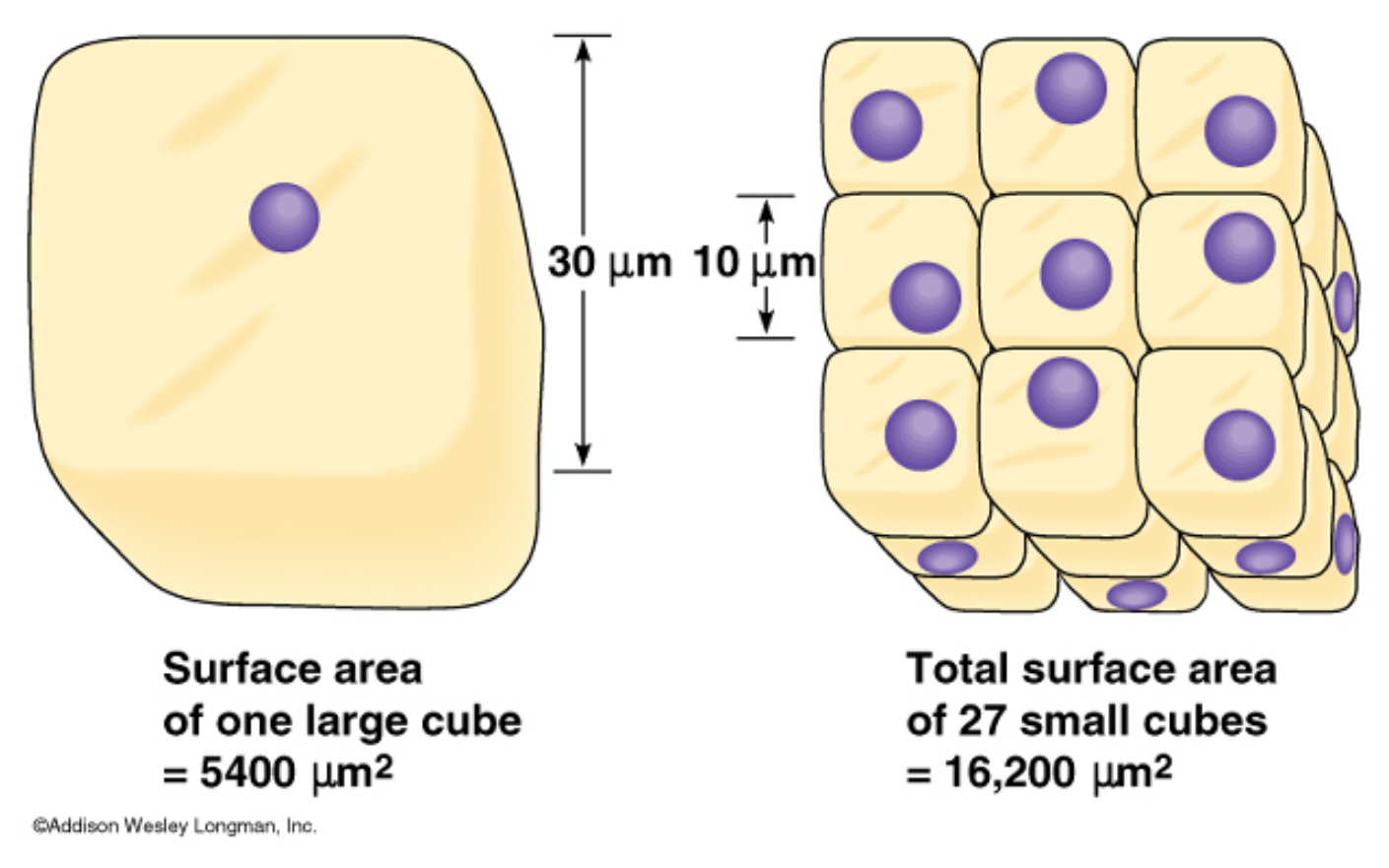
Cell Structure Survey

Warm up:
Design a cell. Is your cell a HETEROTROPH or an AUTOTROPH? How can you tell? How does your cell obtain nutrition? Does it move and if so, how? Is this a PROKARYOTIC or a EUKARYOTIC cell?

Cell Structure Survey

Which cat cools most efficiently?

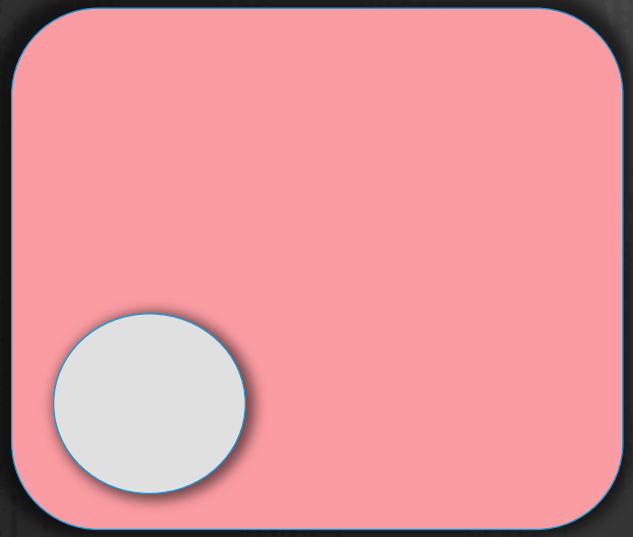
Large cube vs small cubes with same total volume:

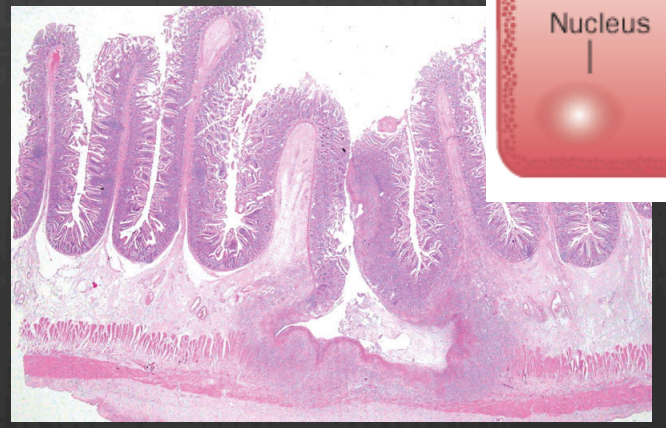


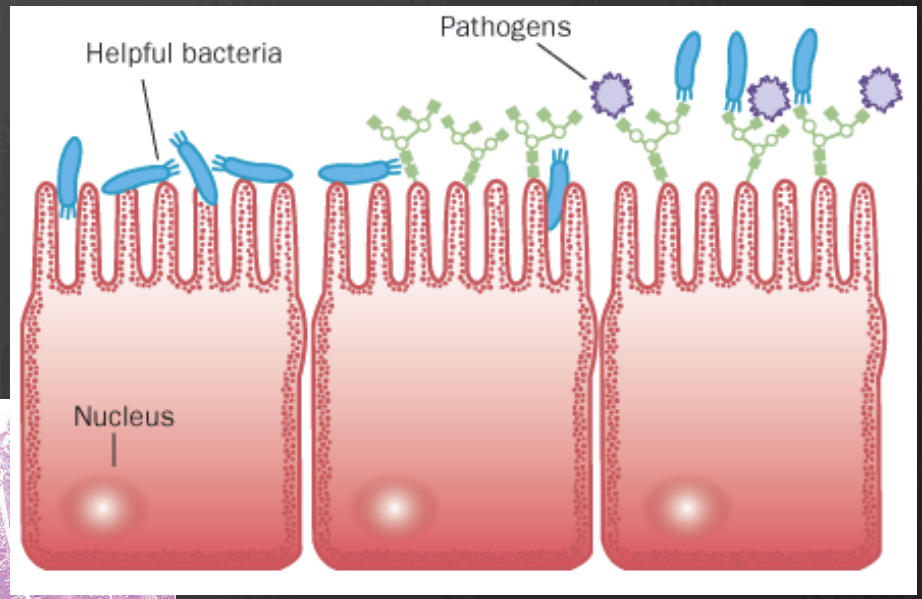
Surface Area = H x W x # of sides

Volume = (length)^3

How might you increase the surface area of this cell:







Why are cells small?

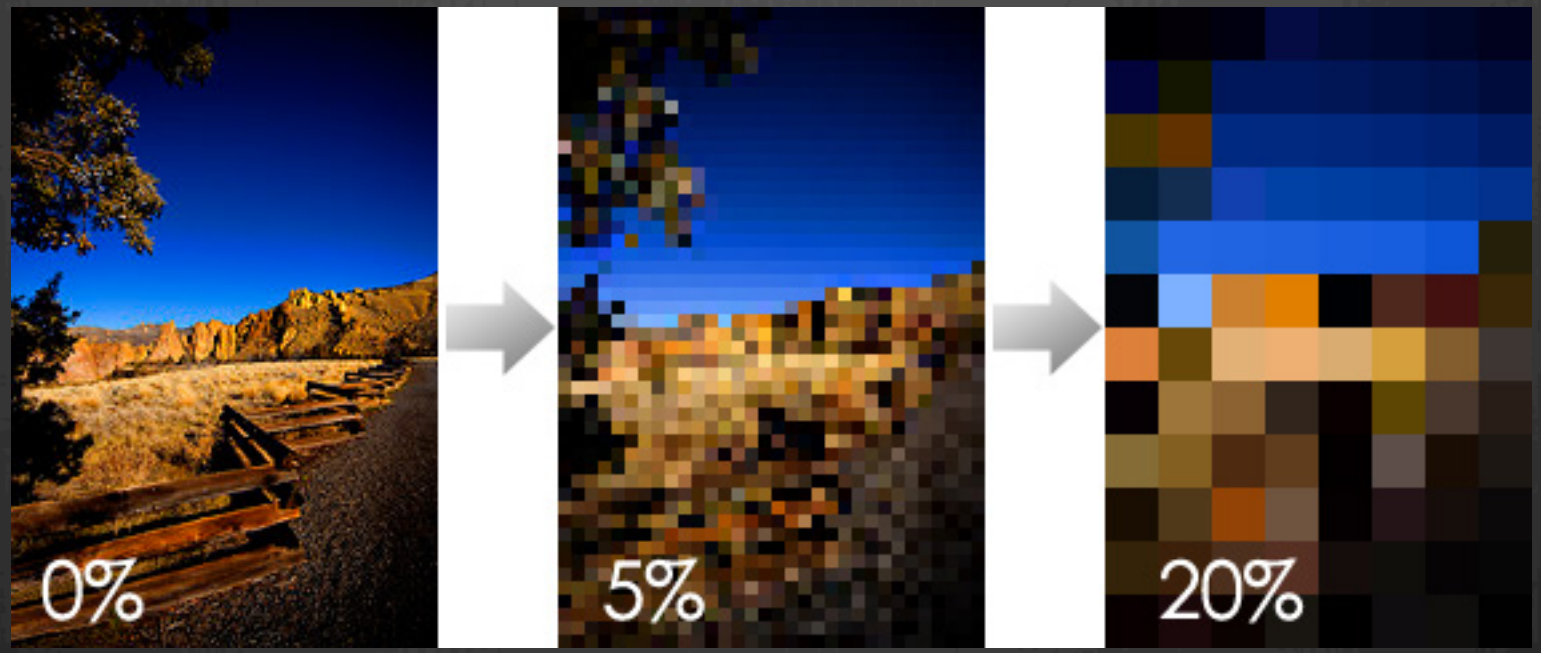
- https://www.youtube.com/watch?v=wuXSEOKNxN8

How did developments in research follow improvements in apparatus:
the invention of the electron microscope led to greater understanding of cell structures.

Microscopy:

- **RESOLUTION**: minimum distance 2 points can be from each other and still be distinguished (measure of image clarity)
- **MAGNIFICATION**: ratio of an object's image size to real size (so 100X objective on light microscope = 100X larger than in real life)
- **CONTRAST**: accentuates differences in parts of sample (through staining for example)

Resolution: shortest distance between two points that can be distinguished.

