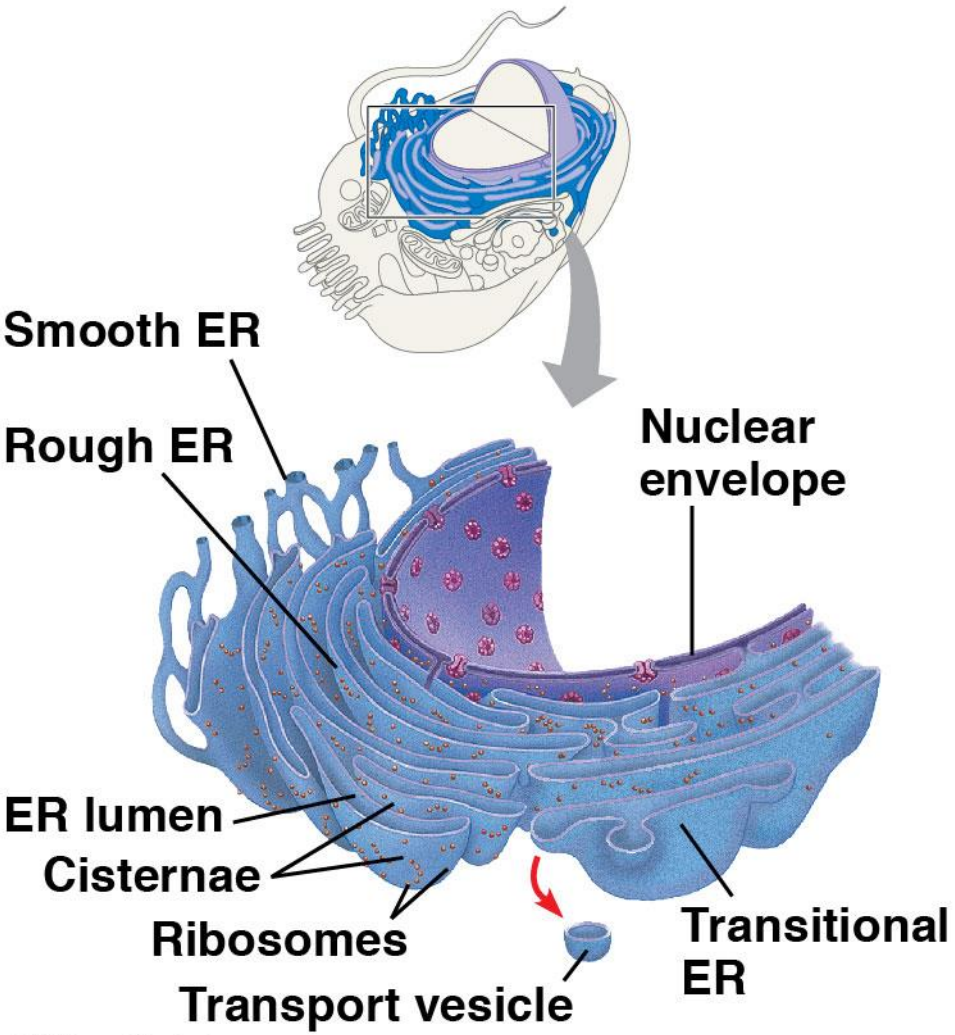
1. Rough ER: ribosomes on surface
   - **Function:** package proteins for secretion, send transport vesicles to Golgi, make replacement membrane

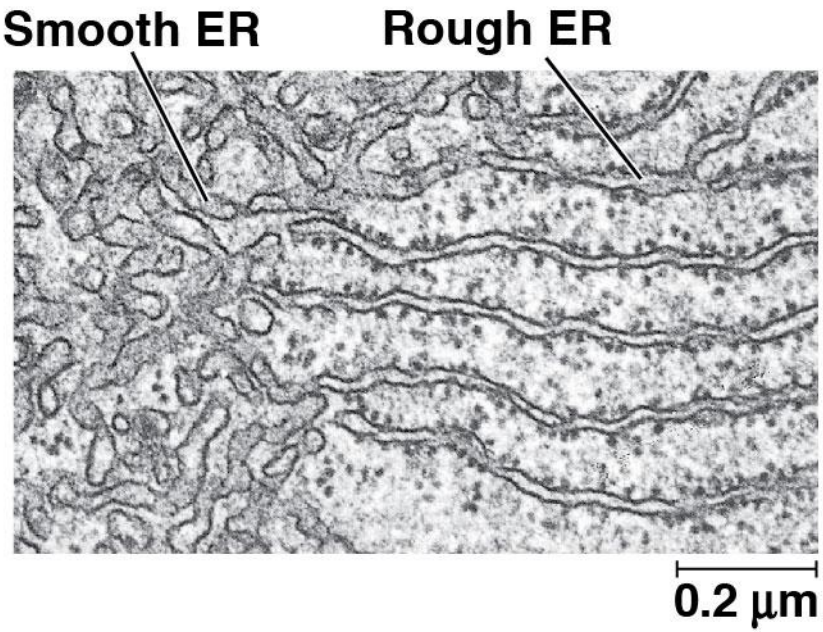
2. Smooth ER: no ribosomes on surface
   - **Function:** synthesize lipids, metabolize carbs, detox drugs & poisons, store Ca^{2+}

Structure:

- Network of membranes and sacs

Endoplasmic Reticulum (ER)





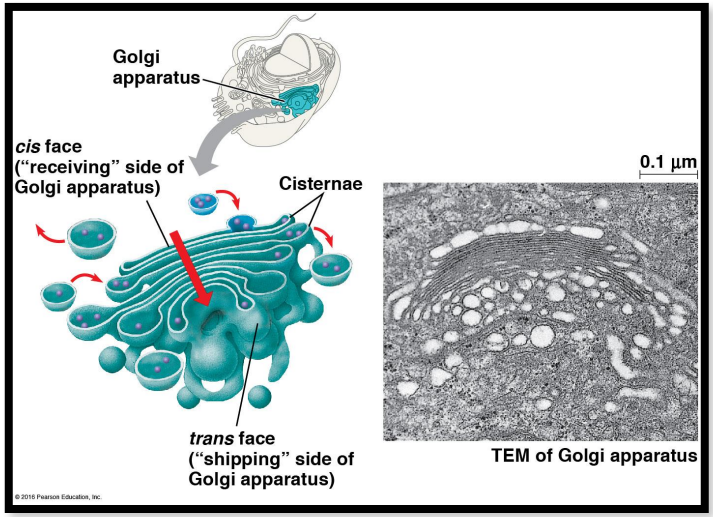
Golgi Apparatus

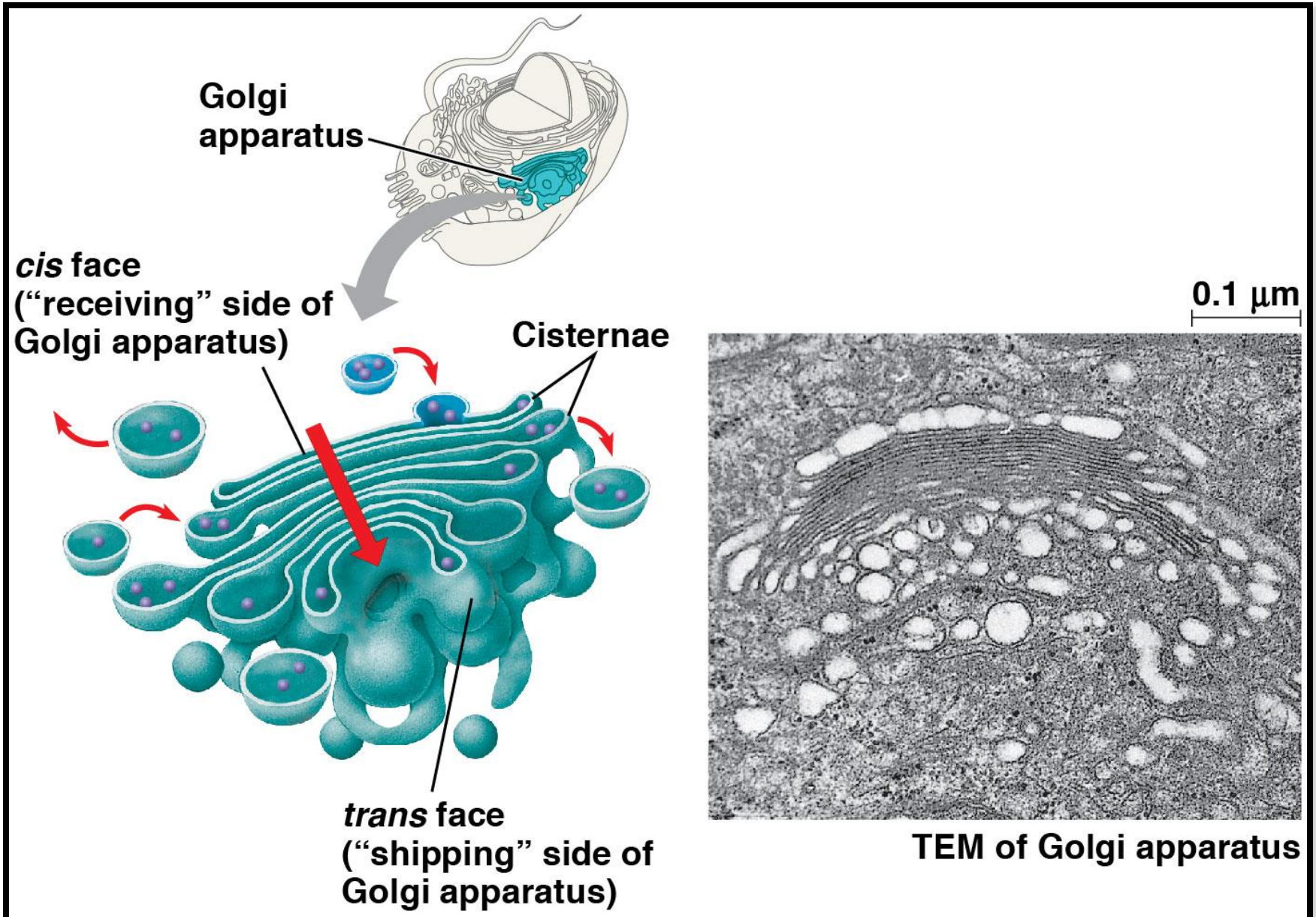
Function:

- Synthesis & packaging of materials (small molecules) for transport (in vesicles); produce lysosomes

Structure:

- Series of flattened membrane sacs (cisternae)
  - *Cis* face: receives vesicles
  - *Trans* face: ships vesicles





