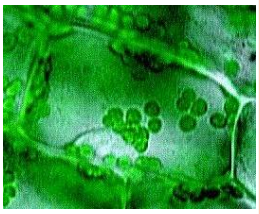
Cell Lecture Part 1

1

CELL THEORY

- All organisms are made of one or more cells.
- Cells are the basic unit of structure and function in living things
- Cells arise by division of pre- existing cells.



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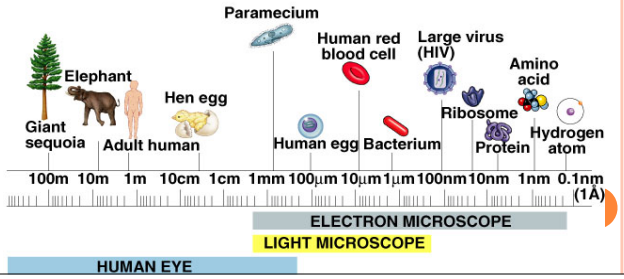
How do we study cells? Cytology

- Microscopes
  - Light microscopes
  - Electron microscopes
    - Transmission (TEM)
    - Scanning electron microscope (SEM)



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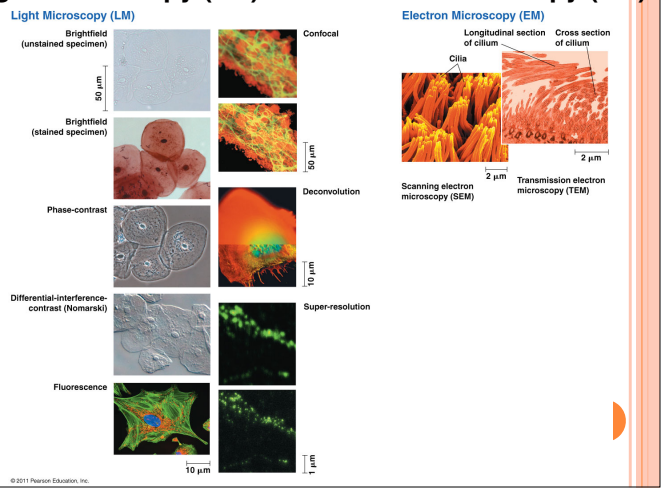
Light Microscopy (LM) vs. Electron Microscopy (EM)



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COMPARISONS OF SCOPES

Light

- Visible light passes through specimen
- Refracts light so specimen is magnified
- Magnify up to 1000X
- Specimen can be alive/ moving
- Color
- Can't see organelles

other than nucleus

Electron

- Focuses a beam of electrons through/onto specimen
- Magnify up to 1,000,000 times
- Specimen non-living and in vacuum
- Can see organelles

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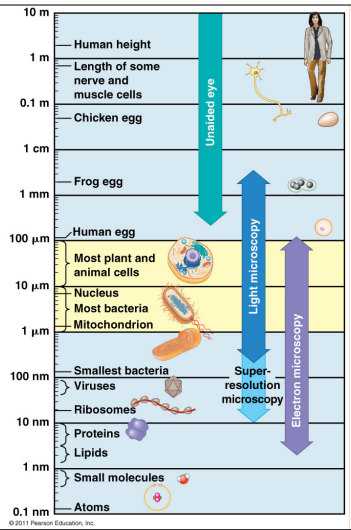
Size range of cells

Note that light microscopes can not magnify as well as electron microscopes



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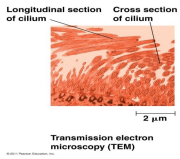
ELECTRON MICROSCOPY

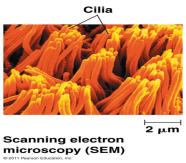
Transmission (TEM)

- 2-D, study internal structures of cells
- Creates a flat image with extreme detail
- Can enhance contrast by staining atoms with heavy metal dyes
- Images called a micrograph



Scanning (SEM)

- 3-D
- Used for detailed study of surface of specimen
- Gives great field of depth
- Sample covered with thin film of gold, beam excited electrons on surface