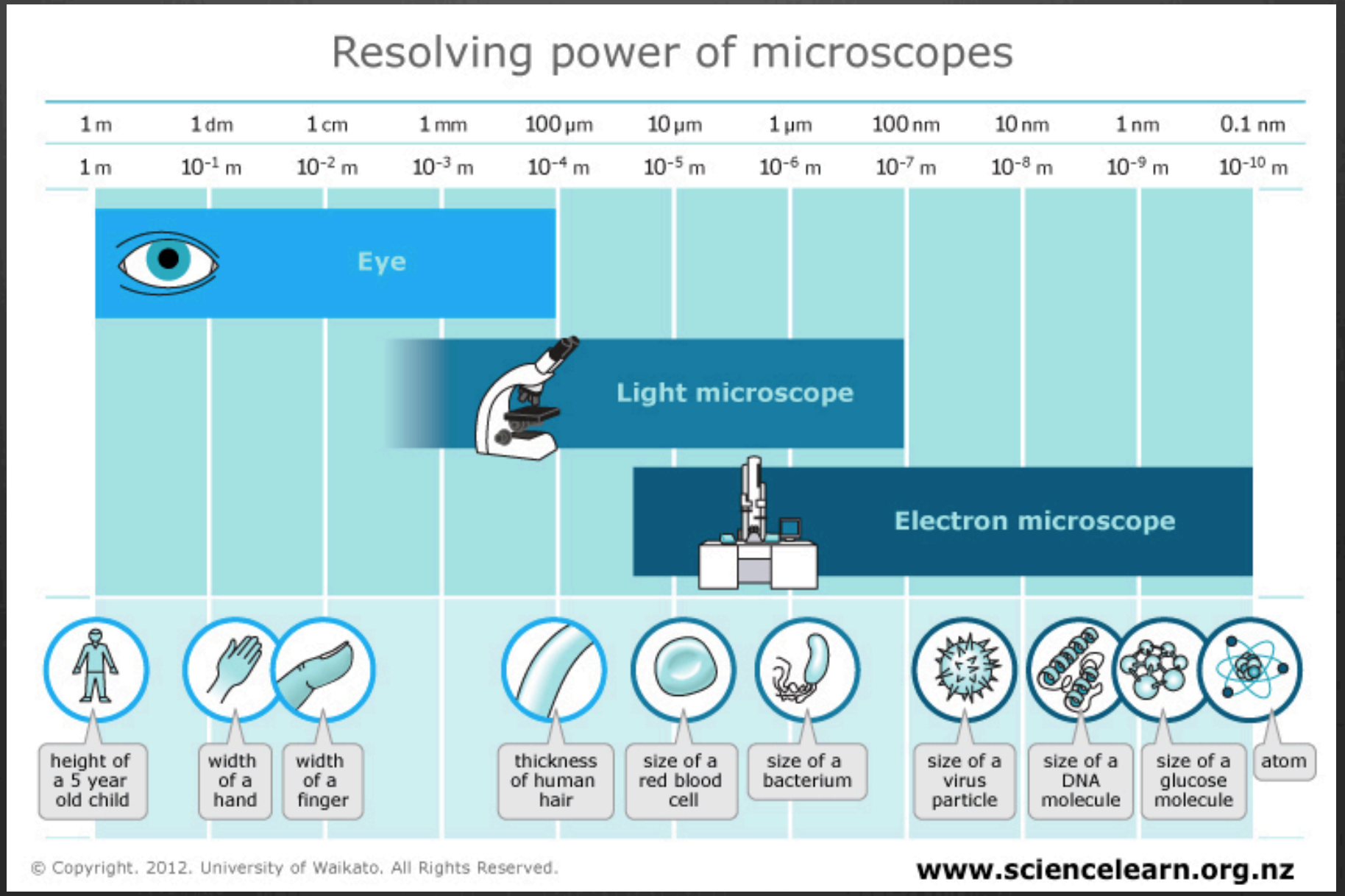


Light Microscopy: resolution limit 0.2 mm

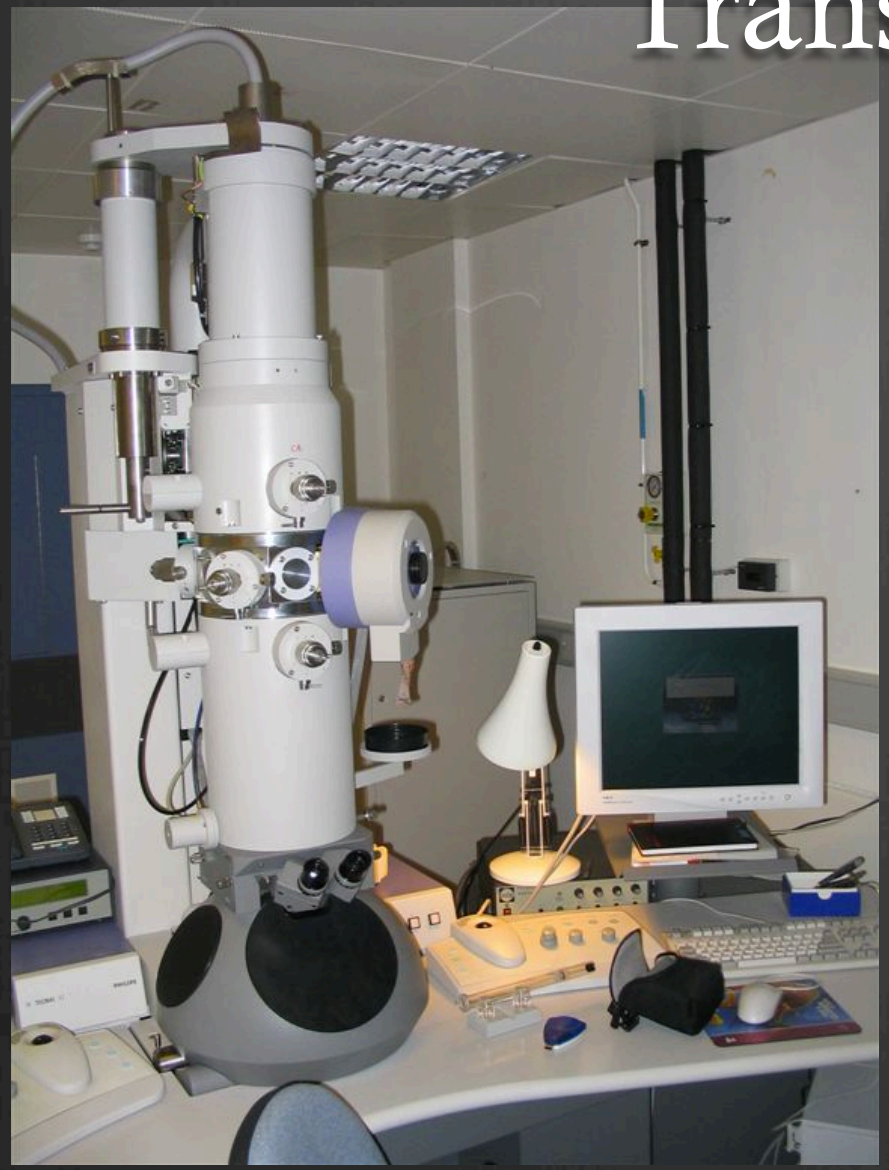
Electron Microscopy

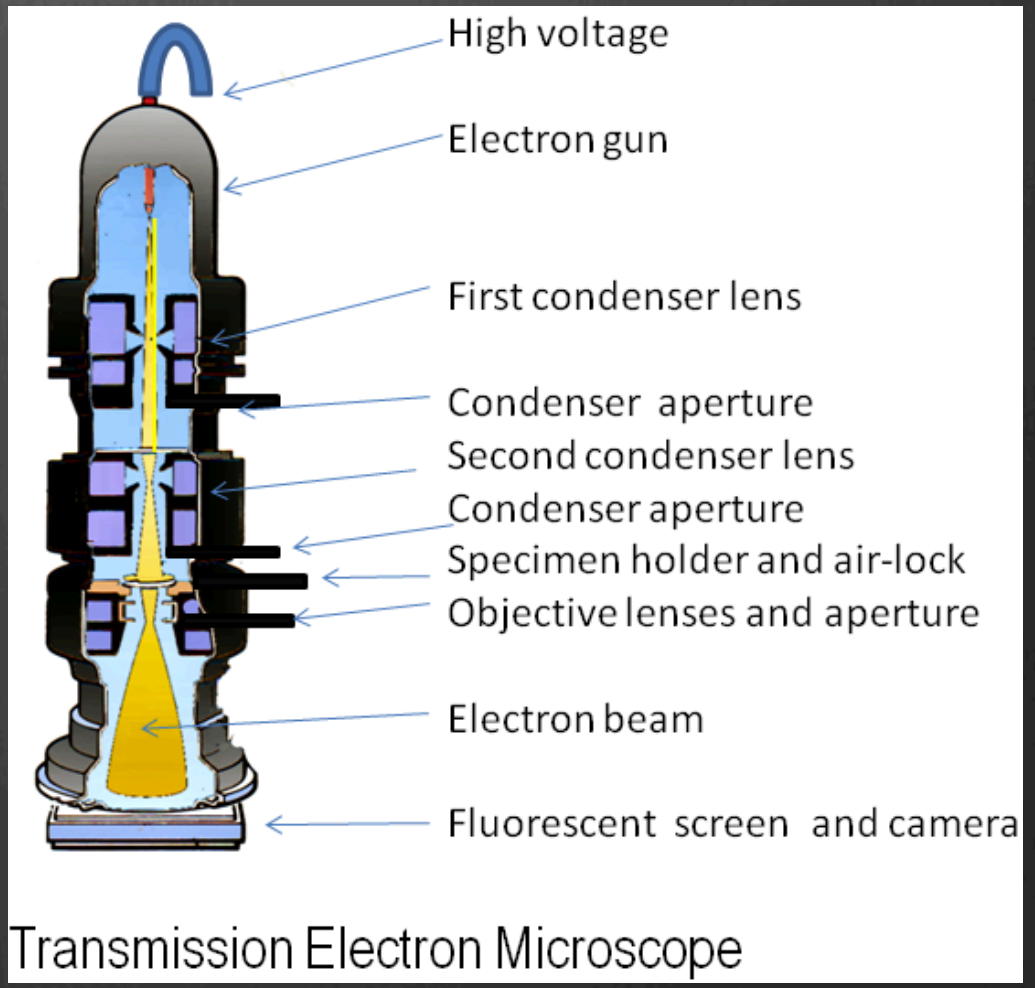
Resolving power is 2 million times that of a light microscope!

EM: increased resolution limits to nanometer range.



Transmission EM

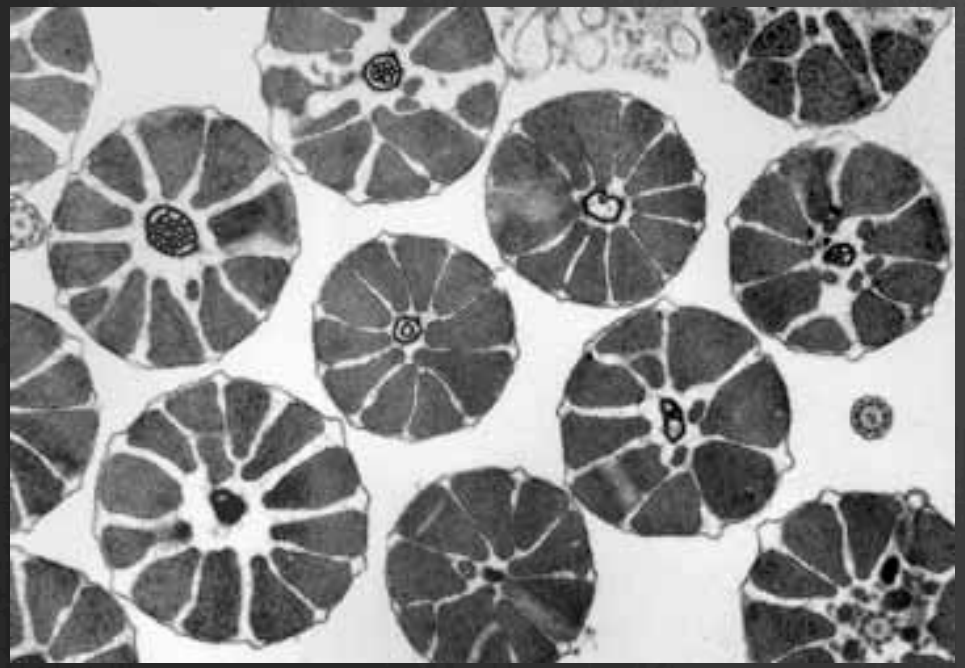




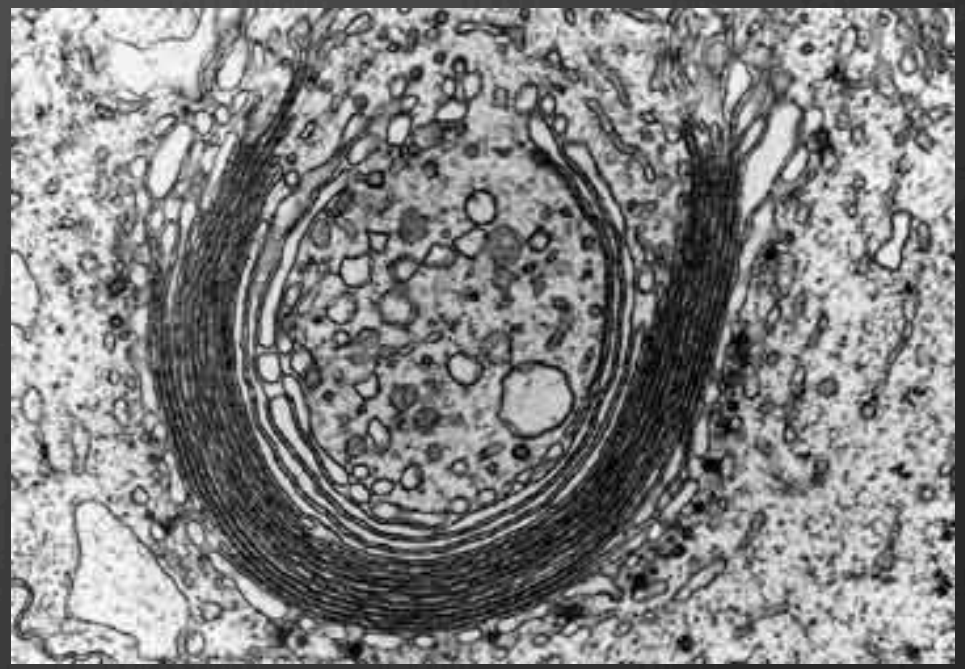
Transmission Electron Microscope

TEM sample preparation: thin sectioning

Transmission Electron Micrograph images (views of thin sections)

