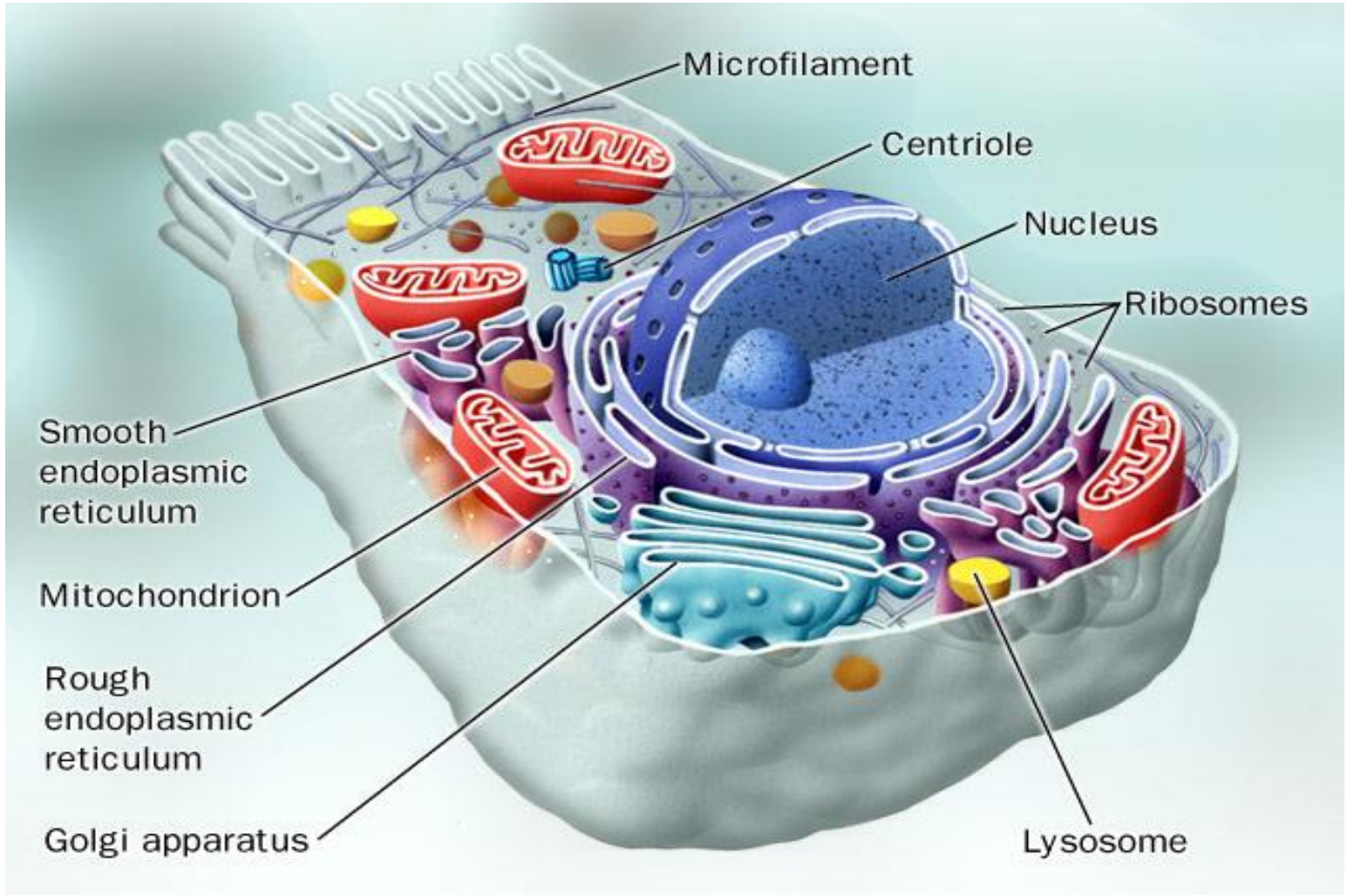
Basic Structure of a Cell



Review Facts About Living Things

What is life?

Alive?

Alive?