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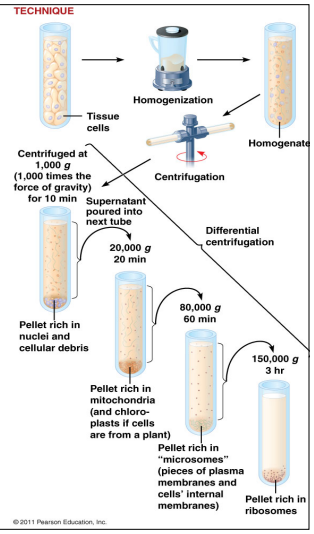
Studying cell structure & function

1. **Cell fractionation - take apart cells, separate major organelles**
2. **Ultracentrifuge - applies force 1 million times the force of gravity to separate further the cell organelles with the most dense at the bottom**



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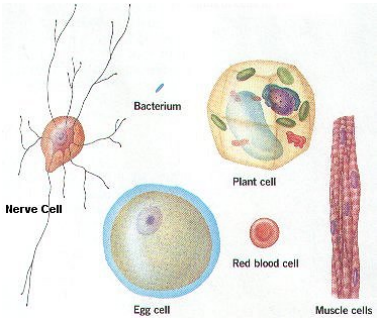

CELL SIZE AND SCALE

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

https://www.youtube.com/watch?v=wuXSEOKNxN8&feature=related- why small

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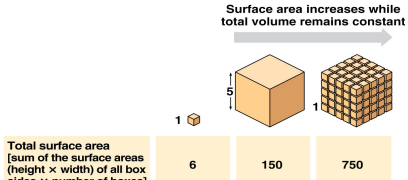
- As cell size increases, the SA/V ration decreases, rates of chemical exchange may then be inadequate for cell size
- Cells must remain small to maintain a large surface area to volume ratio
- Large S.A. allows increased rates of chemical exchange between cell and environment



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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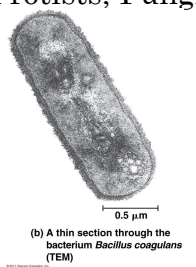
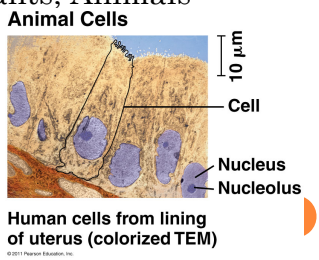
2 TYPES OF CELLS:

1. **Prokaryotes**: Domain Bacteria & Archaea
2. **Eukaryotes** (Domain Eukarya): Protists, Fungi, Plants, Animals





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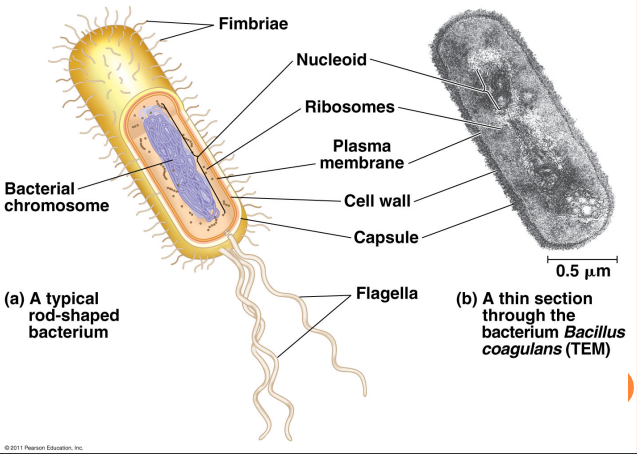
A PROKARYOTIC CELL (BACTERIA)



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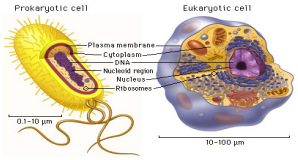
PROKARYOTE VS. EUKARYOTE

- No nucleus (Nucleoid-DNA concentration)
- DNA in a nucleoid
- Cytoplasm/Cytosol
- No organelles other than ribosomes
- Small size
- Primitive
- i.e. bacteria