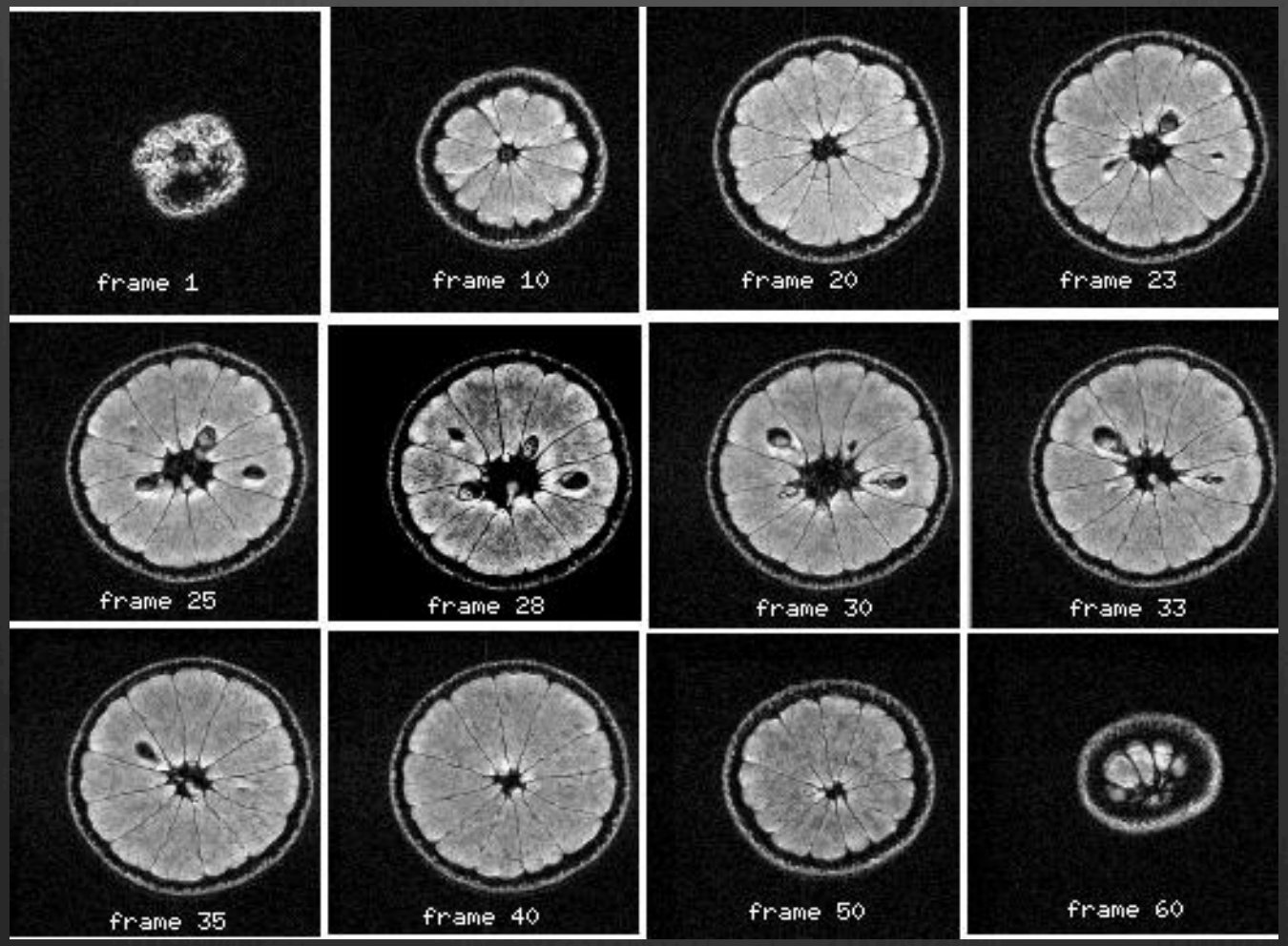


Snail Sperm

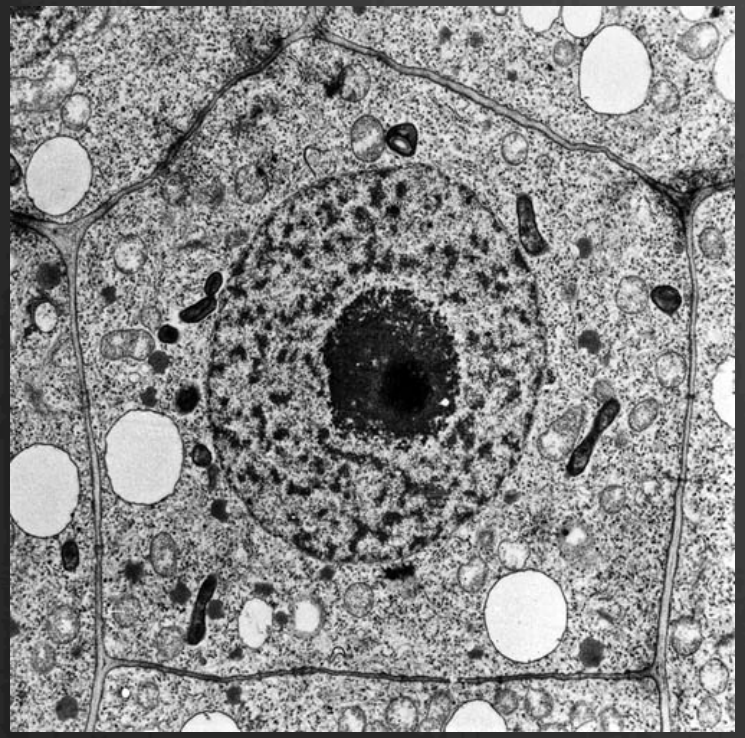


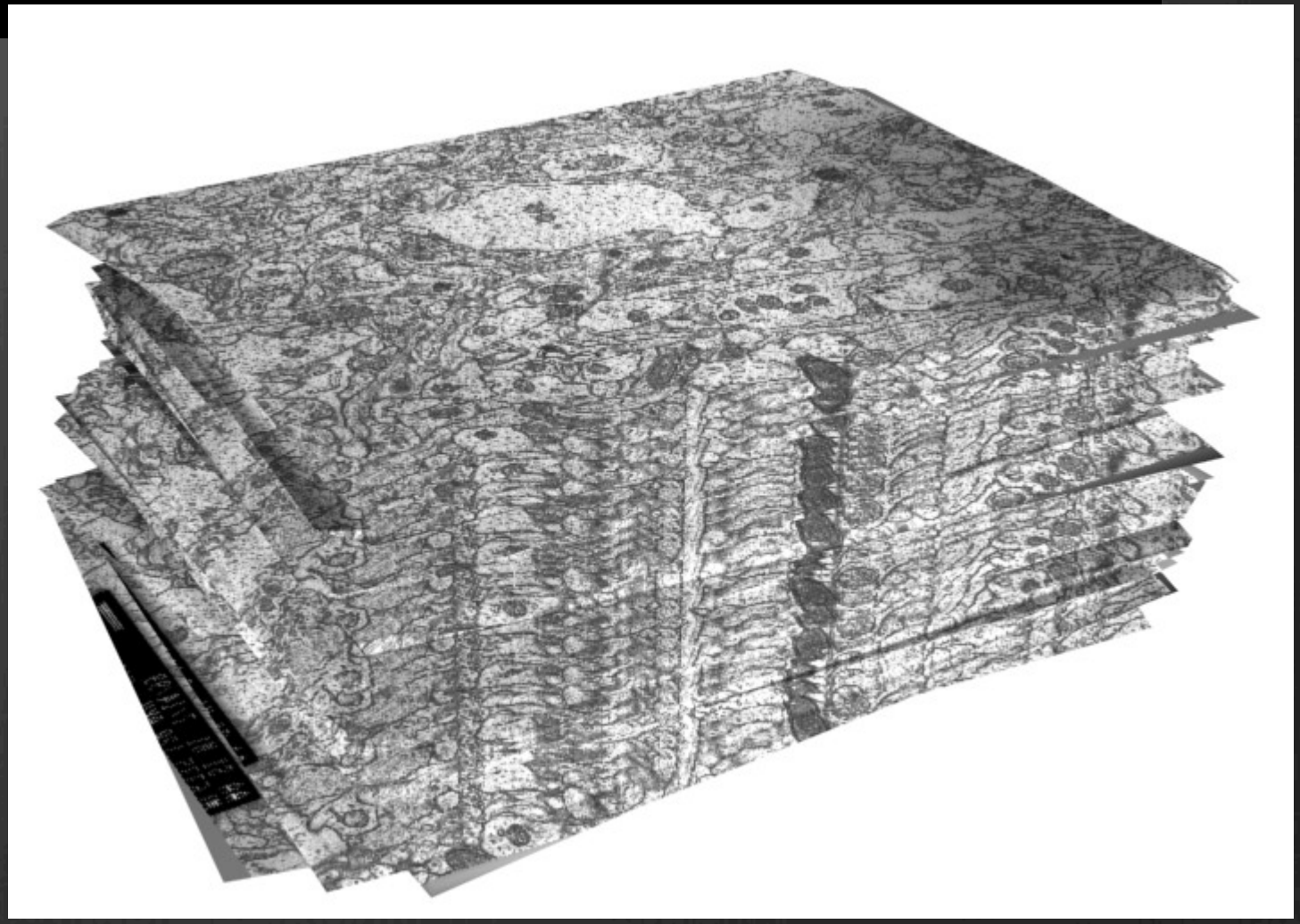
Golgi Apparatus

Perspective: thin section gives one view of one layer



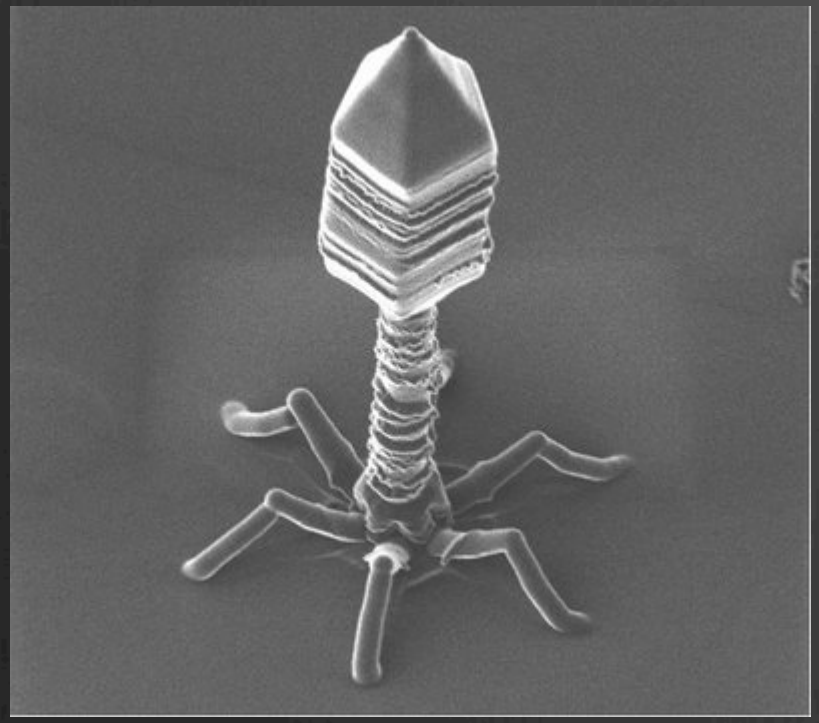
3D visualization comes from stacking 2D images from serial sections