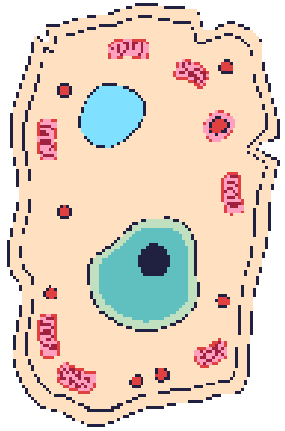
What is life?

- Thus life defies a one sentence answer/definition

- Instead, life is recognized by what living things do and can be categorized into 5 properties of life

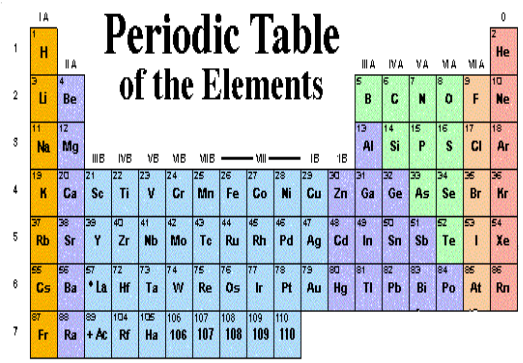
- Life is Organized
- Life Requires Energy
- Life Self Regulates
- Life Reproduces Itself, Grows, and Develops
- Life Adapts & Evolves