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



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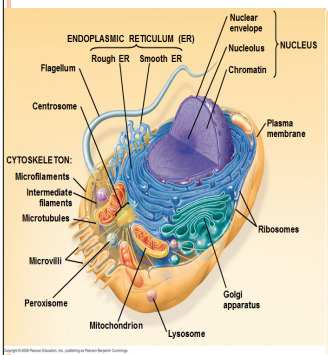
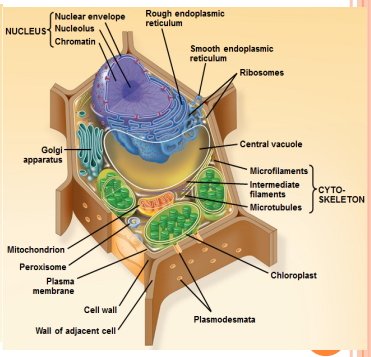
EUKARYOTIC CELLS





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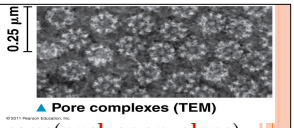
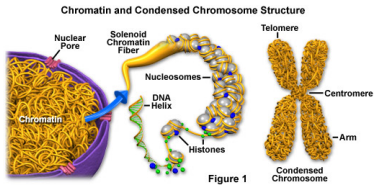
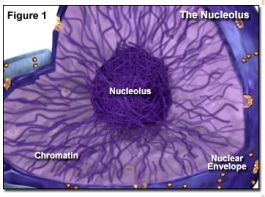
NUCLEUS

- Function: control center of cell
- Contains genetic material
- Surrounded by double membrane with pores(**nuclear envelope**)
  - Continuous with the rough ER
  - Nuclear side of envelope lined with a network of protein filaments (Nuclear Lamina)- maintain shape
- **Nuclear pores**: control what enters/leaves nucleus
- **Chromatin**: complex of DNA + proteins; makes up chromosomes
- **Nucleolus**: region where ribosomal subunits are formed







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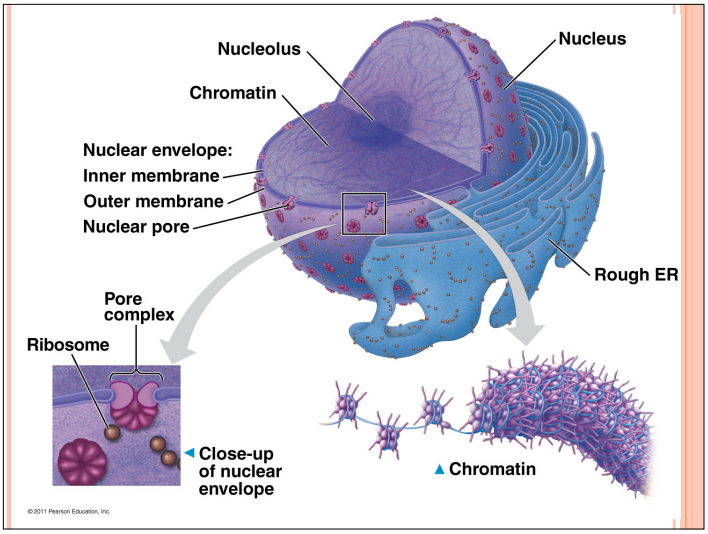

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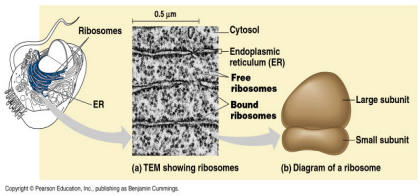
RIBOSOMES

- Function: protein synthesis
- 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



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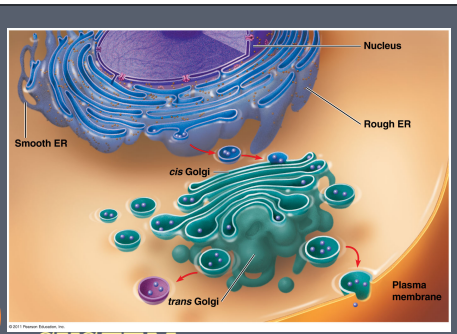