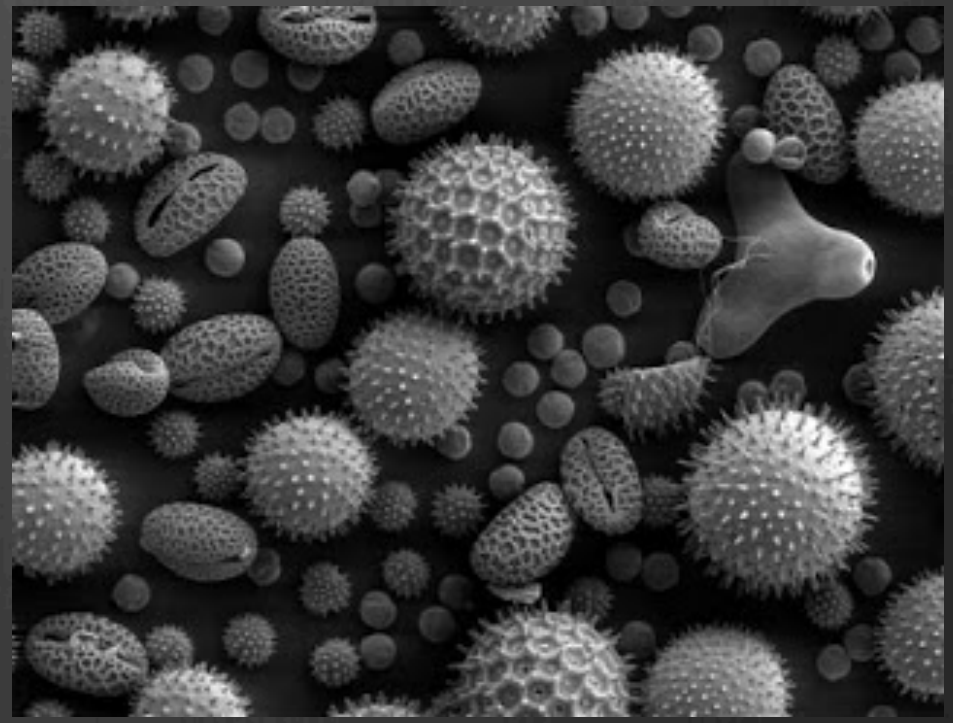


Scanning Electron Microscopy allows surface feature visualization

Scanning Electron Microscopy

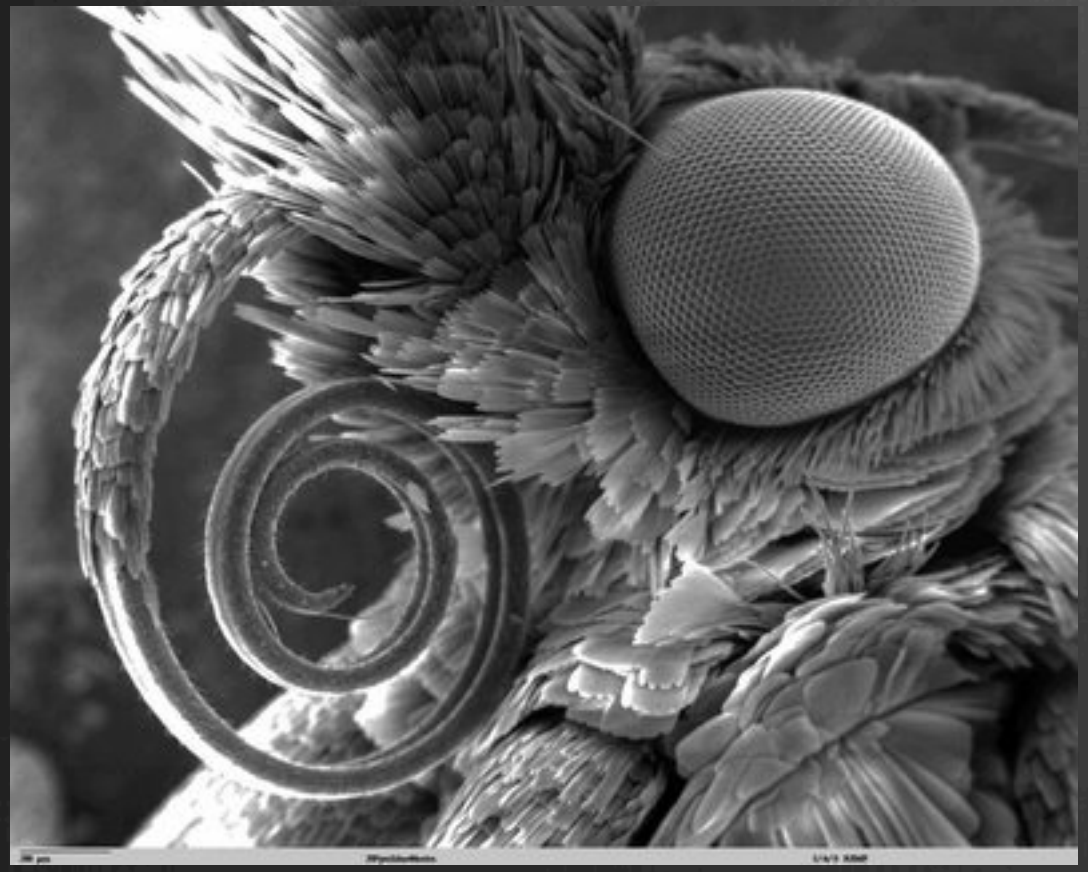


Bacteriophage virus

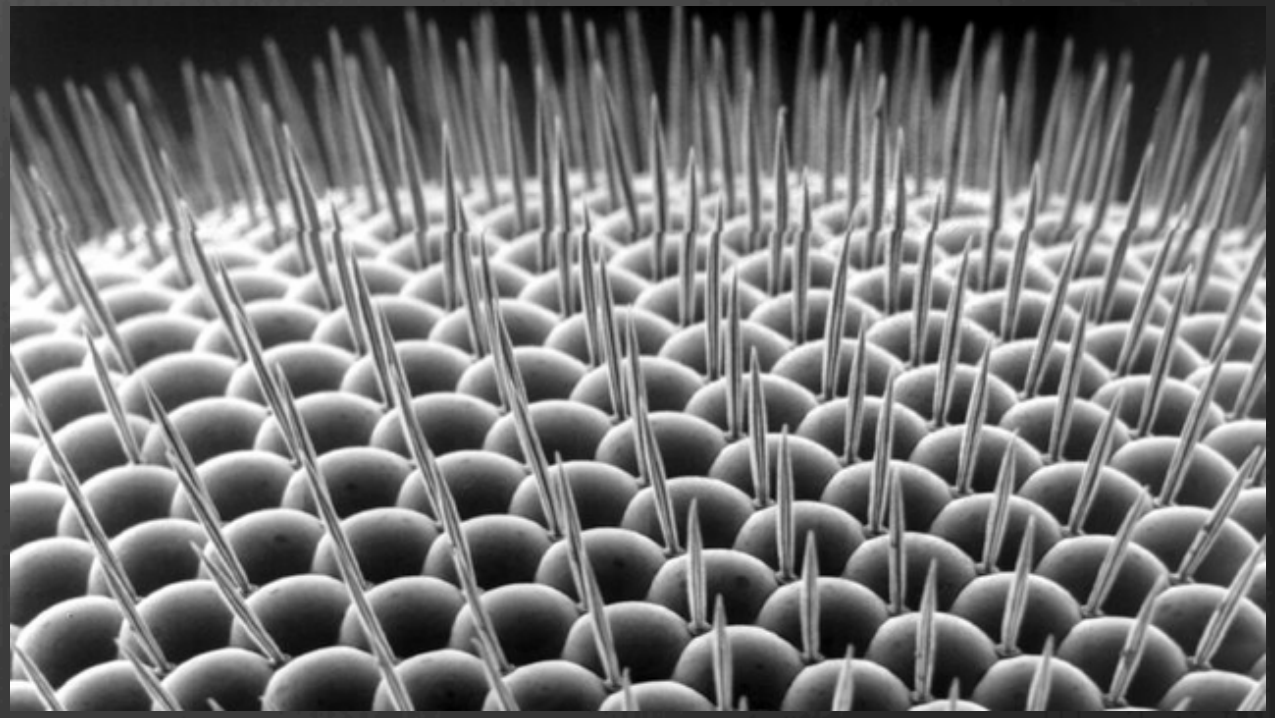


Pollen grains

Scanning Electron microscopy is ideal for viewing surface features

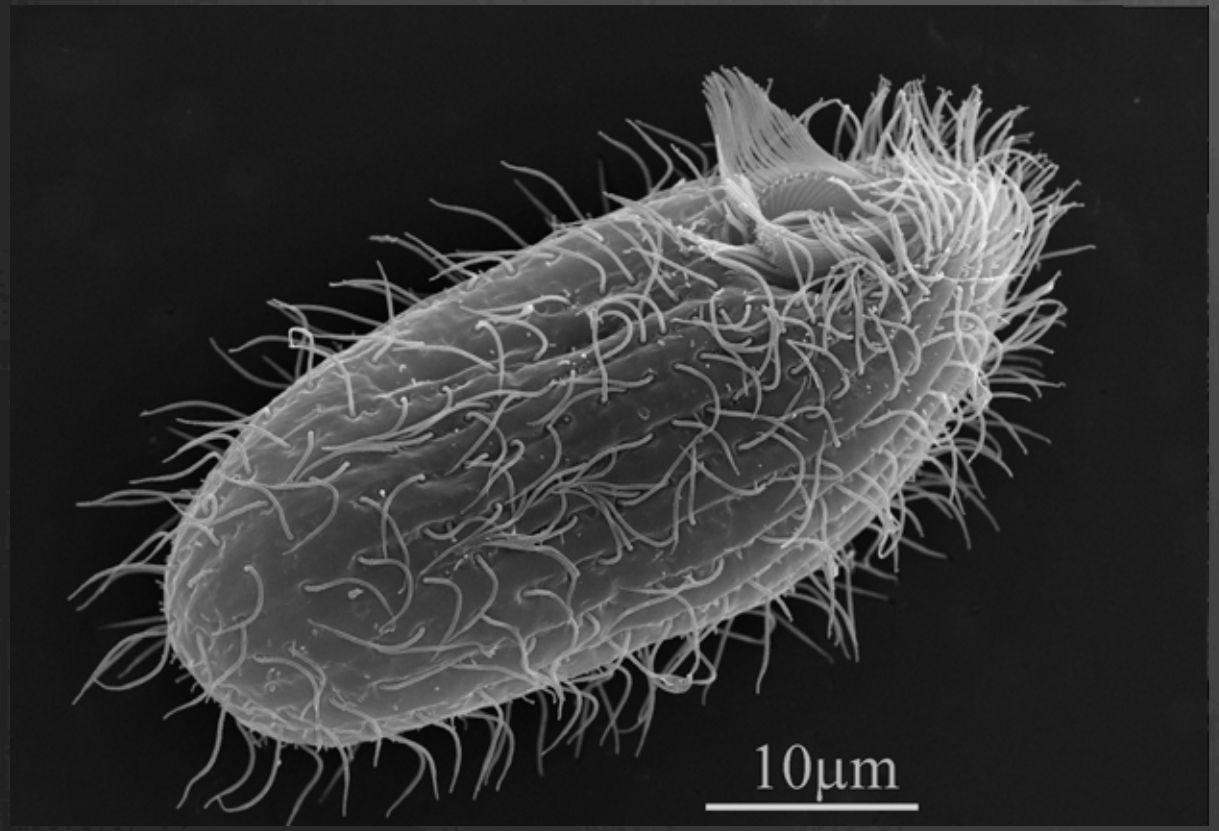


Butterfly tongue

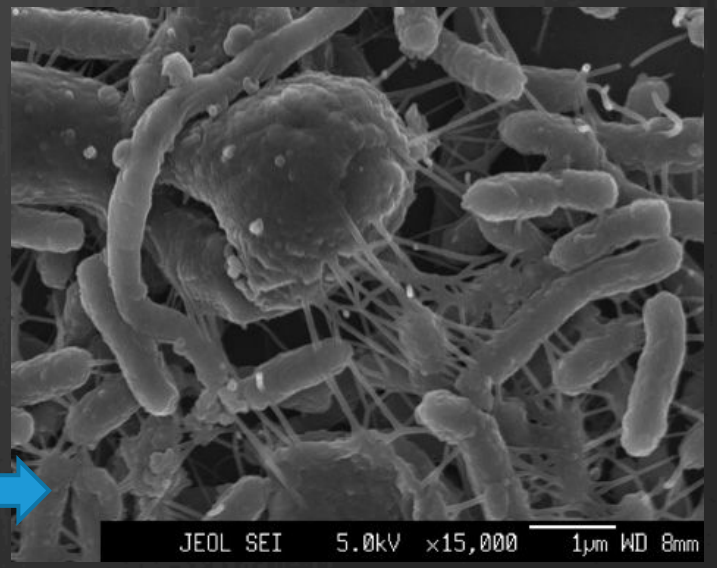


Eye of common house fly

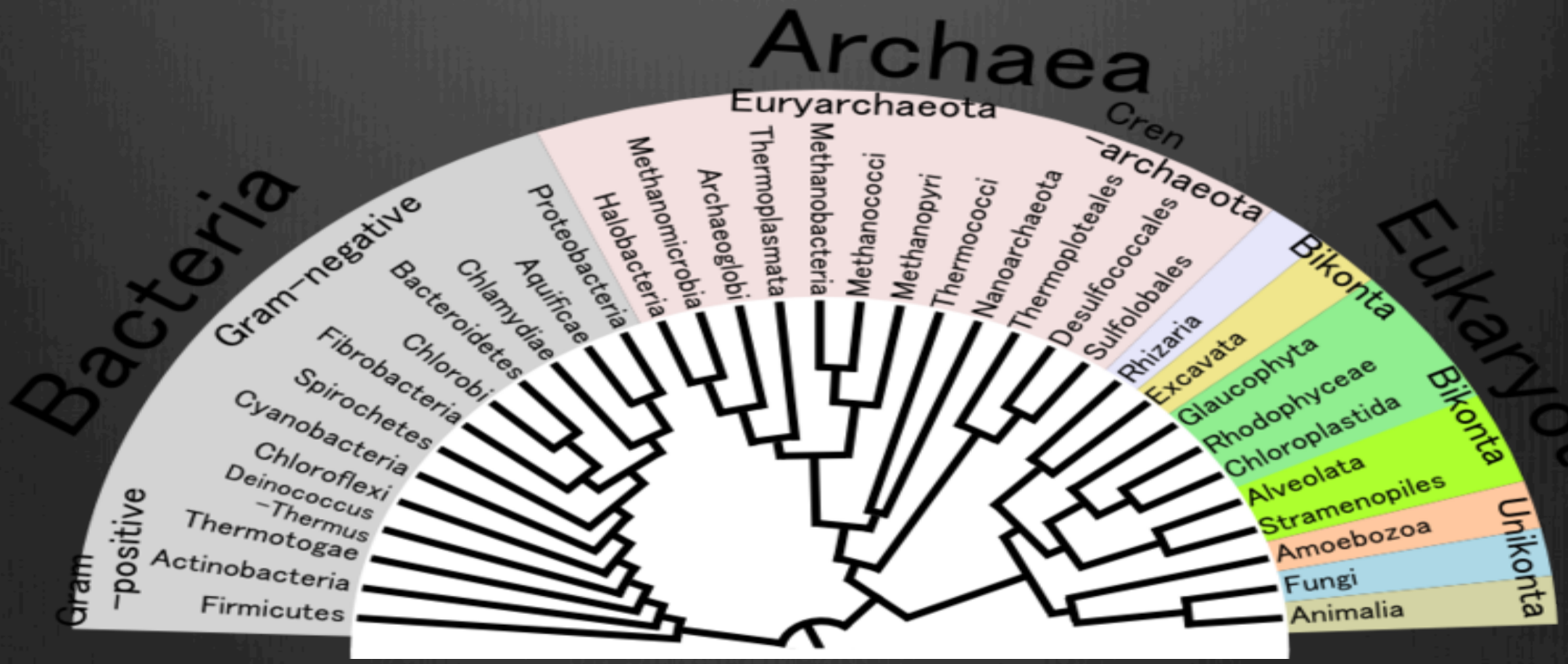
SEM of single Tetrahymena Cell



Agrobacterium 1 µM



Eukaryotes


Bacteria
Gram−positive
Gram
Actinobacteria
Thermotogae
Deinococcus
−Thermus
Chloroflexi
Cyanobacteria
Spirochetes
Fibrobacteria
Chlorobi
Bacteroidetes
Chlamydiae
Aquificae
Proteobacteria
Gram−negative
Archaea
Euryarchaeota
Halobacteria
Methanomicrobia
Archaeoglobi
Thermoplasmata
Methanobacteria
Methanococci
Methanopyri
Thermococci
Nanoarchaeota
Thermoploteales
Desulfococcales
Sulfolobales
Cren
−archaeota
Eukaryota
Rhizaria
Excavata
Bikonta
Glaucophyta
Rhodophyceae
Chloroplastida
Bikonta
Alveolata
Stramenopiles
Amoebozoa
Unikonta
Fungi
Animalia

Eukaryotic Cell Structure: 4 interacting systems

- 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

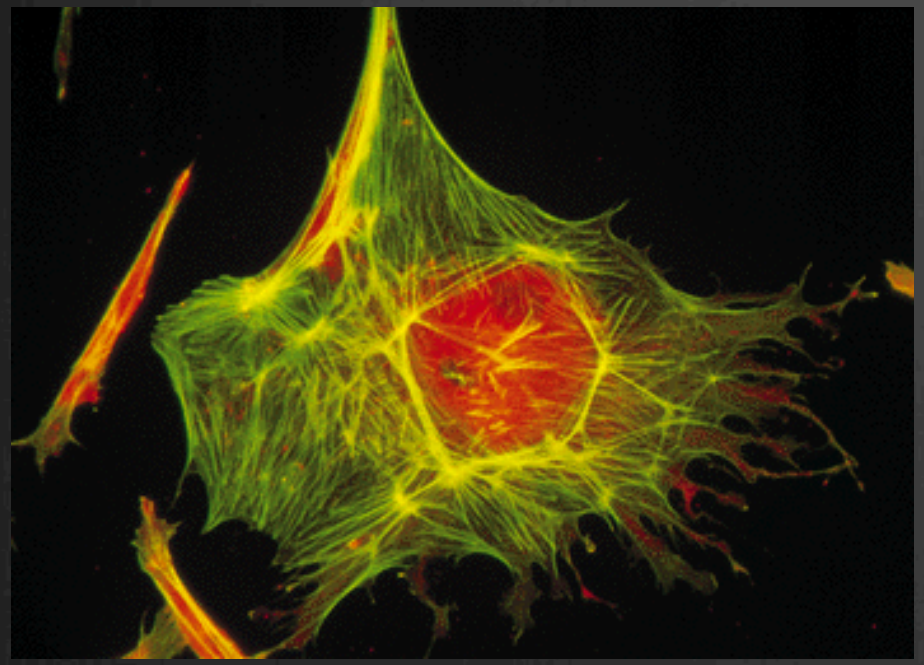
Cytoskeleton

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

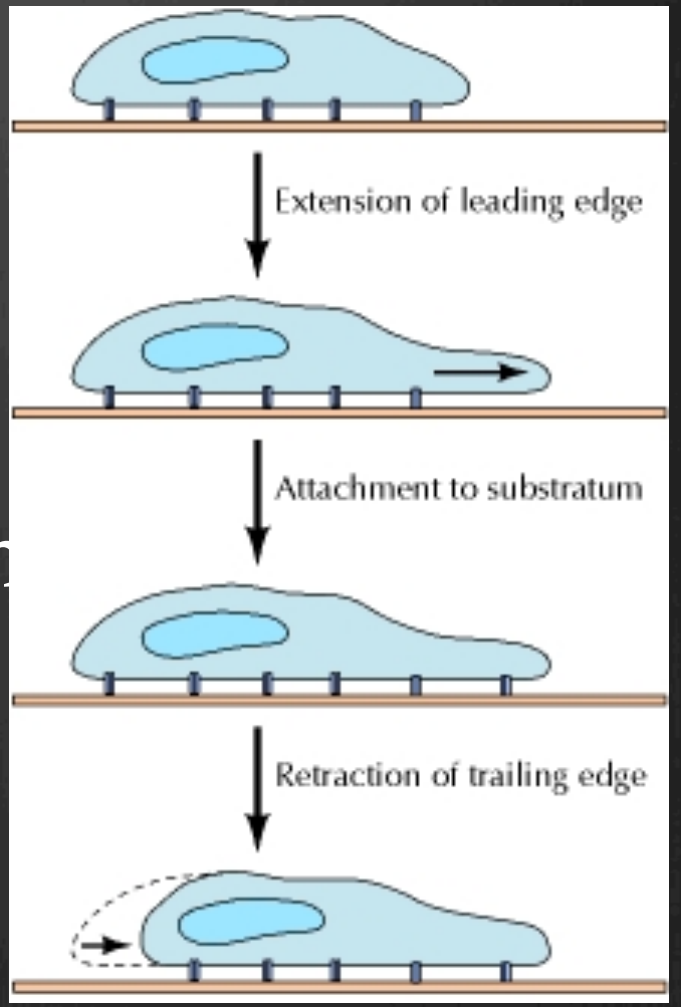
Resist pulling forces

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

Endocytosis, Exocytosis

Actin association with Myosin to allow cell crawling

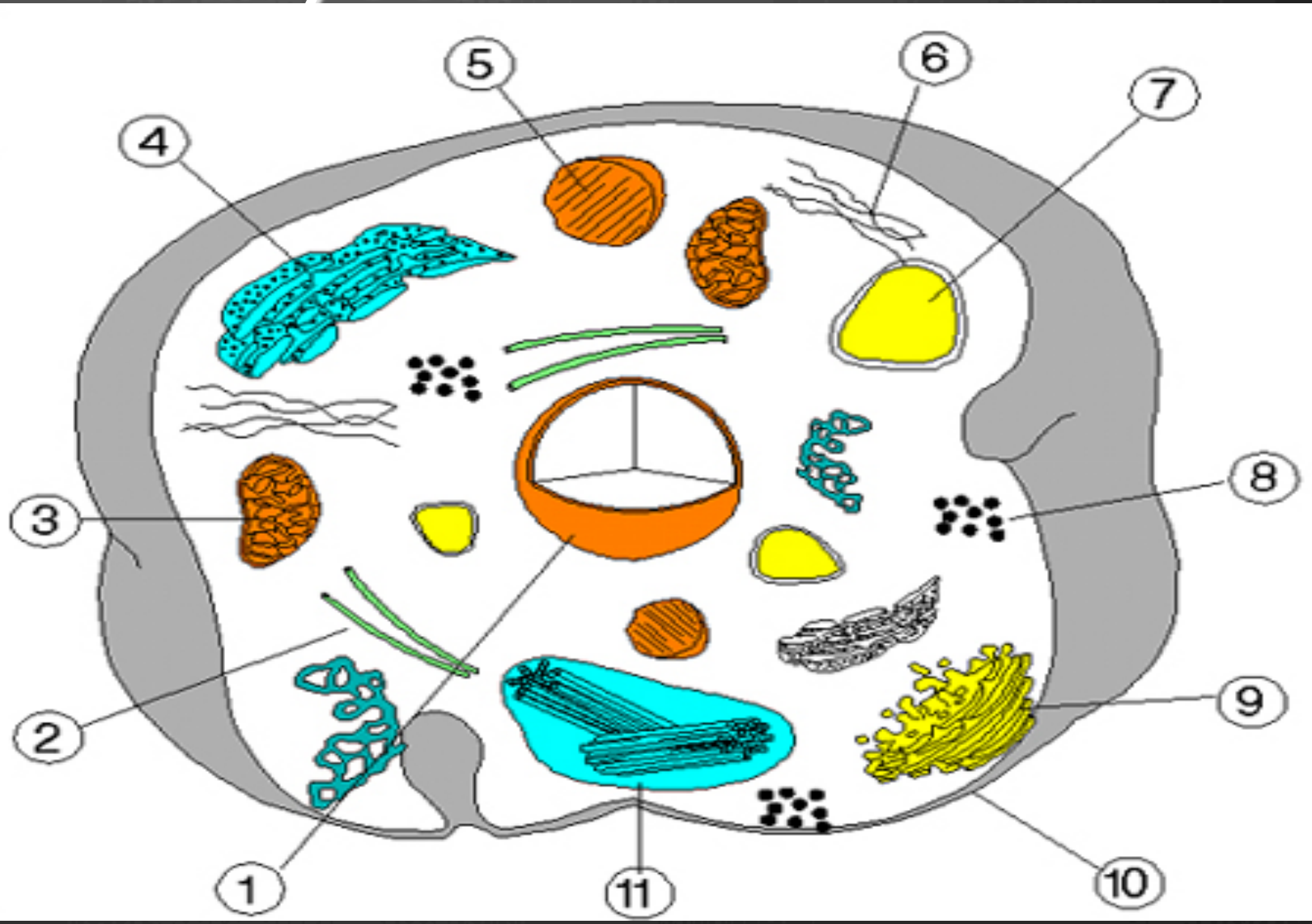
- Amoeba
- Migration of embryonic cells during development
- White blood cells responding to infection
- Wound healing
- metastasis



