Eukaryotic cell structure and compartmentalization

What is a cellular compartment?
What is the "endosymbiosis theory?"

Eukaryotic Cell Structure: 4 interacting compartments

- Cytosol
- Nucleus
- Semi-autonomous organelles
- Endomembrane system

Cytoplasm

- Coordinates response to the environment
  - Proteins receive SIGNALS from the environment
- Where metabolism occurs
  - Synthesis (of macromolecules)
  - Catabolism (for energy release and recycling)
- Cytoskeleton
  - Provides structural support and organization for the cell and facilitates cellular movements

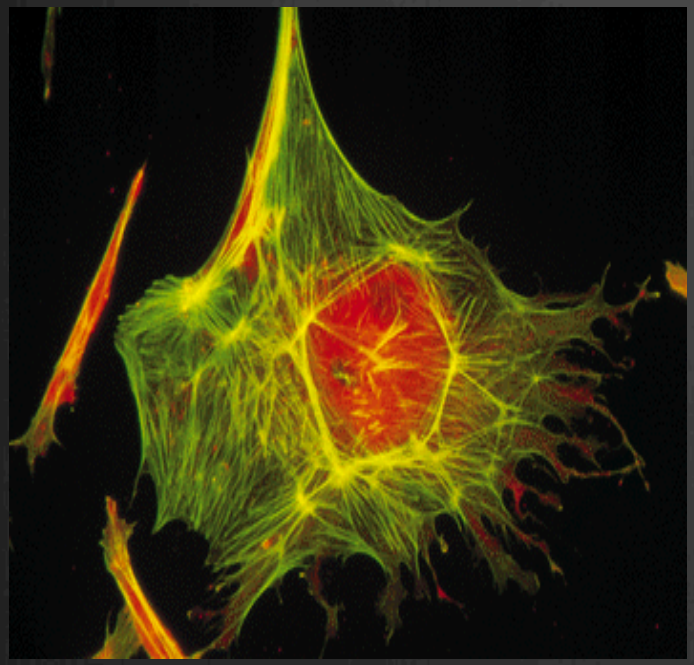
Cytoskeleton

Kenneth Snelson's "Needle Tower"

Dynamic Series of Protein-Protein interactions

Interconnects nucleus and extracellular matrix

Where do we find Actin filaments and what do they do?



Network of proteins found associating with cell membrane

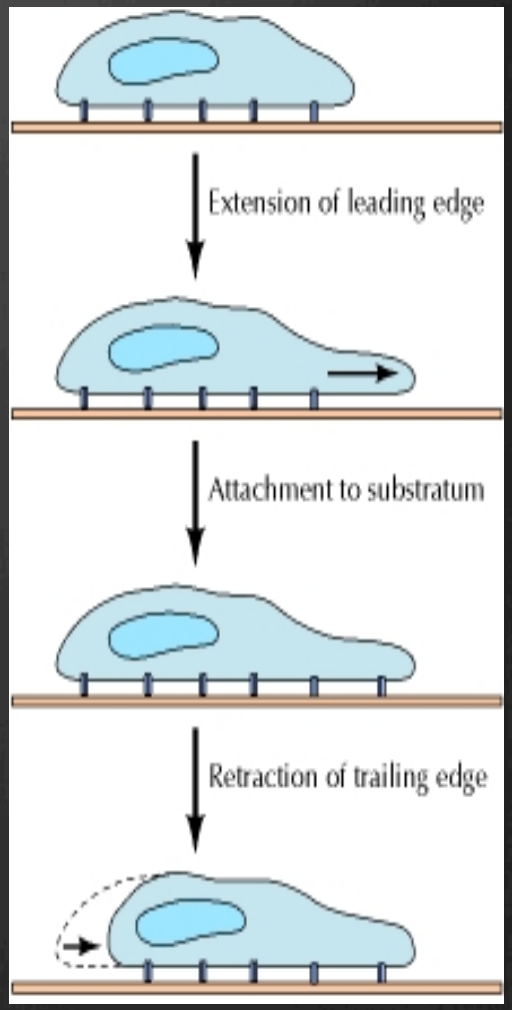
Resist pulling forces

Makes cytosis possible (ability of membranes to grow and fuse)

Endocytosis, Exocytosis

Actin association with Myosin to allow cell crawling

- Amoeba
- Migration of embryonic cells during development
- White blood cells responding infection
- Wound healing
- metastasis

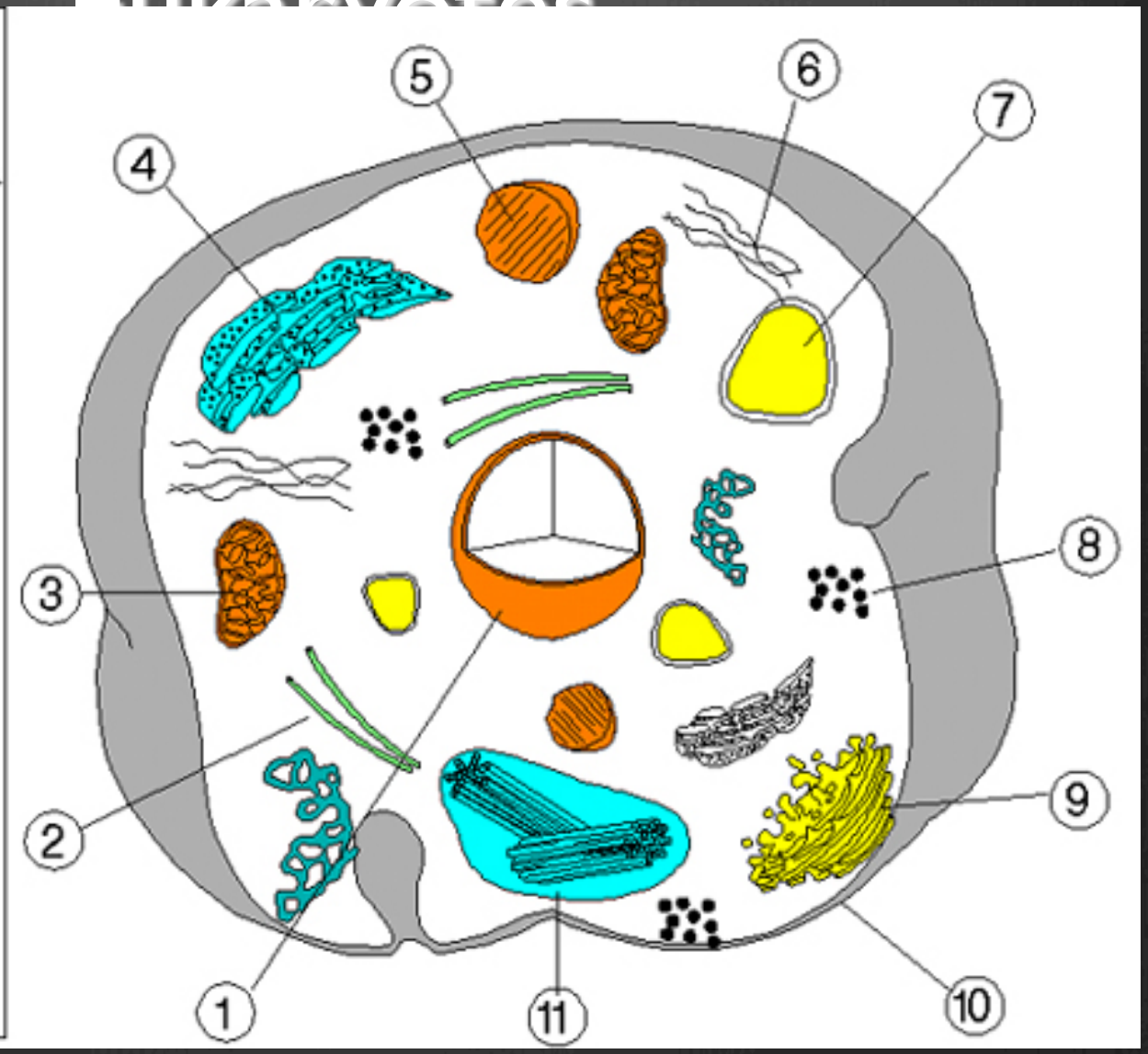


http://www.youtube.com/watch?v=7pR7TNzJ_pA

Eukaryotes

The parts of a cell

1. Nucleus
2. Microtubule
3. Mitochondrion
4. Rough endoplasmic reticulum
5. Lysosome
6. Microfilaments
7. Vacuole
8. Ribosomes
9. Golgi complex
10. Cell membrane
11. Centrosome

