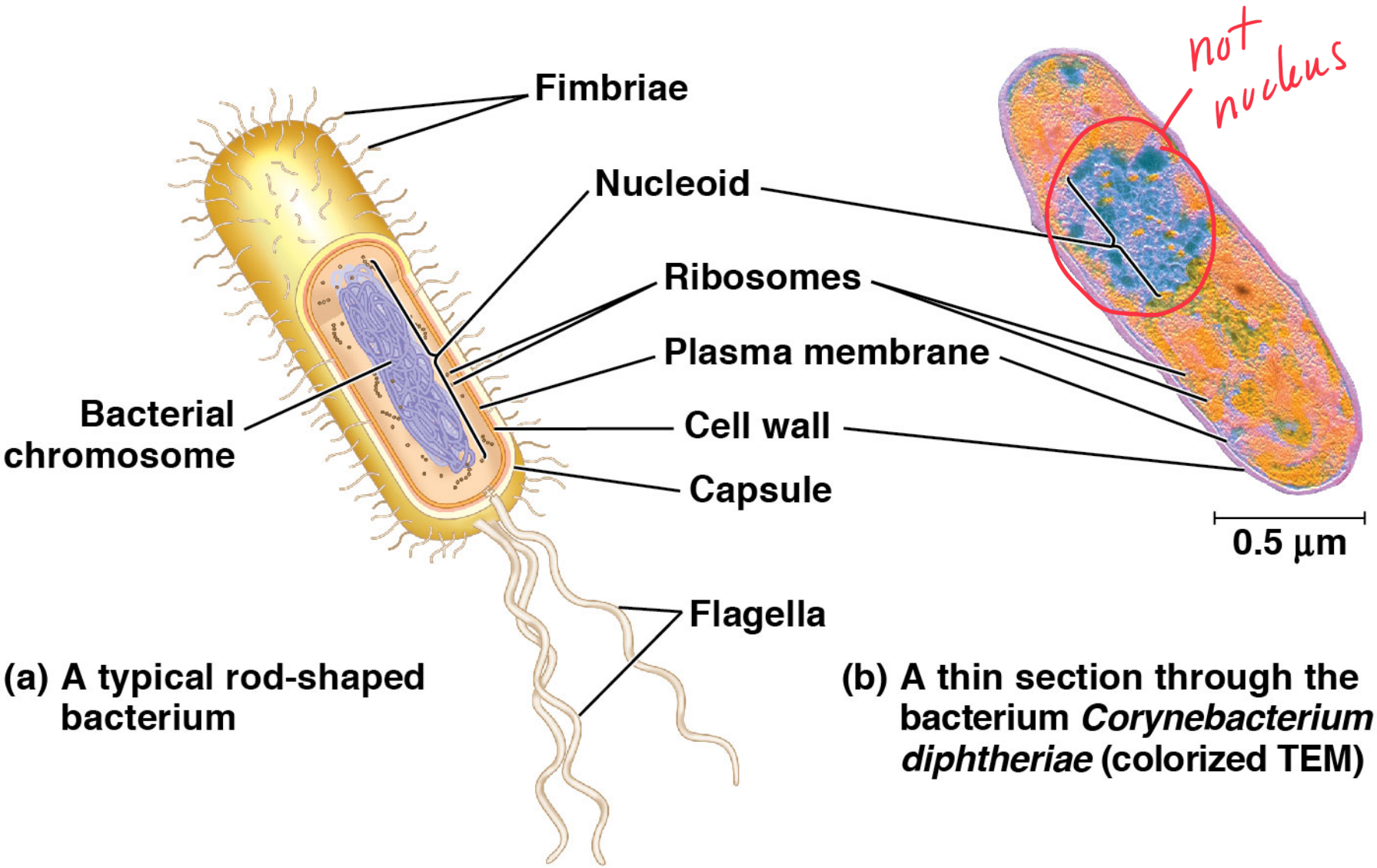
A PROKARYOTIC CELL (BACTERIA)



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PROKARYOTE VS. EUKARYOTE

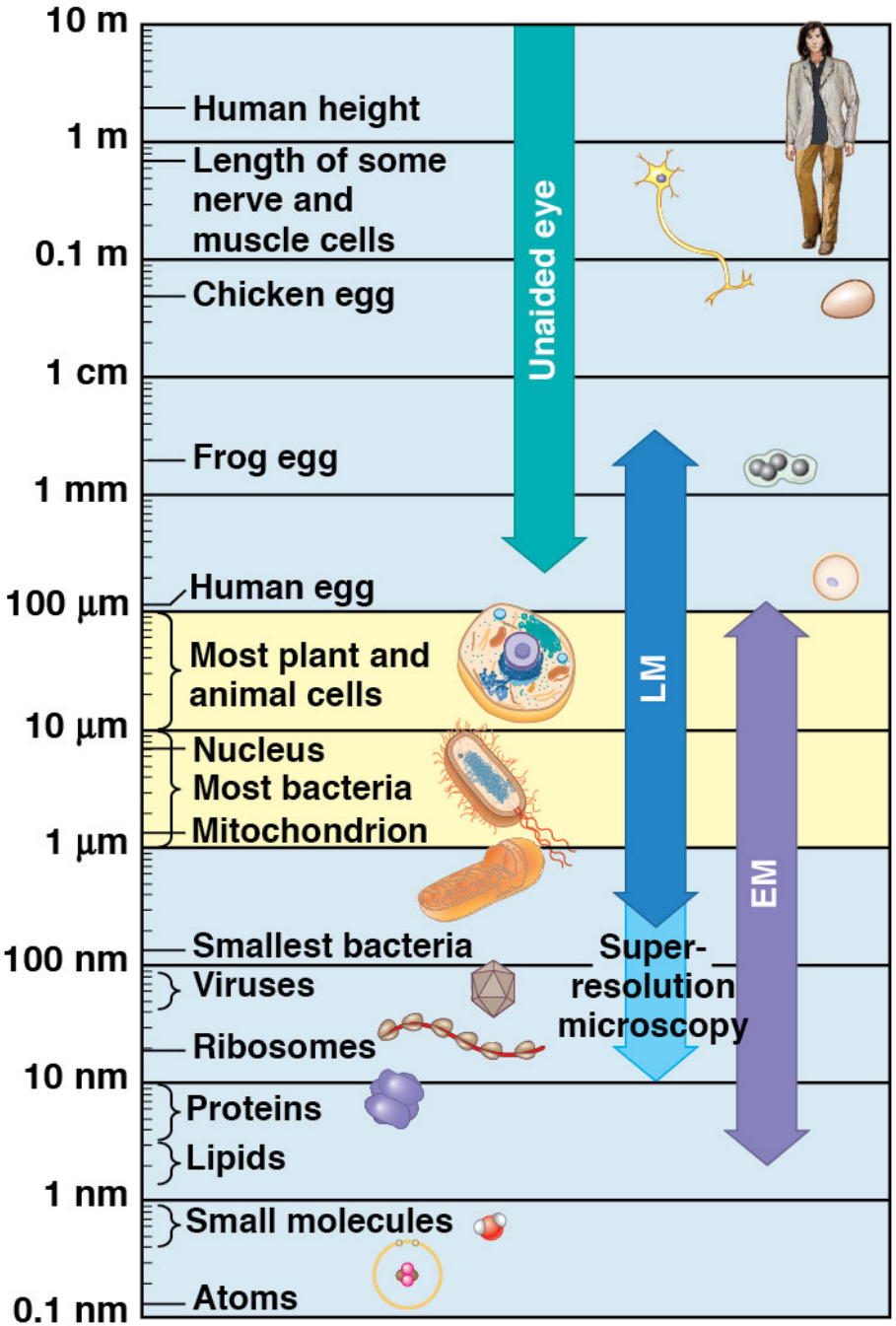
- "before" "kernel"
- No nucleus
- DNA in a nucleoid
- Cytosol
- No organelles other than ribosomes
- Small size
- Primitive
- i.e. Bacteria & Archaea

- "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

know this

fluid

cytoplasm – everything between the nucleus and plasma membrane



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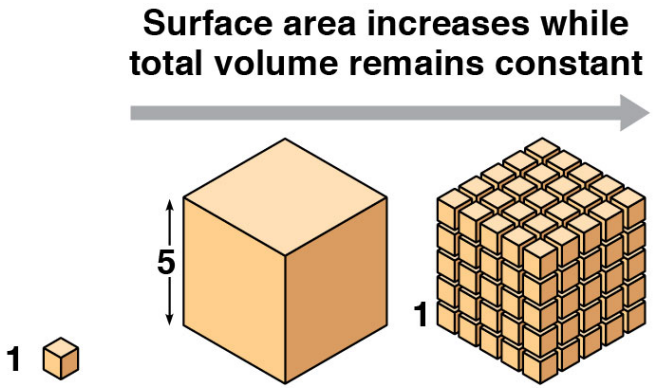
- Cells must be small to maintain a large surface area to volume ratio
- Large S.A. allows ↑ rates of chemical exchange between cell and environment