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

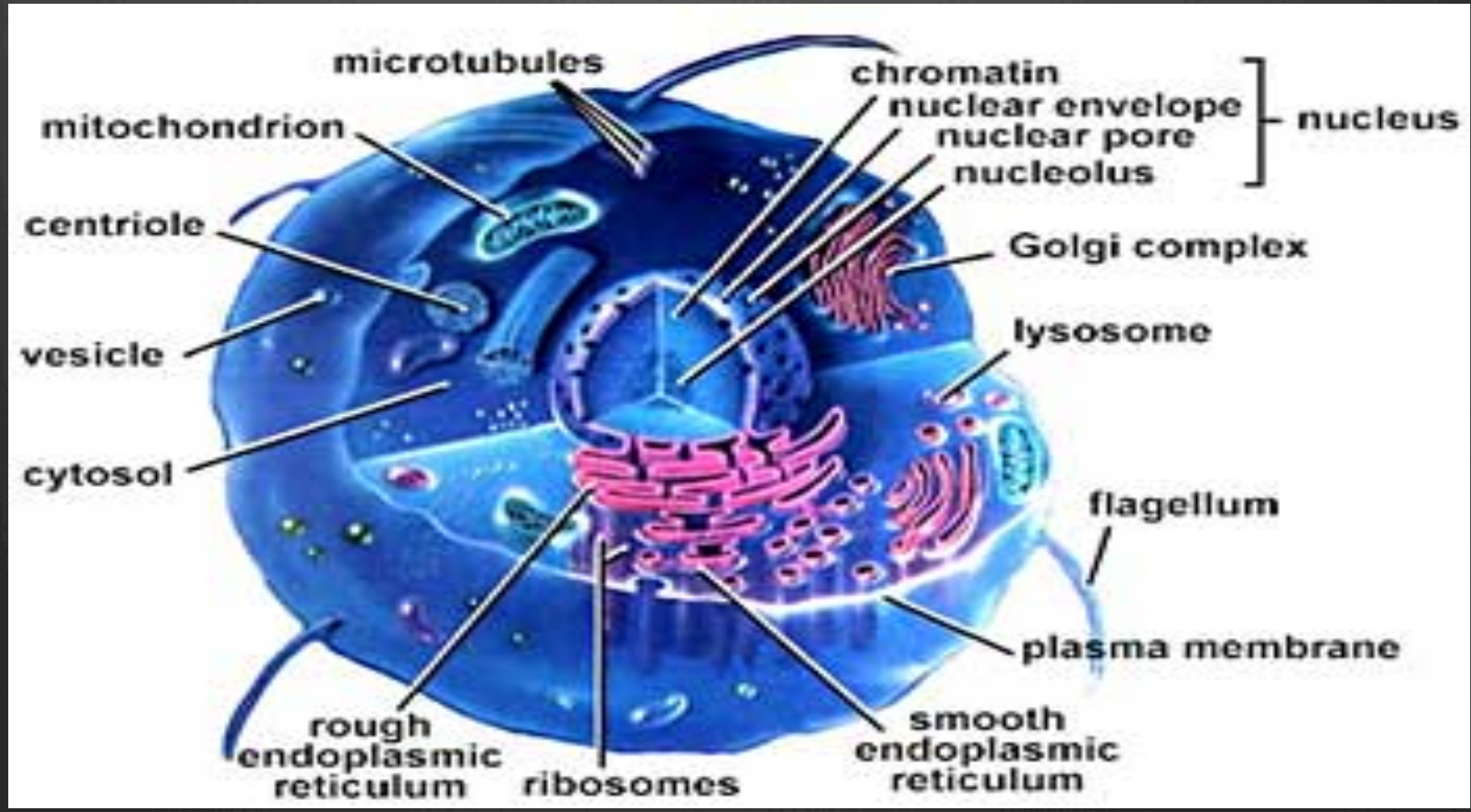


Eukaryotes

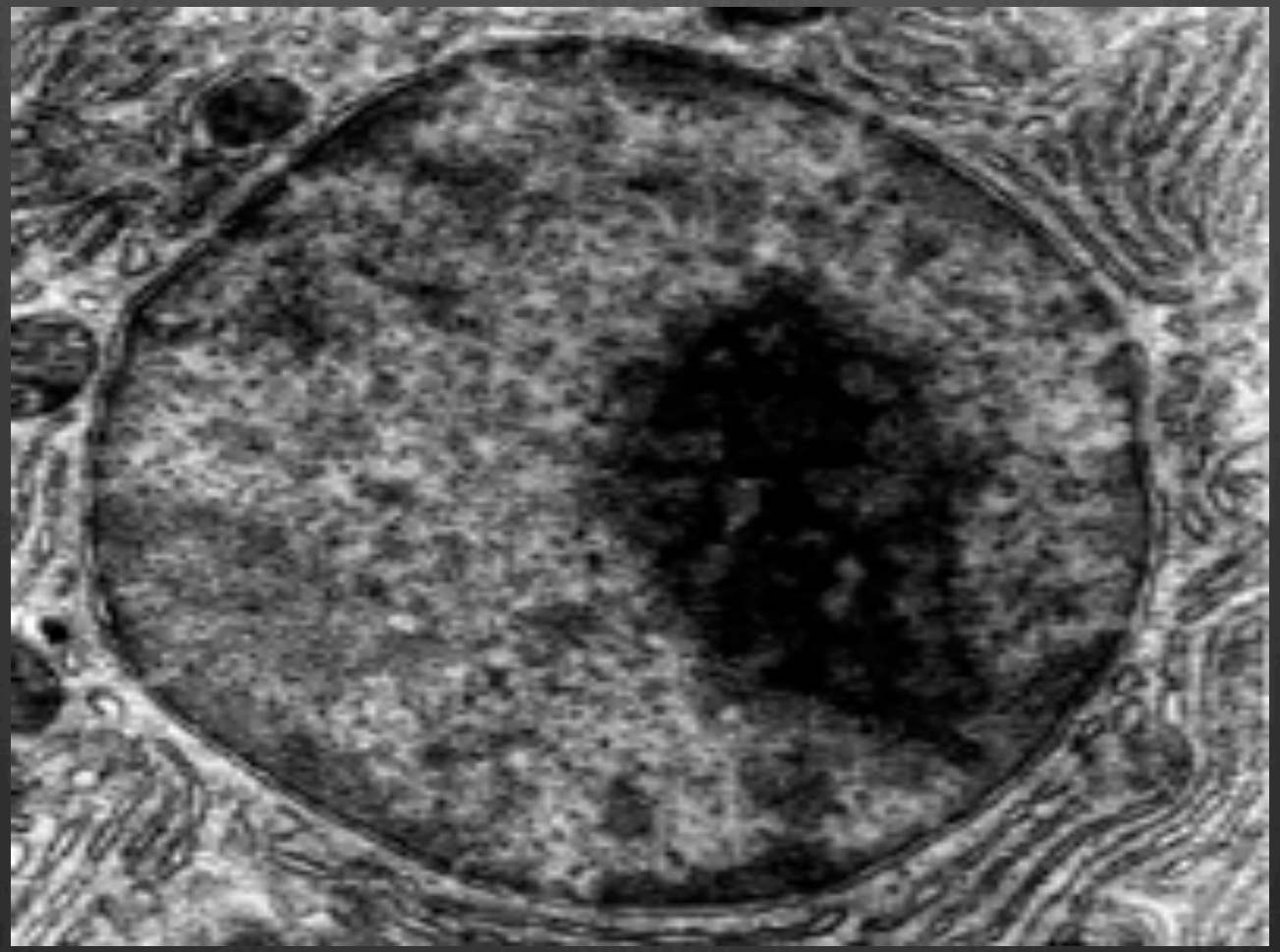
Structure

- *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

Structure

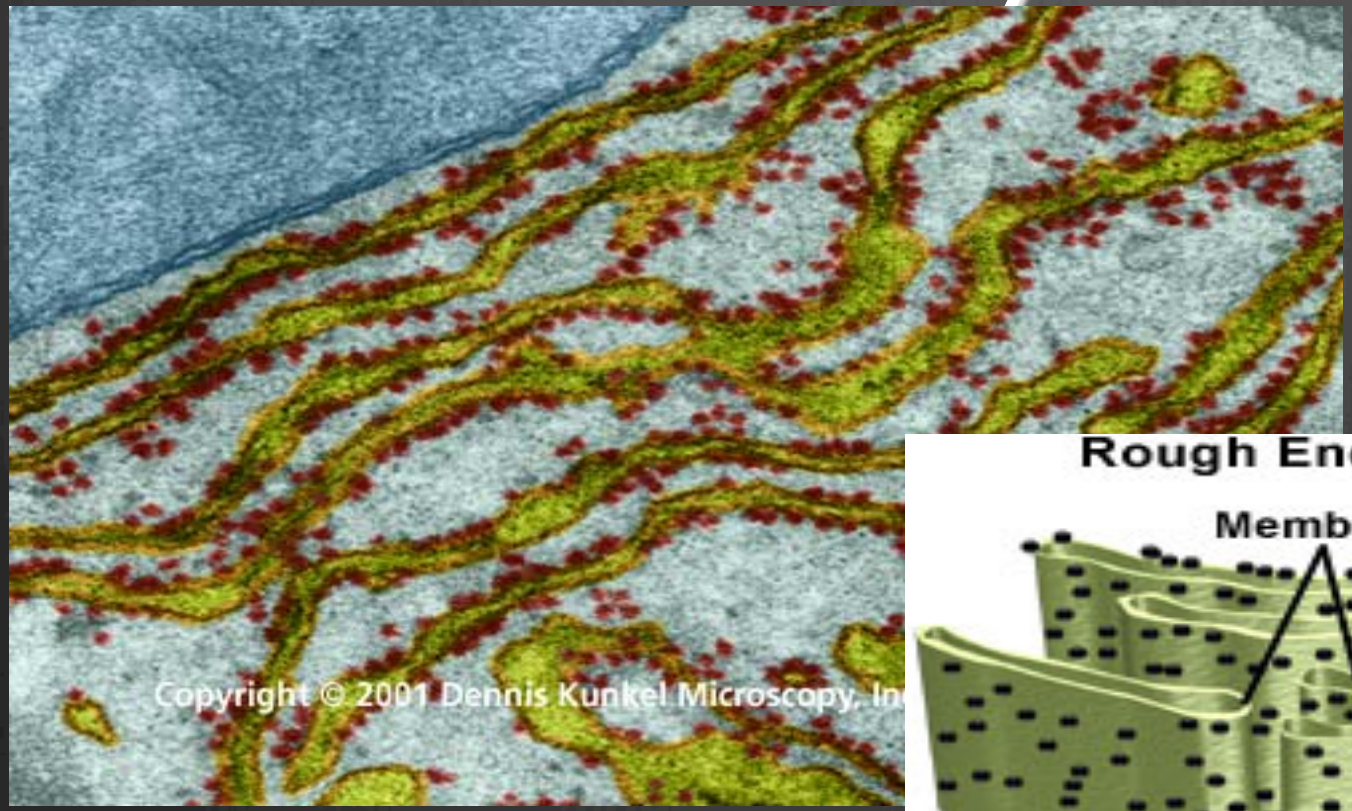
- *Free ribosomes*:
  - Sites of protein synthesis for use within the cytoplasm
  - Ribosomes are constructed in the nuclear region called the nucleolus

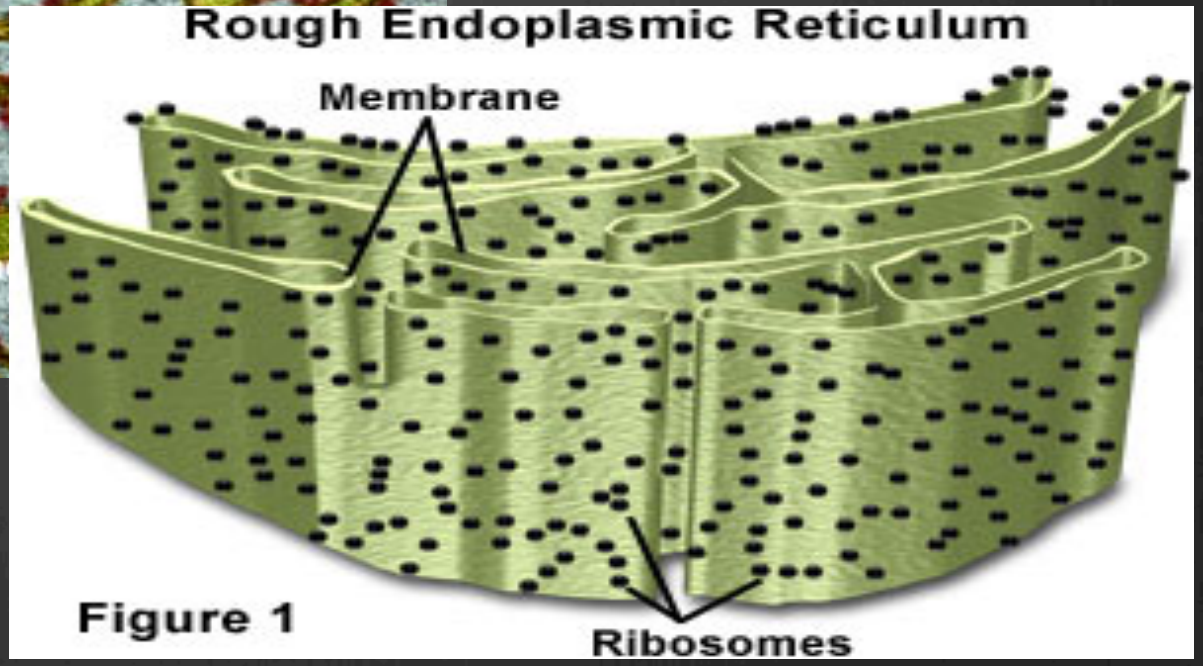
Eukaryotes

Structure

- *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

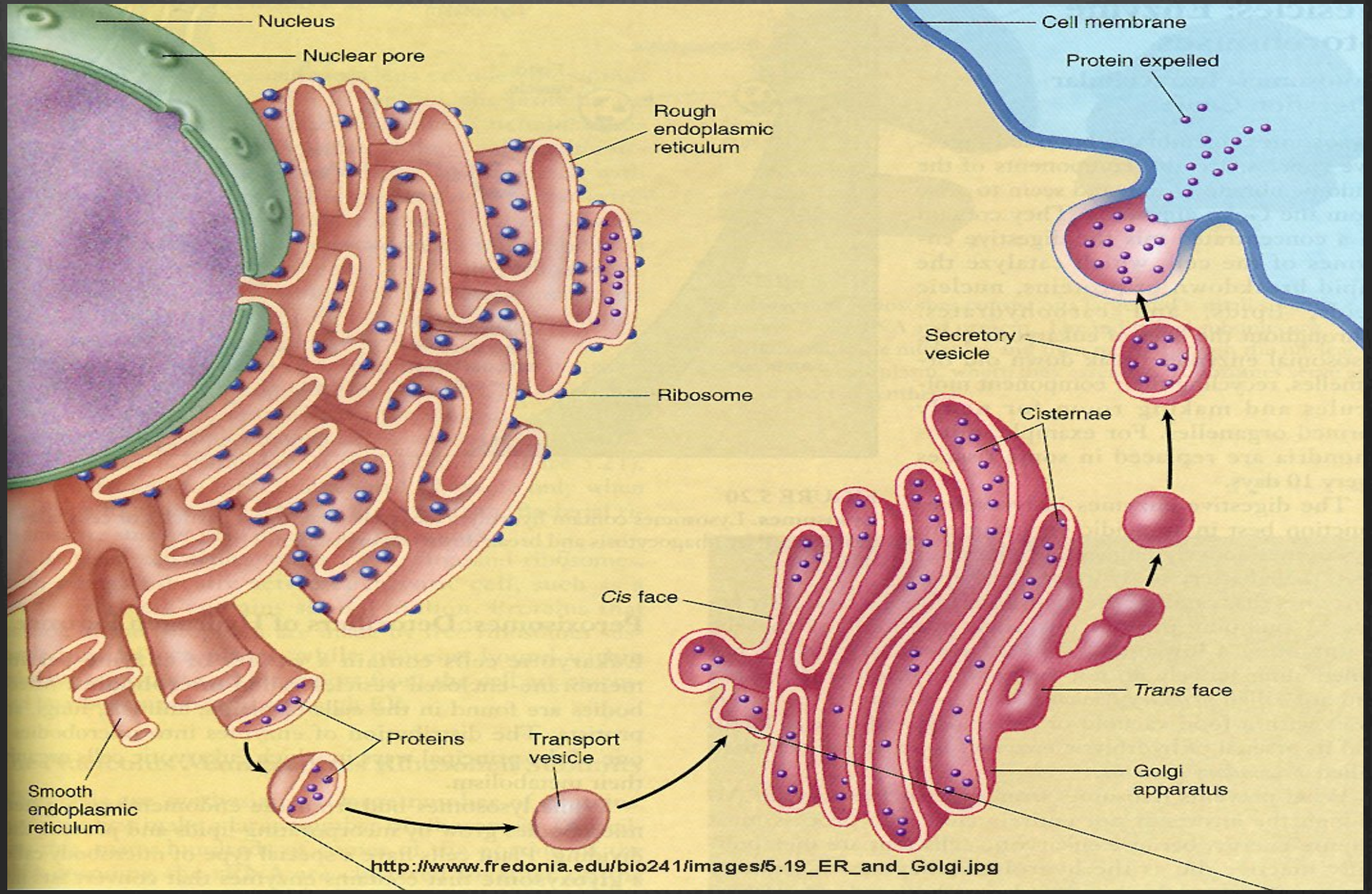

Copyright © 2001 Dennis Kunkel Microscopy, In


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

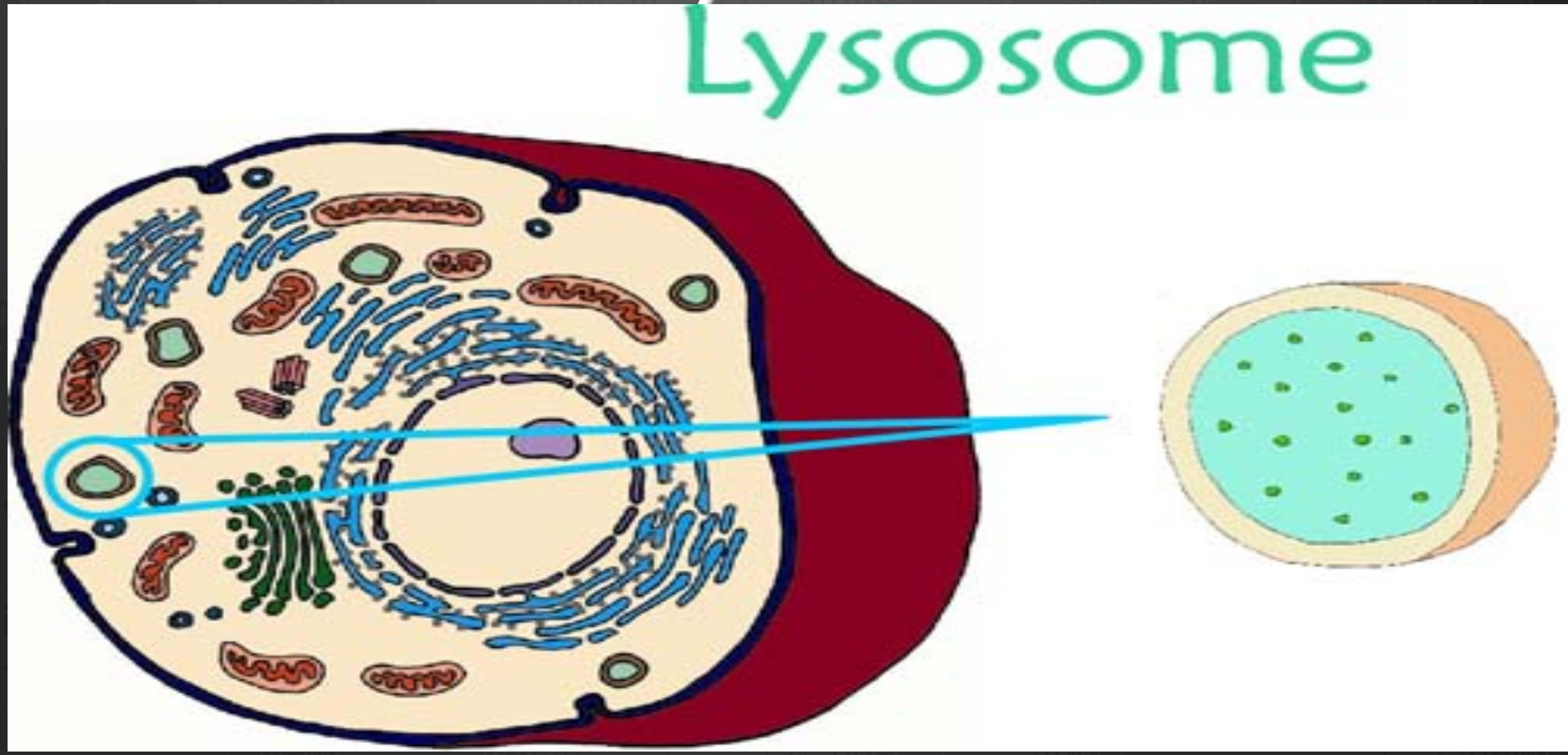

Nucleus
Nuclear pore
Rough endoplasmic reticulum
Ribosome
Cell membrane
Protein expelled
Secretory vesicle
Cisternae
Cis face
Trans face
Golgi apparatus
Proteins
Transport vesicle
Smooth endoplasmic reticulum
http://www.fredonia.edu/bio241/images/5.19_ER_and_Golgi.jpg