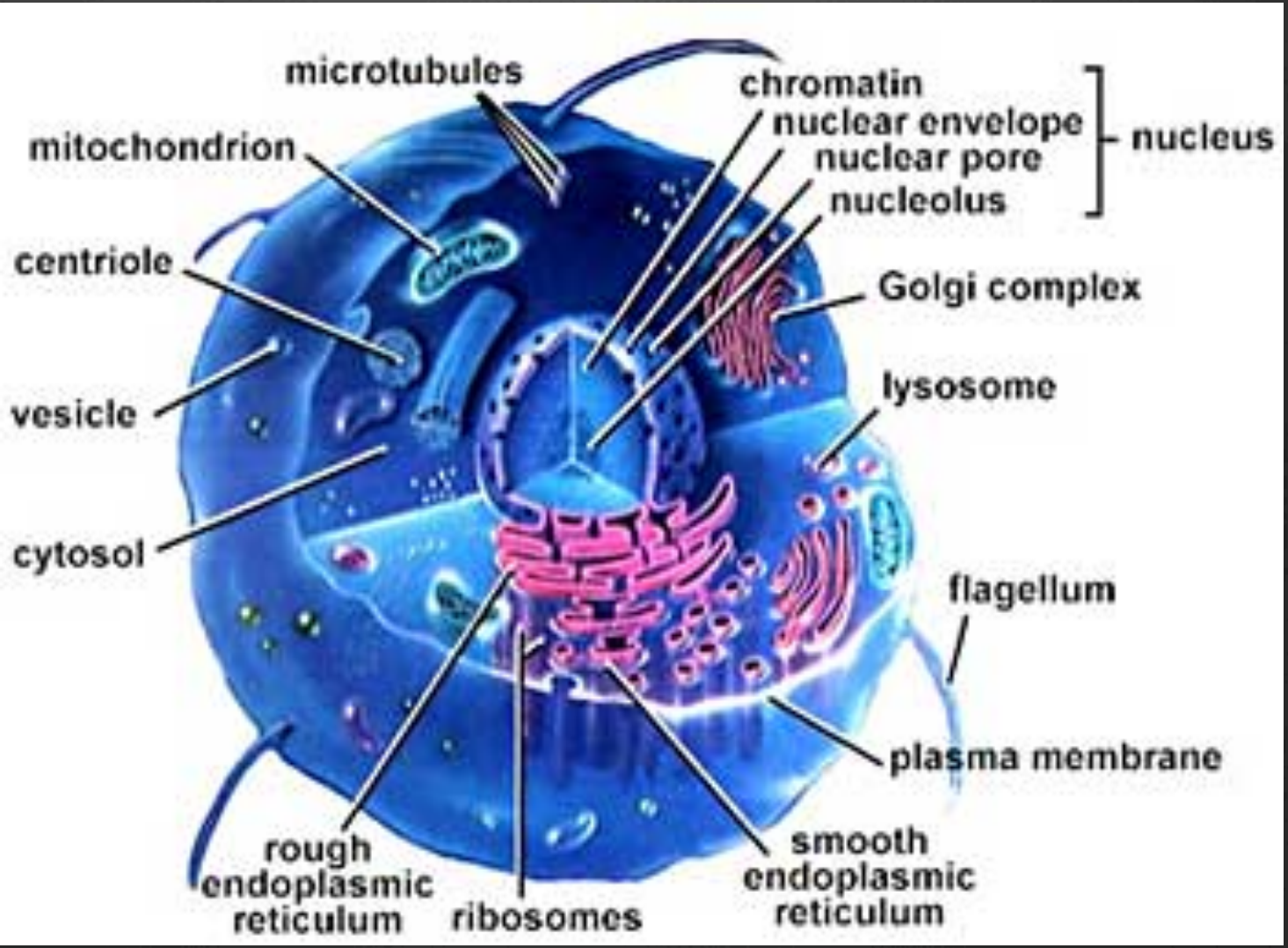


Eukaryotes

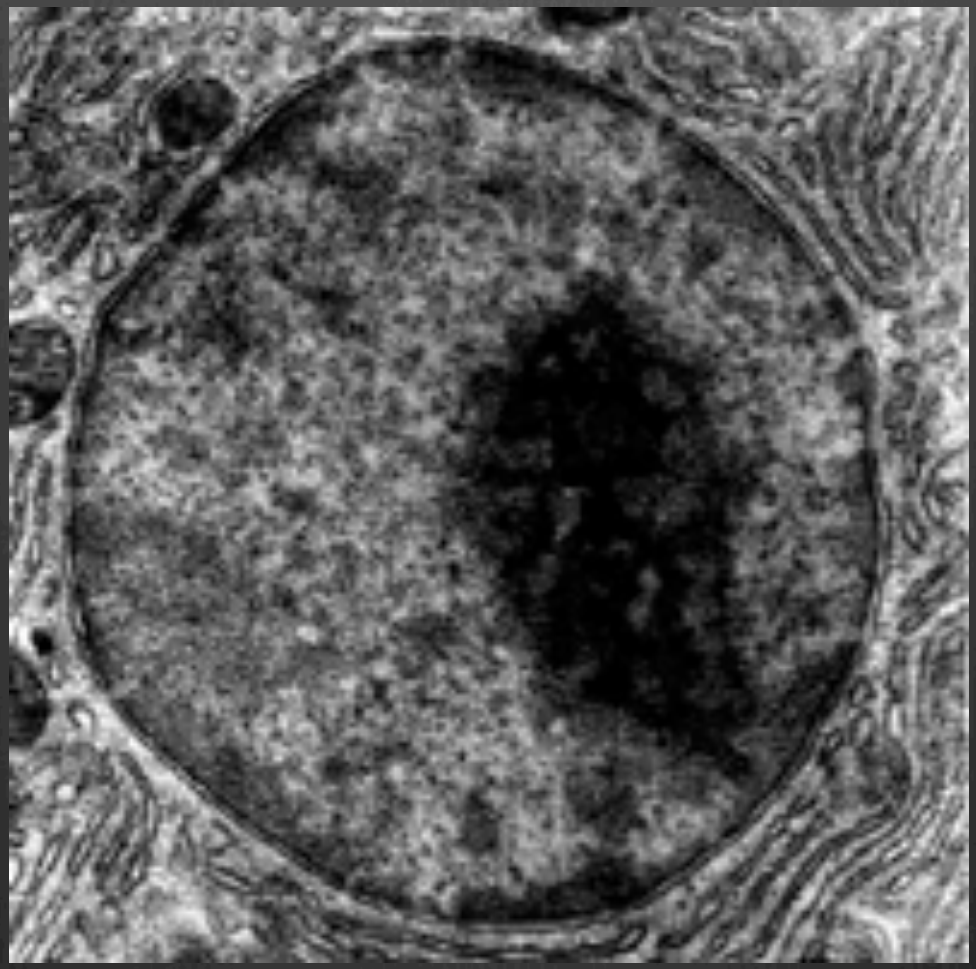
<u>Structure</u>

- *Nucleus*:
  - Double membrane bound
    - Membrane contains pores for transport of proteins and ribosomes
  - Contains chromosomes
    - Made of DNA + protein
    - Uncoiled chromosomes = chromatin
  - Site of DNA replication and transcription into RNA

Eukaryotes


microtubules
mitochondrion
centriole
vesicle
cytosol
chromatin
nuclear envelope
nuclear pore
nucleolus
nucleus
Golgi complex
lysosome
flagellum
plasma membrane
rough endoplasmic reticulum
ribosomes
smooth endoplasmic reticulum

Eukaryotes



Eukaryotes

<u>Structure</u>

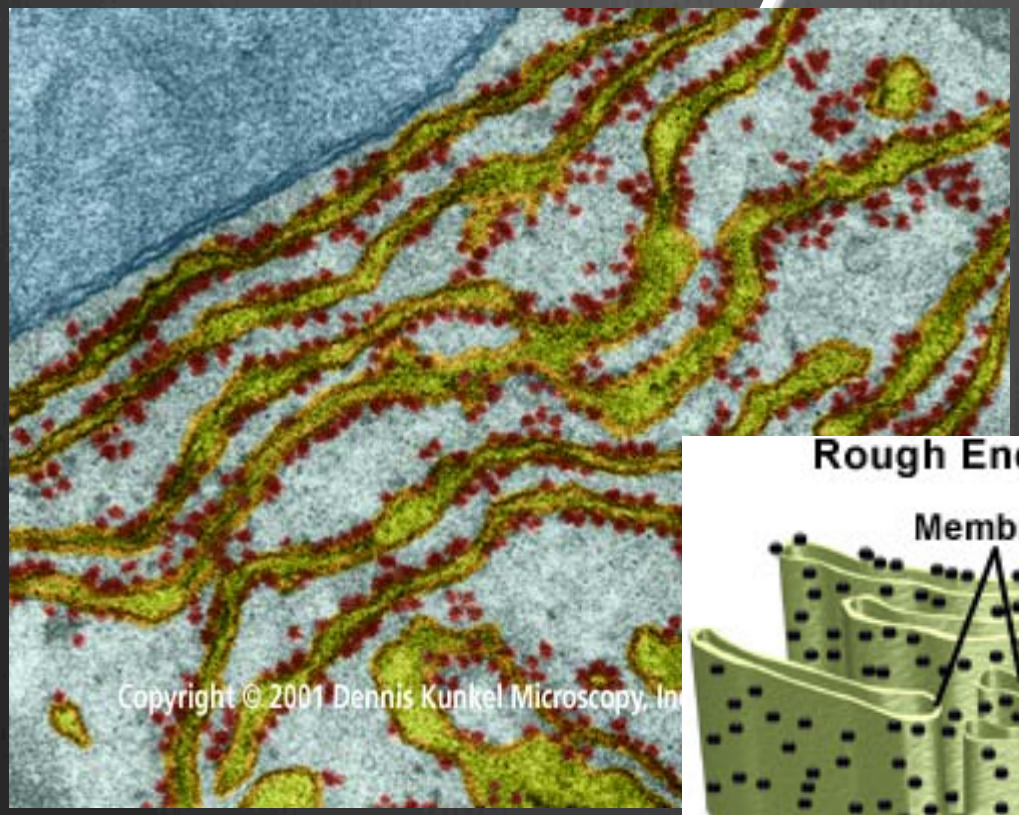
- *Free ribosomes*:
  - Sites of protein synthesis for use within the cytoplasm
  - Ribosomes are constructed in the nuclear region called the nucleolus