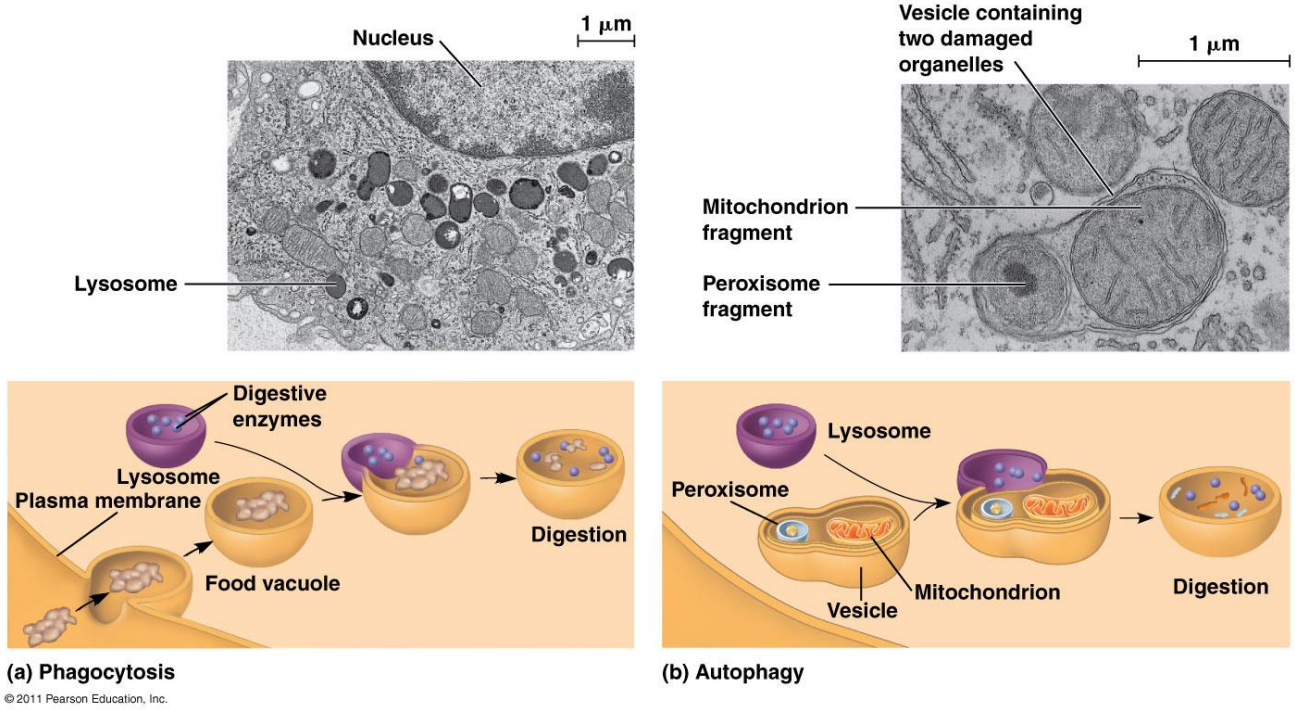
Lysosomes

Function:

- Intracellular digestion; recycle cell's materials; programmed cell death (apoptosis)

Structure:

- Membranous sac containing *hydrolytic enzymes (Hydrolysis!)*



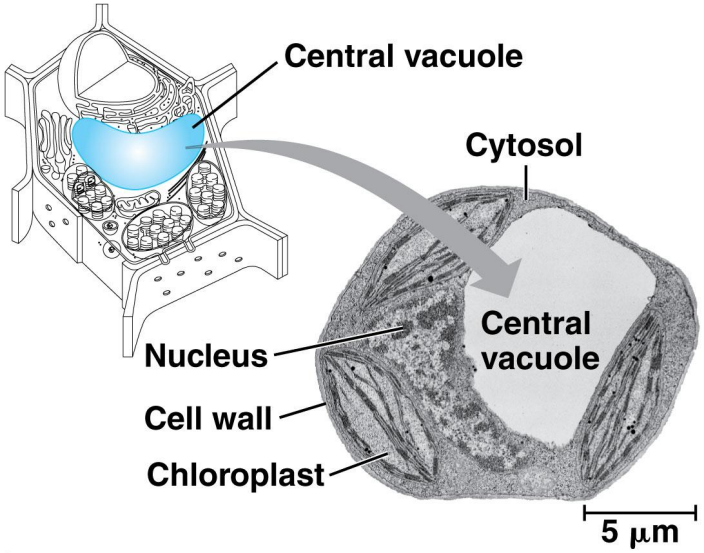
Vacuoles

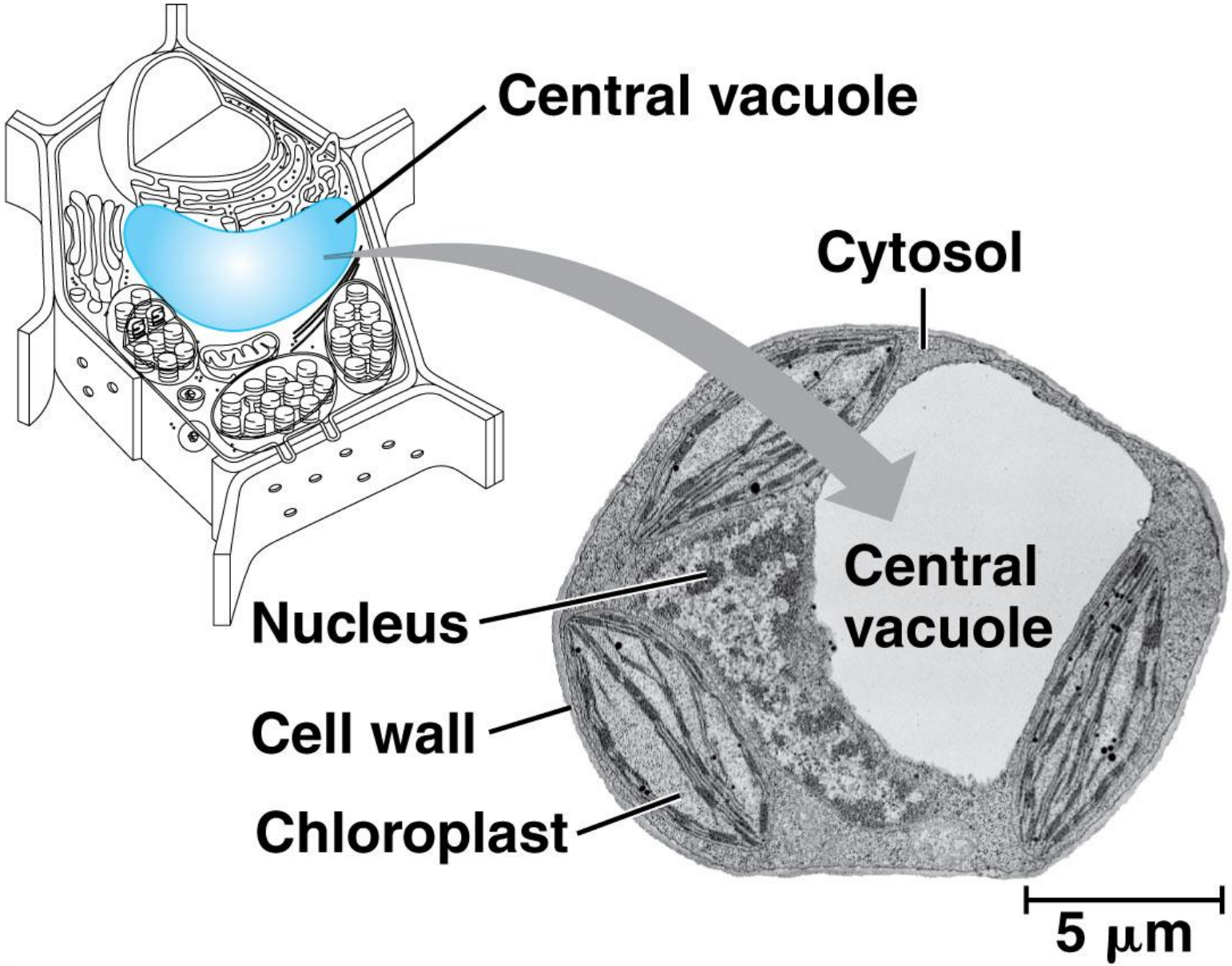
Function:

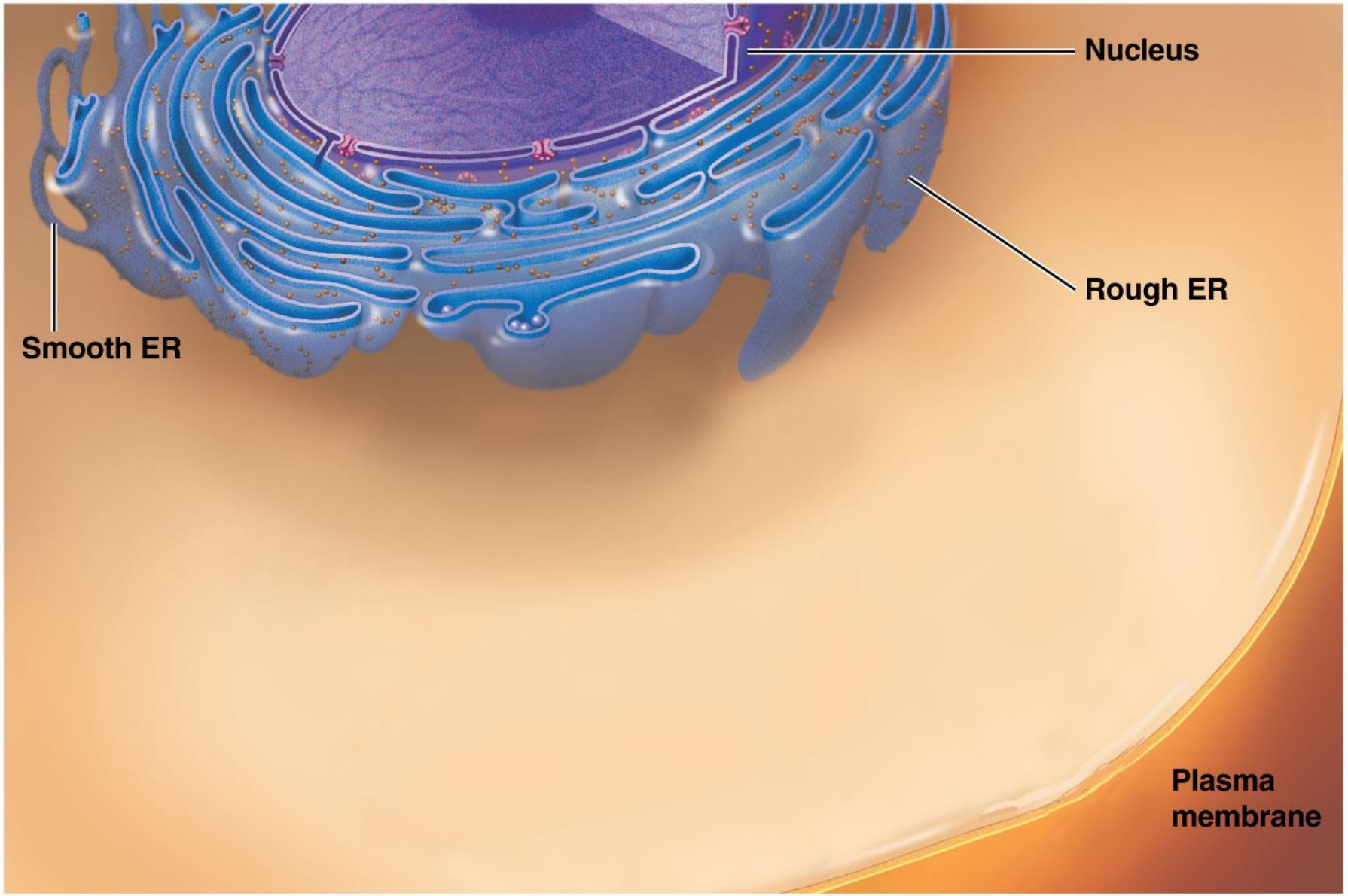
- Storage of materials (food, water, minerals, pigments, poisons)