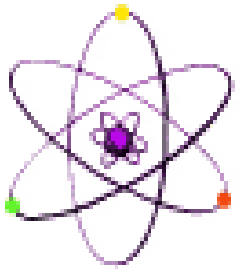
Organization Levels of Life

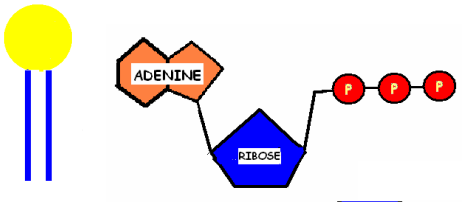


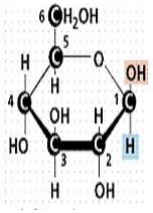
Atoms to Organisms

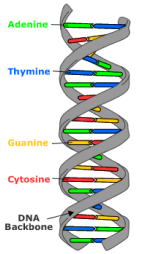
Nonliving Levels

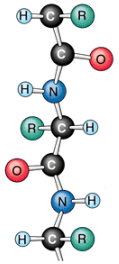


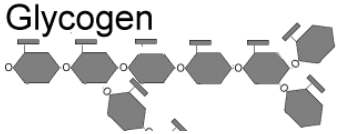


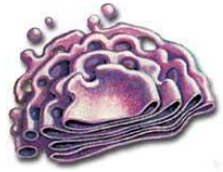


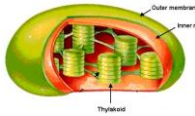


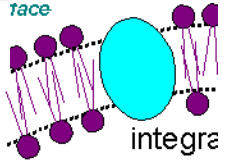


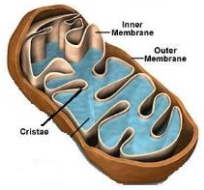






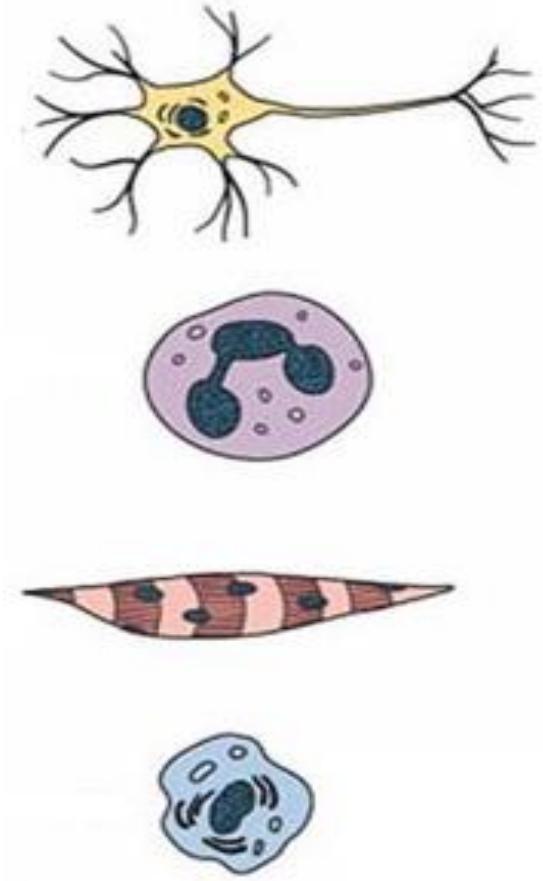






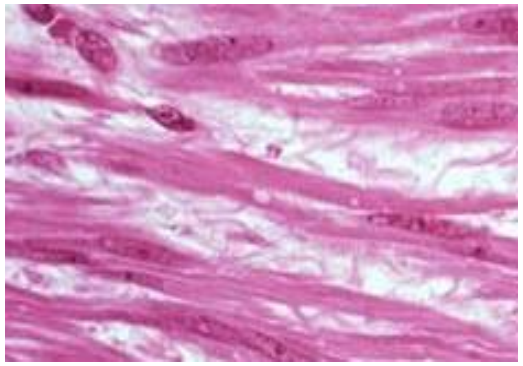
ATOMS → MOLECULES → ORGANELLES

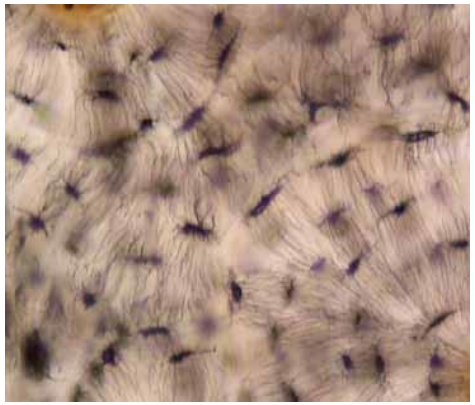
Living Levels