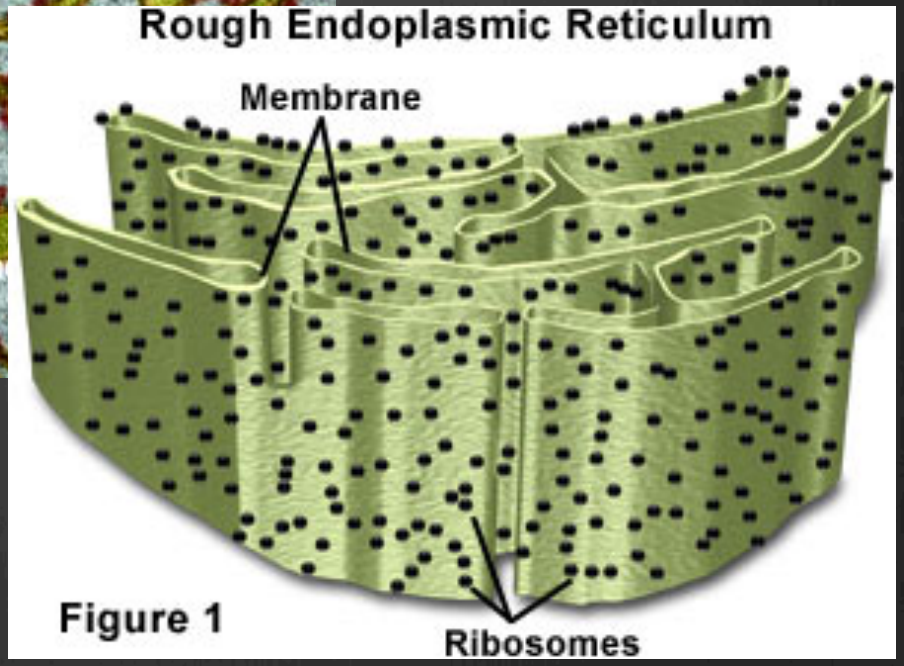
Eukaryotes

<u>Structure</u>

- *Rough Endoplasmic Reticulum (RER):*
  - Flattened membrane sacs (cisternae)
  - Ribosomes attached to outside of cisternae
  - Proteins synthesized by ribosomes enter cisternae
  - Proteins collected within cisternae are packaged in vesicles
  - Vesicles transport proteins to Golgi apparatus

Eukaryotes


Copyright © 2001 Dennis Kunkel Microscopy, In

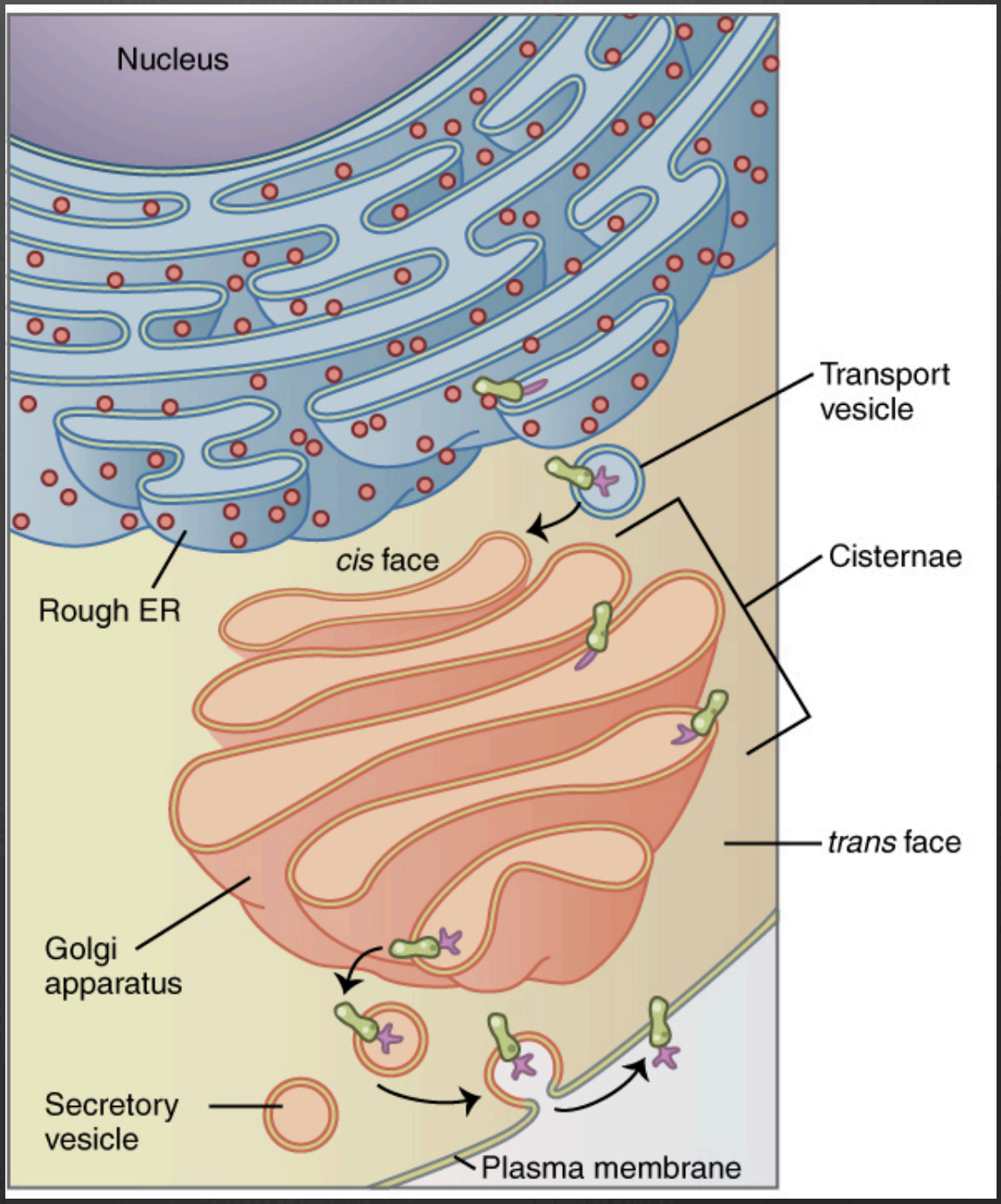

Rough Endoplasmic Reticulum
Membrane
Figure 1
Ribosomes

Eukaryotes

Structure

- *Golgi apparatus*:
  - Flattened membrane sacs called cisternae
    - Unlike ER, cisternae are curved, shorter, and lack ribosomes
  - Proteins received from arriving vesicles are processed
  - Carbohydrates added to proteins to form glycoproteins
    - Vesicles of glycoproteins exit Golgi for exocytosis or intracellular use

Secretory pathway

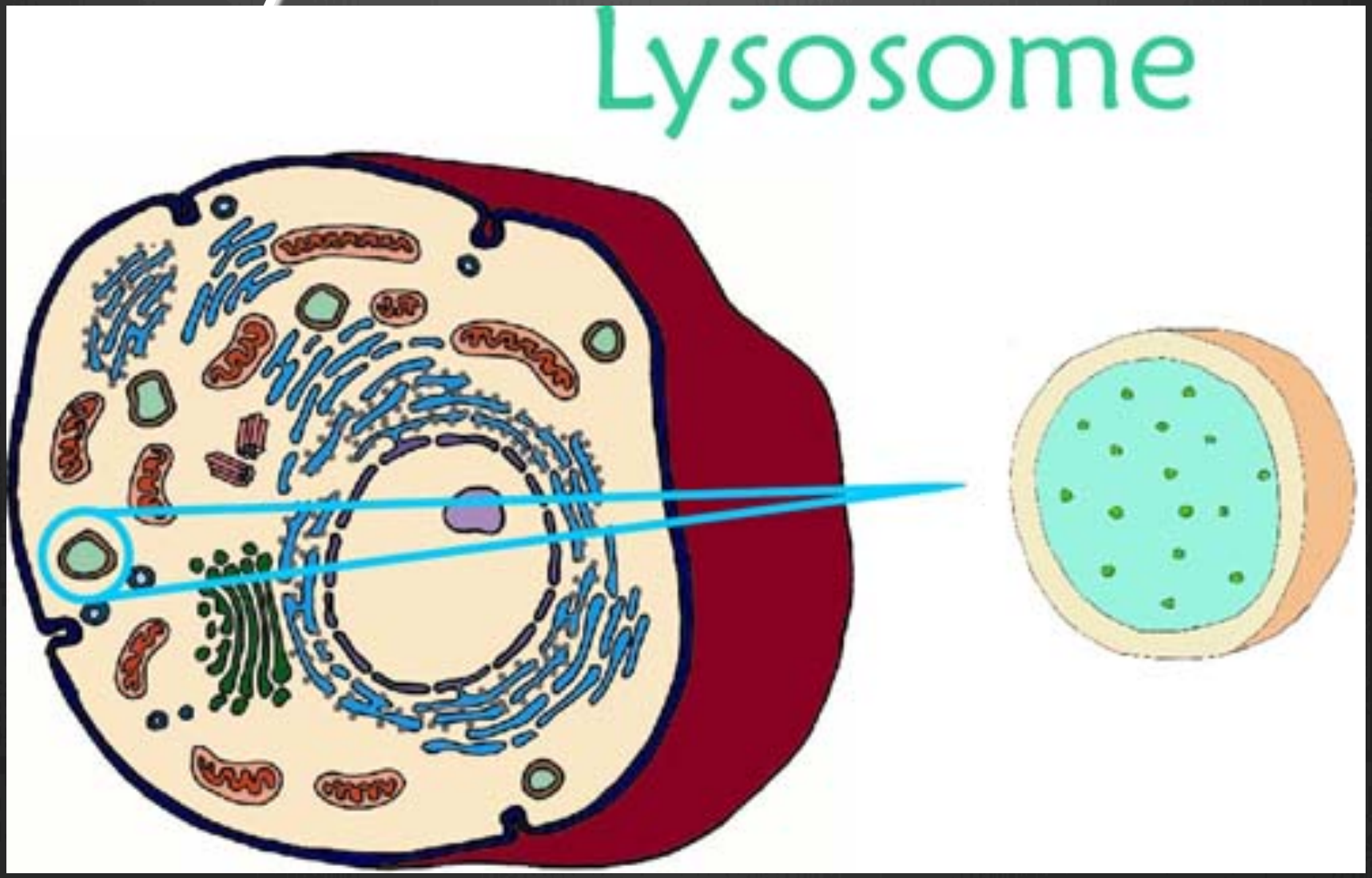


Lysosomes

<u>Structure</u>

- *Lysosomes*:
  - Spherical vesicles formed by Golgi apparatus
  - Contain hydrolytic/digestive enzymes
    - Enzymes for breaking down ingested food, damaged organelles, or entire cells