Eukaryotes

Structure

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

Eukaryotes

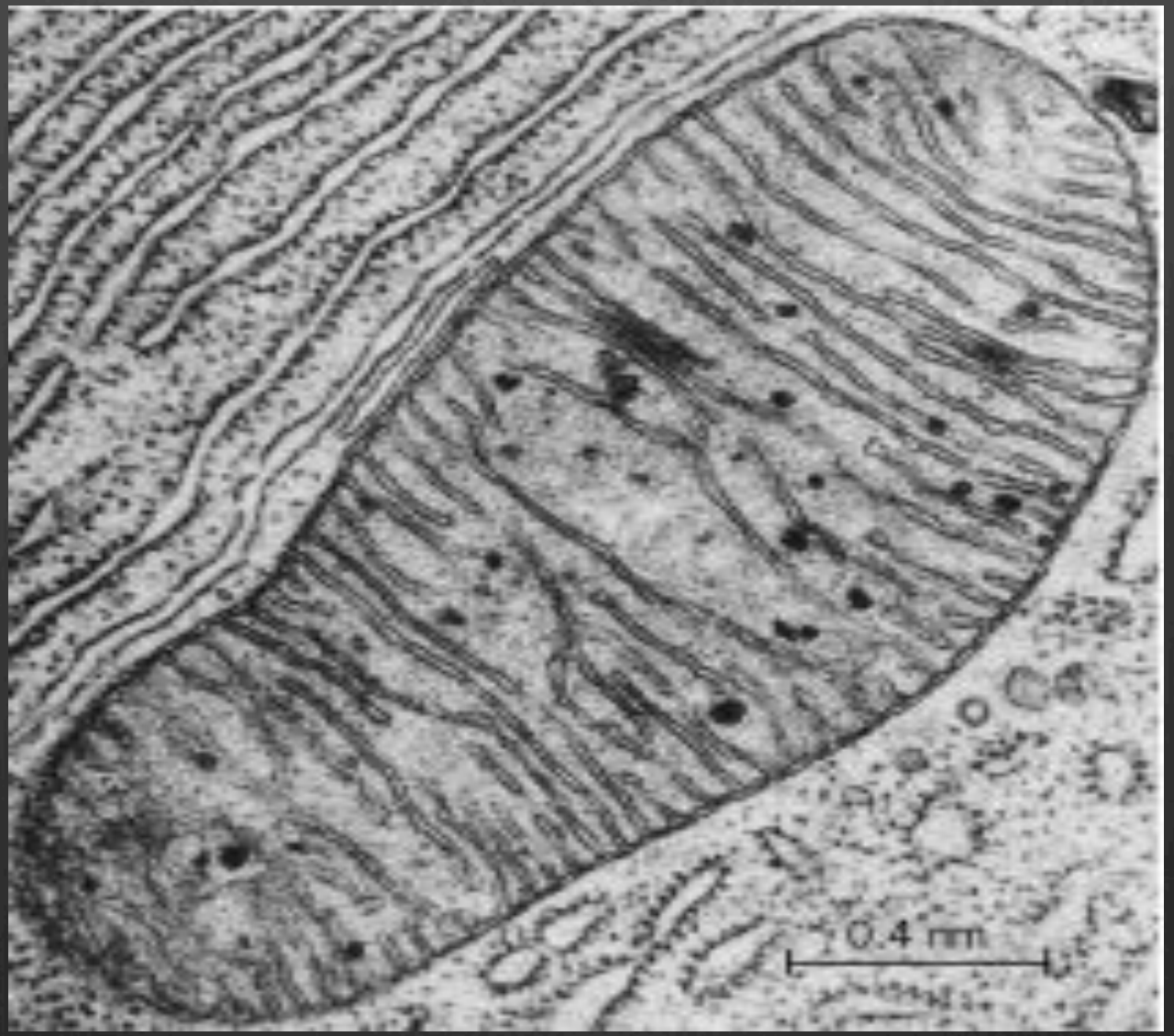


Eukaryotes

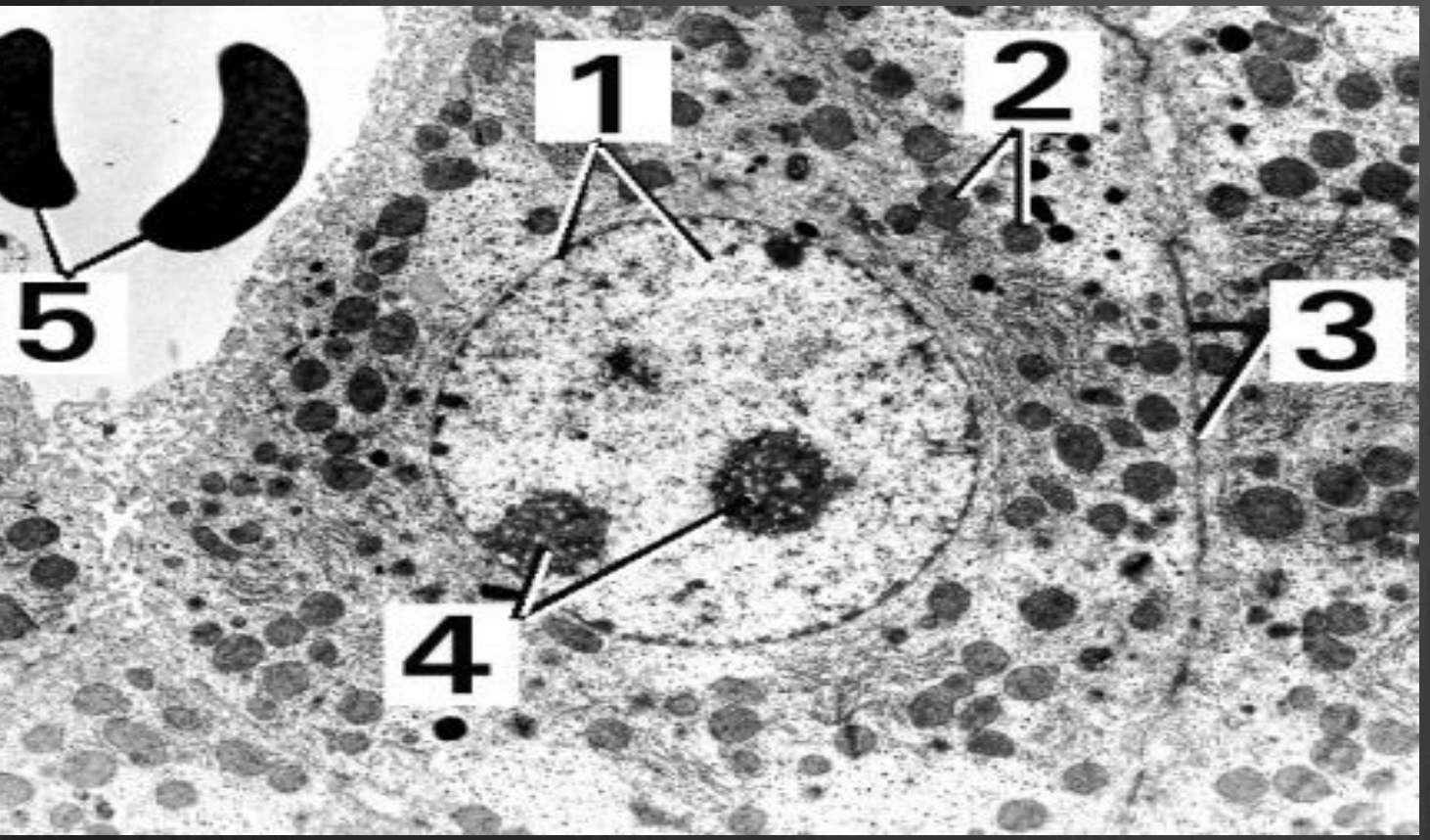
Structure

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

Eukaryotes

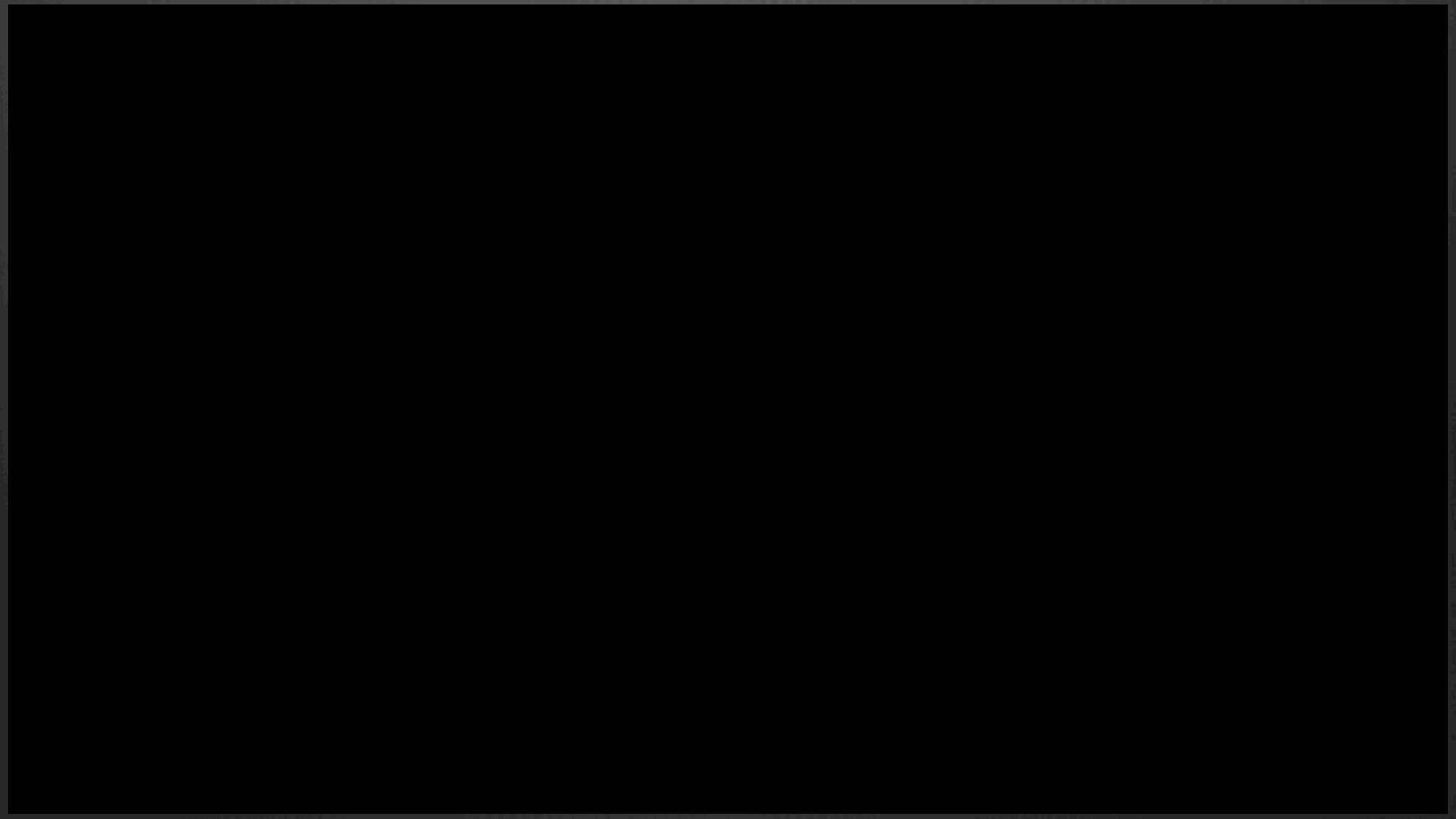


Eukaryotes

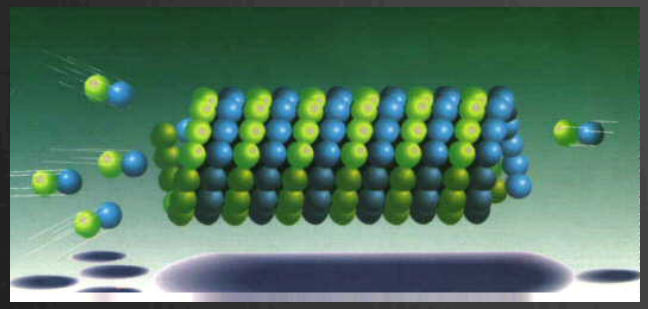


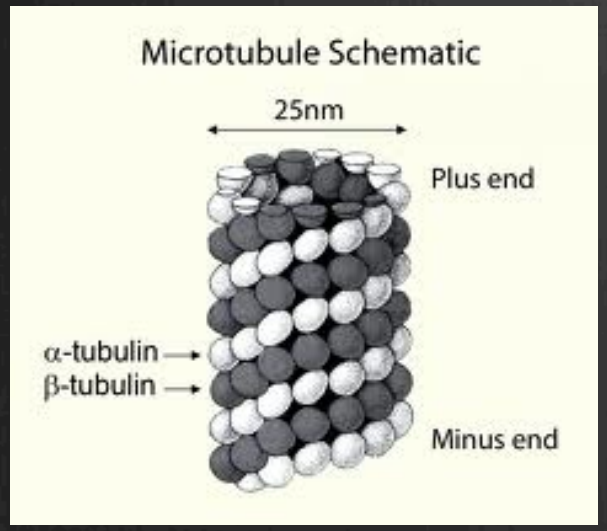
1. Nucleus
2. Mitochondria
3. Plasma membrane
4. Nucleoli
5. Red blood cells
   - in adjacent blood vessel

Eukaryotes



Microtubules



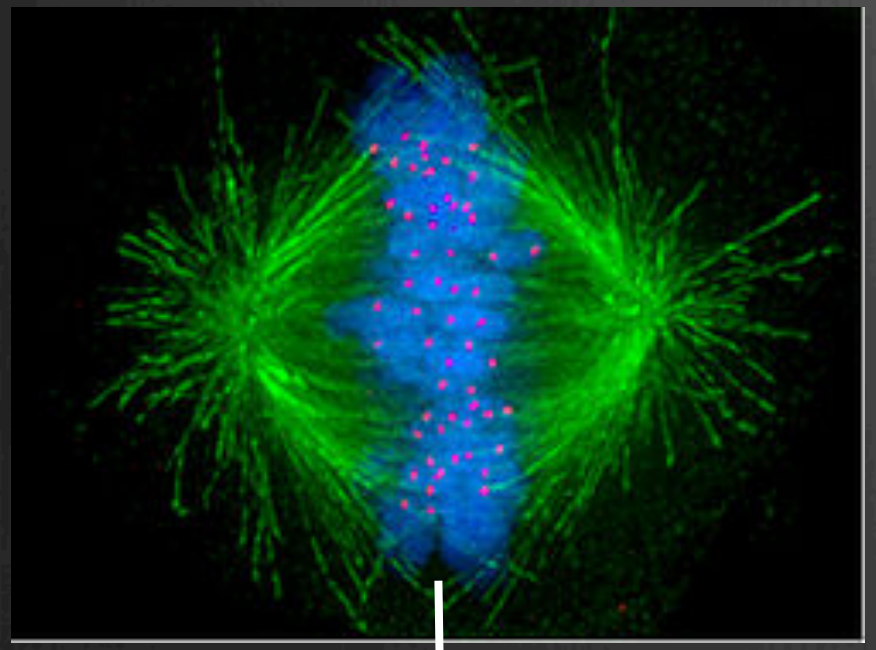


Hollow tubule composed of monomers

- Dynamic (like actin)
- Assembled and disassembled as needed in the cell
- Interact with motor proteins (dyneins and kinesins) to move cellular cargo