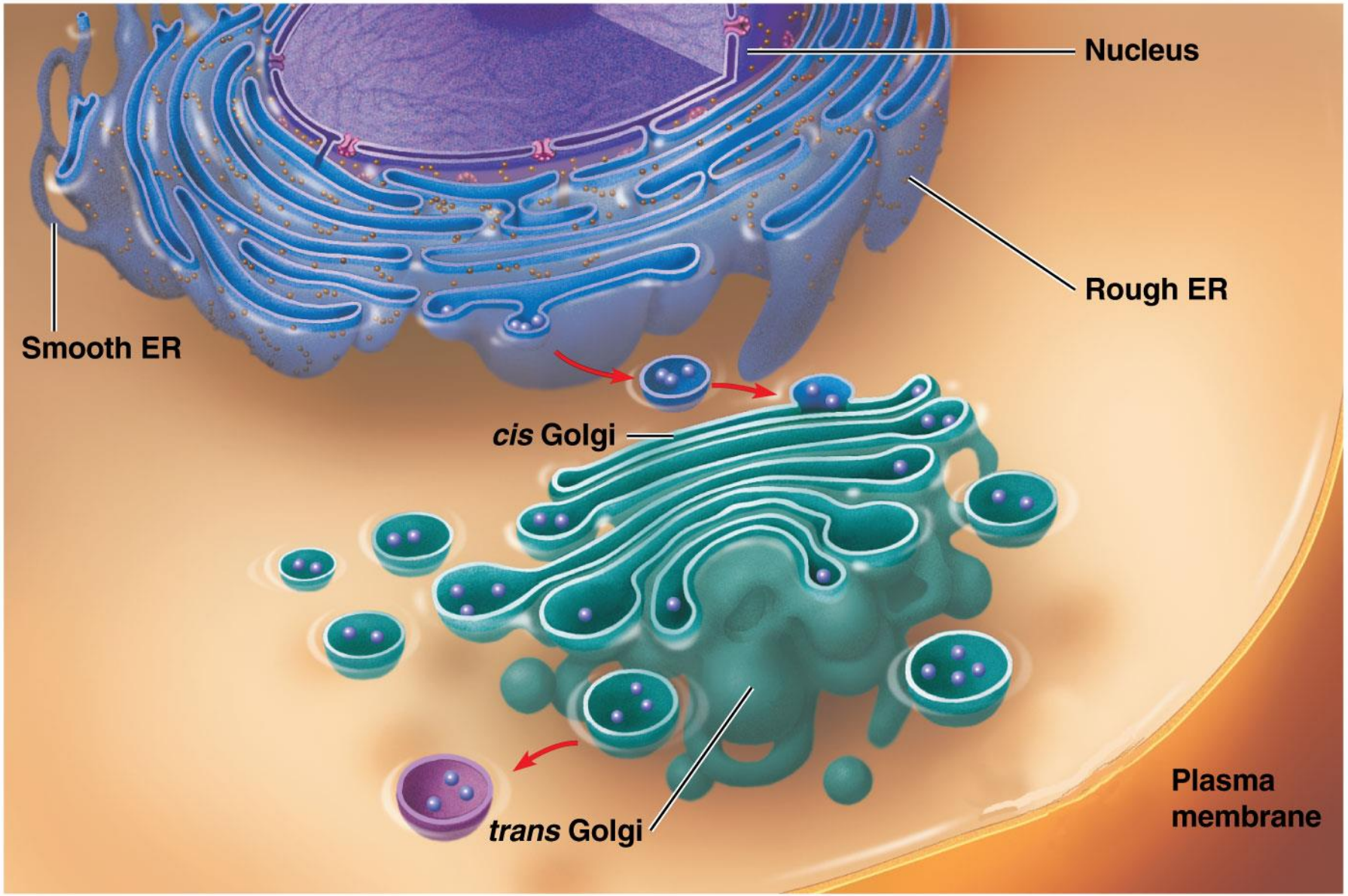
Structure:

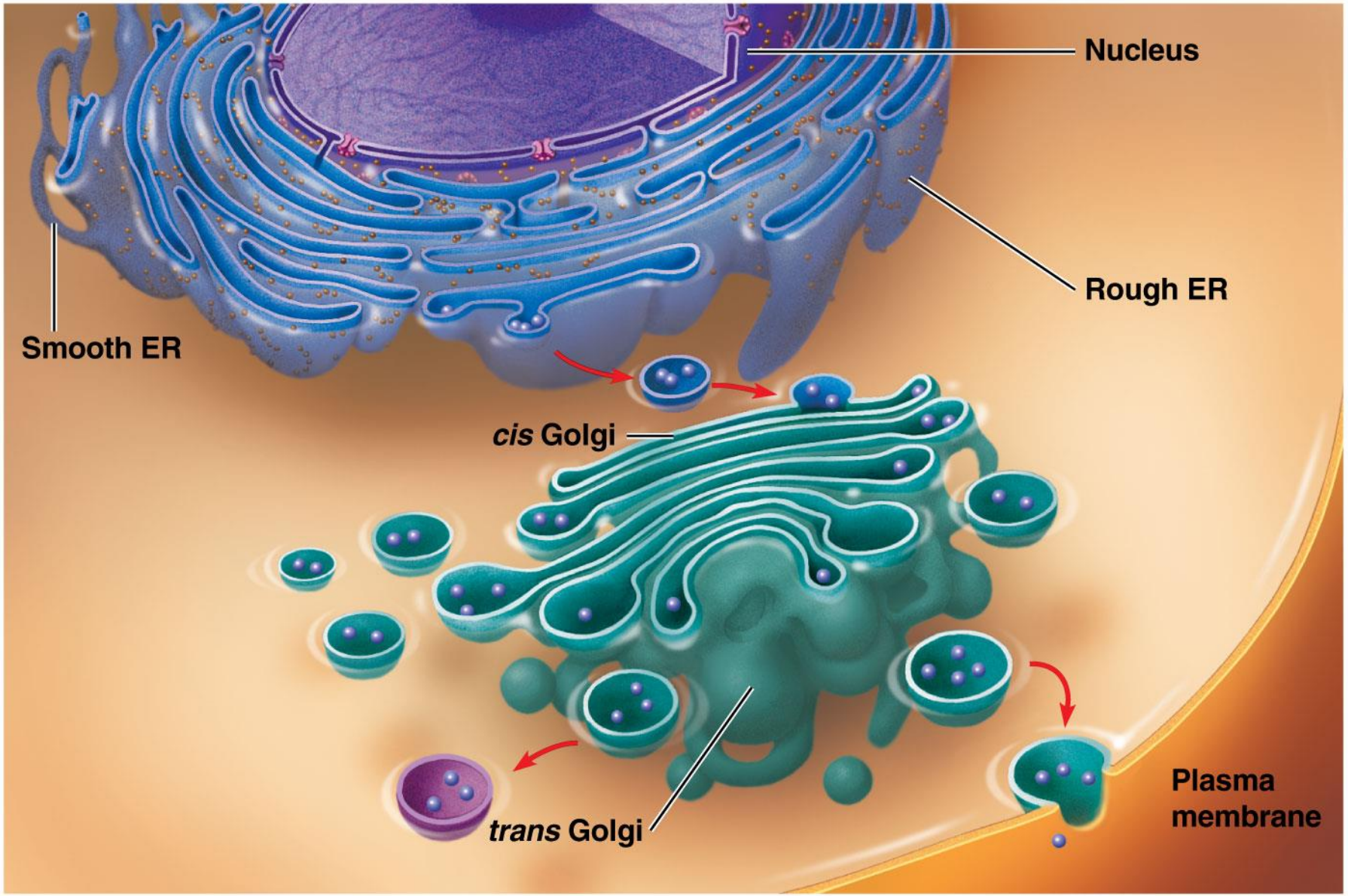
- Membrane-bound vesicles
- Eg. food vacuoles, contractile vacuoles
- Plants: large central vacuole -- stores water, ions; retains water for turgor pressure