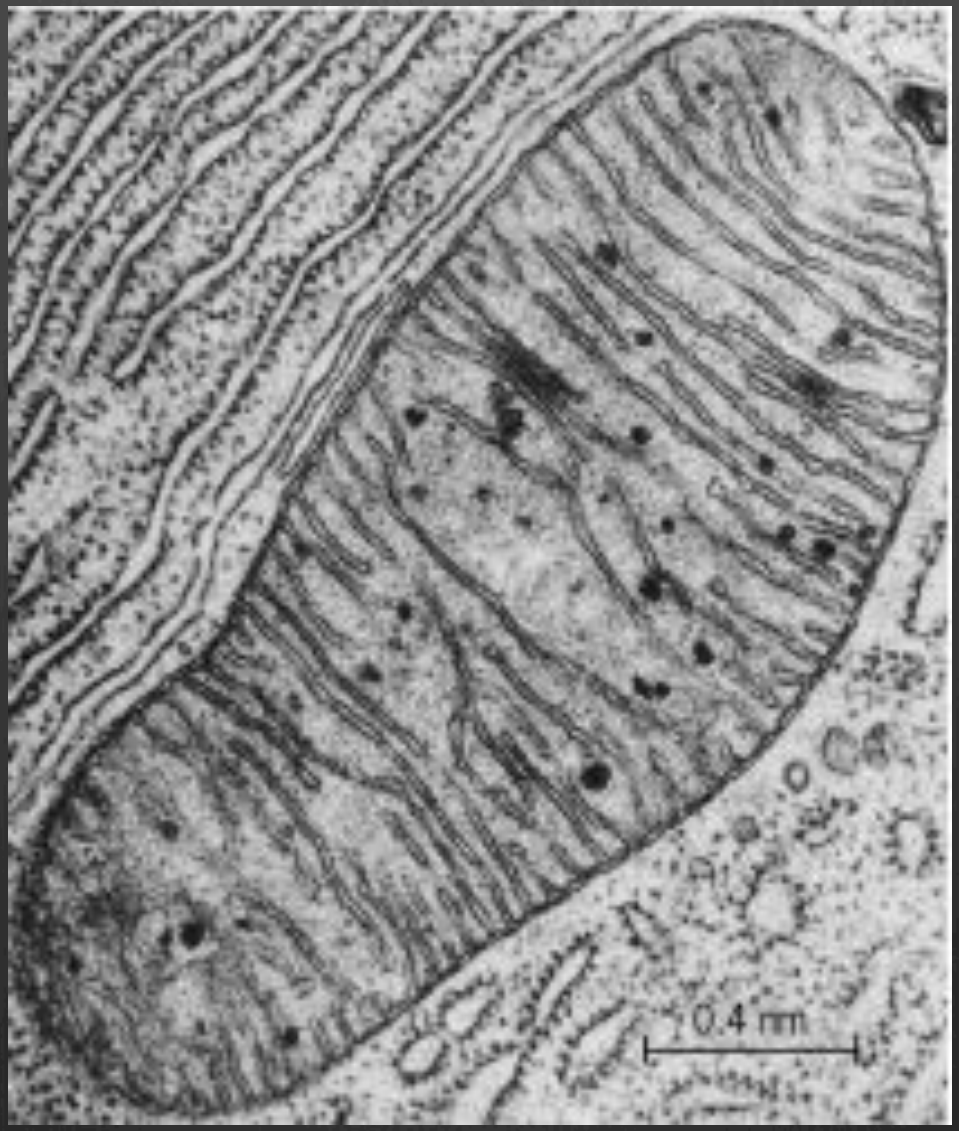
Eukaryotes



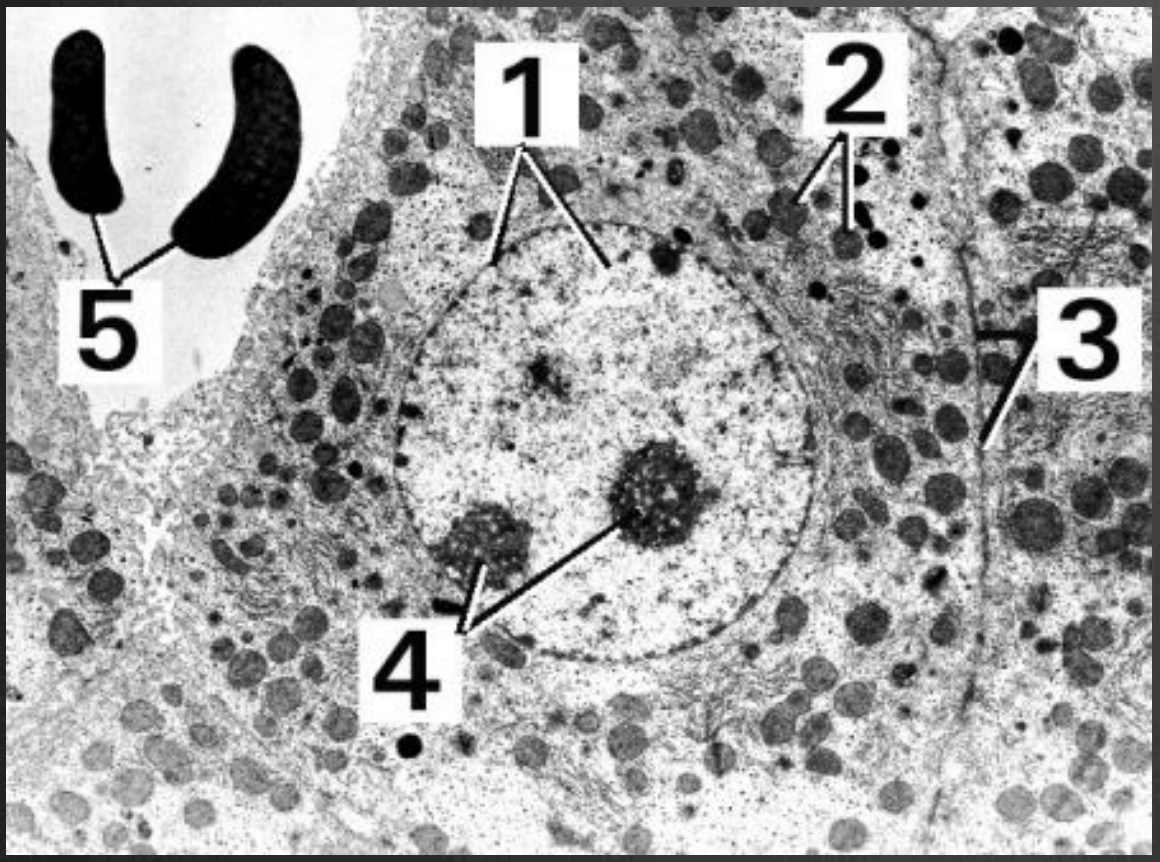
Structure

- *Mitochondria*
  - Double membrane bound
  - Inner membrane invaginated to form cristae
  - Site of aerobic respiration
    - Producing ATP

Eukaryotes

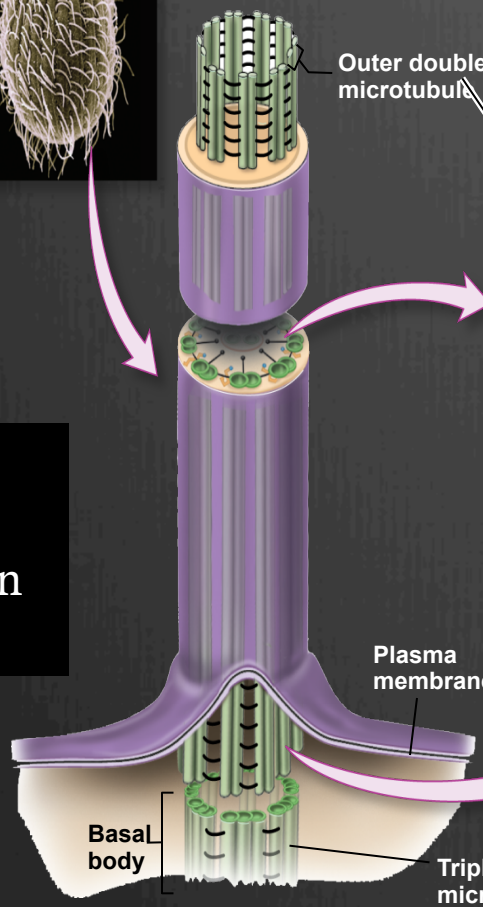


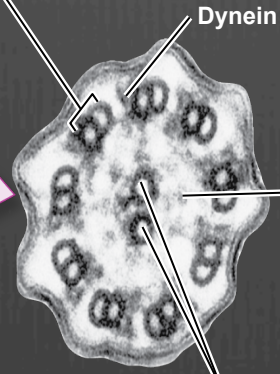
Ultrastructure

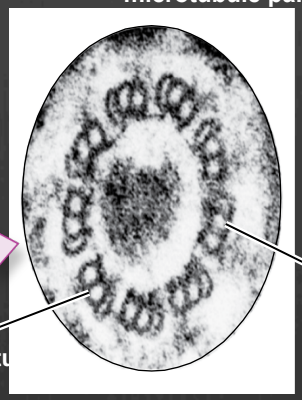


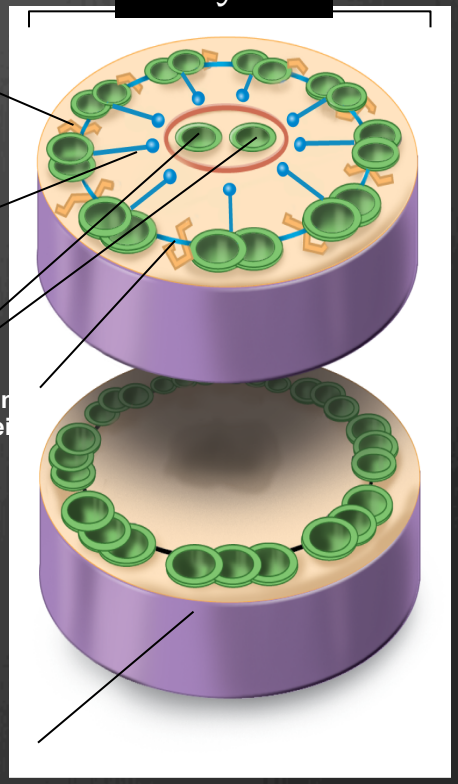
1. Nucleus
2. Mitochondria
3. Plasma membrane
4. Nucleoli
5. Red blood cells
   - in adjacent blood vessel