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

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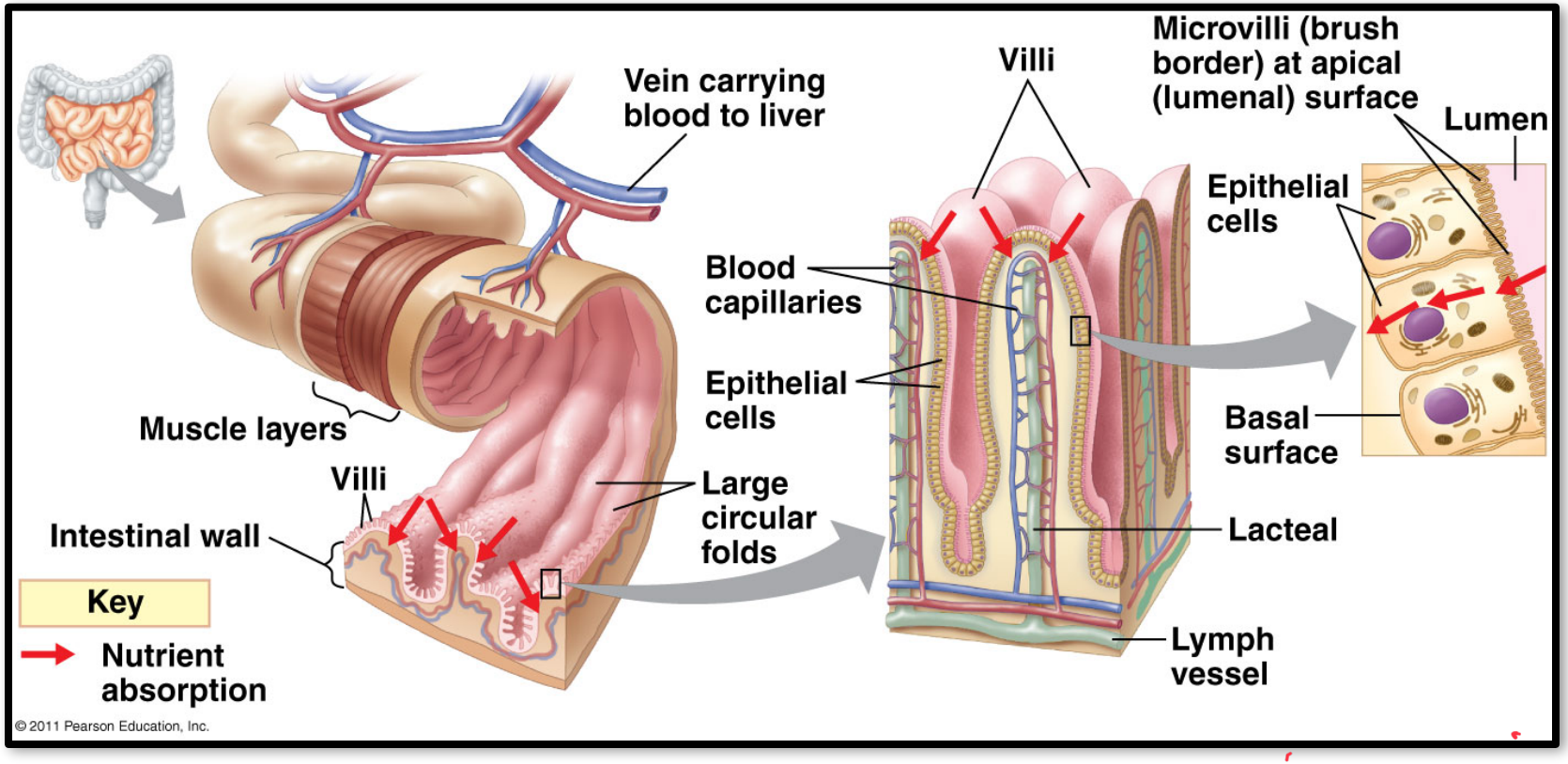
SURFACE AREA EXAMPLE (ANIMAL):

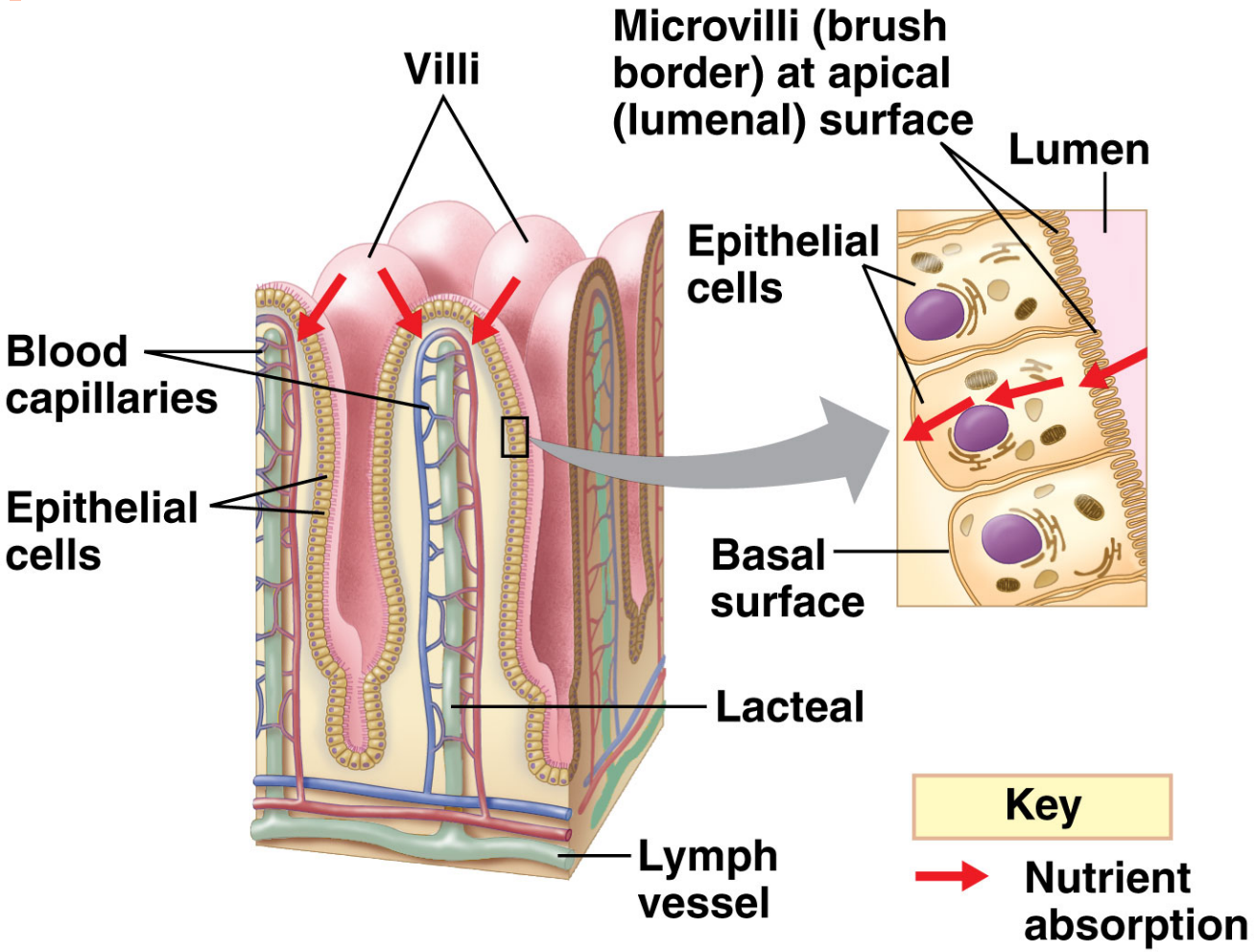


Small Intestine: *highly folded surface* to increase absorption of nutrients

increasing surface area

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

Folds → Villi → Microvill



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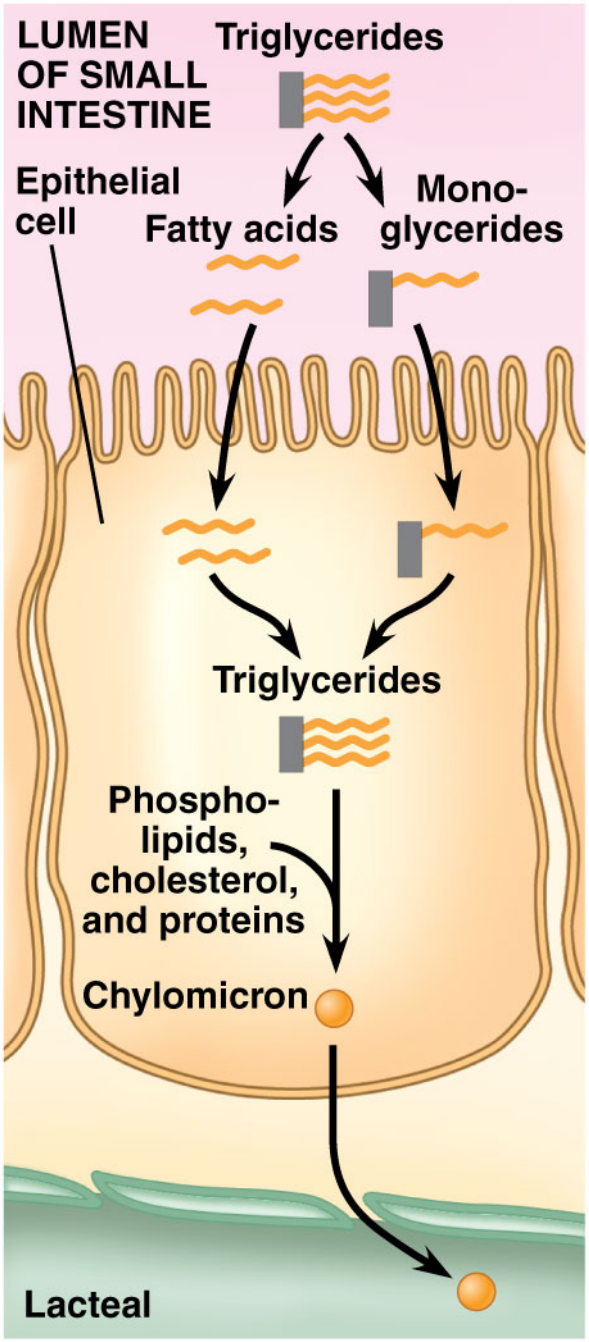