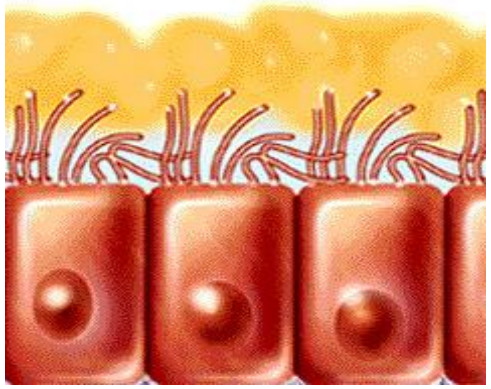


CELLS – life starts here

→



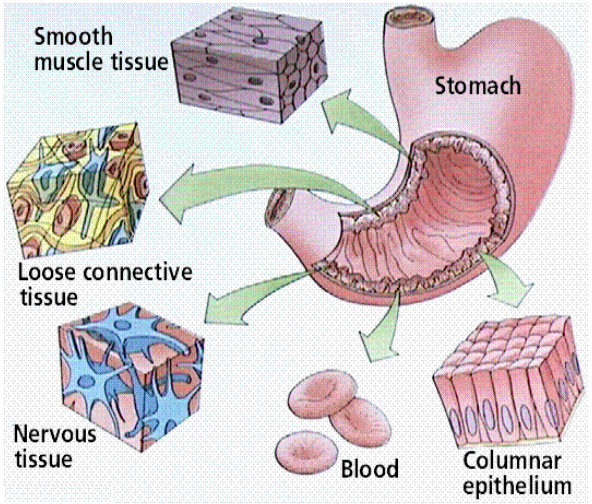


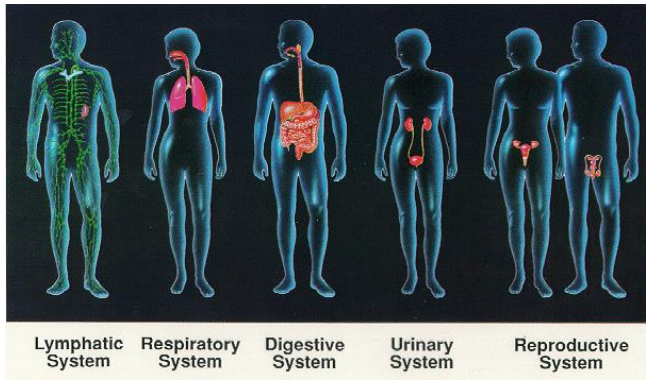


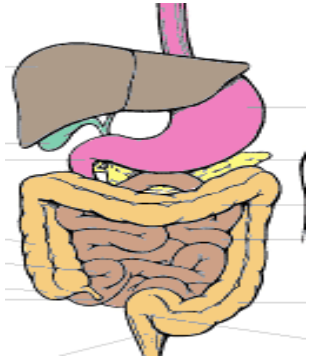
→

TISSUES – Similar cells working together

More Living Levels





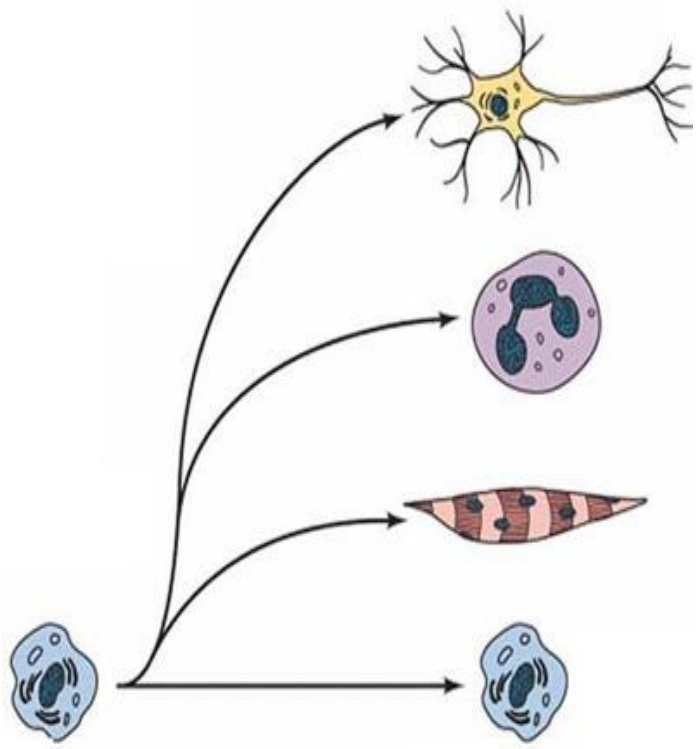


ORGANS → ORGAN SYSTEMS → ORGANISM

Different tissues working together

Different organs working together

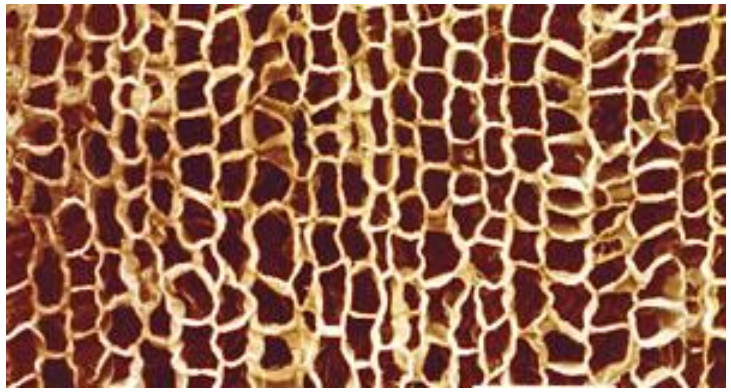
History of Cells & the Cell Theory



First to View Cells

Do not write, just background

- In 1665, Robert Hooke used a microscope to examine a thin slice of cork (dead plant cell walls)
- What he saw looked like small boxes or jail cells