Structure of eukaryotic cilium or flagellum





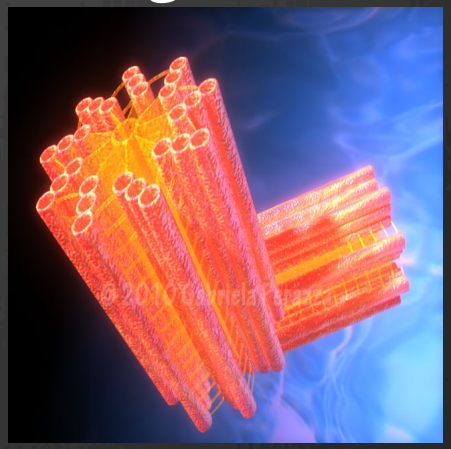




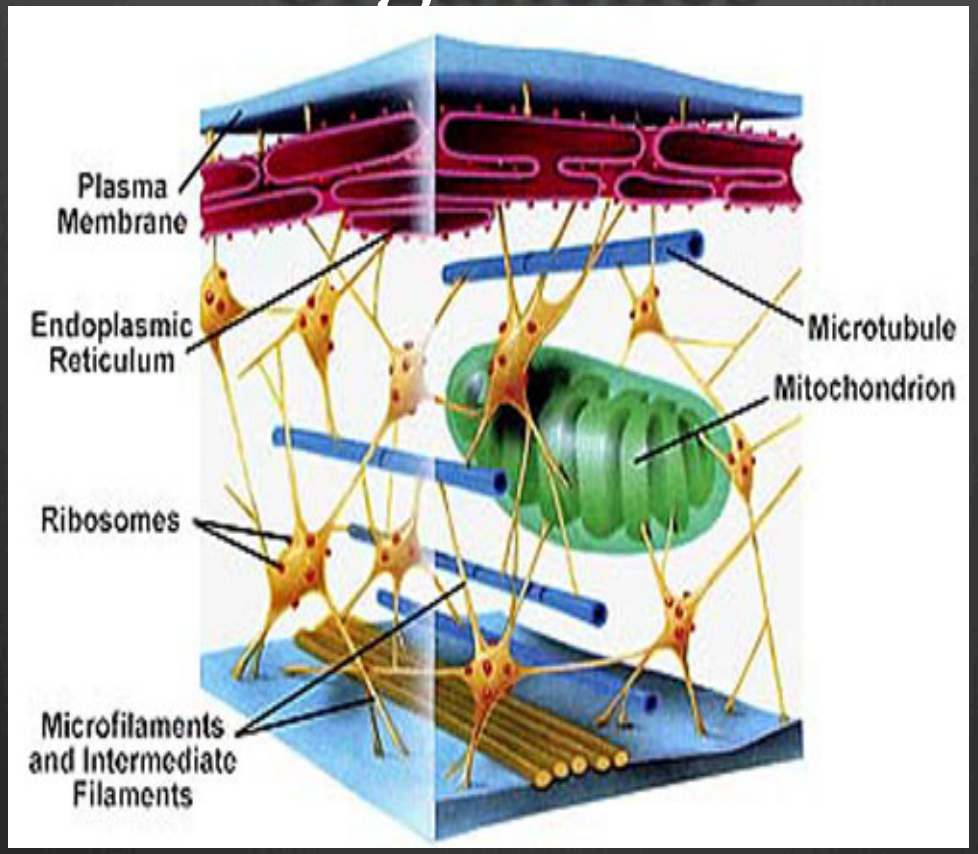
Axoneme
Microtubules
Linker protein
(dynein)

MTOC (microtubule organizing center)

Centrioles are made of microtubules and sit at right angles to each other in the MTOC (which gives rise to the spindle structure during cell division.



Cytoskeleton proteins interact to support and anchor cellular organelles



Cells perceive gravity through cytoskeleton!

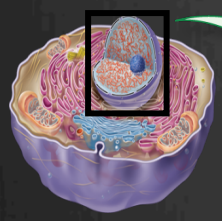
↓

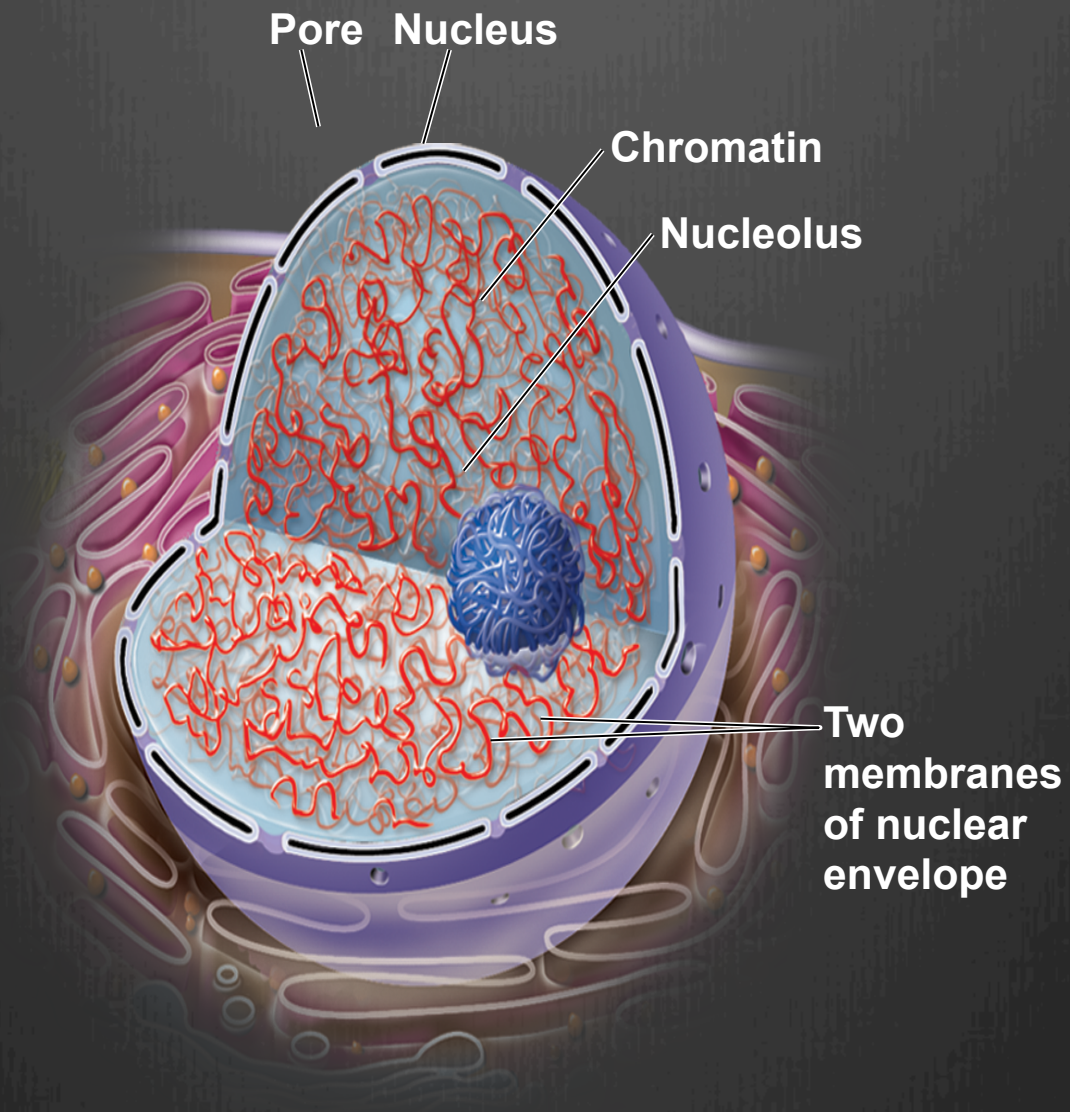
Changes in gene expression in response to mechanical stress