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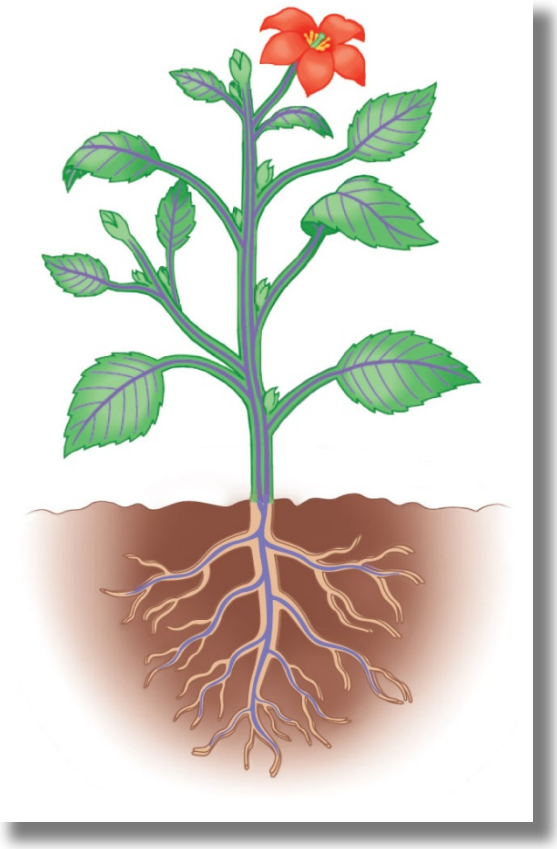
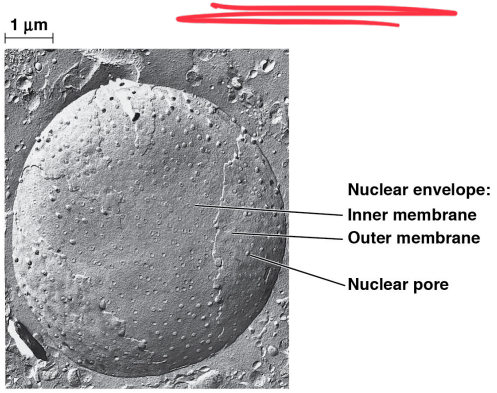
SURFACE AREA EXAMPLE (PLANT):

Root hairs: extensions of root epidermal cells; increase surface area for absorbing water and minerals

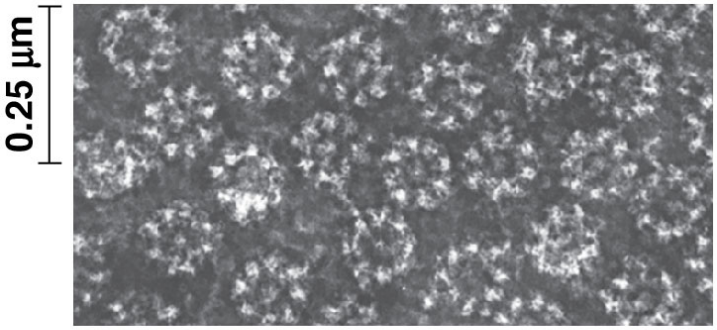


NUCLEUS

- Function: control center of cell
- Contains DNA (& mRNA)
- Surrounded by double membrane (**nuclear envelope**)
  - Continuous with the rough ER
- **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)

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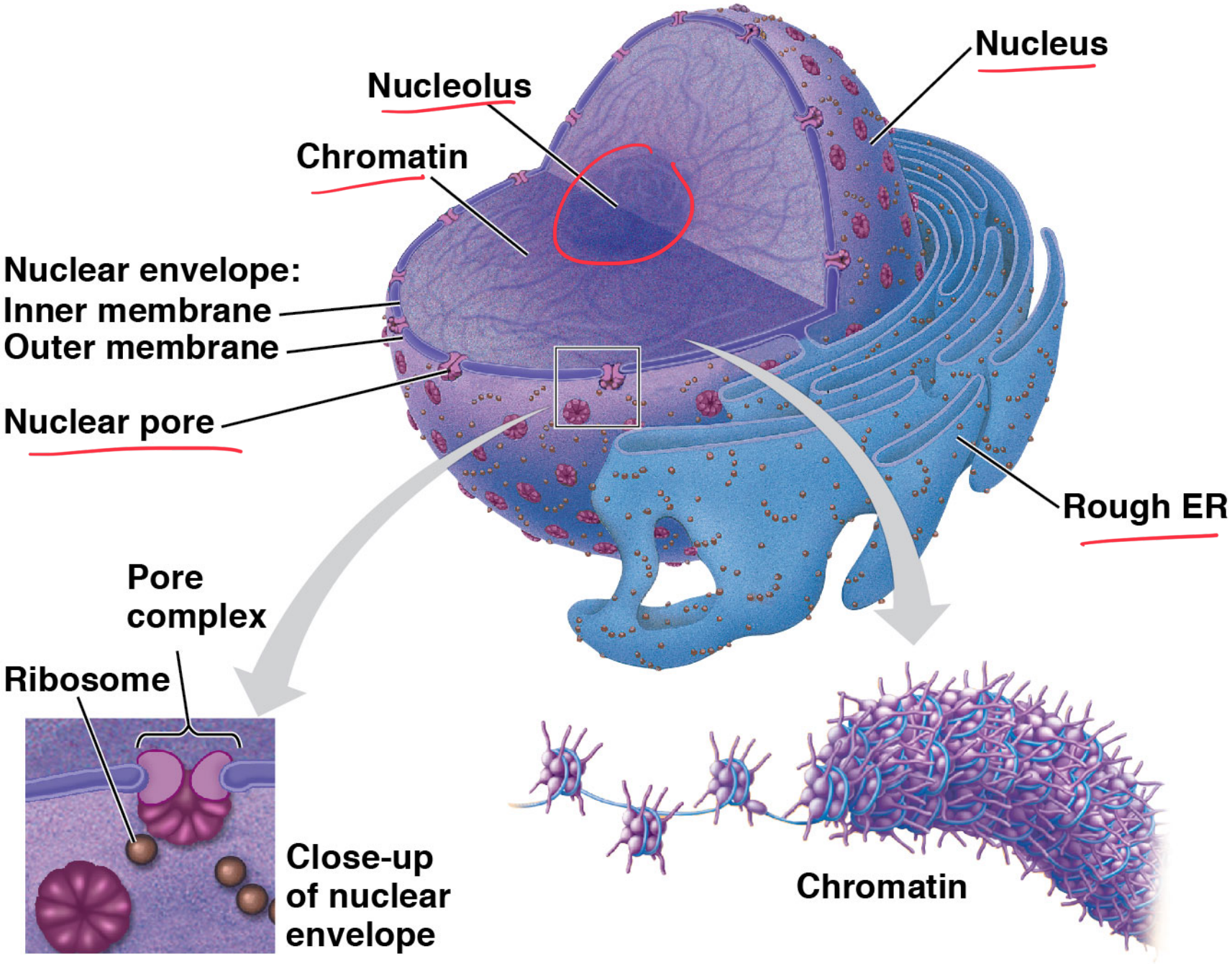

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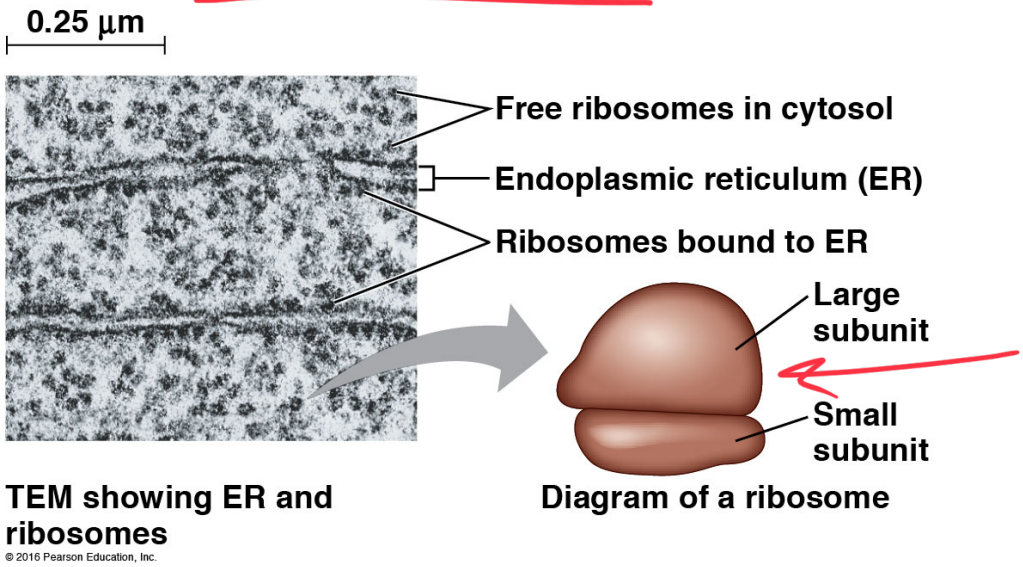
RIBOSOMES

translate proteins

- Function: protein synthesis
- Composed of rRNA + protein
- Large subunit + small subunit
- Types:

there is no difference

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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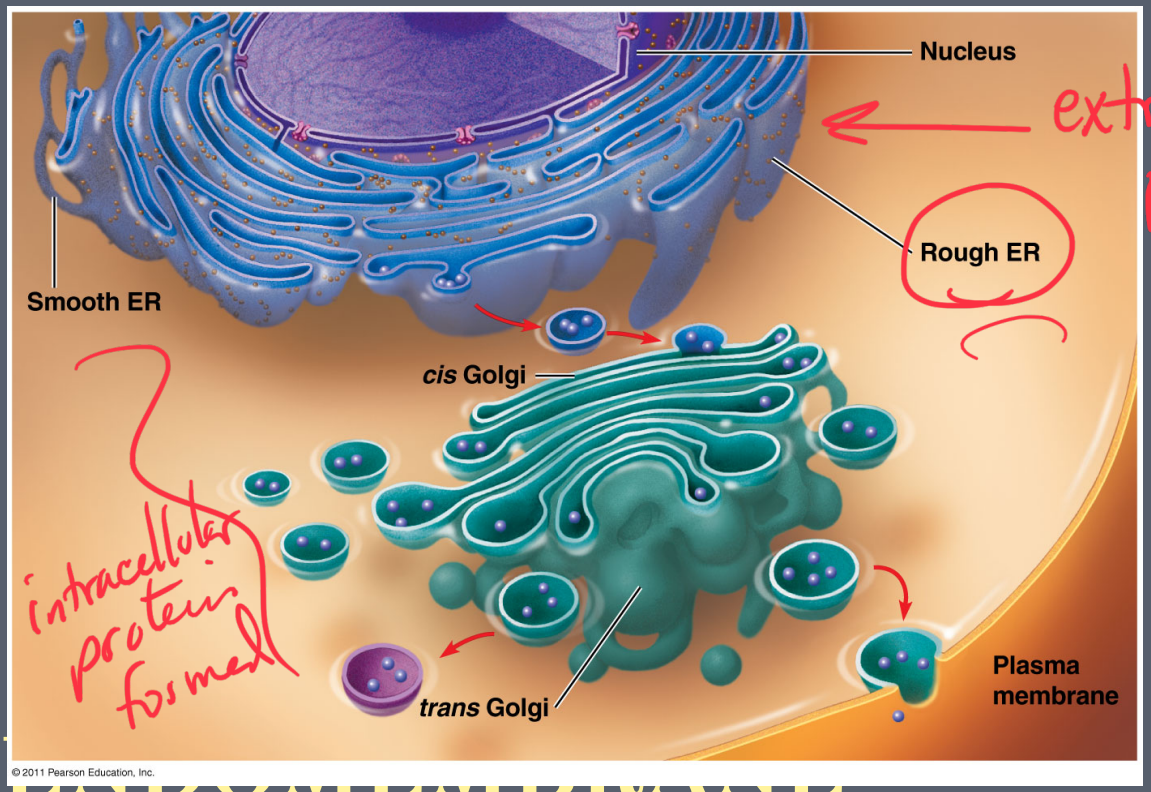


ENDOMEMBRANE SYSTEM:

Regulates protein traffic & performs metabolic functions

ENDOPLASMIC RETICULUM (ER)

- Network of membranes and sacs
- Types:
  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+}

post-translational modification – changes made to proteins after they are formed

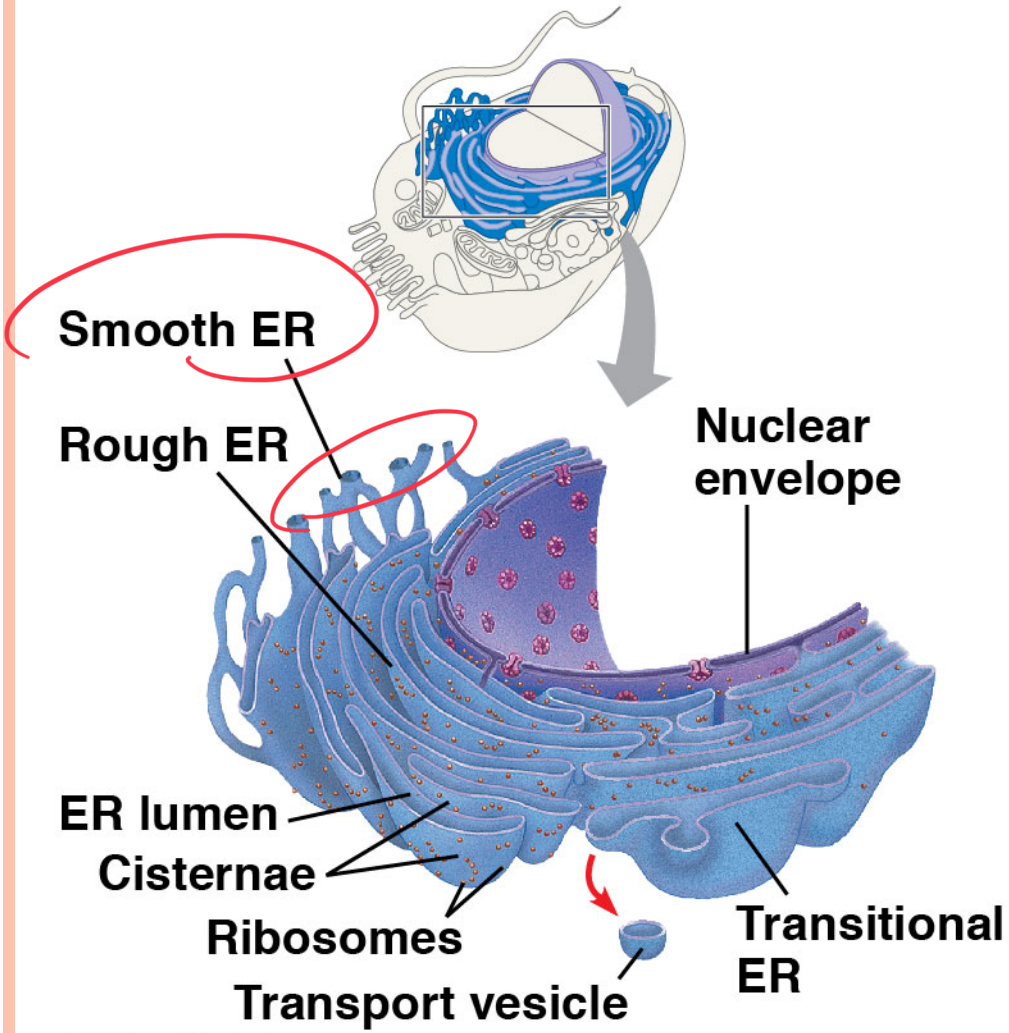
extracellular environment

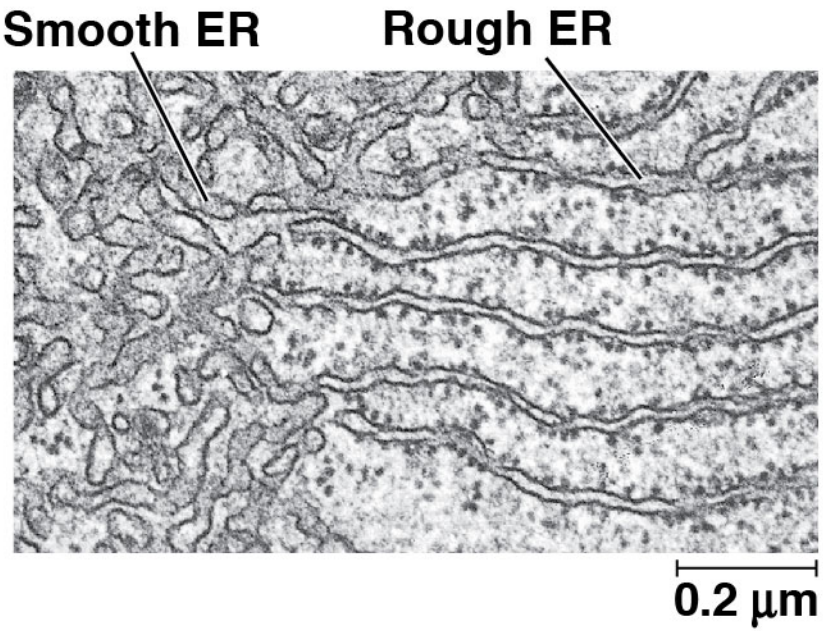
extracellular proteins made

not where protein is made

Rough + smooth are not same

ENDOPLASMIC RETICULUM (ER)





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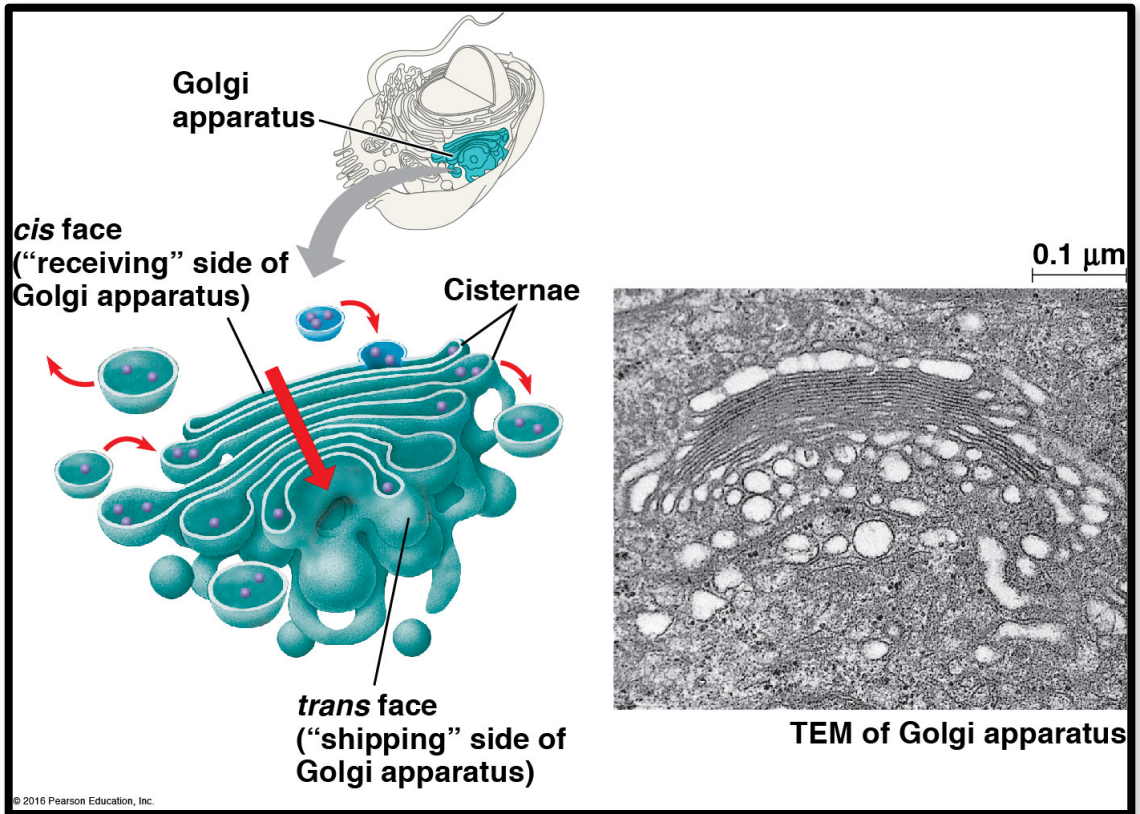
GOLGI APPARATUS

also involve in post-translational modification

- Function: synthesis & packaging of materials (small molecules) for transport (in vesicles); produce lysosomes
- Series of flattened membrane sacs (cisternae)
  - ***Cis* face**: receives vesicles
  - ***Trans* face**: ships vesicles