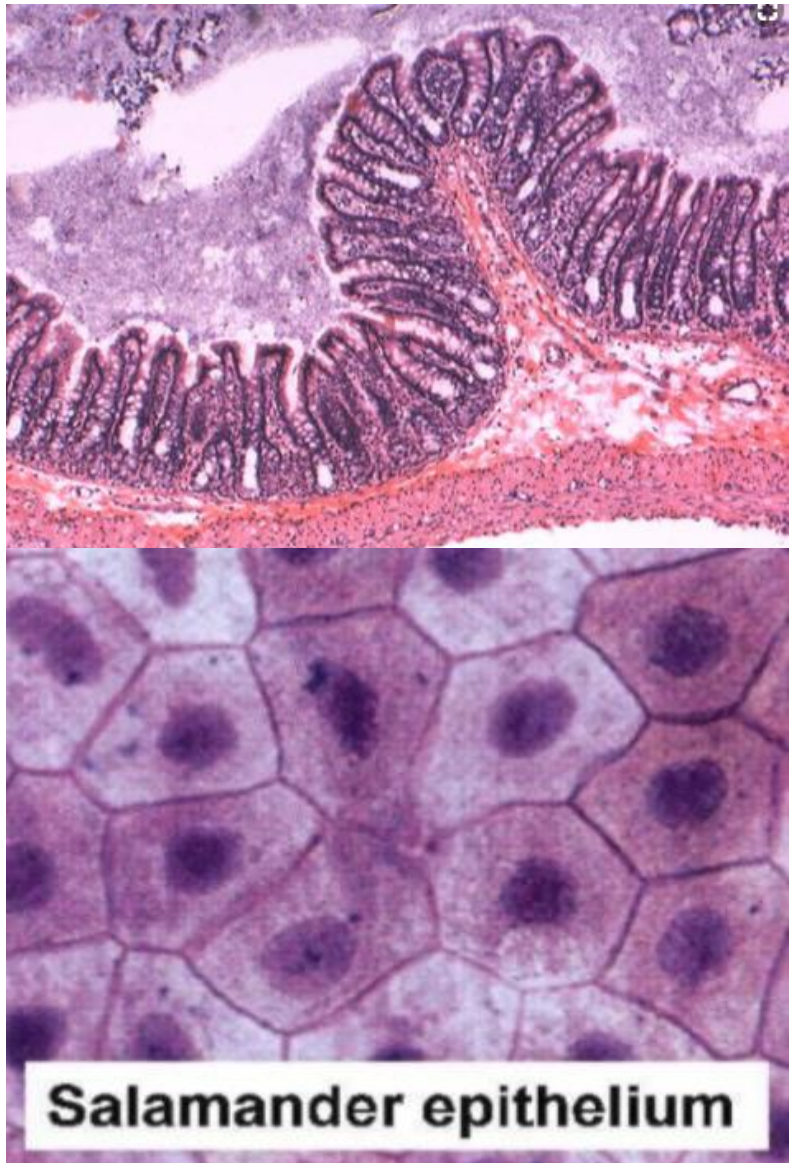


Cell Theory

- 1. All living things are made of cells.
- 3. New cells are produced from existing cells (aka cell reproduction or mitosis)
- 2. Cells are the basic unit of structure and function in living things.

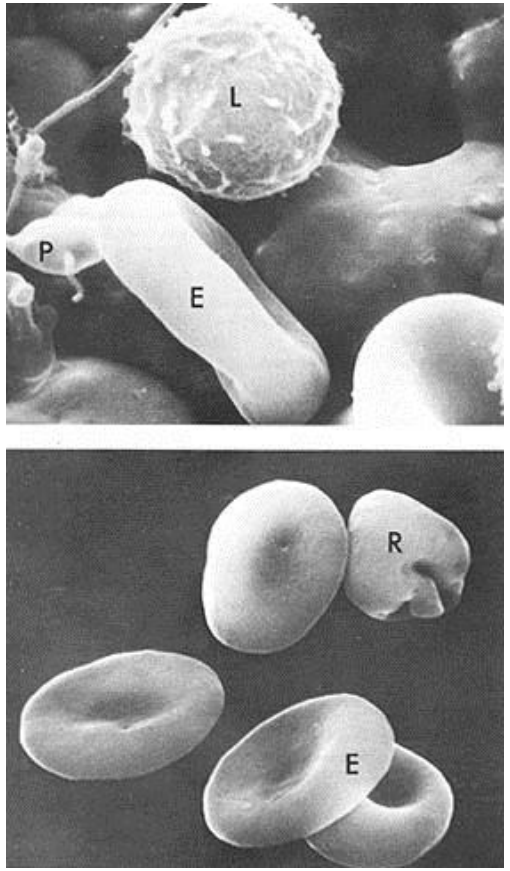
Cell Exploration through Advancements in Technology

- **Light Microscopes**
  - **Living organisms can be seen**
  - **Light limits the resolution so extremely small things like proteins and viruses cannot be observed**