Nucleus

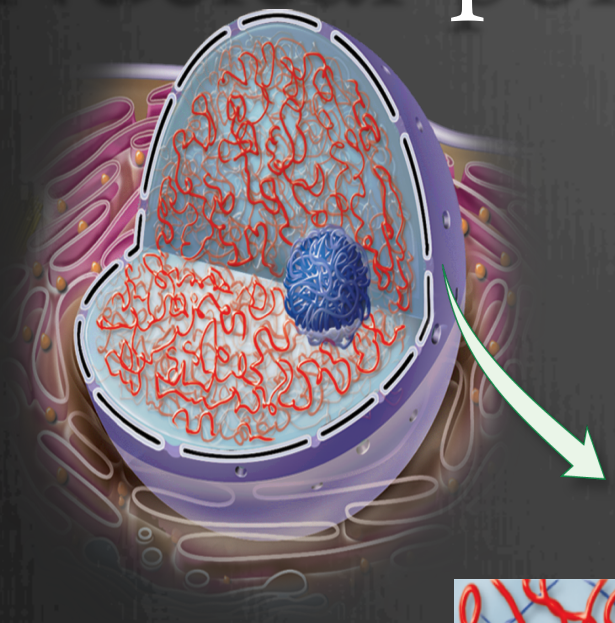
- Primary functions:
- Organization, protection and replication of DNA
- Gene expression
- Site of ribosome assembly (nucleolus)- only visible in non dividing cells

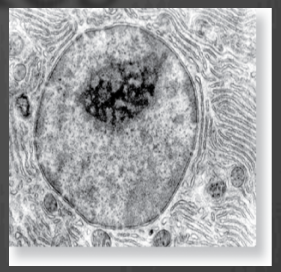
Nucleus and the Nuclear Envelope

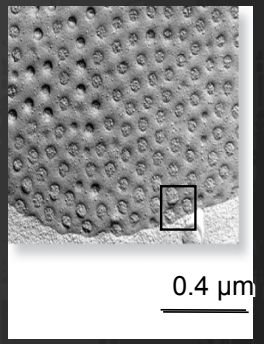


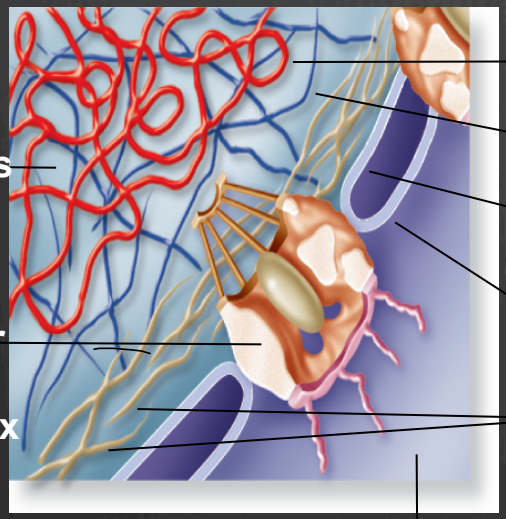


Nuclear pore complexes









Chromatin in nucleus

Internal nuclear matrix

Inner membrane

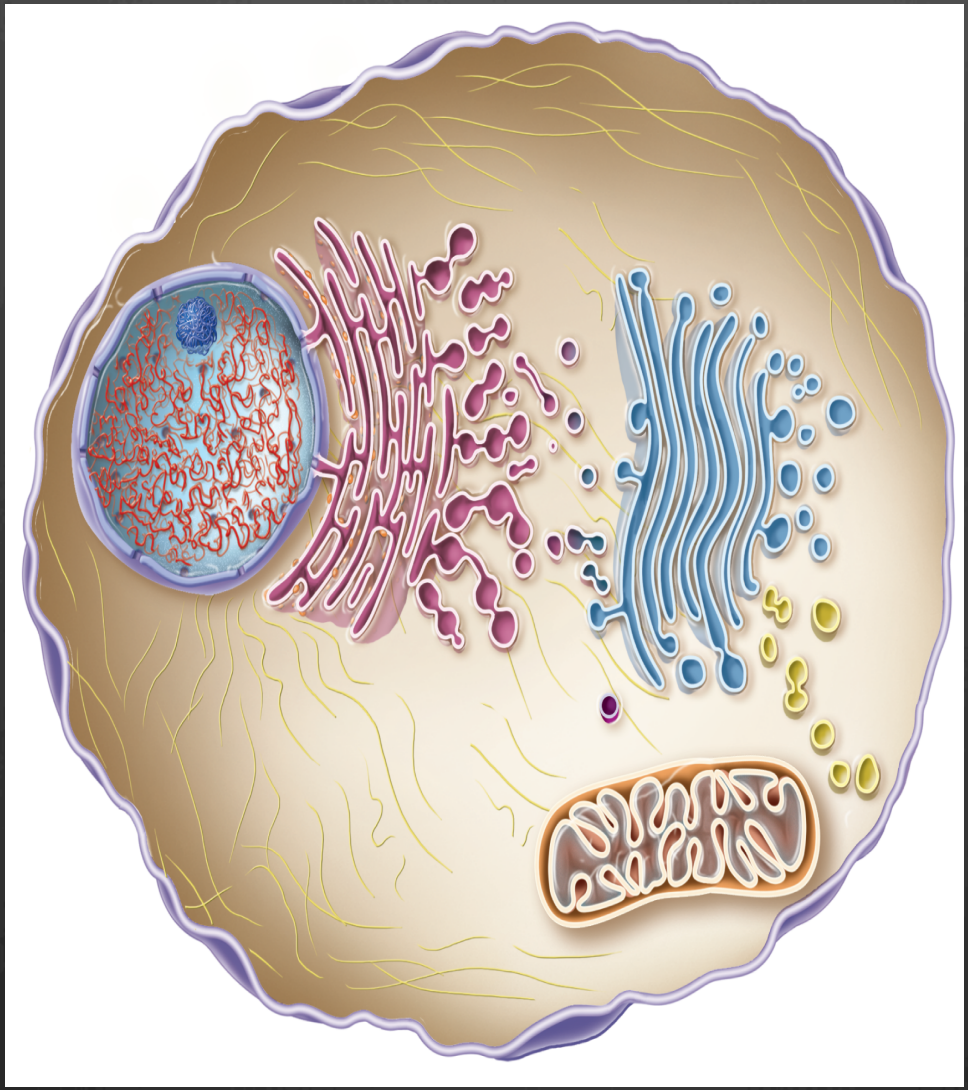
Nuclear envelope

Outer membrane

Nuclear lamin proteins

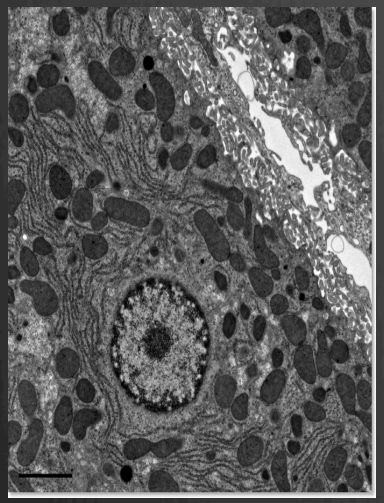
Ribosome Assembly

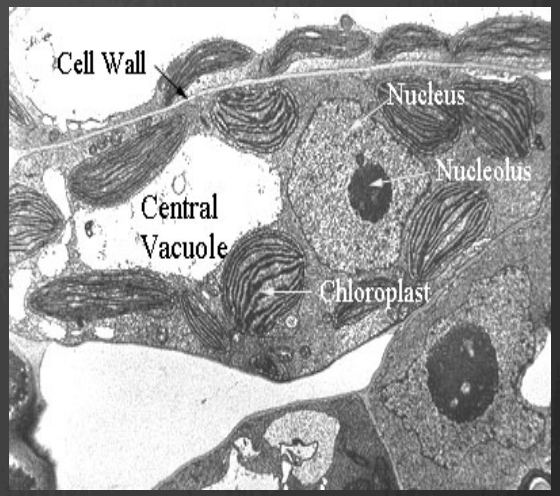
- Ribosomes are composed of RNA complexed with proteins
- Ribosomal proteins are synthesized in the CYTOPLASM and imported into the nucleus



"Semi-autonomous Organelles"