SYSTEM:

-Regulates protein traffic & performs metabolic functions

- Includes: nuclear envelope, ER, Golgi, Lysosomes, Vacuoles, and Plasma Membrane

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ENDOPLASMIC RETICULUM (ER)

- Network of membranes and sacs that are continuous with nuclear envelope
- 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 (in liver), store Ca^{2+} (muscles)- helps regulate muscle contraction

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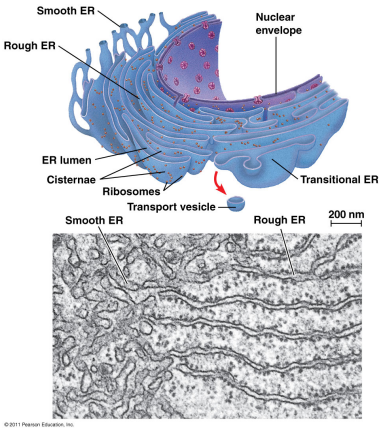
ENDOPLASMIC RETICULUM (ER)



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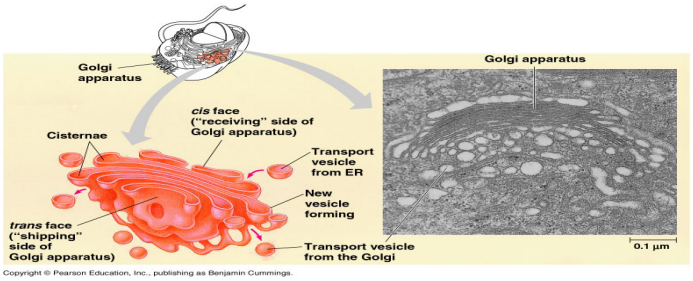
GOLGI APPARATUS

- Function: modify, store, & ship proteins
- Flattened sacs of membranes arranged in stacks
  - **Cisternae**: flattened membranous sacs that receives vesicles
  - ***Cis Face*** : receiving ***Trans face***: shipping



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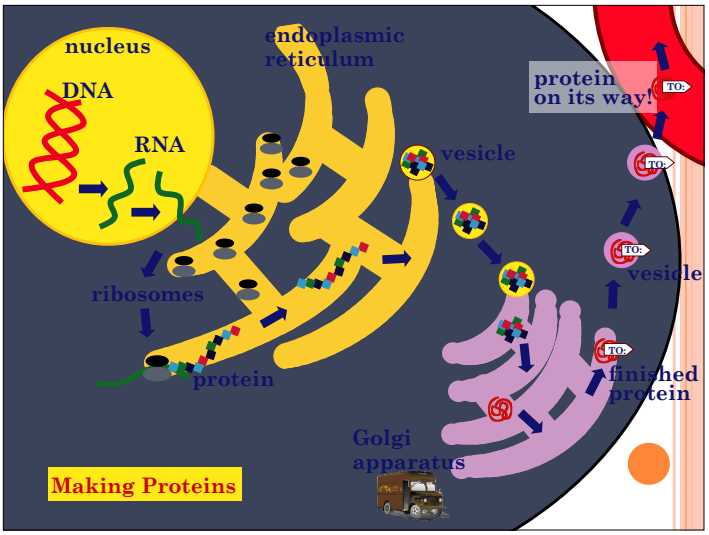

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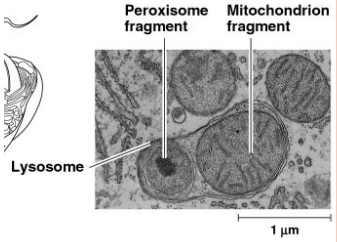
LYSOSOMES