Microtubules

Spindle apparatus of cell division



chromosomes

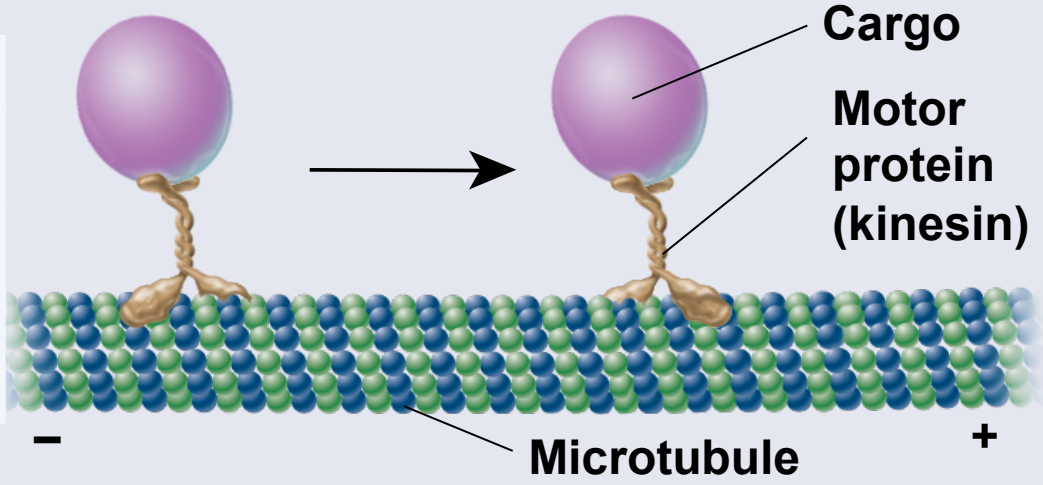
Cell division, cell locomotion

Used as “rails” to slide cellular components along

Flagellar assembly

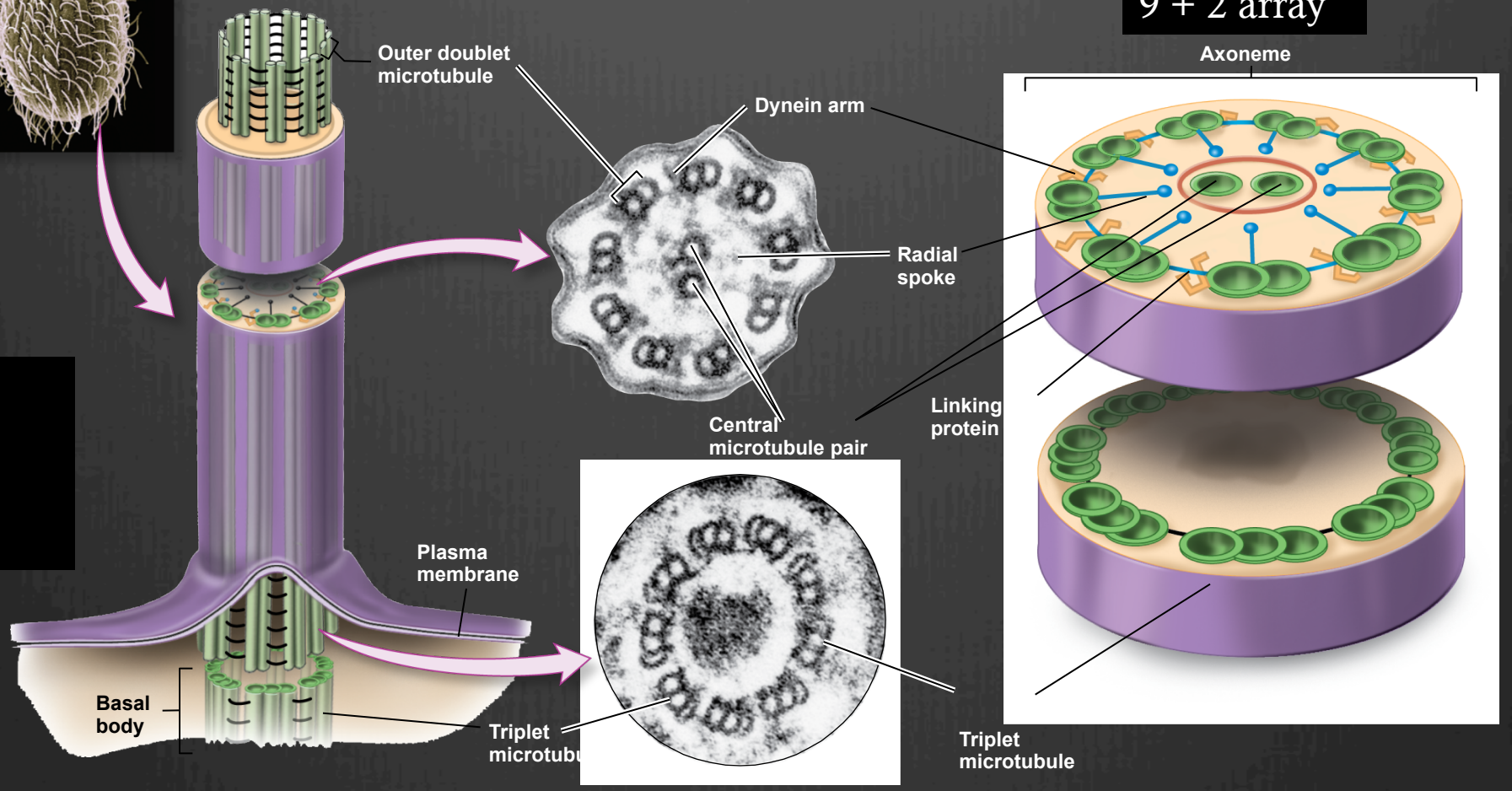
Kinesin "marches" down the microtubule dragging cargo along

Motor proteins "walk" along a microtubule from the minus end to the plus end carrying a cargo.

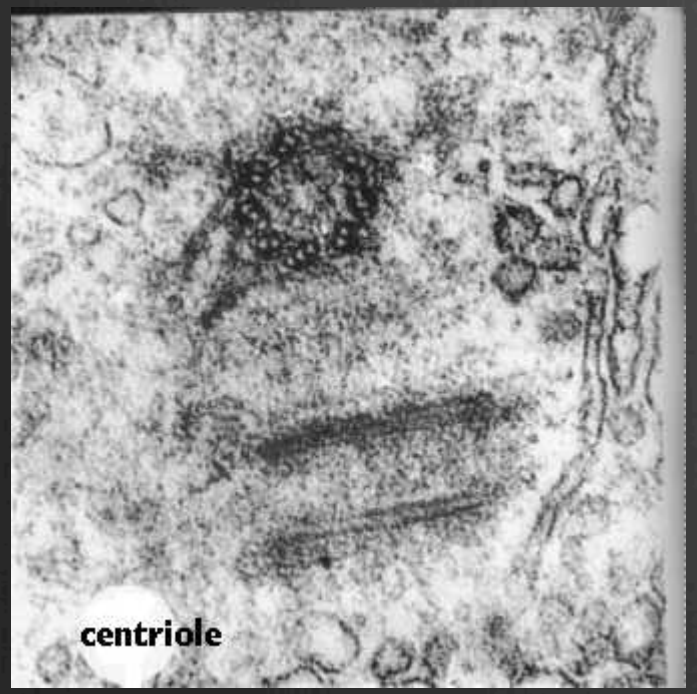


Structure of eukaryotic cilium or flagellum

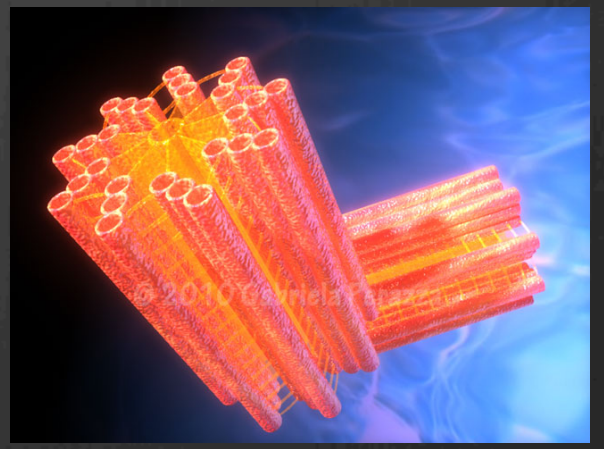
Axoneme
Microtubules
Linker protein
(dynein)



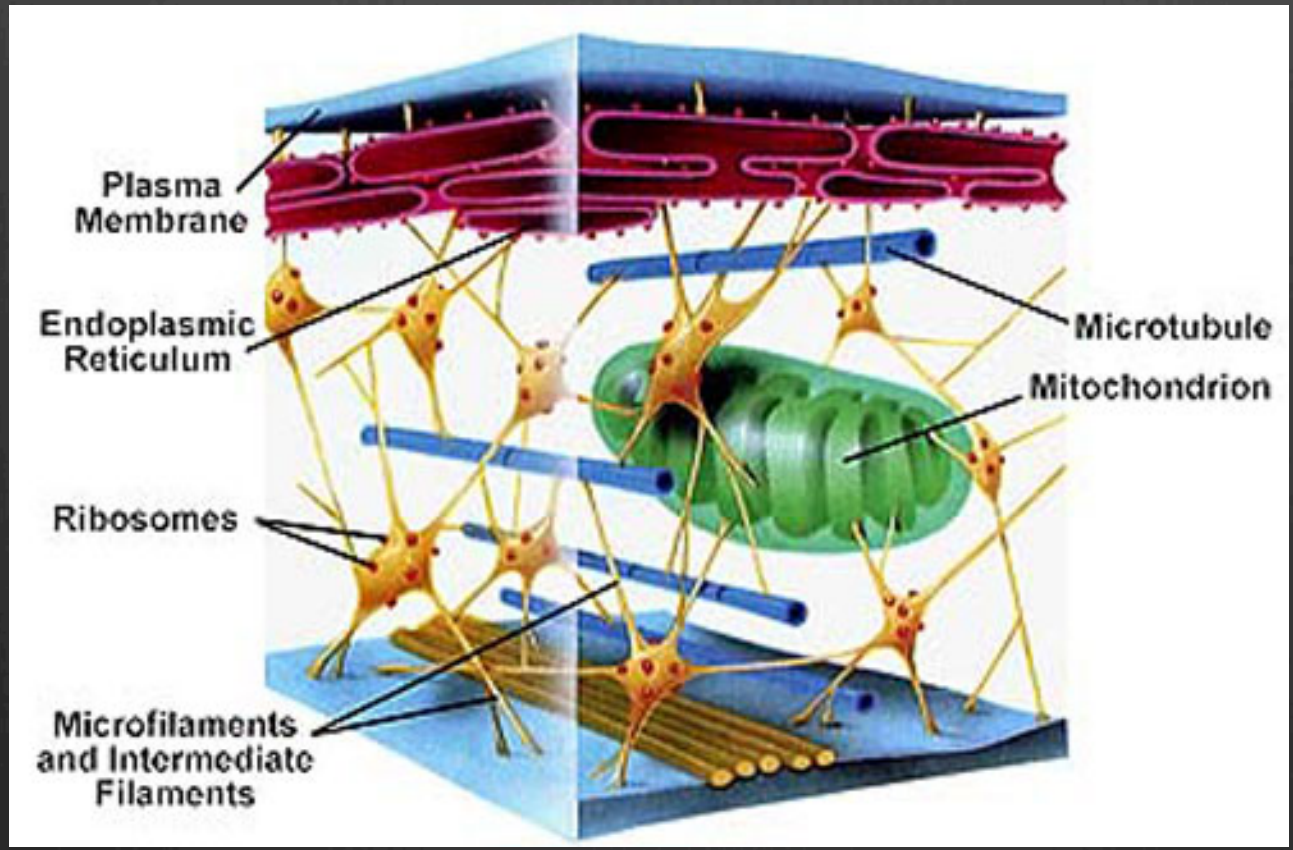
MTOC (microtubule organizing center)



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



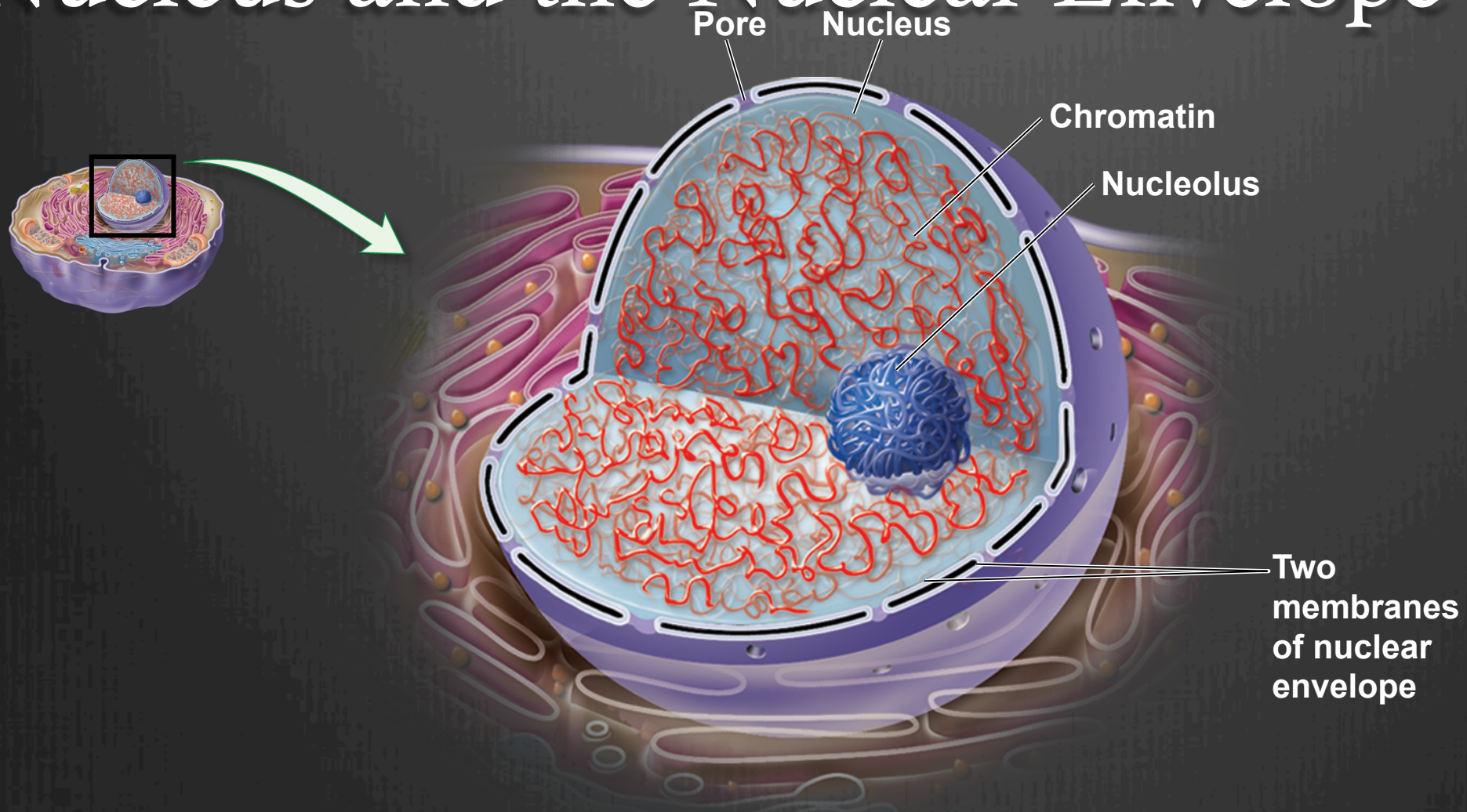
Cells perceive gravity through cytoskeleton!

Changes in gene expression in response to mechanical stress

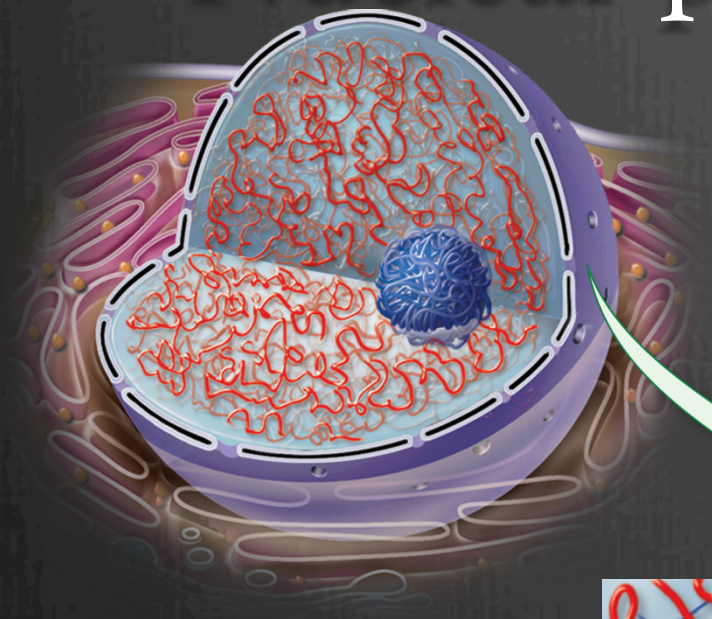
Nucleus

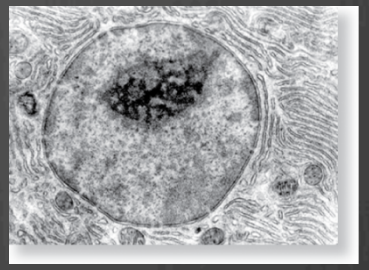
- Primary functions:
- Organization, protection and replication of DNA
- Gene expression
- Site of ribosome assembly (nucleolus)-only visible in non dividing cells