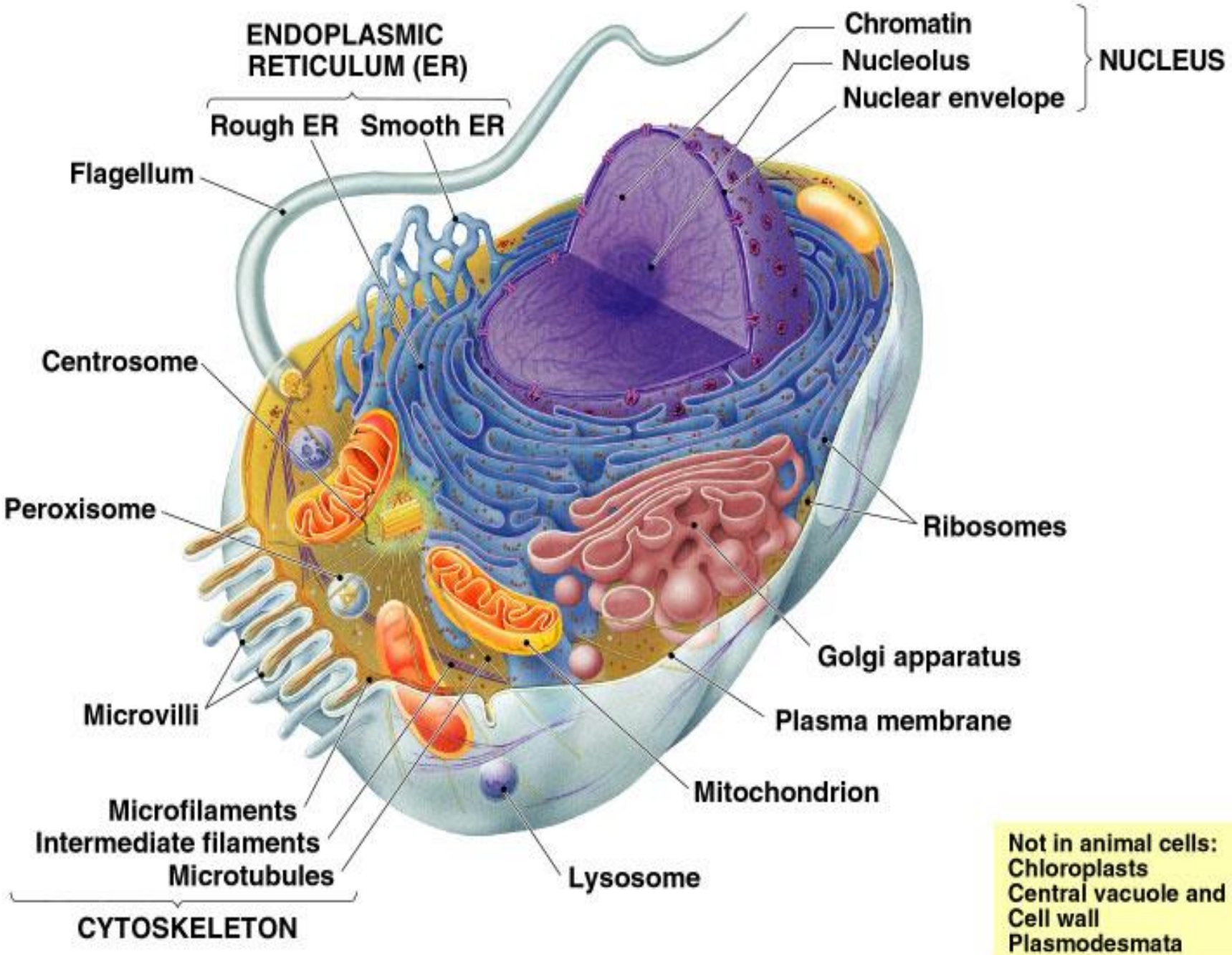


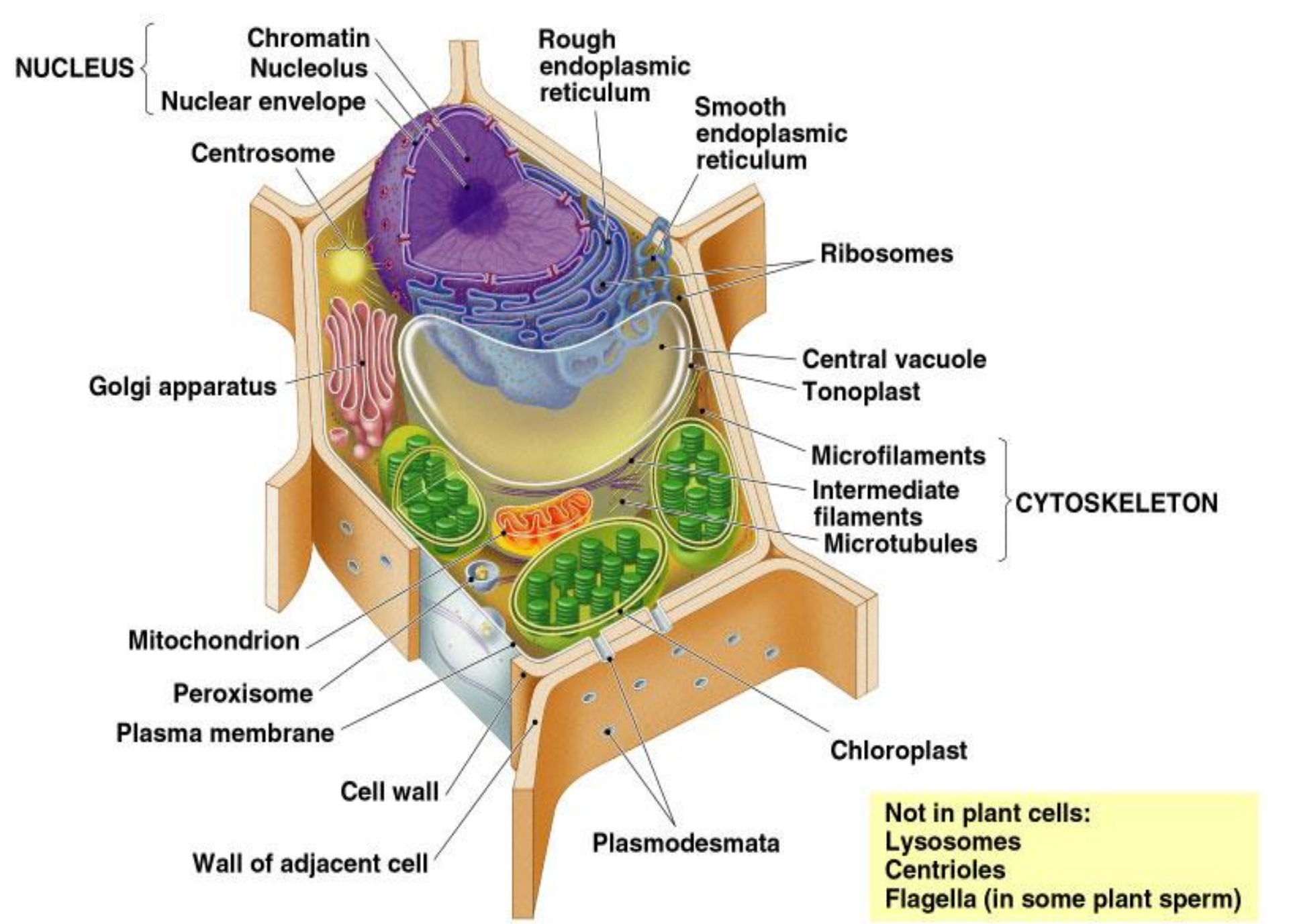












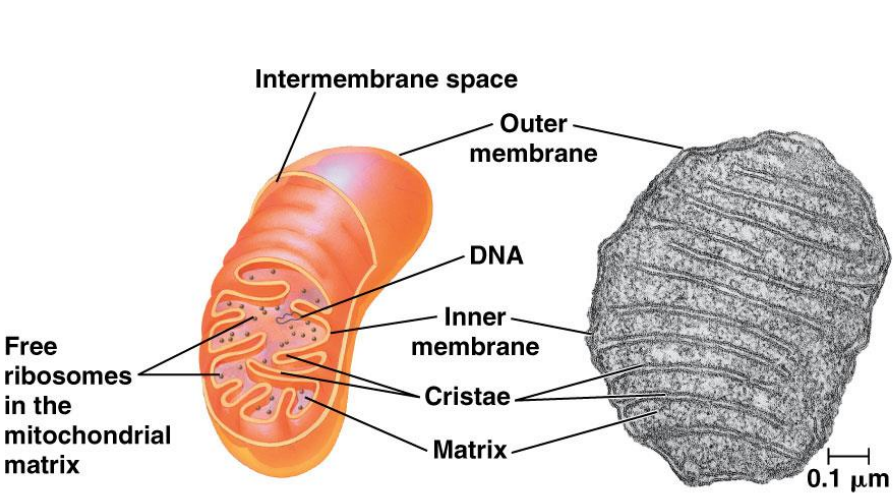
Mitochondria

Function:

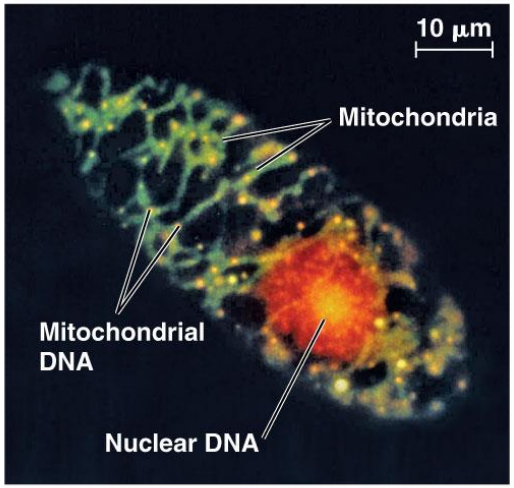
- site of cellular respiration

Structure:

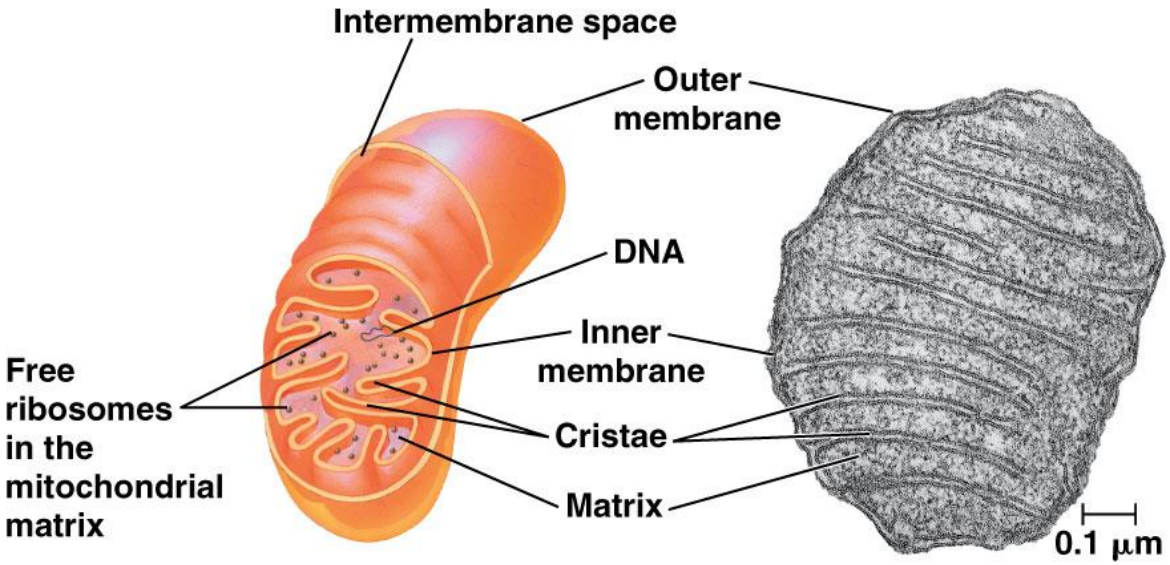
- Double membrane: outer and inner membrane
- Cristae: folds of inner membrane; contains enzymes for ATP production; increased surface area to ↑ ATP made
- Matrix: fluid-filled inner compartment



(a) Diagram and TEM of mitochondrion



(b) Network of mitochondria in a protist cell (LM)



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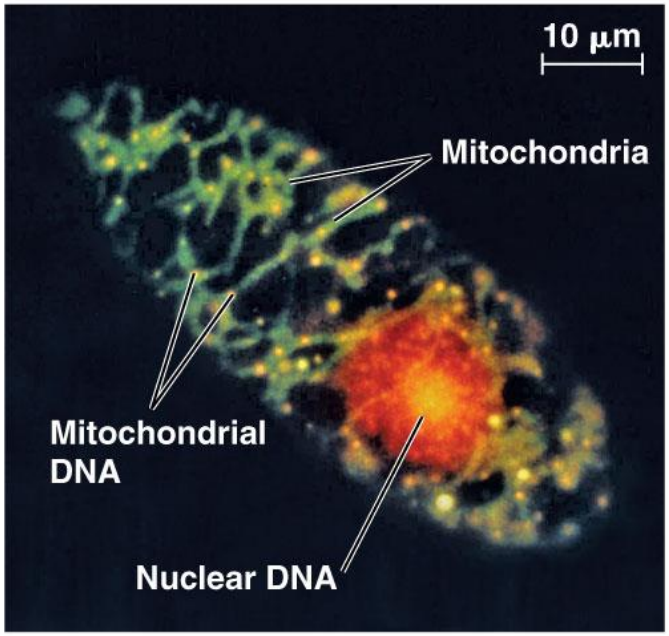


(b) Network of mitochondria in a protist cell (LM)

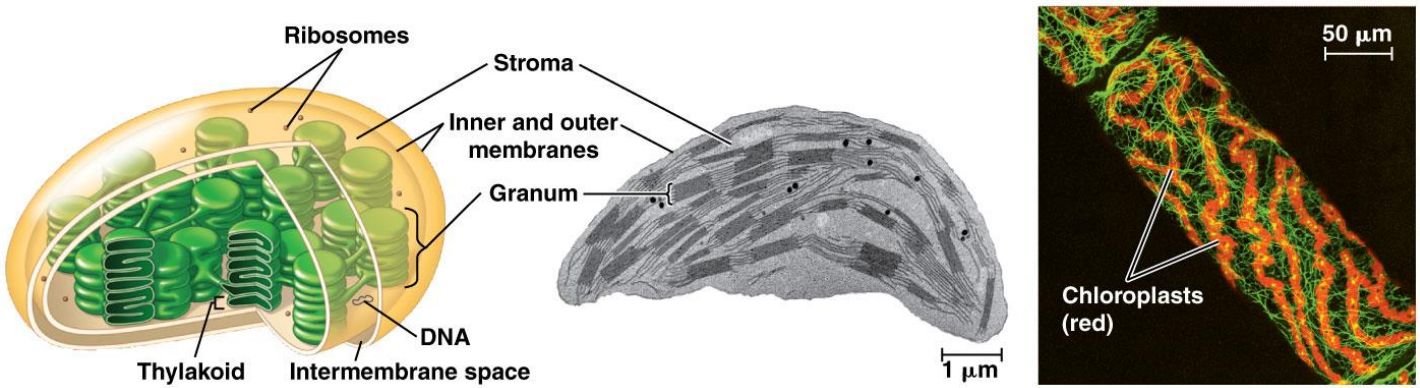
Chloroplasts

Function:

- Site of photosynthesis

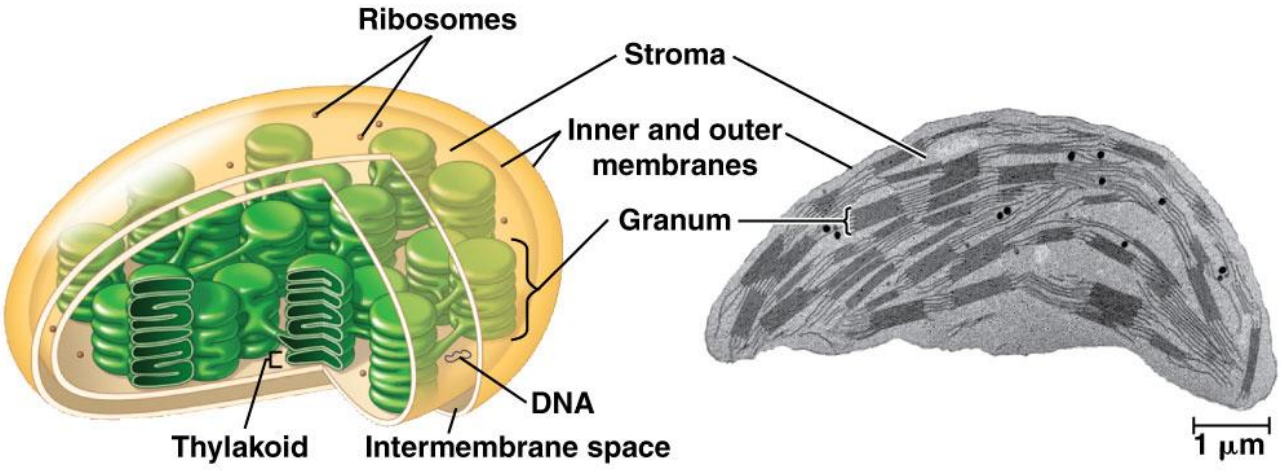
Structure:

- Double membrane
- Thylakoid disks in stacks (grana); stroma (fluid)
- Contains chlorophylls (pigments) for capturing sunlight energy

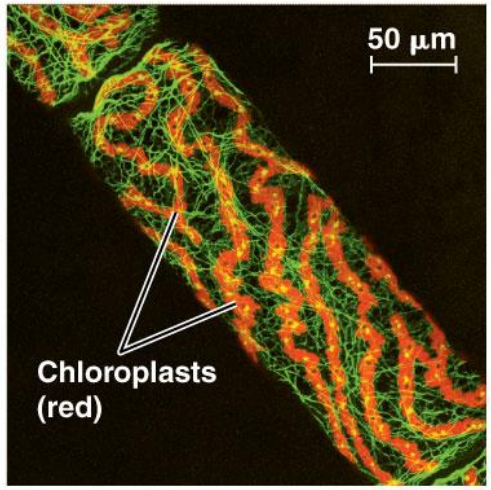


(a) Diagram and TEM of chloroplast

(b) Chloroplasts in an algal cell

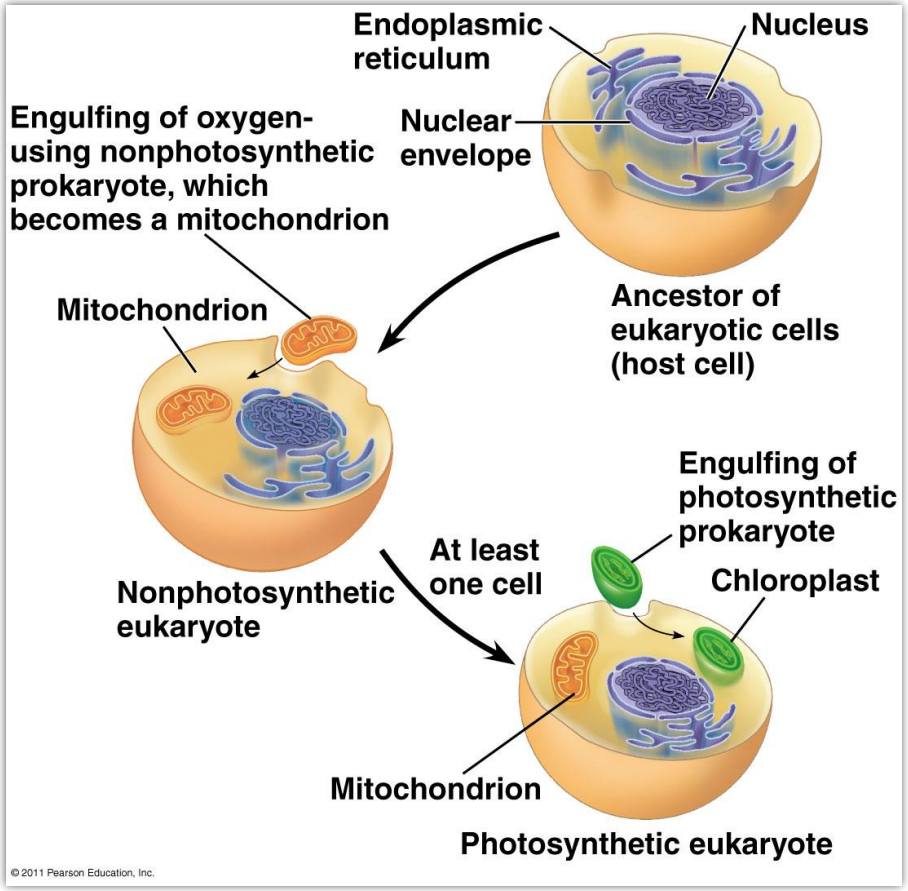


(a) Diagram and TEM of chloroplast



(b) Chloroplasts in an algal cell

Endosymbiont theory

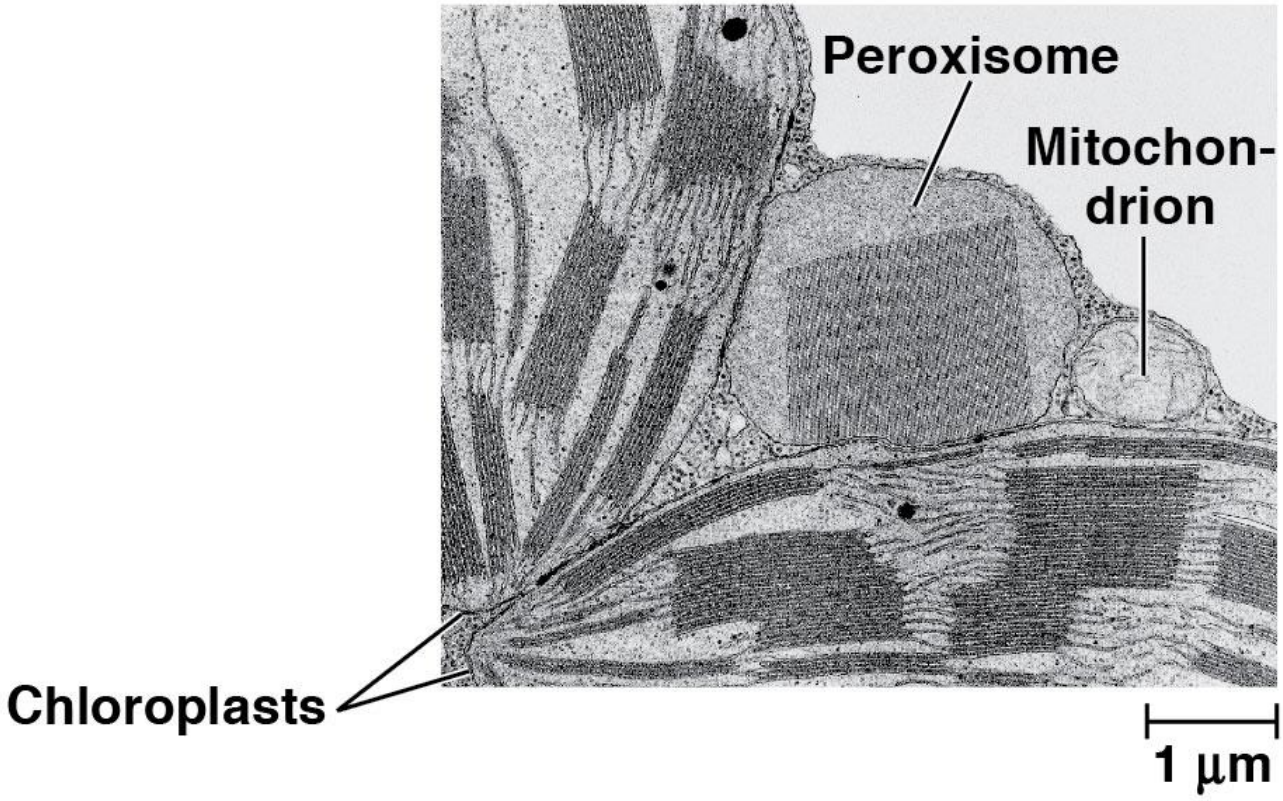


- Mitochondria & chloroplasts share similar origin
- Prokaryotic cells engulfed by ancestors of eukaryotic cells
- Evidence:
  - Double-membrane structure
  - Have own ribosomes & DNA
  - Reproduce independently within cell

Peroxisomes

Functions:

- Break down fatty acids; detox alcohol
- Involves production of hydrogen peroxide (H_2O_2)



Cytoskeleton: network of protein fibers

Function:

- Support, motility, regulate biochemical activities

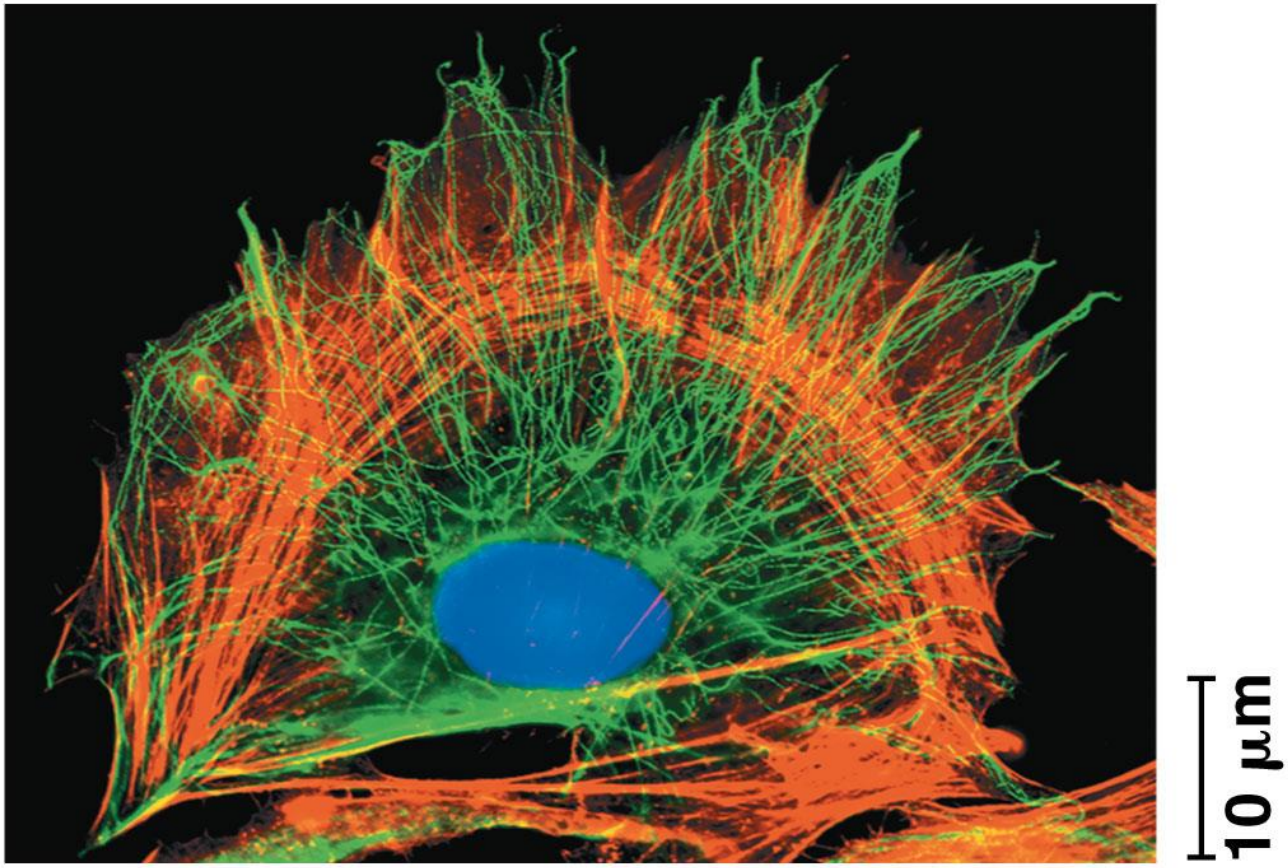
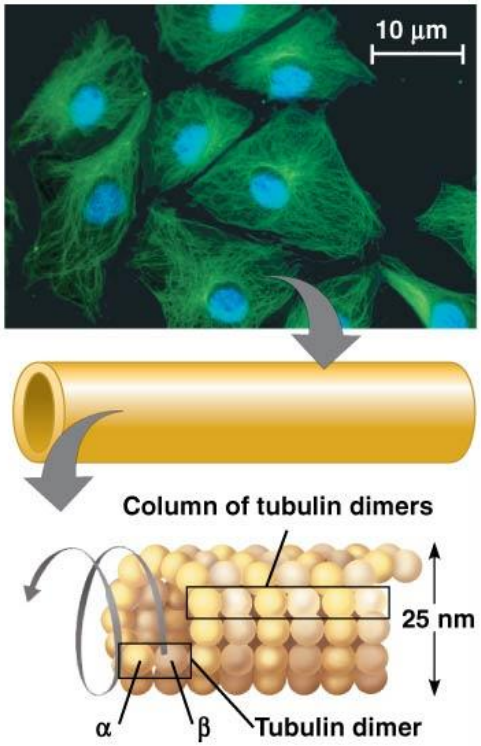
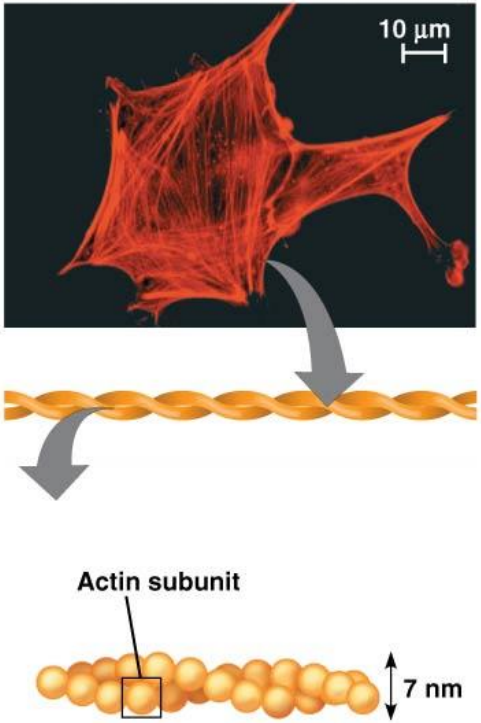
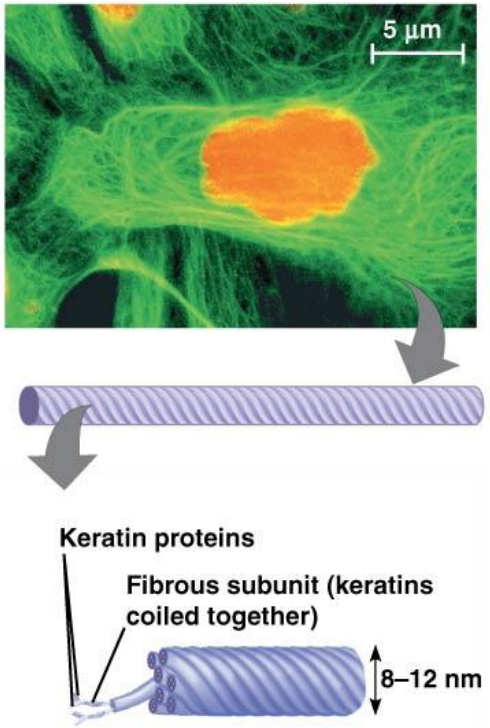


Table 4.1 The Structure and Function of the Cytoskeleton

Property	Microtubules (Tubulin Polymers)	Microfilaments (Actin Filaments)	Intermediate Filaments
Structure	Hollow tubes	Two intertwined strands of actin	Fibrous proteins coiled into cables
Diameter	25 nm with 15-nm lumen	7 nm	8–12 nm
Protein subunits	Tubulin, a dimer consisting of α-tubulin and β-tubulin	Actin	One of several different proteins (such as keratins)
Main functions	Maintenance of cell shape; cell motility; chromosome movements in cell division; organelle movements	Maintenance of cell shape; changes in cell shape; muscle contraction; cytoplasmic streaming (plant cells); cell motility; cell division (animal cells)	Maintenance of cell shape; anchorage of nucleus and certain other organelles; formation of nuclear lamina
Fluorescence micrographs of fibroblasts. Fibroblasts are a favorite cell type for cell biology studies because they spread out flat and their internal structures are easy to see. In each, the structure of interest has been tagged with fluorescent molecules. The DNA in the nucleus has also been tagged in the first micrograph (blue) and third micrograph (orange).			

Plant Cells

Cell wall Function:

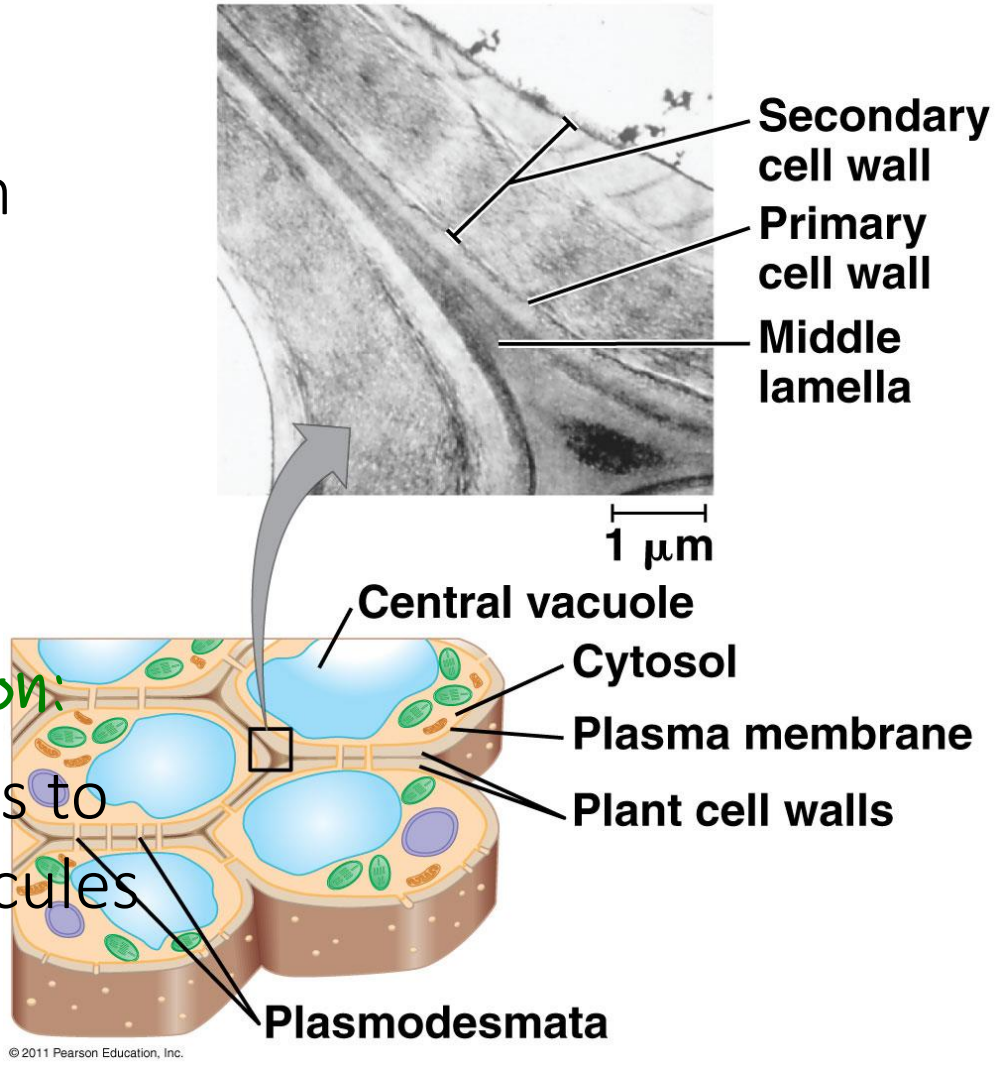
- Protect plant, maintain shape

Structure:

- Composed of cellulose

Plasmodesmata Function:

- Channels between cells to allow passage of molecules from cell to cell



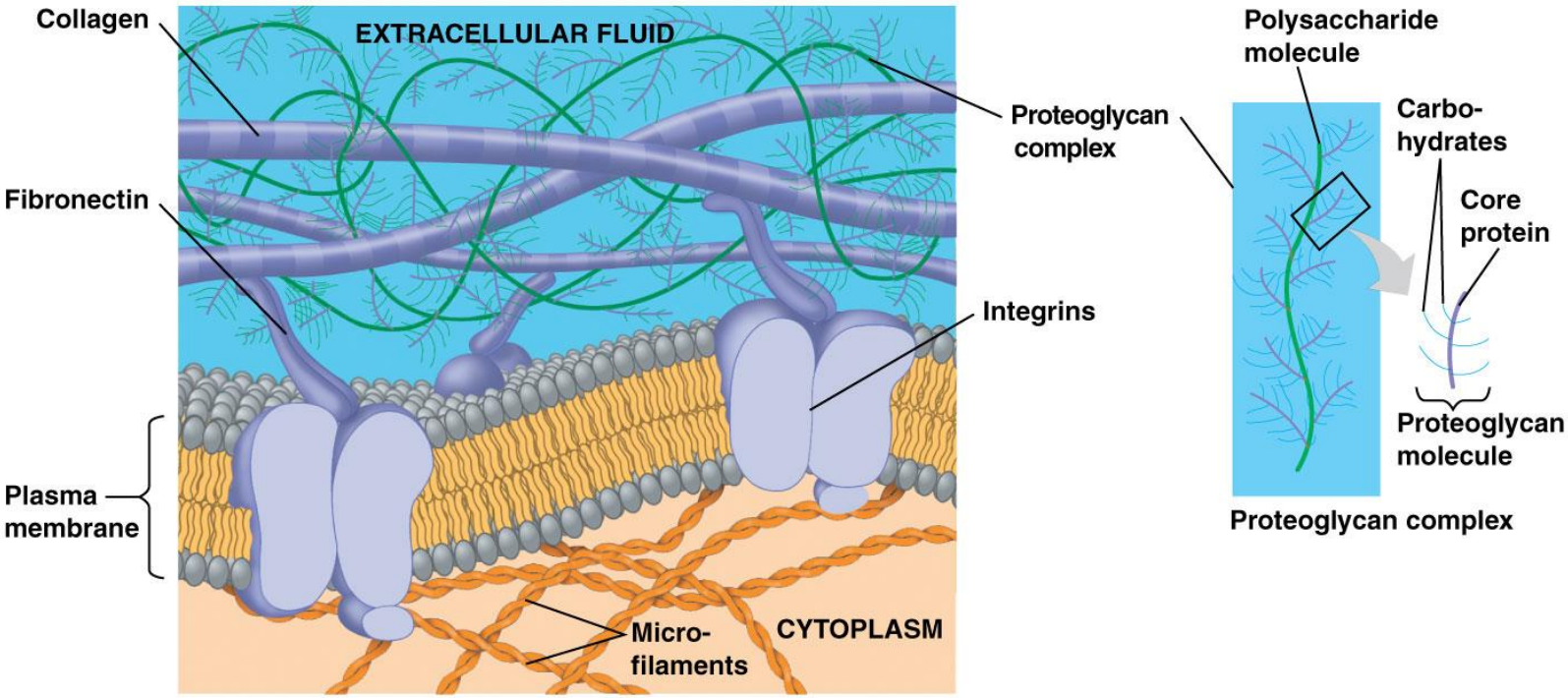
Extracellular Matrix (ECM)