Cell Exploration through Advancements in Technology

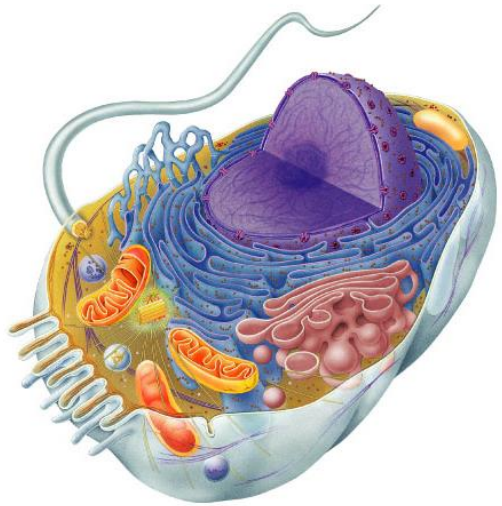
- **Scanning Electron**
  - **Produces a 3D image**
  - **Can see individual organelles and even DNA!!!!**

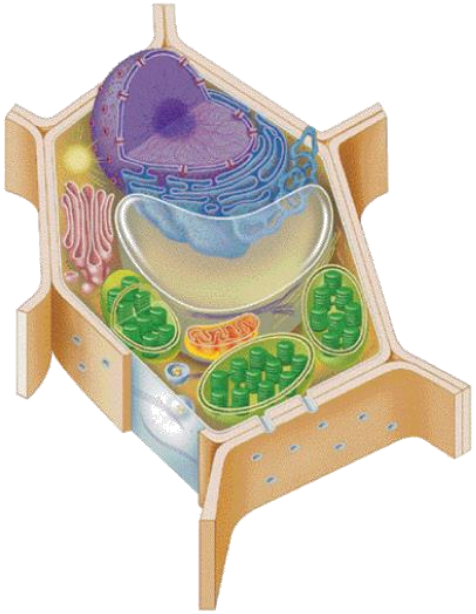


Cells functions

- Building proteins
  - What organelles and steps are used to build proteins?

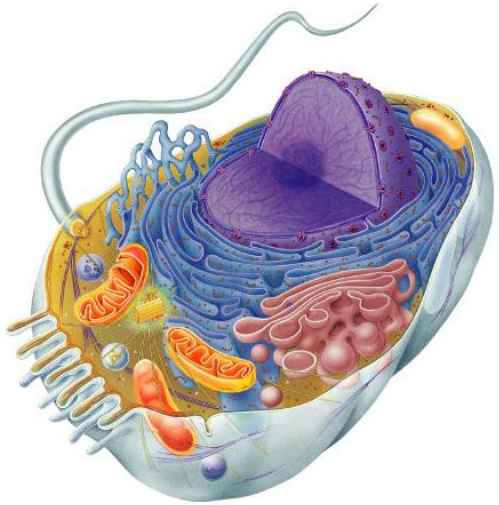
Knowledge Target: A confident scientist can identify the organelles and responsible for building proteins
Reasoning Target: A confident scientist can explain the order each organelle and why the position of the organelle matters