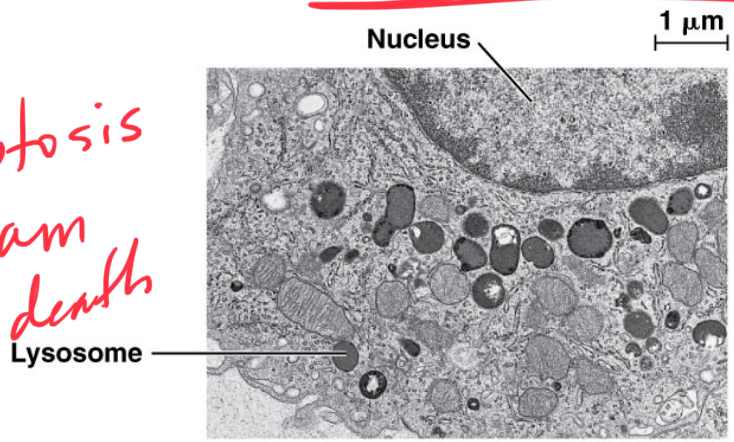
LYSOSOMES

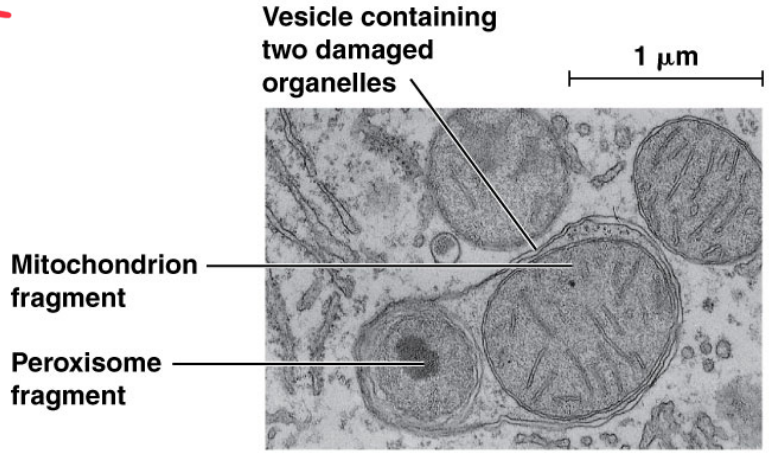
very acidic

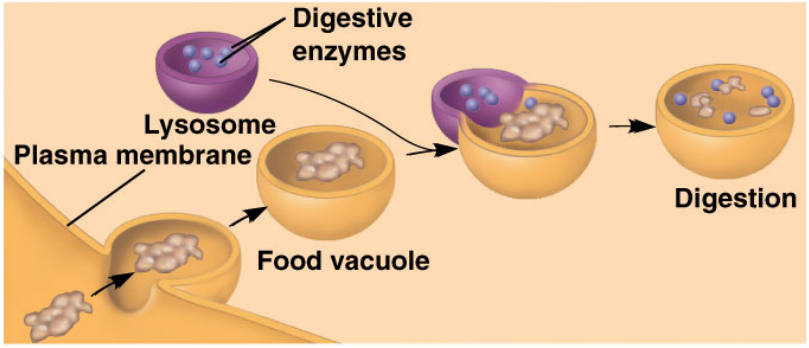
- Function: intracellular digestion, recycle cell's materials; programmed cell death (apoptosis)
- Contains **hydrolytic enzymes**

water cutting

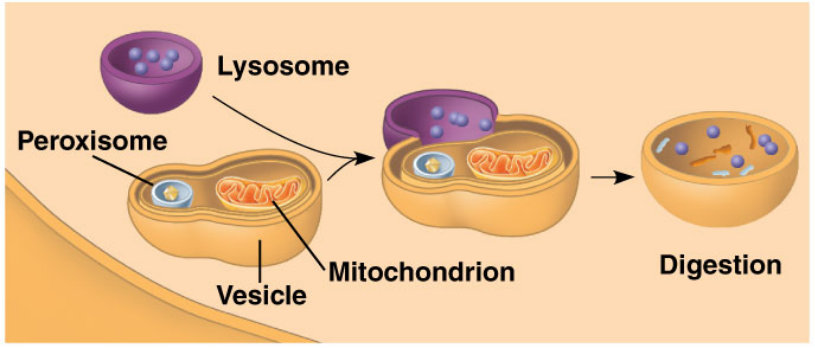
cell apoptosis program cell death







(a) Phagocytosis



(b) Autophagy

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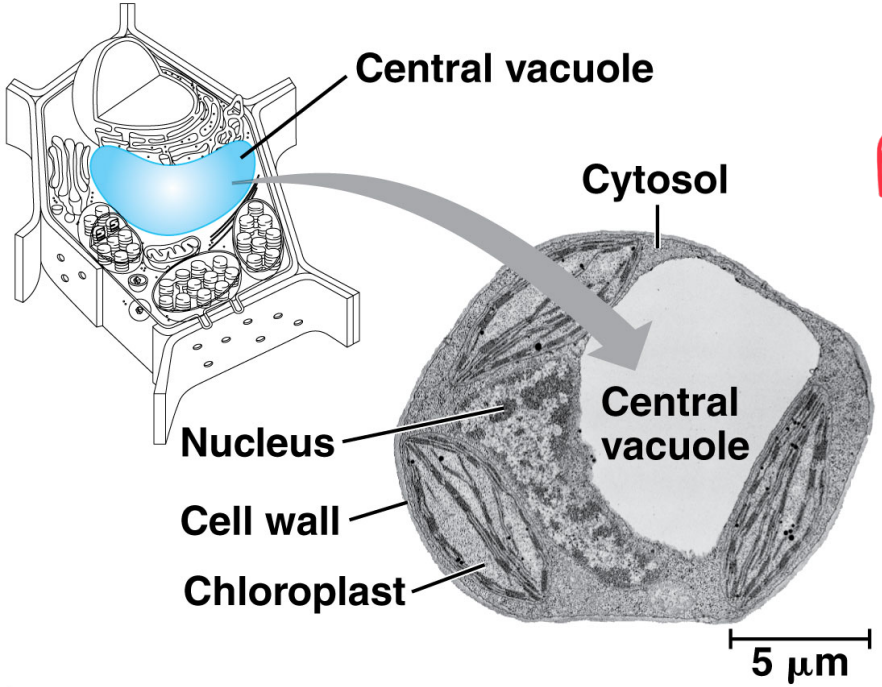
VACUOLES

- Function: storage of materials (food, water, minerals, pigments, poisons)
- Membrane-bound vesicles
- Eg. food vacuoles, contractile vacuoles
- **Plants: large central vacuole -- stores water, ions; retains water for turgor pressure**



plant cells grow when vacuole fills with wate

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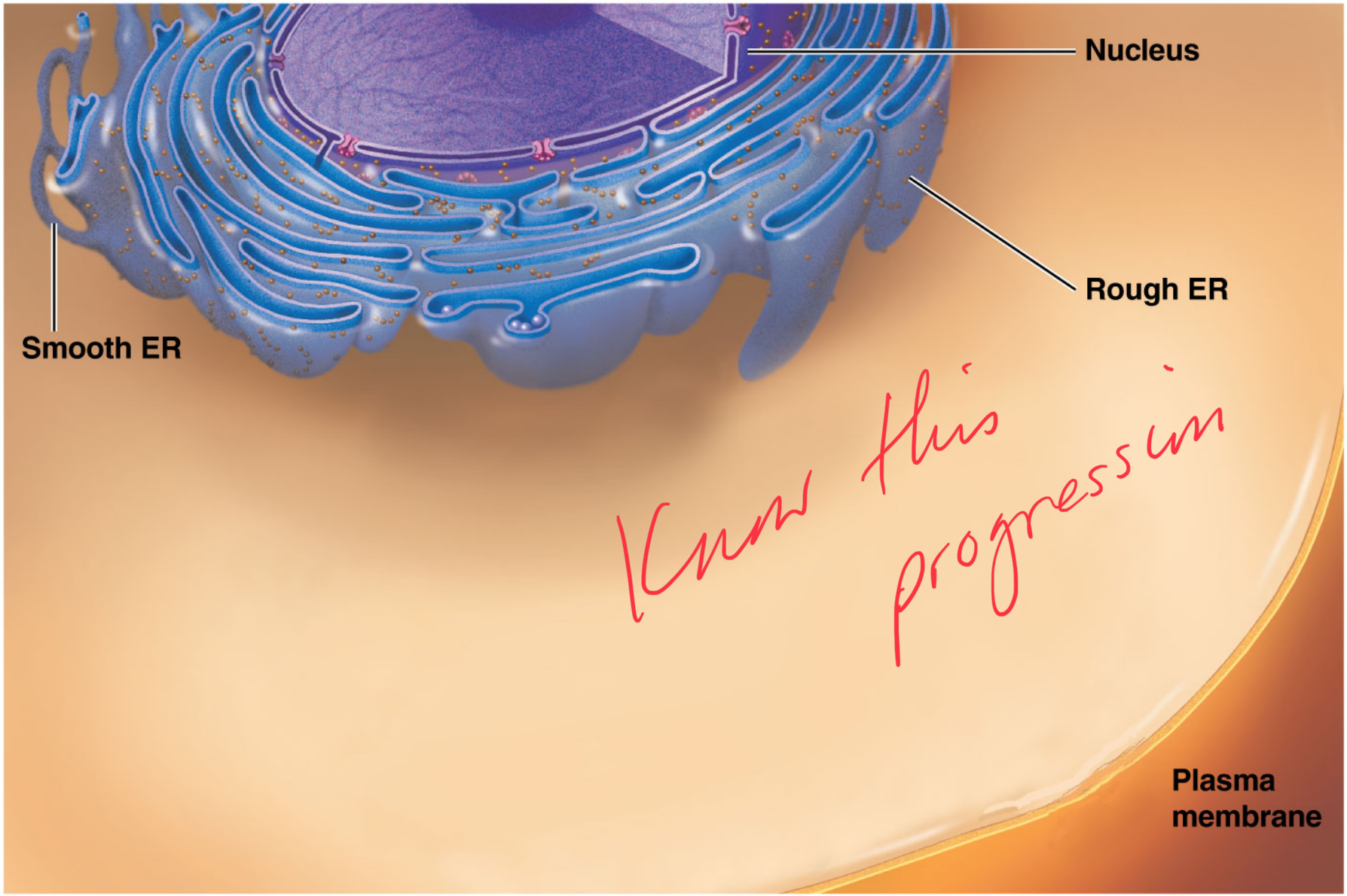