Function:

- Strengthens tissues and transmits external signals to cell

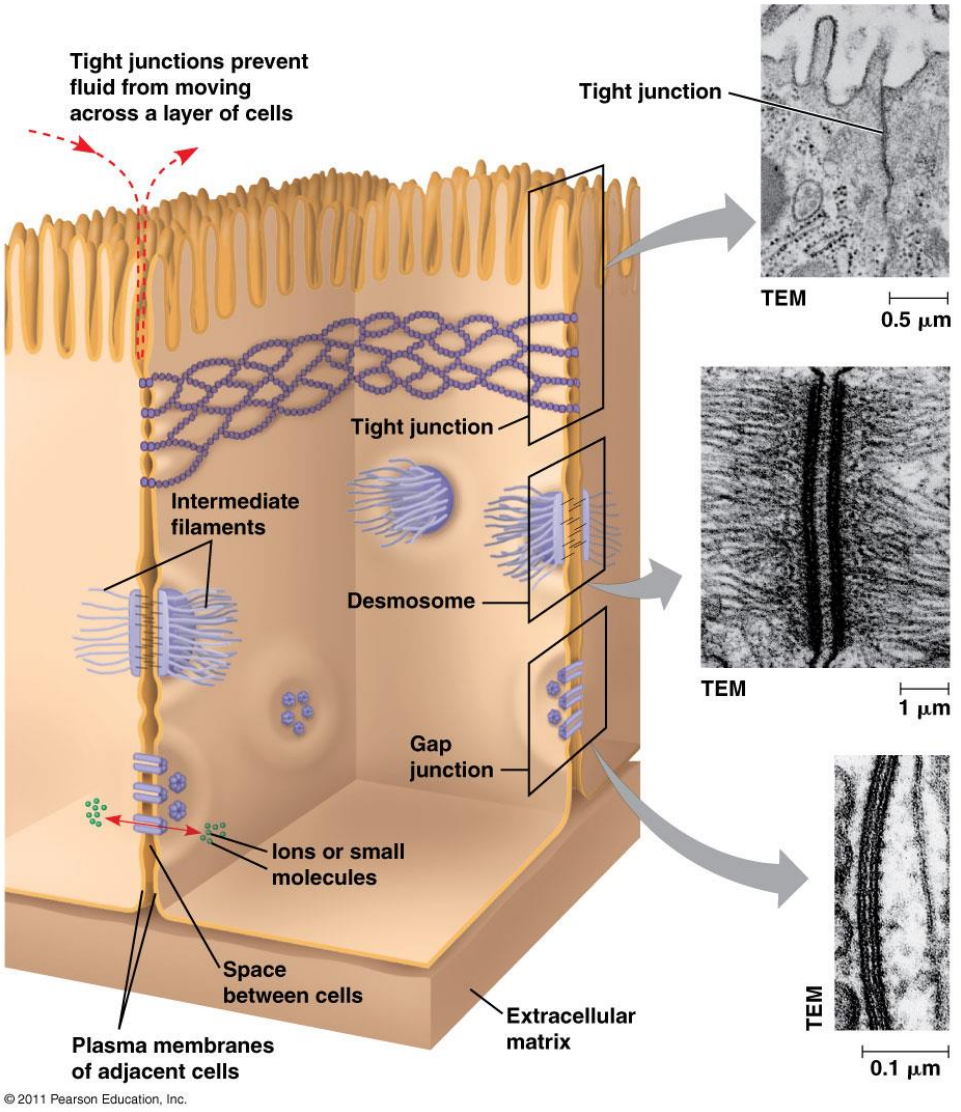
Structure:

- Outside plasma membrane of animal cells
- Composed of glycoproteins (ex. collagen)



Intercellular Junctions (Animal cells)

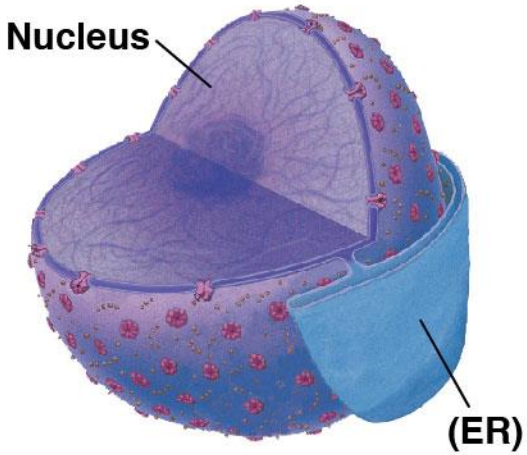
- Tight junctions: 2 cells are fused to form watertight seal
- Desmosomes: "rivets" that fasten adjacent cells into strong sheets
- Gap junctions: channels through which ions, sugar, small molecules can pass

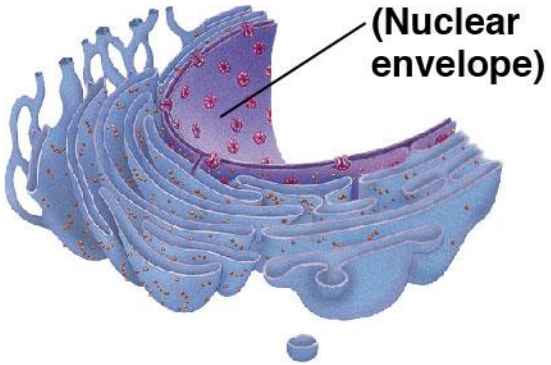
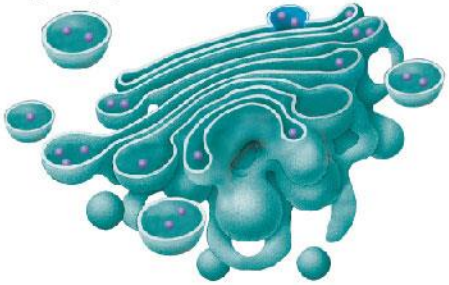
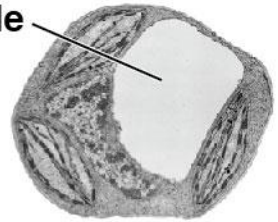


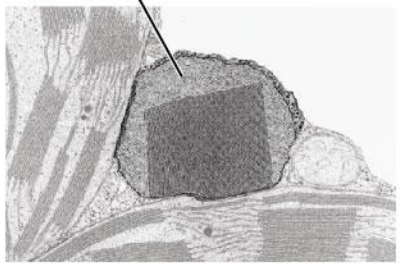
Plant Cells Only	Animals Cells Only
Central vacuoles	Lysosomes
Chloroplasts	Centrioles
Cell wall of cellulose	Flagella, cilia
Plasmodesmata	Desmosomes, tight and gap junctions
	Extracellular matrix (ECM)

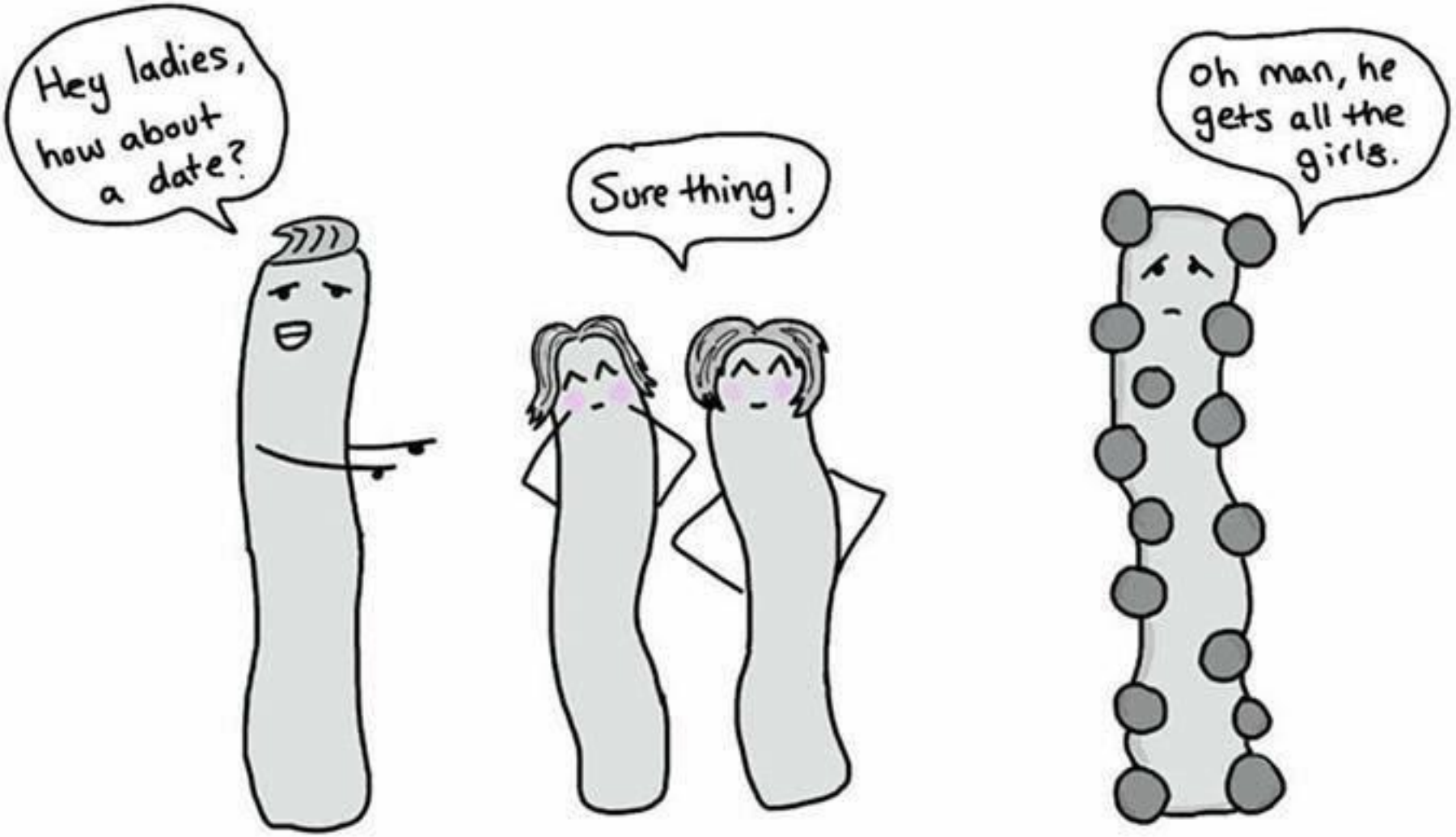
Harvard cell video

https://www.youtube.com/watch?v=wJyUtbn0O5Y

Cell Component	Structure	Function
	Surrounded by nuclear envelope (double membrane) perforated by nuclear pores; nuclear envelope continuous with endoplasmic reticulum (ER)	Houses chromosomes, which are made of chromatin (DNA and proteins); contains nucleoli, where ribosomal subunits are made; pores regulate entry and exit of materials
Ribosome 	Two subunits made of ribosomal RNA and proteins; can be free in cytosol or bound to ER	Protein synthesis