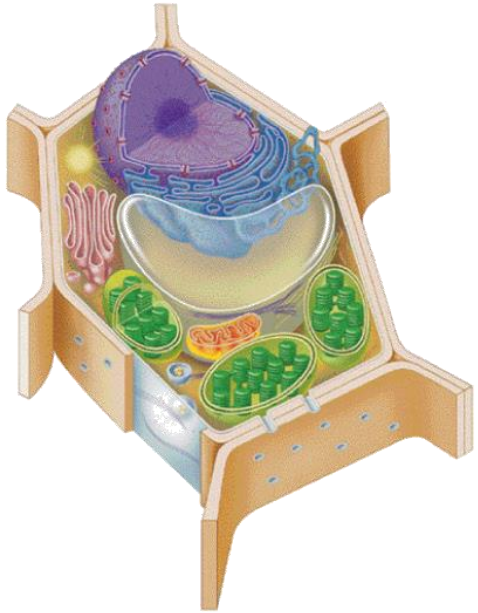




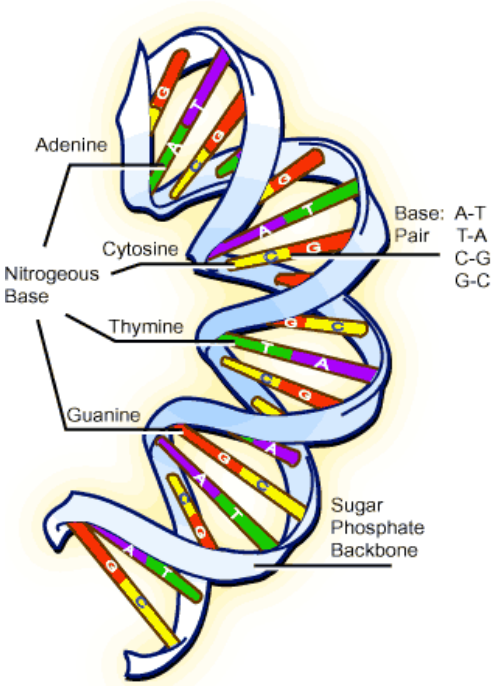
Cells gotta work to live!

- What jobs do cells have to do?
  - make proteins
    - proteins control every cell function
  - make energy
    - for daily life
    - for growth
  - make more cells
    - growth
    - repair
    - renewal

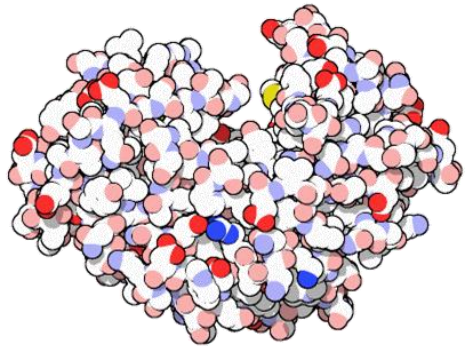




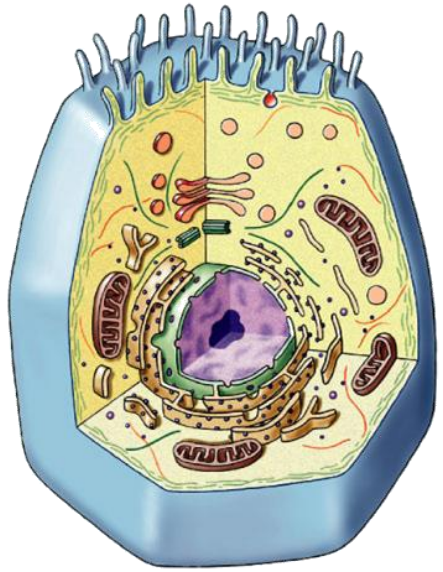
Proteins do all the work!