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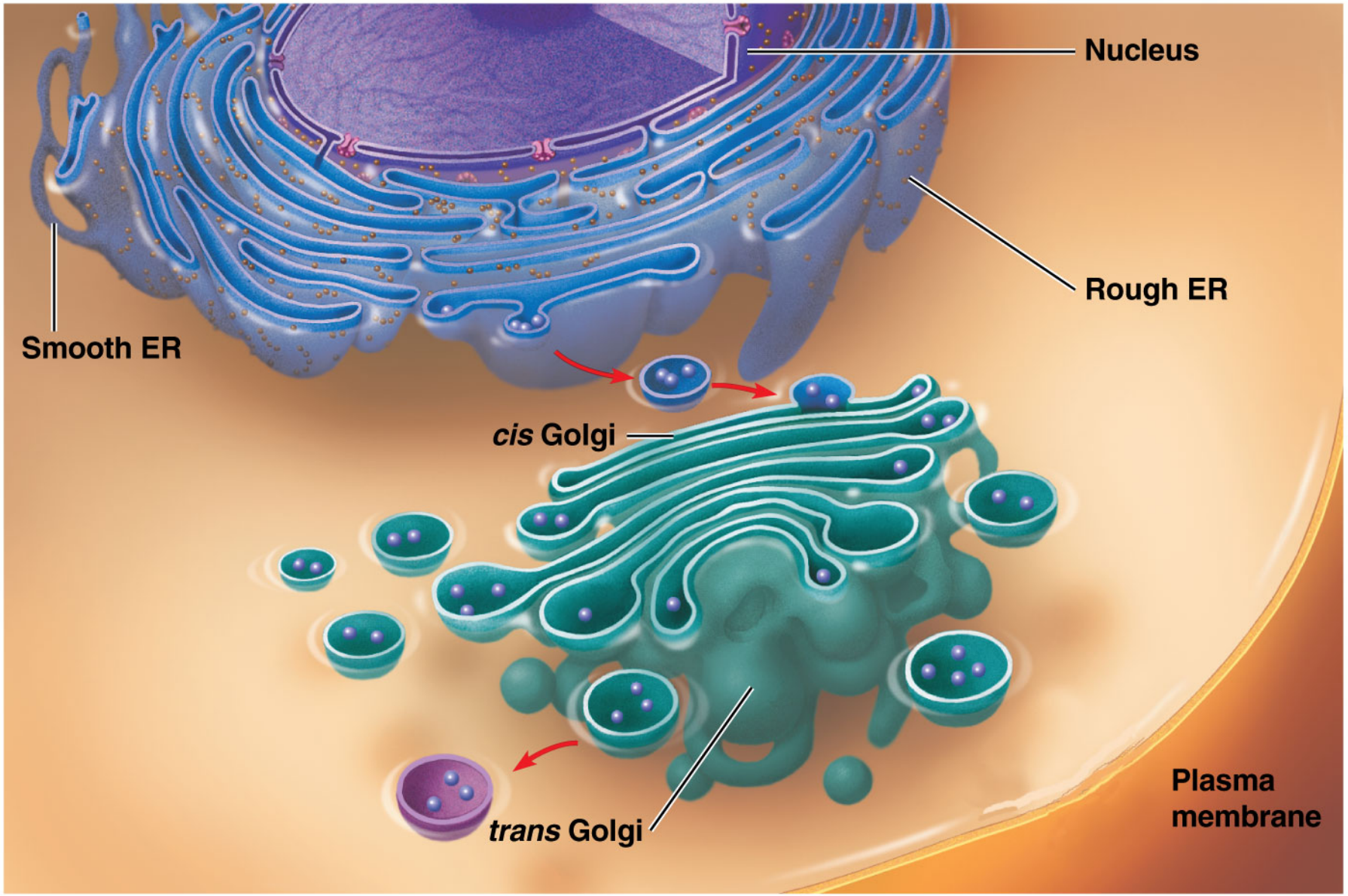

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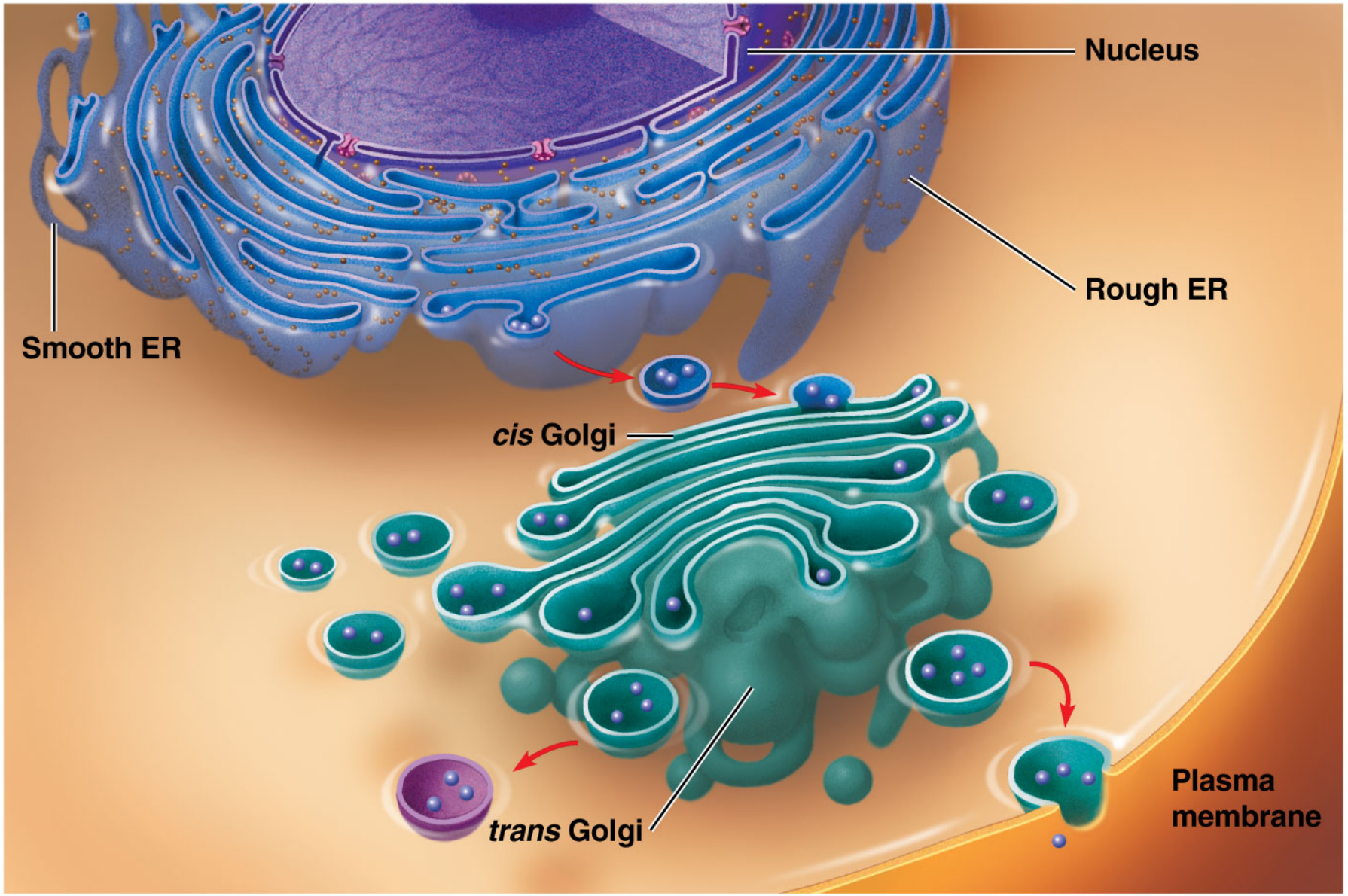