- Function
  - little "stomach" of the cell
    - digests macromolecules
  - "clean up crew" of the cell
    - cleans up broken down organelles
- Structure
  - vesicles of digestive enzymes

only in animal cells

synthesized by rER, transferred to Golgi



(b) A lysosome in action

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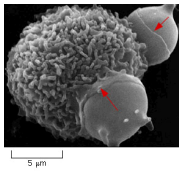
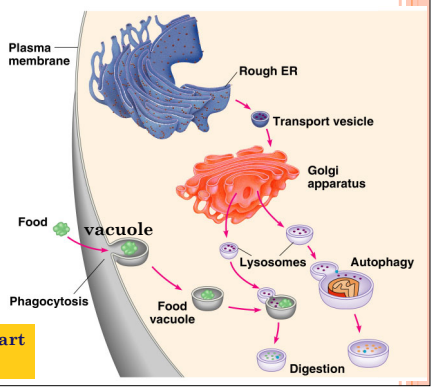
CELLULAR DIGESTION (PHAGOCYTOSIS)

- Lysosomes fuse with food vacuoles
  - polymers digested into monomers
    - pass to cytosol to become nutrients of cell





- lyso– = breaking things apart
- –some = body

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WHEN THINGS GO BAD…

- Diseases of lysosomes are often fatal
  - digestive enzyme not working in lysosome
  - picks up biomolecules, but can't digest one
    - lysosomes fill up with undigested material
  - grow larger & larger until disrupts cell & organ function
    - lysosomal storage diseases
      - more than 40 known diseases
    - example:
      Tay-Sachs disease
      build up undigested fat
      in brain cells

-http://www.youtube.com/watch?v=i3boE3rGWHk&feature=related

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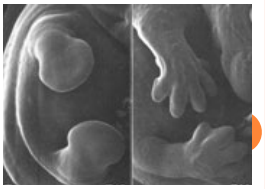
BUT SOMETIMES CELLS NEED TO DIE…

- Lysosomes can be used to kill cells when they are supposed to be destroyed
  - some cells have to die for proper development in an organism
    - apoptosis
      - "auto-destruct" process
      - lysosomes break open & kill cell
    - ex: tadpole tail gets re-absorbed when it turns into a frog
    - ex: loss of webbing between your fingers during fetal development



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APOPTOSIS

- programmed destruction of cells in multi-cellular organisms
  - programmed development
  - control of cell growth
    - example:
      if cell grows uncontrollably this self-destruct mechanism is triggered to remove damaged cell
    - cancer must over-ride this to enable tumor growth

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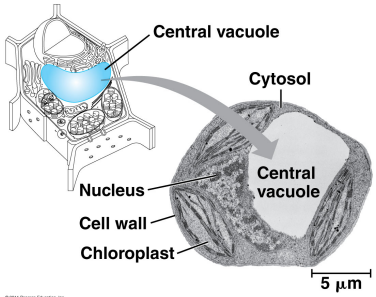
VACUOLES

- Function: storage of food, water, minerals
- Membrane-bound vesicles
- Eg. food vacuoles, contractile vacuoles
- **Plants: large central vacuole – stores water, ions**



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VACUOLES

- Food vacuoles- form by phagocytosis and fuse with lysosomes
- Contractile vacuoles in freshwater protist- pump excess water out/maintain water and salt balance
- Large central vacuole in plants- stockpile proteins, dispose of byproducts, hold pigments, store defensive compounds
- Large vacuole reduces area of cytosol, so SA/V ratio increases