Cell Component	Structure	Function
Endoplasmic reticulum 	Extensive network of membrane-bounded tubules and sacs; membrane separates lumen from cytosol; continuous with nuclear envelope	Smooth ER: synthesis of lipids, metabolism of carbohydrates, Ca^{2+} storage, detoxification of drugs and poisons Rough ER: aids in synthesis of secretory and other proteins from bound ribosomes; adds carbohydrates to proteins to make glycoproteins; produces new membrane
Golgi apparatus 	Stacks of flattened membranous sacs; has polarity (*cis* and *trans* faces)	Modification of proteins, carbohydrates on proteins, and phospholipids; synthesis of many polysaccharides; sorting of Golgi products, which are then released in vesicles
Lysosome 	Membranous sac of hydrolytic enzymes (in animal cells)	Breakdown of ingested substances, cell macromolecules, and damaged organelles for recycling
Vacuole 	Large membrane-bounded vesicle	Digestion, storage, waste disposal, water balance, plant cell growth and protection

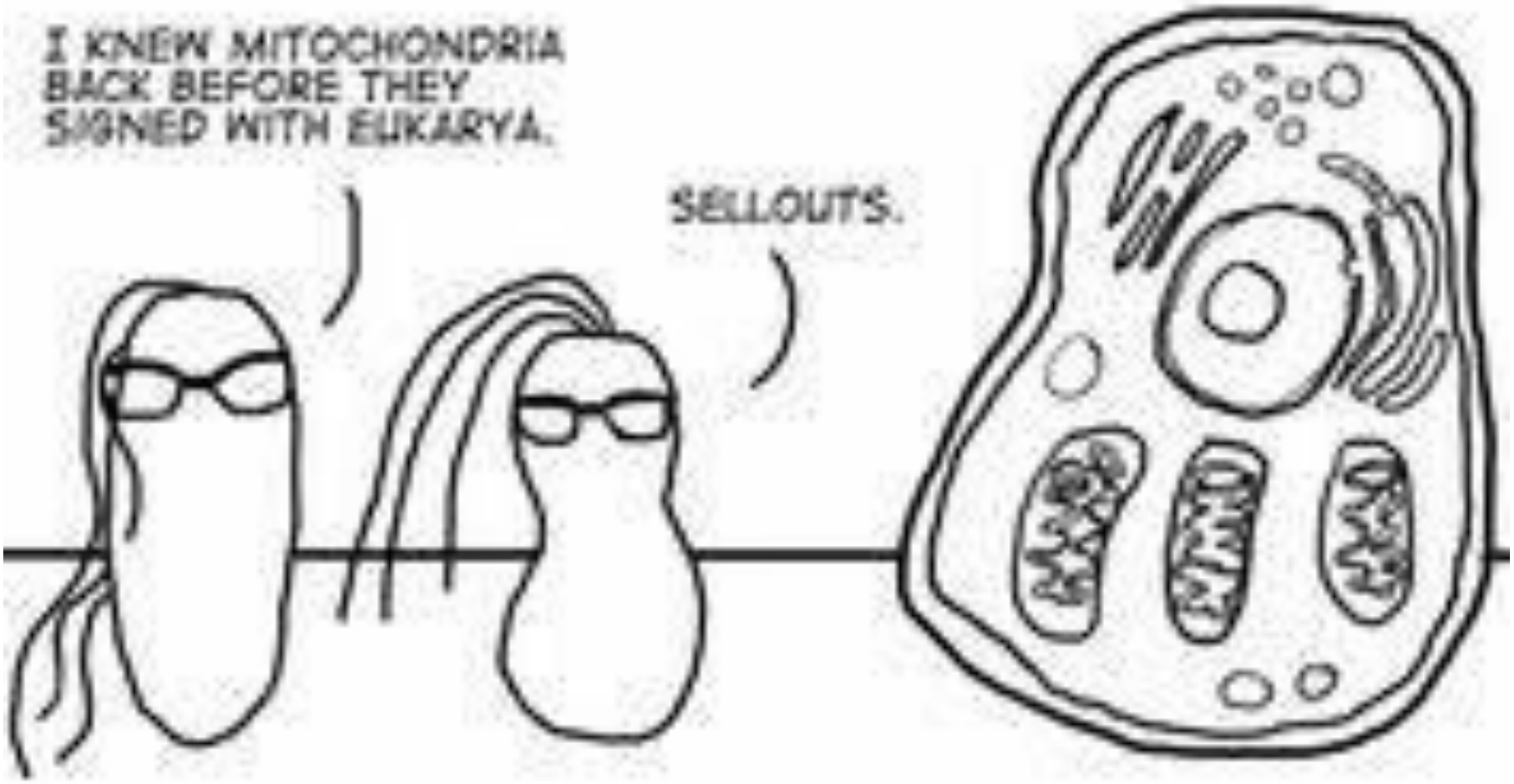
Cell Component	Structure	Function
Mitochondrion 	Bounded by double membrane; inner membrane has infoldings (cristae)	Cellular respiration
Chloroplast 	Typically two membranes around fluid stroma, which contains thylakoids stacked into grana (in cells of photosynthetic eukaryotes, including plants)	Photosynthesis
Peroxisome 	Specialized metabolic compartment bounded by a single membrane	Contains enzymes that transfer hydrogen atoms from certain molecules to oxygen, producing hydrogen peroxide (H_2O_2) as a by-product; H_2O_2 is converted to water by another enzyme

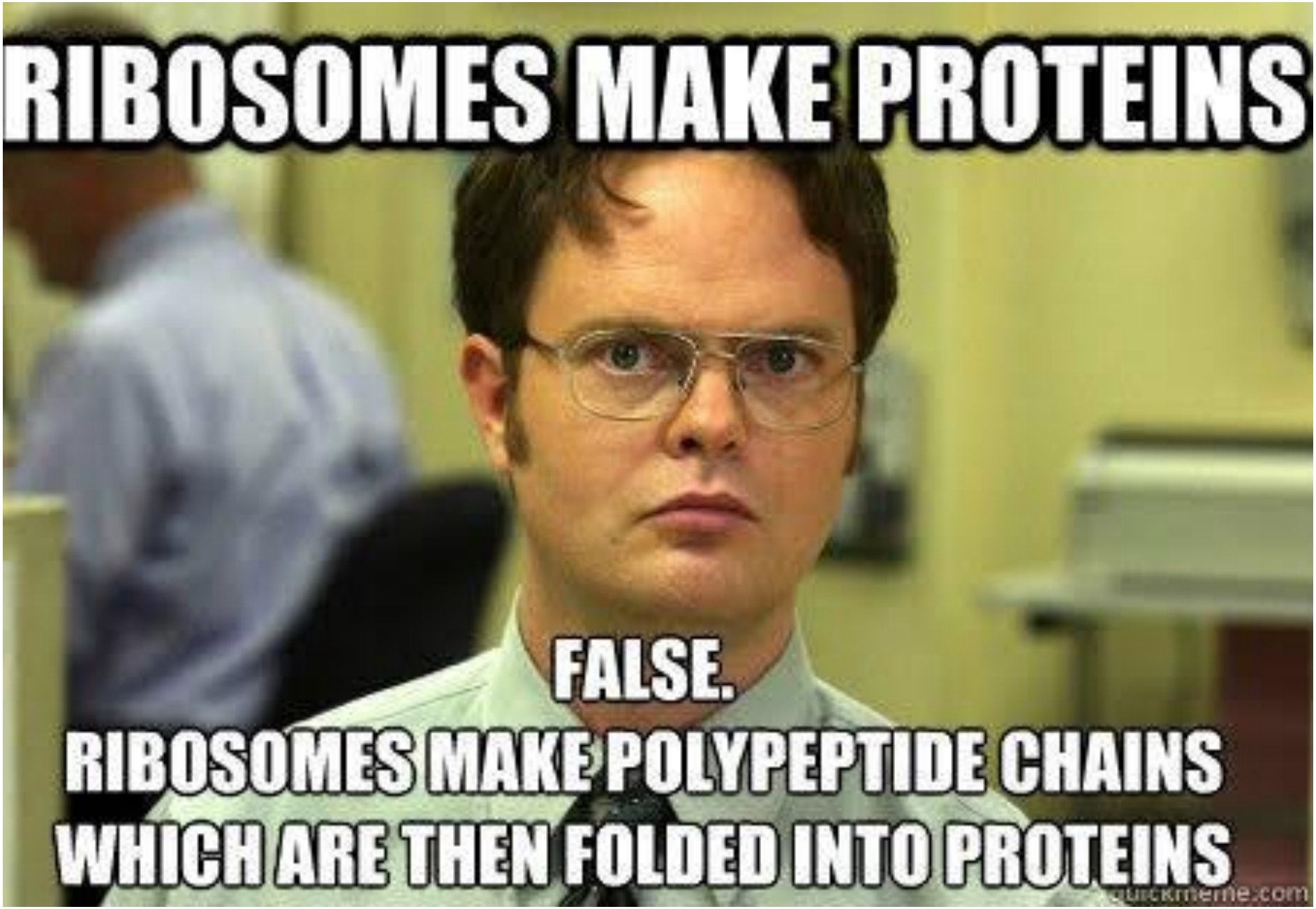


Smooth Endoplasmic Reticulum

might-ochondria

definitely-chondria


I KNEW MITOCHONDRIA BACK BEFORE THEY SIGNED WITH EUKARYA.
SELLOUTS.


RIBOSOMES MAKE PROTEINS
FALSE.
RIBOSOMES MAKE POLYPEPTIDE CHAINS
WHICH ARE THEN FOLDED INTO PROTEINS
quickmeme.com

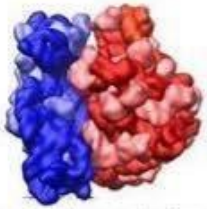
mitochondria

-tumblr famous
-only drinks gatorade
-powerhouse of the cell

nucleus

-control freak
-"everyone is important uwu"
-unofficial squad leader

ribosome

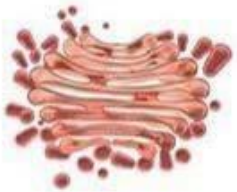


-actually works for a living
-always making things for their friends
-highkey wants to be nucleus's bff

nucleolus

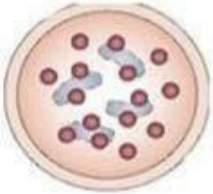
-nucleus's actual bff
-superiority complex
-basically 12 years old

golgi apparatus



-loves duct tape
-gives great advice
-unproblematic fave

lysosome



-always salty
-loves dogs
-will fight anyone

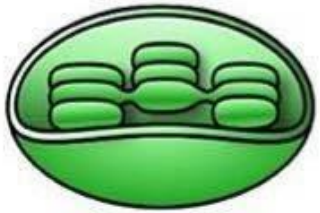
ER

-total mom friend
-better than you at literally everything
-only one who can drive

vacuole

-really quiet except when they're not
-v dependable
-does crossfit

chloroplast



-super elitist
-only wears green except on st patricks day
-lowkey hippie