Grow in cytosol much like a bacterial cell grows in culture medium



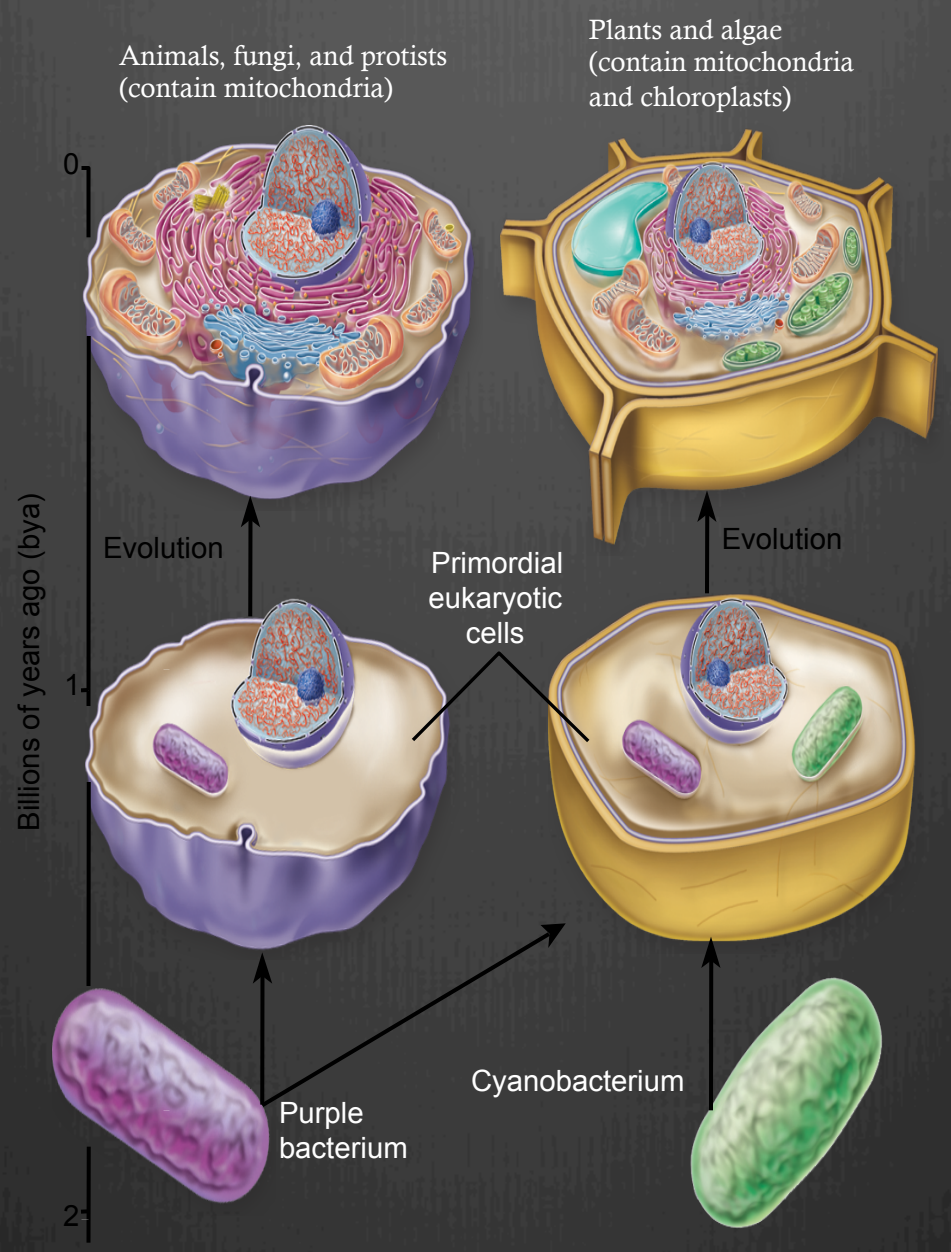


Mitochondria

Take in nutrients and generate ATP which drives cell processes that are energetically unfavorable

Chloroplasts

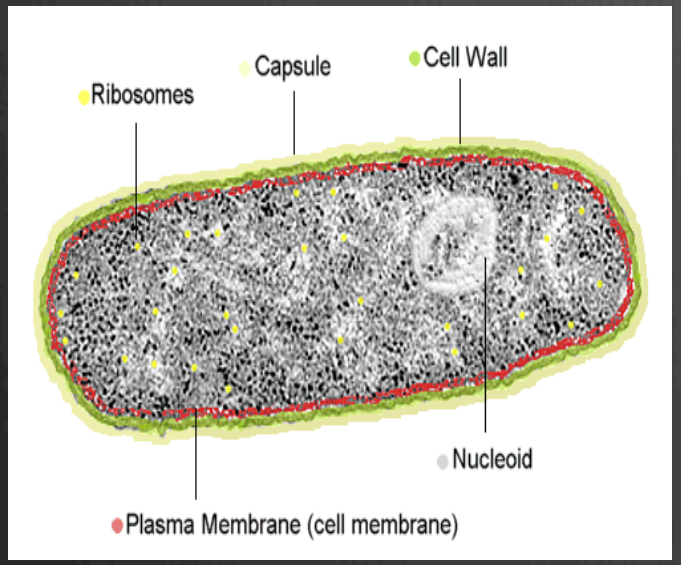
Harvest light energy and synthesize organic molecules



(a) Mitochondria originated from endosymbiotic purple bacteria.

(b) Chloroplasts originated from endosymbiotic cyanobacteria.

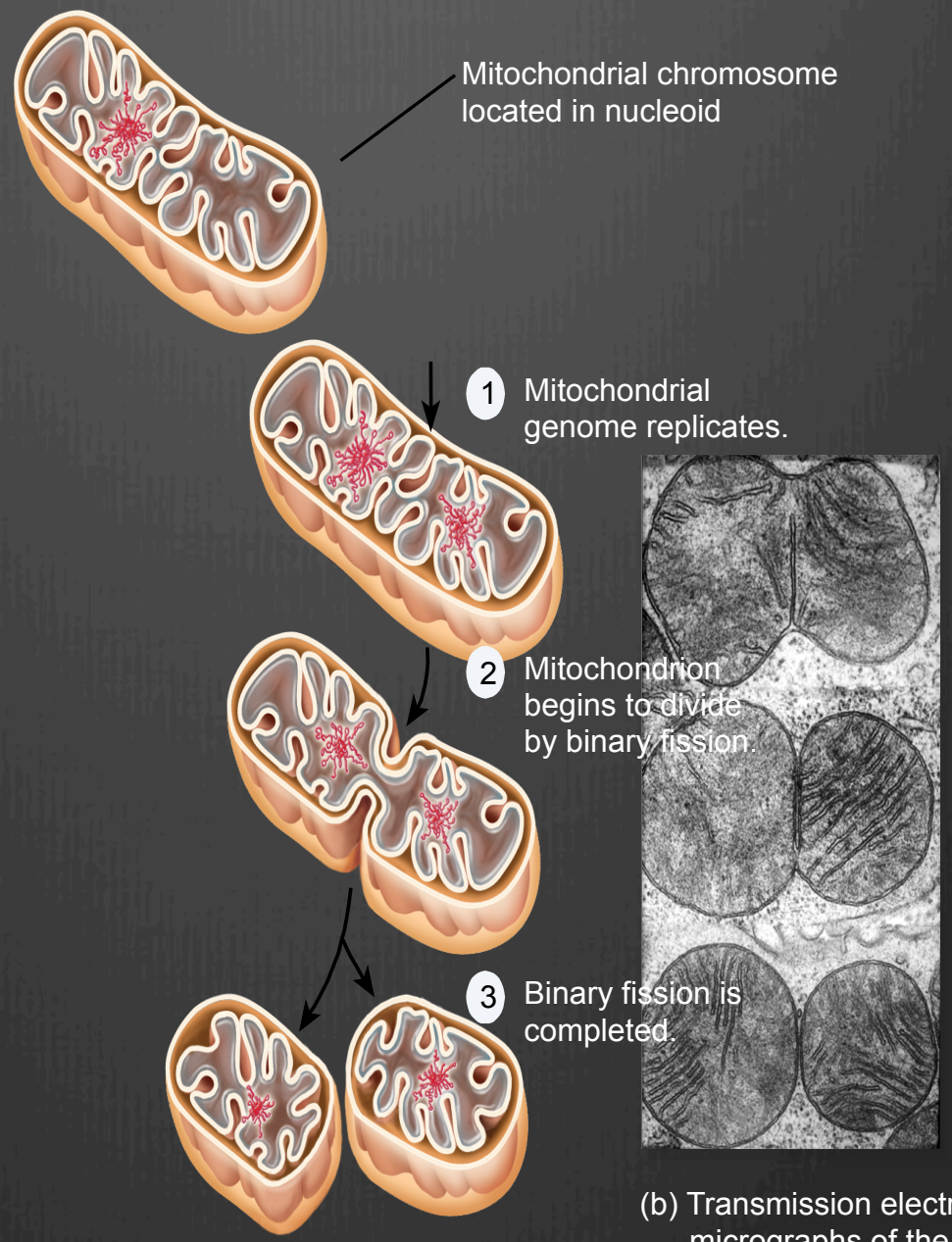
Prokaryote vs mitochondrion



Mitochondria divide by binary fission (like prokaryotes)