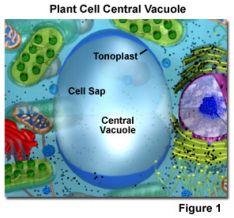

Figure 1

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REVIEW

- http://www.youtube.com/watch?v=aczbMlSMr8U

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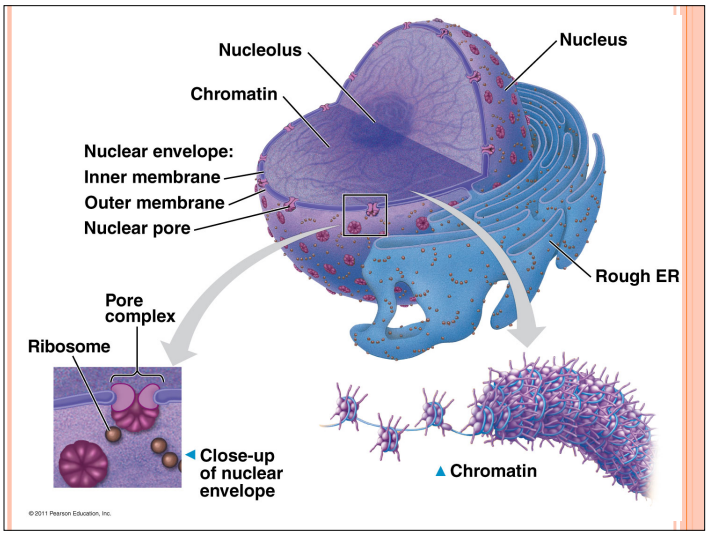

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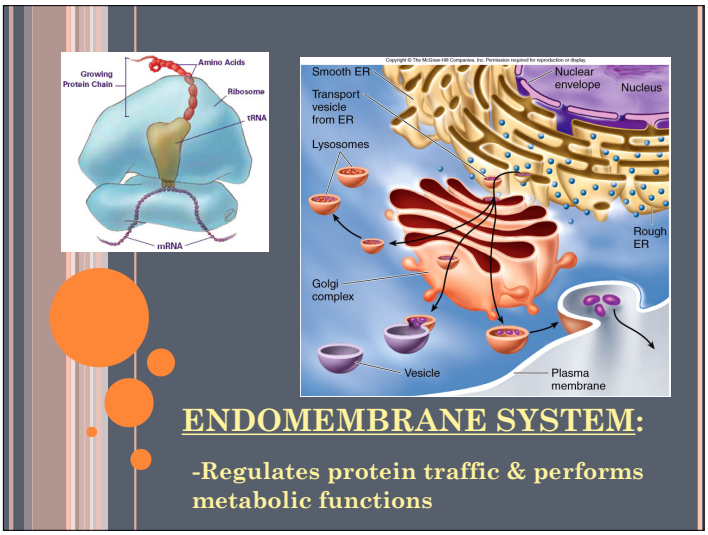

ENDOMEMBRANE SYSTEM:

-Regulates protein traffic & performs metabolic functions

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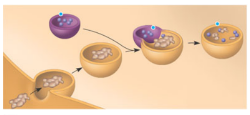
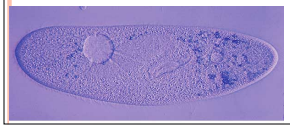
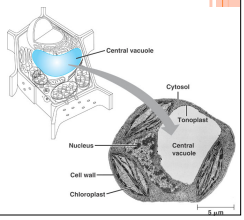
VACUOLES & VESICLES



- Function
  - little "transfer ships"
    - Food vacuoles
      - phagocytosis, fuse with lysosomes
    - Contractile vacuoles
      - in freshwater protists, pump excess H_2O out of cell
    - Central vacuoles
      - in many mature plant cells





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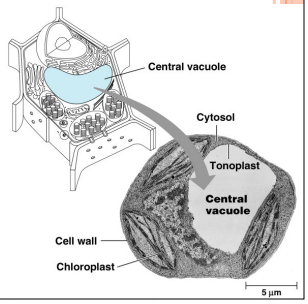
VACUOLES IN PLAKTS

- Functions
  - storage
    - stockpiling proteins or inorganic ions
    - depositing metabolic byproducts
    - storing pigments
    - storing defensive compounds against herbivores
    - selective membrane
      - control what comes in or goes out



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ENERGY ORGANELLES

- https://www.youtube.com/watch?v=ZrNt1FaUxe0
- Cells must convert incoming energy to forms that they can use for work
  - mitochondria: from glucose to ATP 

  - chloroplasts: from sunlight to ATP & carbohydrates
    - ATP = active energy
    - carbohydrates = stored energy