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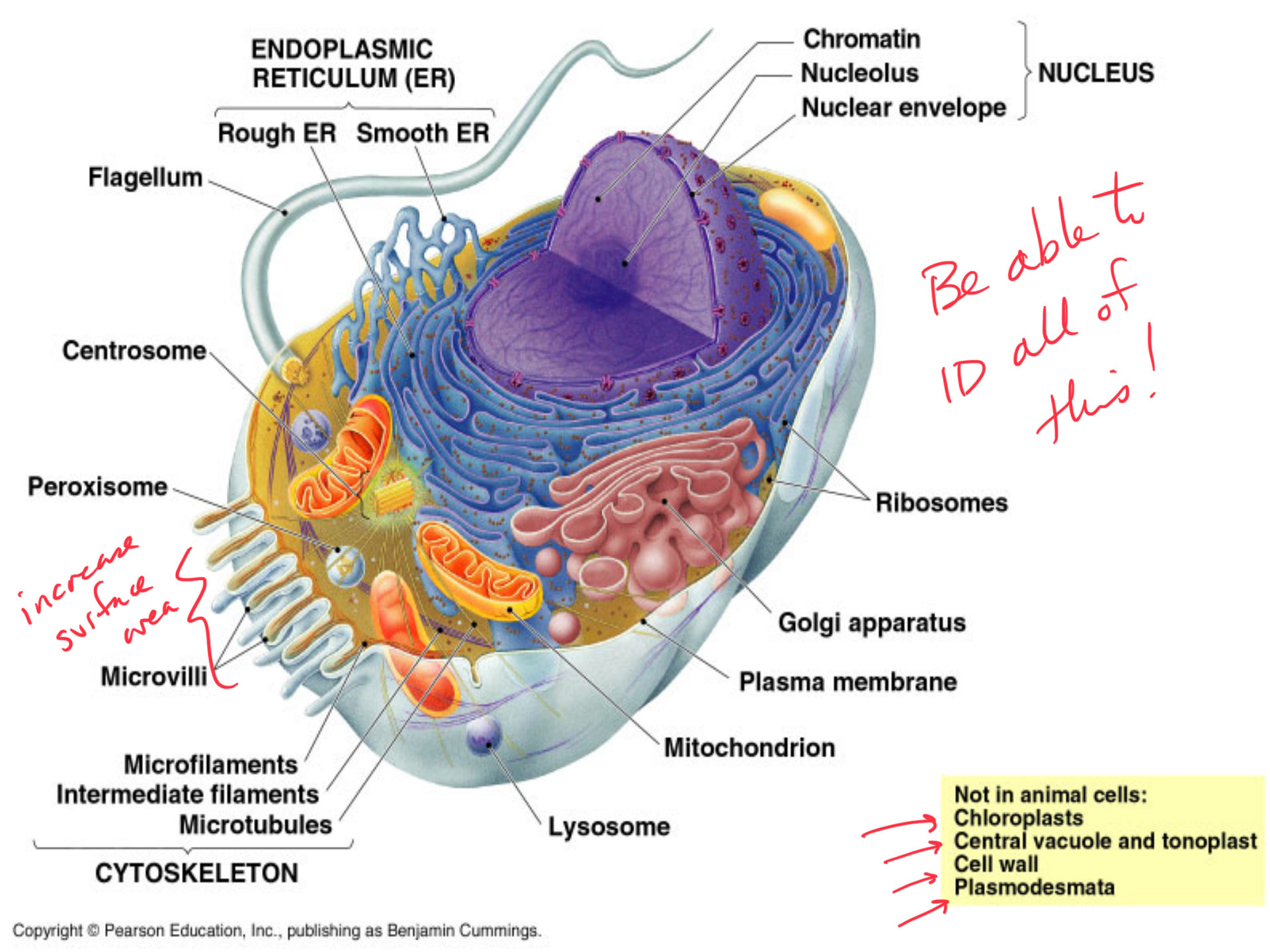

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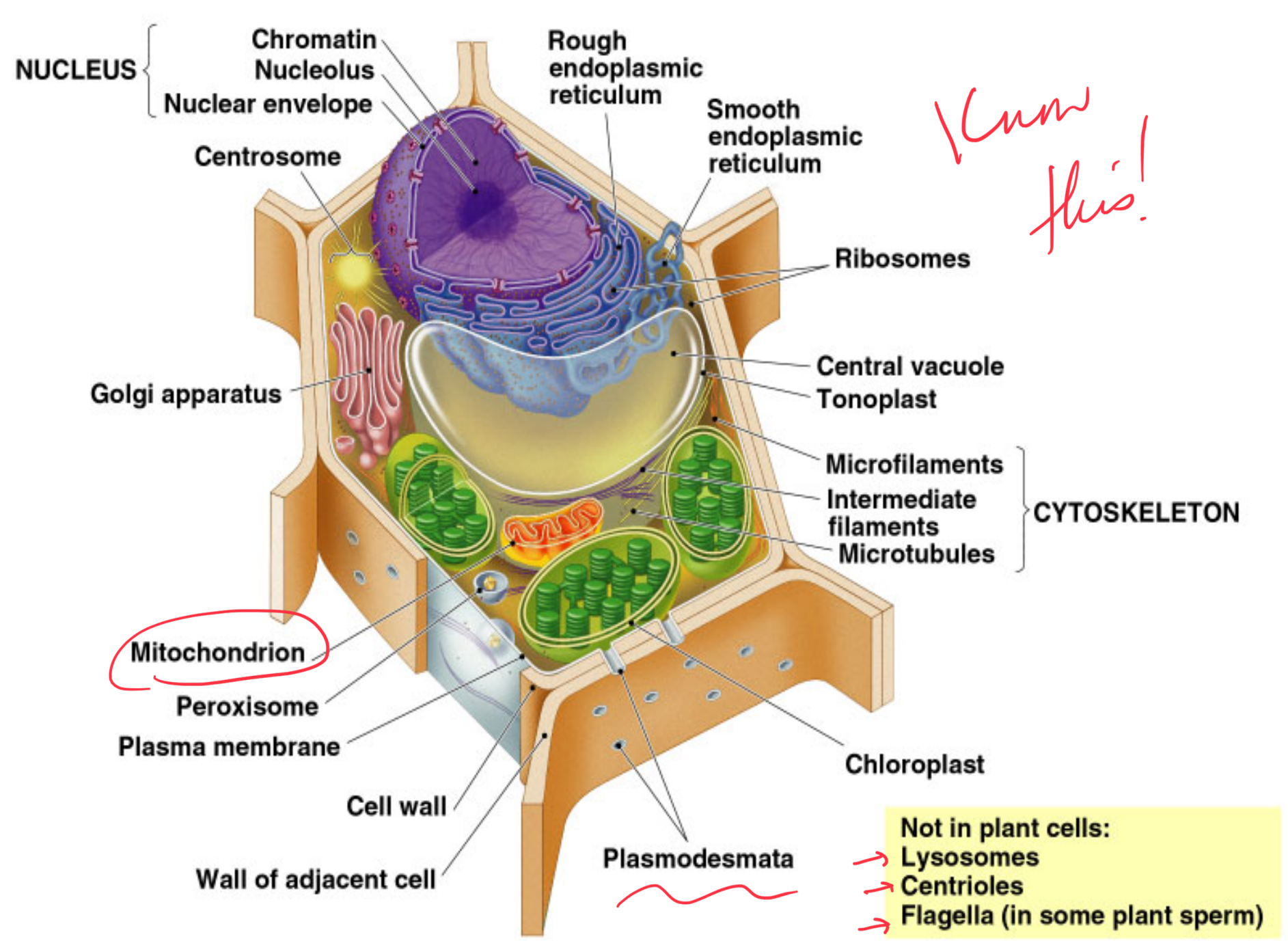

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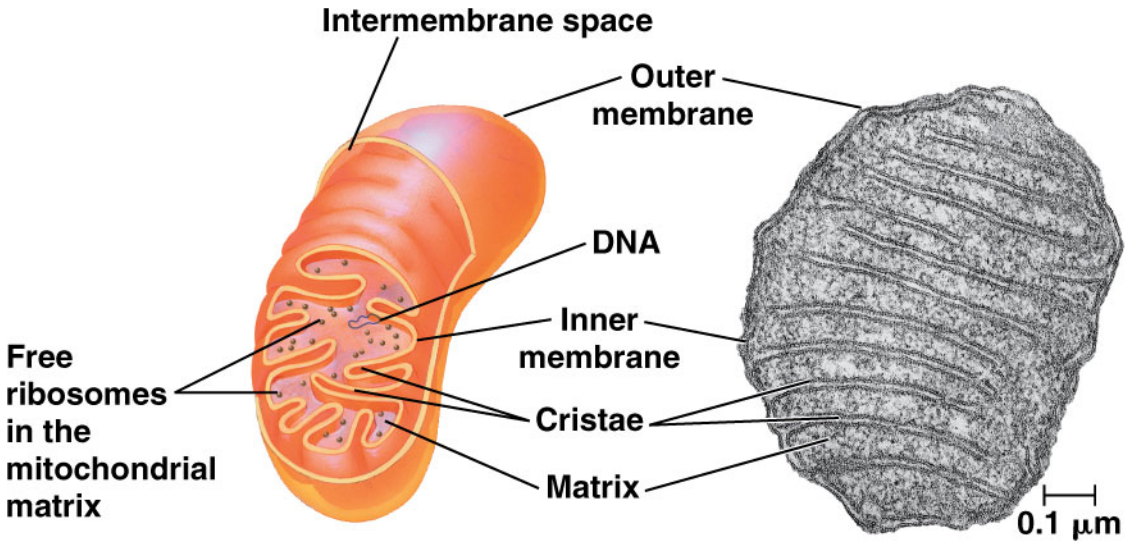
MITOCHONDRIA