They can also fuse together

Numbers can increase to meet energy demand

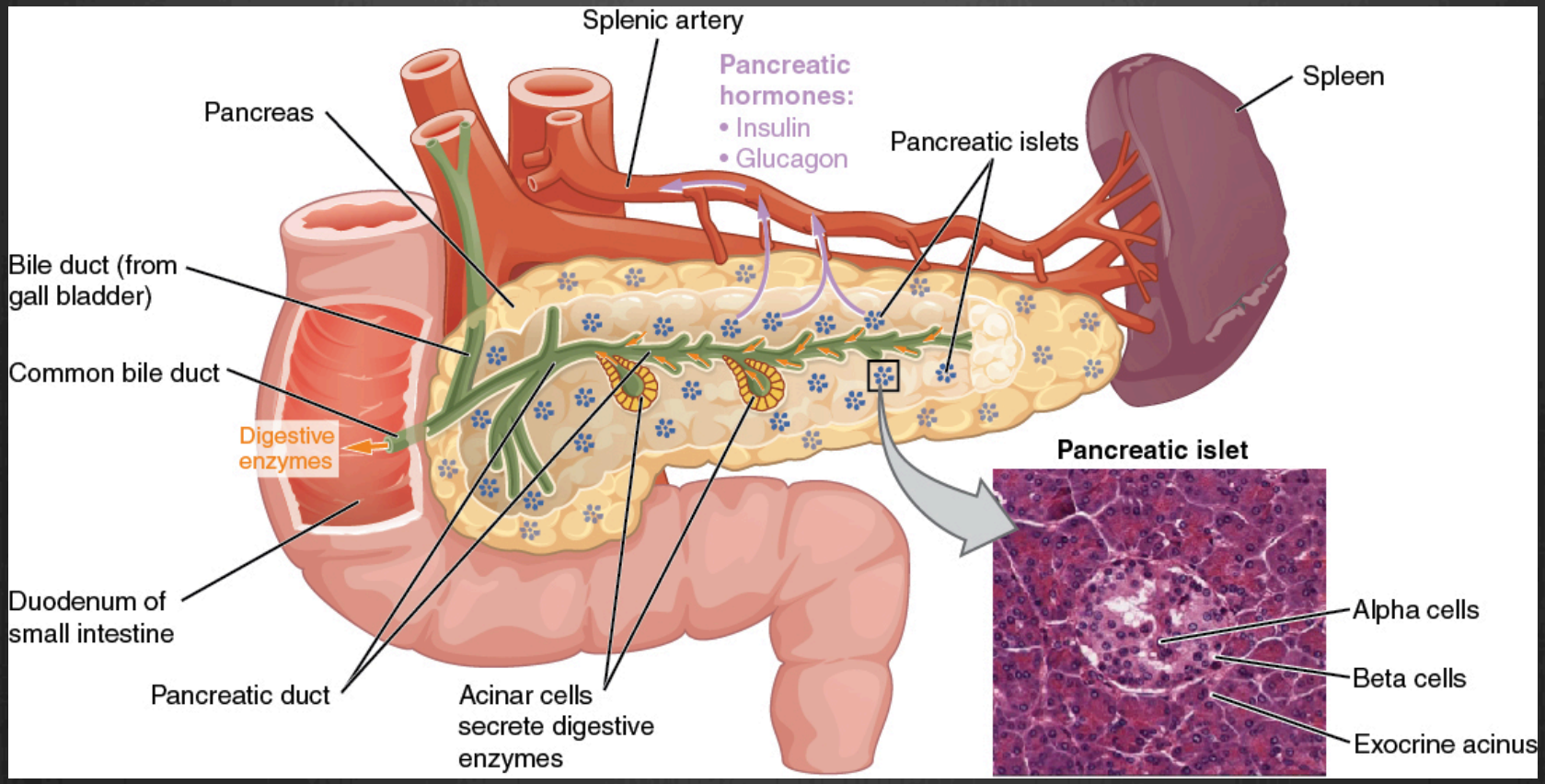


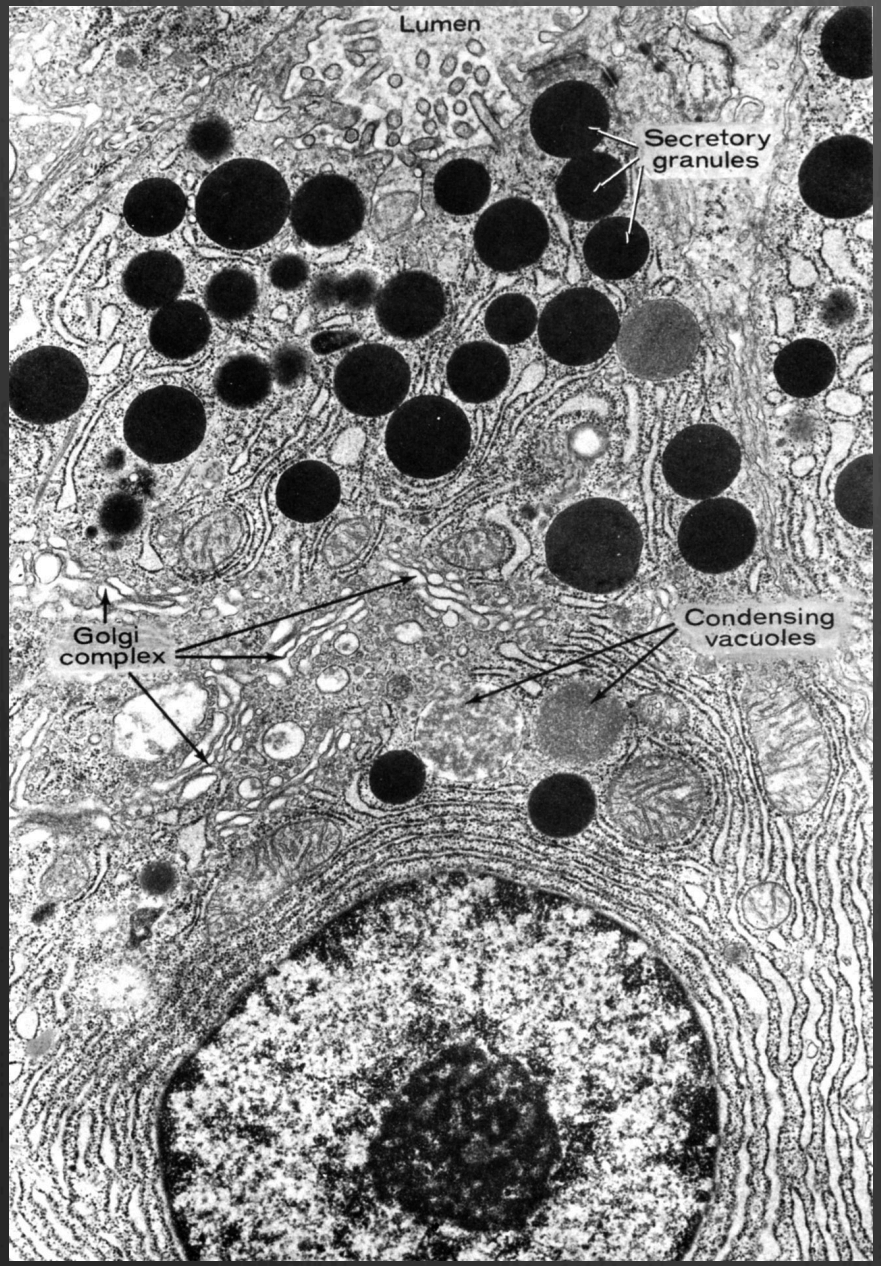
(a) Binary fission of mitochondria

(b) Transmission electron micrographs of the process

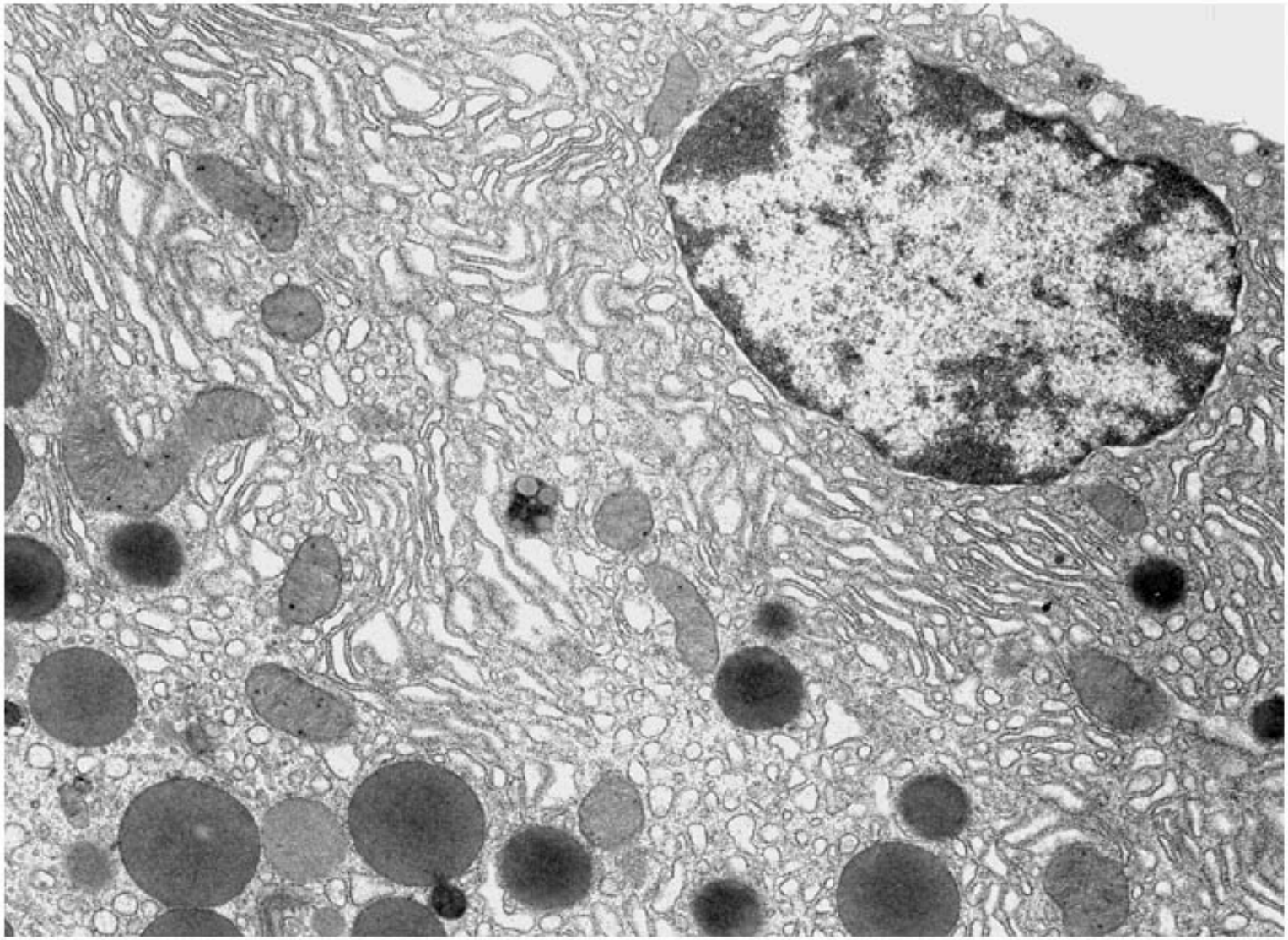
Mitochondria

- ATP production
- Calcium homeostasis
  - If calcium levels too high in cytosol, mitochondria can retain excess calcium
- Generation of reactive oxygen
- Mitochondrial movement is important in polar cell types (such as neurons)
- Mitochondrial defects are now thought to play a role in the development of Alzheimer's disease & some cancers
  - Errors in replication accumulate as cells age


Splenic artery
Pancreatic hormones:
• Insulin
• Glucagon
Spleen
Pancreas
Pancreatic islets
Bile duct (from gall bladder)
Common bile duct
Digestive enzymes
Pancreatic islet
Duodenum of small intestine
Alpha cells
Beta cells
Exocrine acinus
Pancreatic duct
Acinar cells secrete digestive enzymes


Lumen
Secretory granules
Golgi complex
Condensing vacuoles

Mouse liver cell



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