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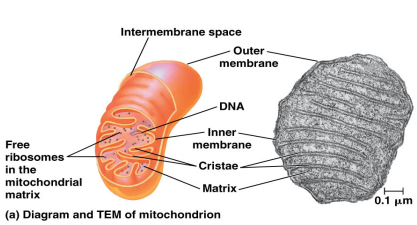
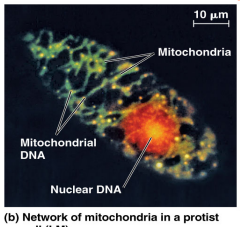
MITOCHONDRIA- POWERHOUSE

- Function: site of cellular respiration (use oxygen to make ATP, breaks down carbohydrates)
- Generate ATP in presence of Oxygen
- Break down larger molecule into smaller to generate energy= catabolism
- Generate energy in presence of Oxygen (aerobic respiration)





Why 2 membranes?

increase surface area for membrane-bound enzymes that synthesize ATP

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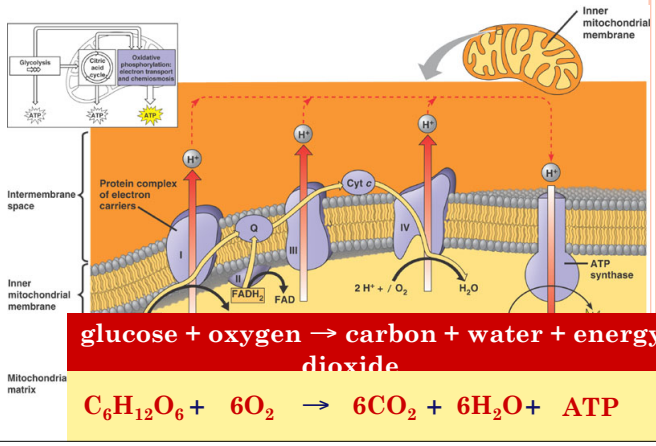
MEMBRANE-BOUND ENZYMES



glucose + oxygen → carbon + water + energy dioxide

$C_6H_{12}O_6 + 6O_2 \rightarrow 6CO_2 + 6H_2O + ATP$

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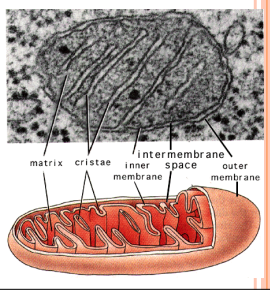
MITOCHONDRIA

- Almost all eukaryotic cells have mitochondria
  - there may be 1 very large mitochondrion or 100s to 1000s of individual mitochondria
  - number of mitochondria is correlated with aerobic metabolic activity
    - more activity = more energy needed = more mitochondria

What cells would have a lot of mitochondria?

active cells:
- **muscle cells**
- **nerve cells**



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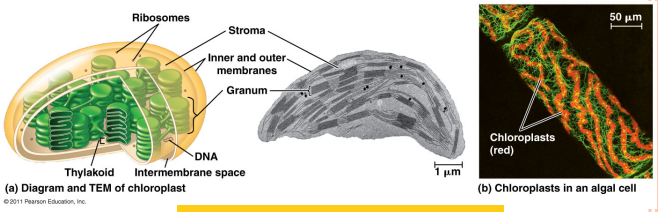
CHLOROPLASTS- PLANTS ONLY

- Function: site of photosynthesis (converts light energy into chemical energy ie. carbohydrates)
- Contains **chlorophyll** (green pigment) for capturing sunlight energy



Why internal sac

increase surface area for membrane-bound enzymes that synthesize ATP

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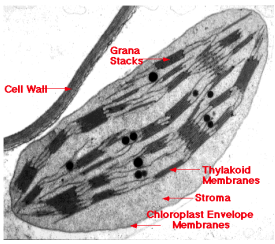
CHLOROPLASTS