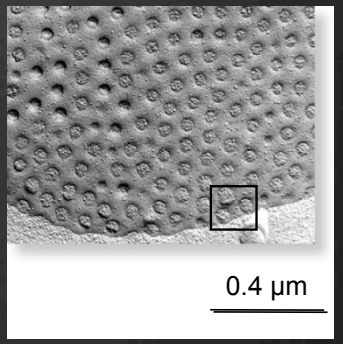
Nucleus and the Nuclear Envelope

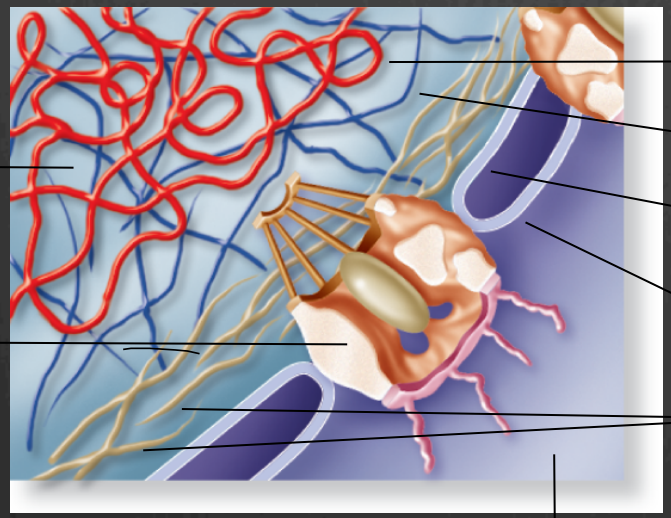


Nuclear pore complexes









Nucleus

Nuclear pore complex

Chromatin in nucleus

Internal nuclear matrix

Inner membrane

Outer membrane

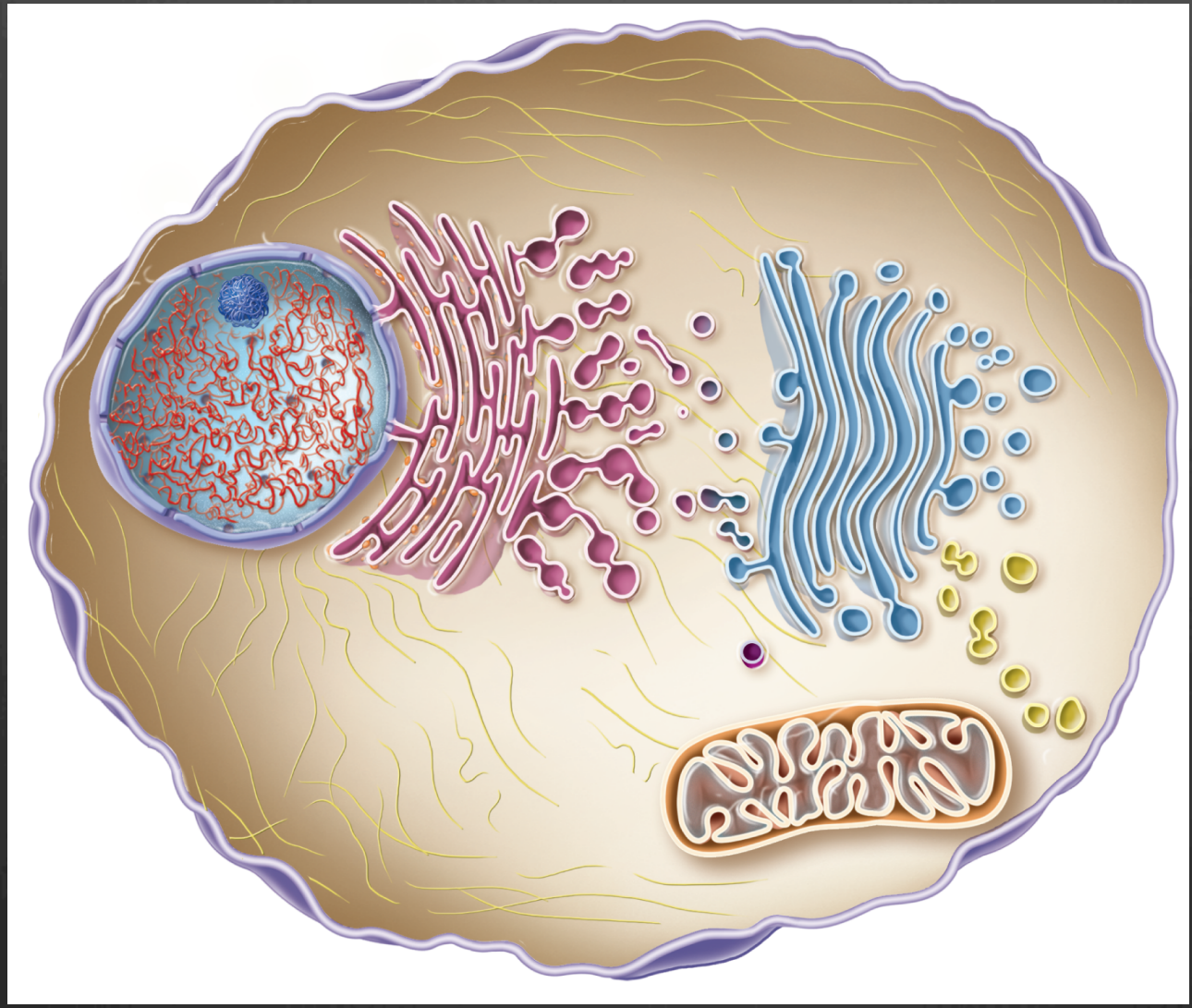
Nuclear envelope

Nuclear lamin proteins

Cytosol

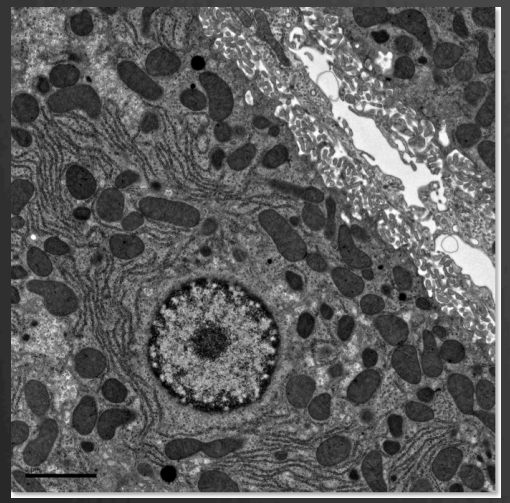
Ribosome Assembly

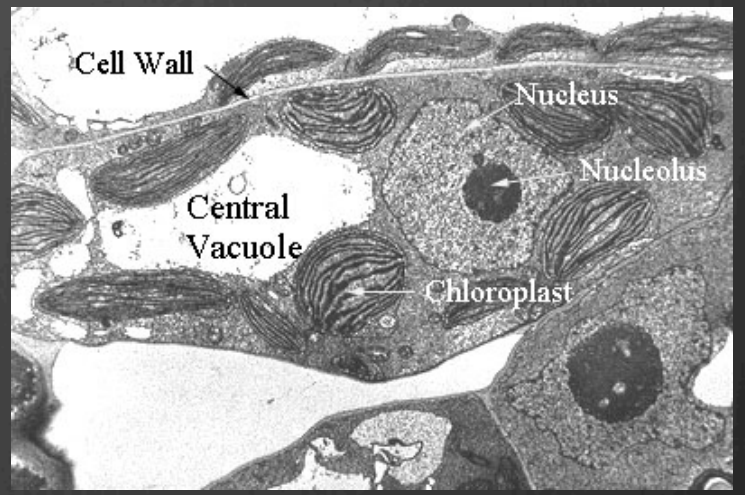
- Ribosomes are composed of RNA complexed with proteins
- Ribosomal proteins are synthesized in the CYTOPLASM and imported into the nucleus



“Semi-autonomous Organelles”

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



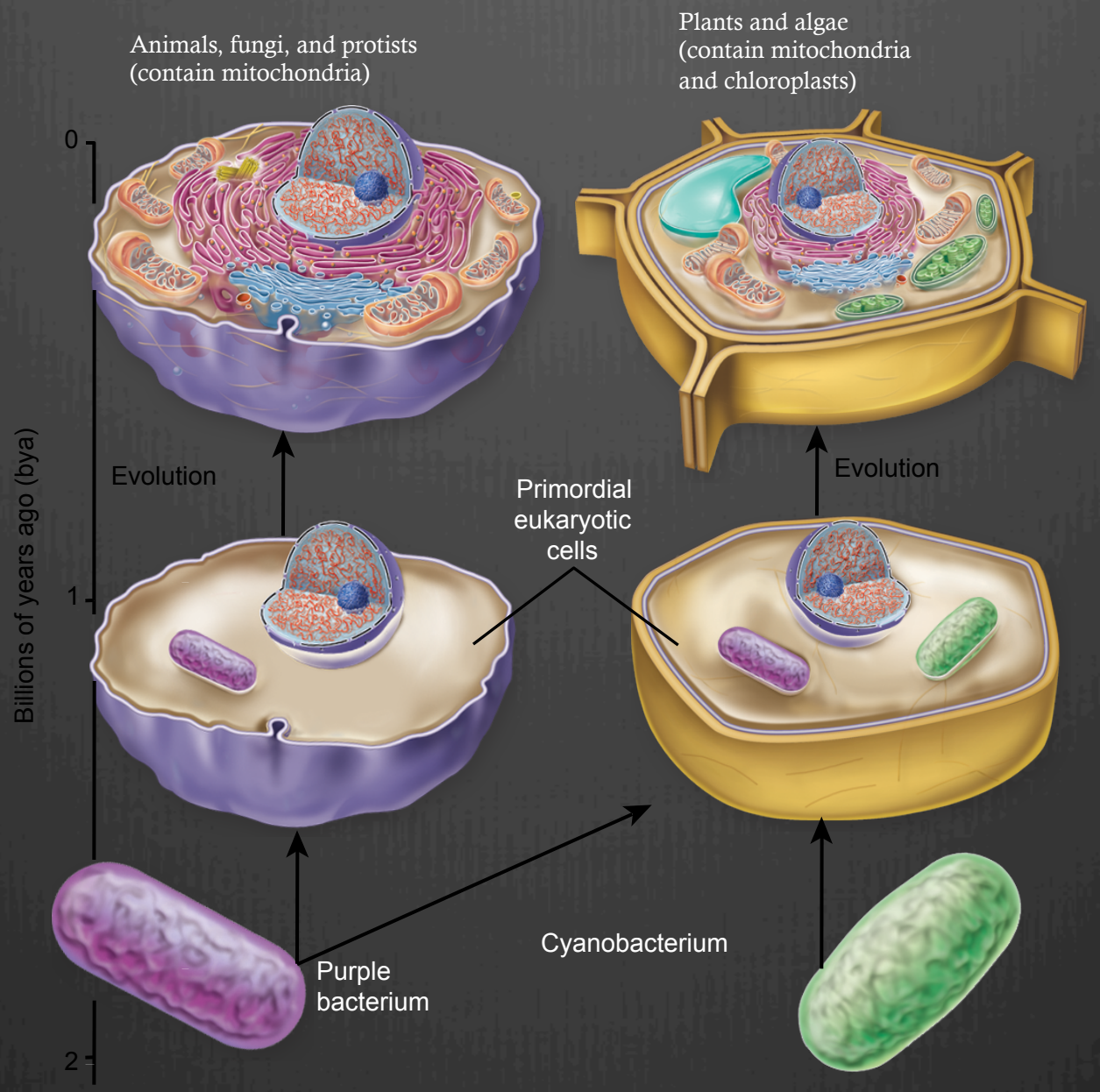


Mitochondria

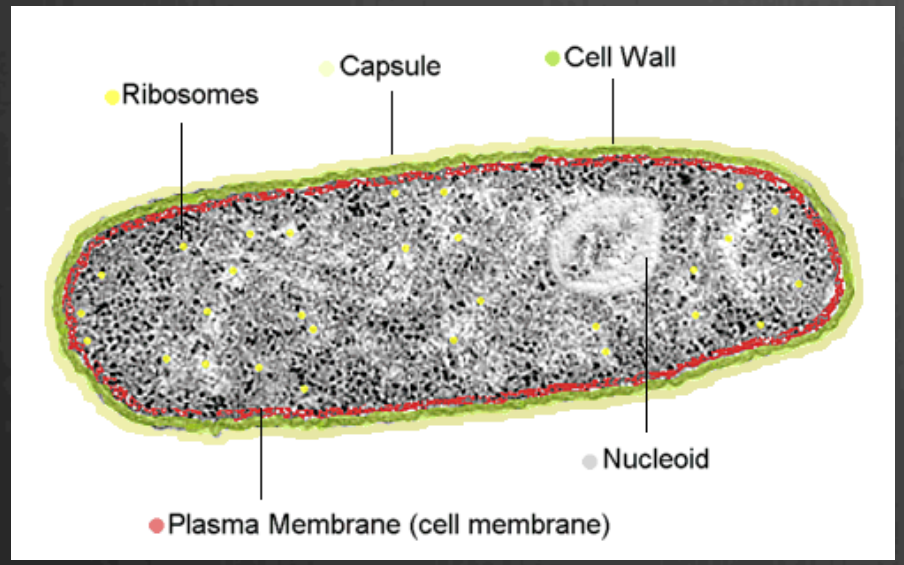
Take in nutrients and generate ATP which drives cell processes that are energetically unfavorable

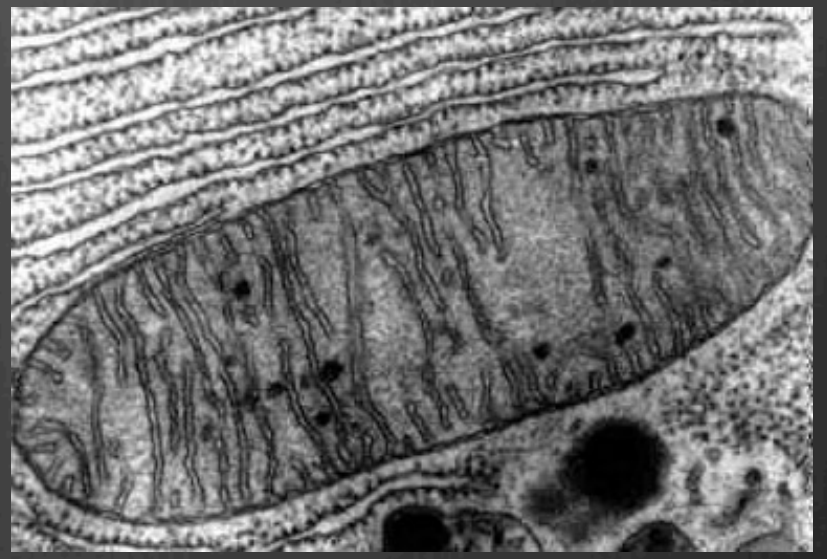
Chloroplasts

Harvest light energy and synthesize organic molecules



Prokaryote vs mitochondrion

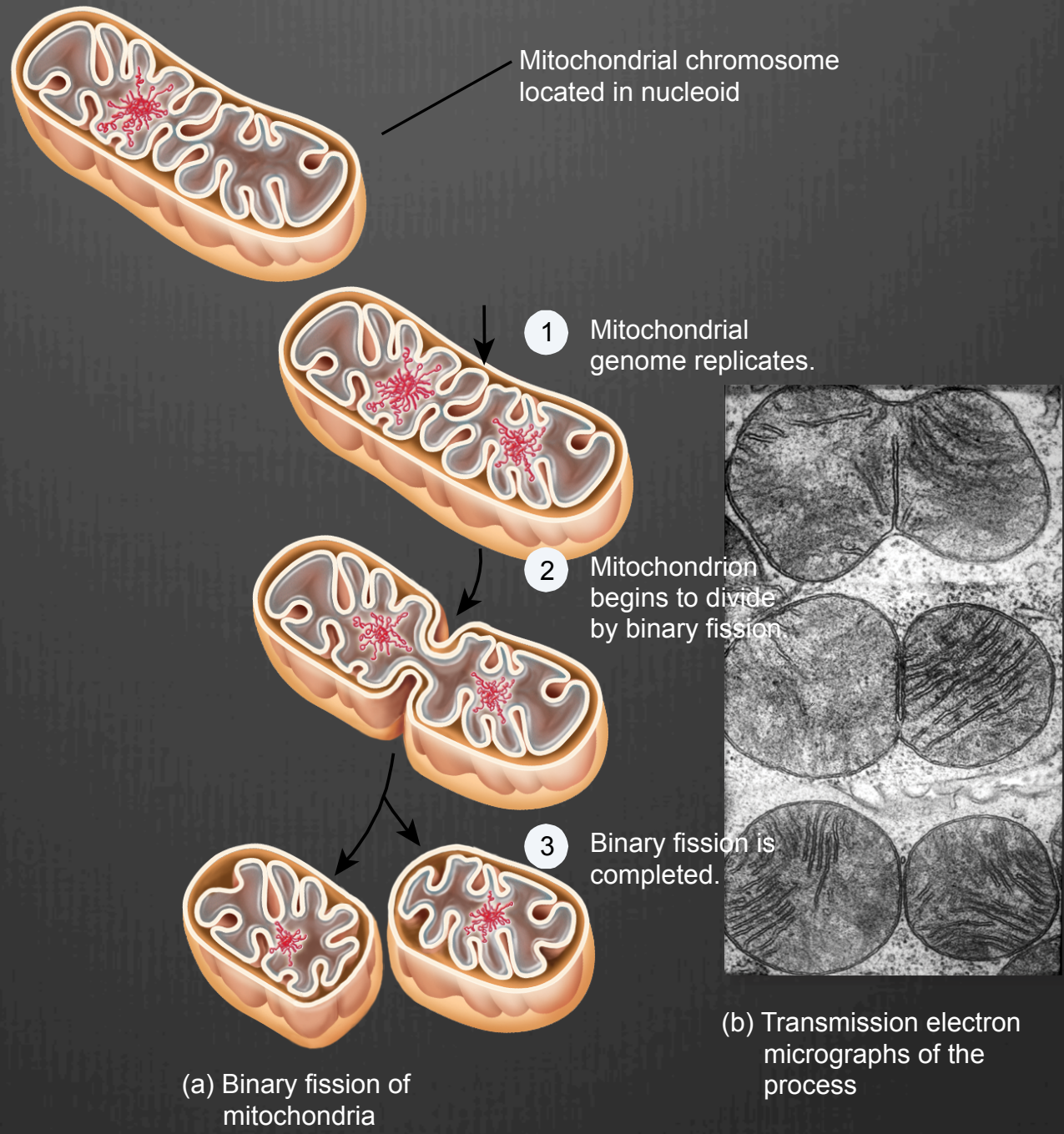




Mitochondria divide by binary fission (like prokaryotes)

They can also fuse together

Numbers can increase to meet energy demand



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