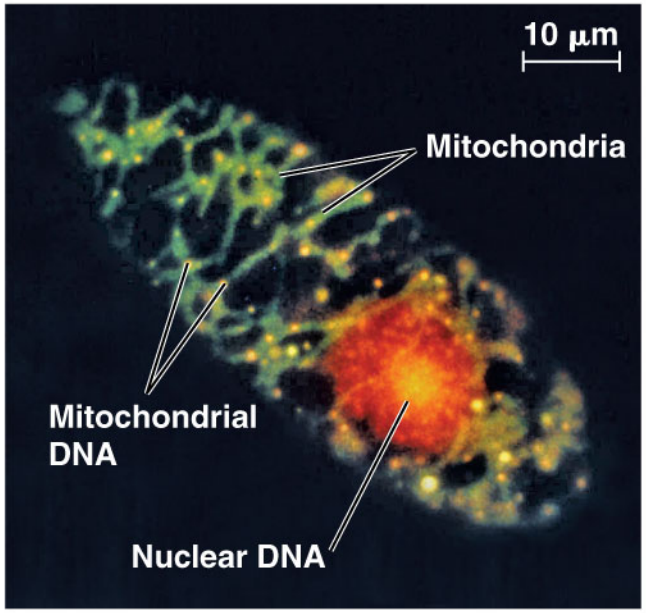
gives us ATP (30 ATP)

- Function: site of cellular respiration
- 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

needs oxygen



(a) Diagram and TEM of mitochondrion



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

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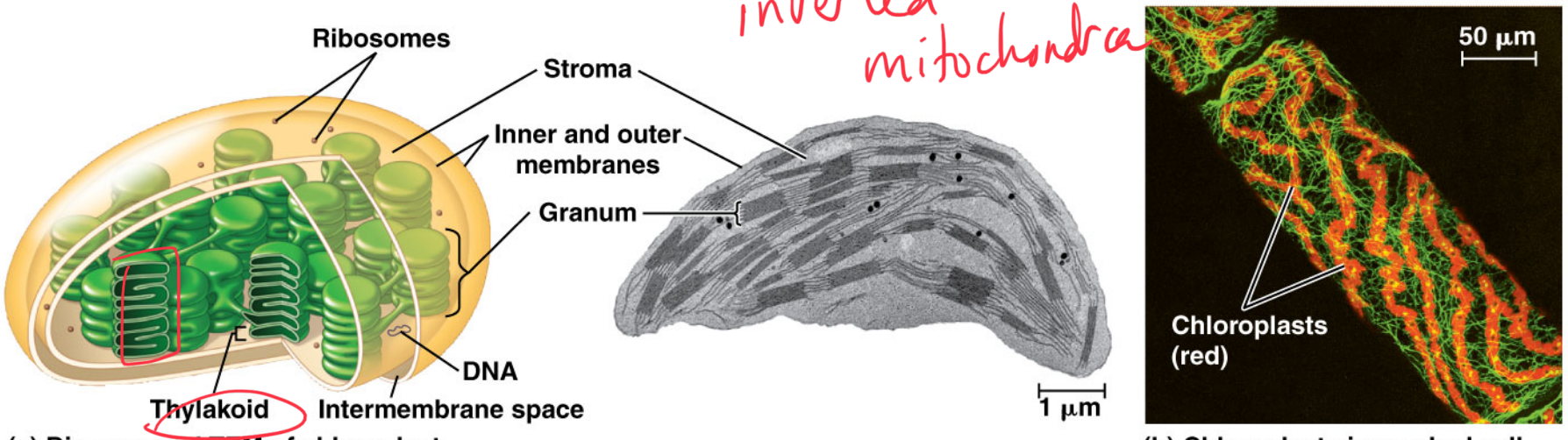
CHLOROPLASTS

are also bacterial

- Function: site of photosynthesis
- Double membrane
- Thylakoid disks in stacks (grana); stroma (fluid)
- Contains **chlorophylls** (pigments) for capturing sunlight energy

antenna

inverted mitochondria



(a) Diagram and TEM of chloroplast

(b) Chloroplasts in an algal cell

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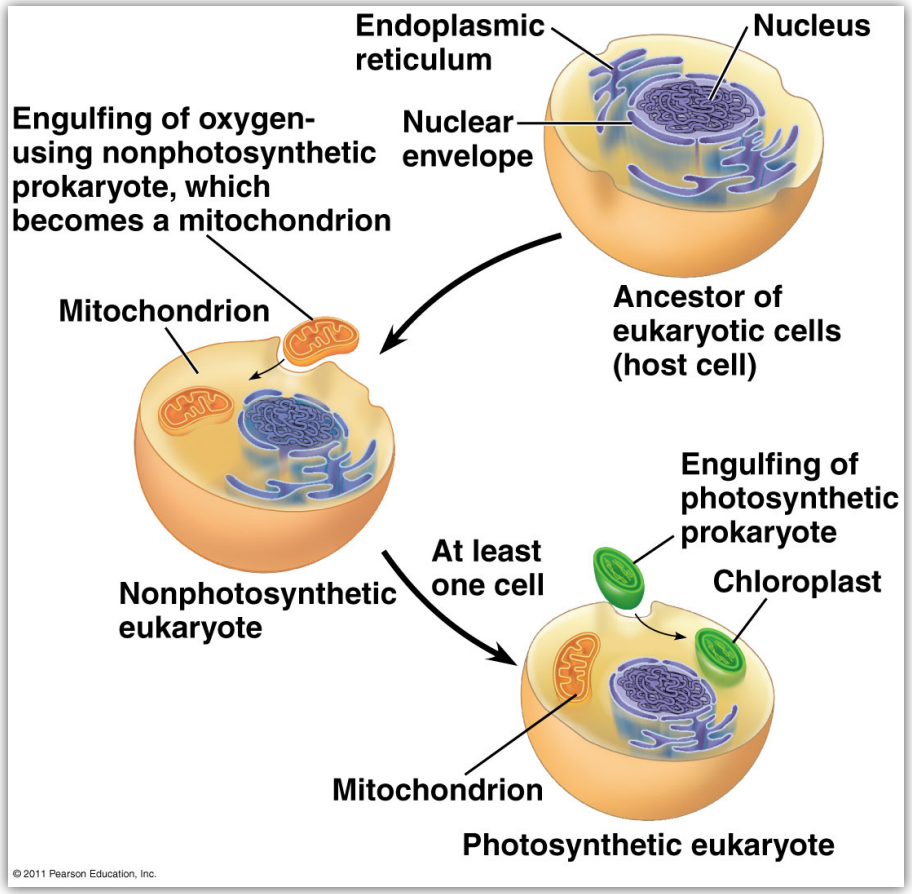
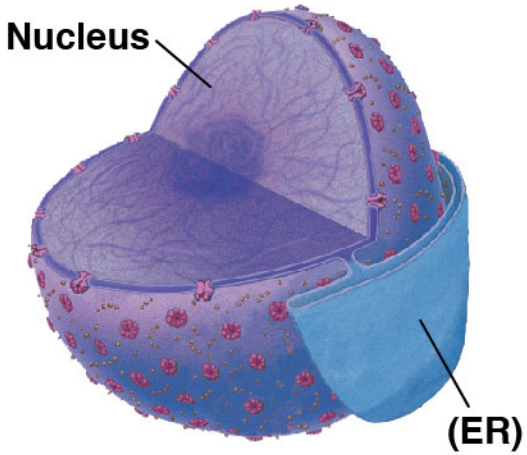
ENDOSYMBIONT THEORY



- Mitochondria & chloroplasts share similar origin
- Prokaryotic cells engulfed by ancestors of eukaryotic cells
- Evidence: ingested but not digested
  - Double-membrane structure
  - Have own ribosomes & DNA
  - Reproduce independently within cell binary fission

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)

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

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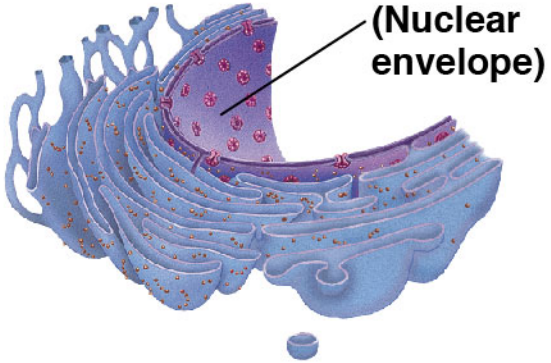
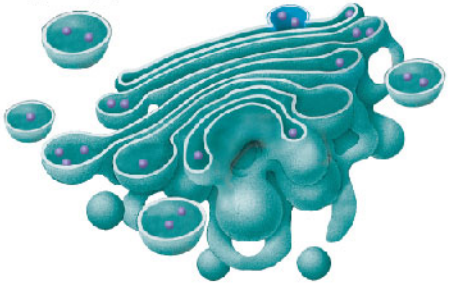
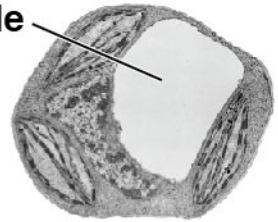
Cell Component	Structure	Function
Endoplasmic reticulum 	Extensive network of membrane-bounded tubules and sacs; membrane separates lumen from cytosol; continuous with nuclear envelope	Smooth ER: synthesis of lipids, metabolism of carbohydrates, Ca^{2+} storage, detoxification of drugs and poisons Rough 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

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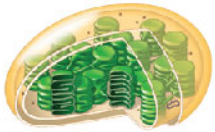
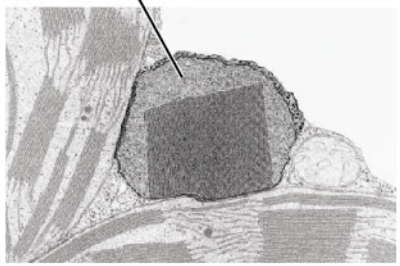
Cell Component	Structure	Function
Mitochondrion	Bounded by double membrane; inner membrane has infoldings (cristae)	Cellular respiration
Chloroplast 	Typically two membranes around fluid stroma, which contains thylakoids stacked into grana (in cells of photosynthetic eukaryotes, including plants)	Photosynthesis
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

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