- Chloroplasts are plant organelles
  - class of plant structures = plastids
    - amyloplasts
      - store starch in roots & tubers
    - chromoplasts
      - store pigments for fruits & flowers
    - chloroplasts
      - store chlorophyll & function in photosynthesis
      - in leaves, other green structures of plants & in eukaryotic algae



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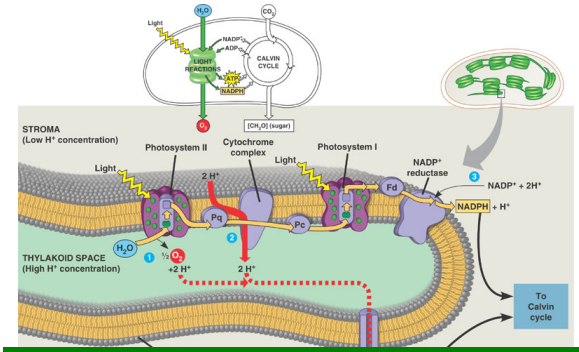
MEMBRANE-BOUND ENZYMES



carbon + water + energy → glucose + oxygen dioxide

$6CO_2 + 6H_2O + \text{light energy} \rightarrow C_6H_{12}O_6 + 6O_2$

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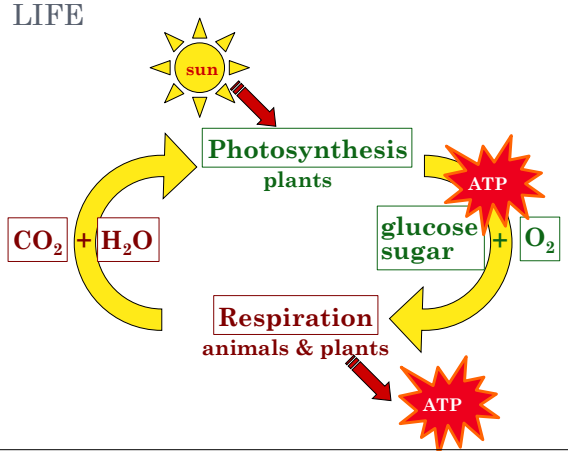
THE GREAT ENERGY CIRCLE OF LIFE



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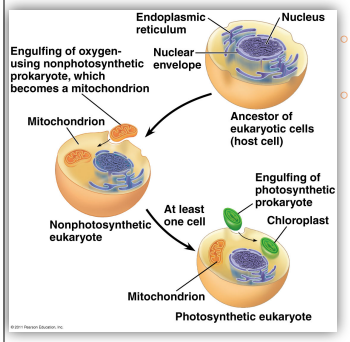
ENDOSYMBIONT THEORY



- Mitochondria & chloroplasts share similar origin
- Prokaryotic cells engulfed by ancestors of eukaryotic cells
- Evidence:
  - Double-membrane structure
  - Transform energy
  - Have own ribosomes & circular DNA, enzymes
  - Reproduce independently within cell
  - Semi-autonomous (move, divide, change shape)

https://www.youtube.com/watch?v=LfBZ2E1lNSc

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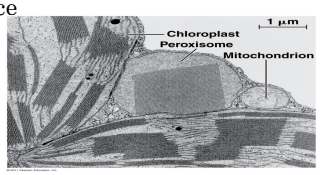
PEROXISOMES- DIGESTIVE ENZYME SAC

- Functions: break down fatty acids to sugars; detox cell of alcohol and other poisons
- Found in plants and animals
- Human cells- 60 enzymes involved in metabolic processes
- Involves production of hydrogen peroxide (H_2O_2) , which is broken down by catalase (imports H) resulting in water and oxygen
- Glyoxysomes: convert oils to sugars in seeds for energy source



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COOL DOWN QUESTIONS

- Which organelle is the site for respiration?
- Which organelle is the site for photosynthesis?
- Which TWO organelles contain digestive enzymes that are essential to cells?
- What is the benefit to the inner folds on chloroplasts and mitochondria?
- What evidence supports the endosymbiosis theory?
- True or False. Chloroplast, Mitochondria, and Peroxisomes are part of the endomembrane system.

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