DNA

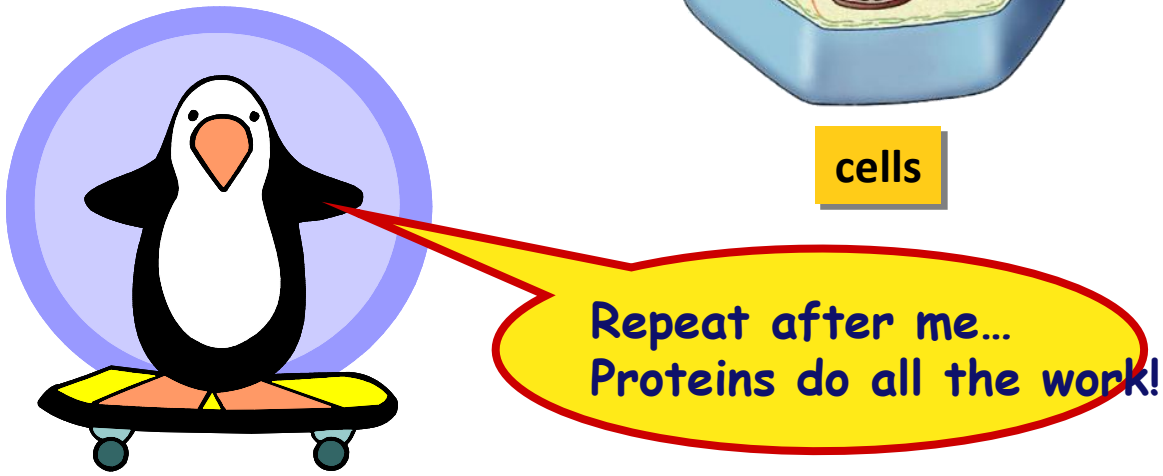


proteins



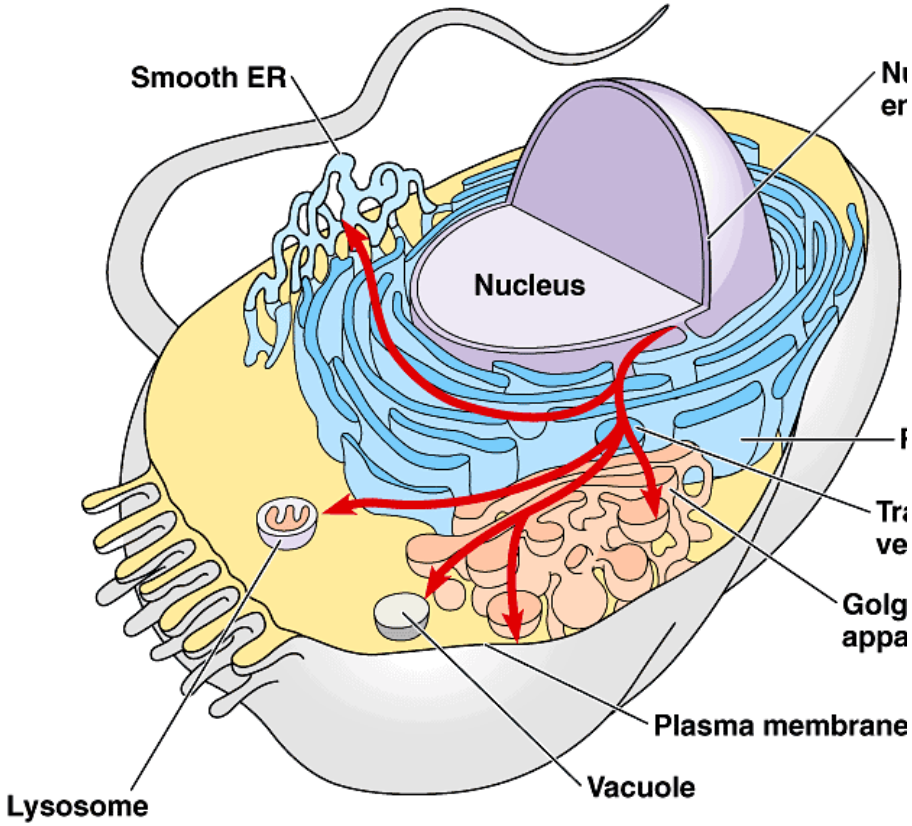
cells

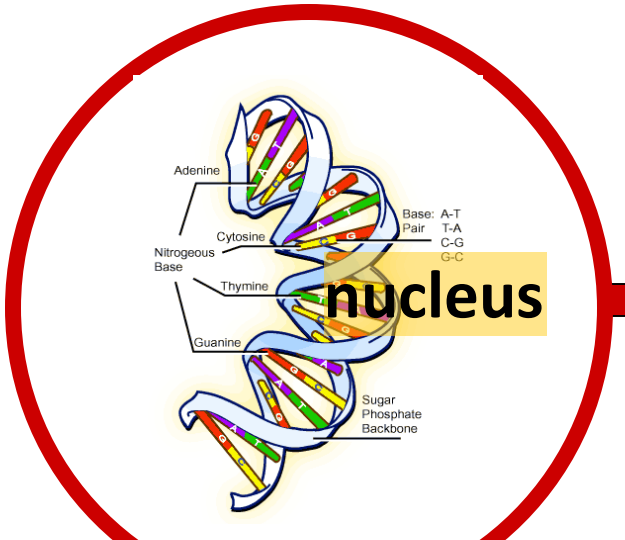
organism



Building Proteins

- Organelles involved
  - nucleus
  - ribosomes
  - endoplasmic reticulum (ER)
  - Golgi apparatus
  - vesicles





The Protein Assembly Line

nucleus → **ribosome** → **ER** → **Golgi apparatus** → **vesicles**

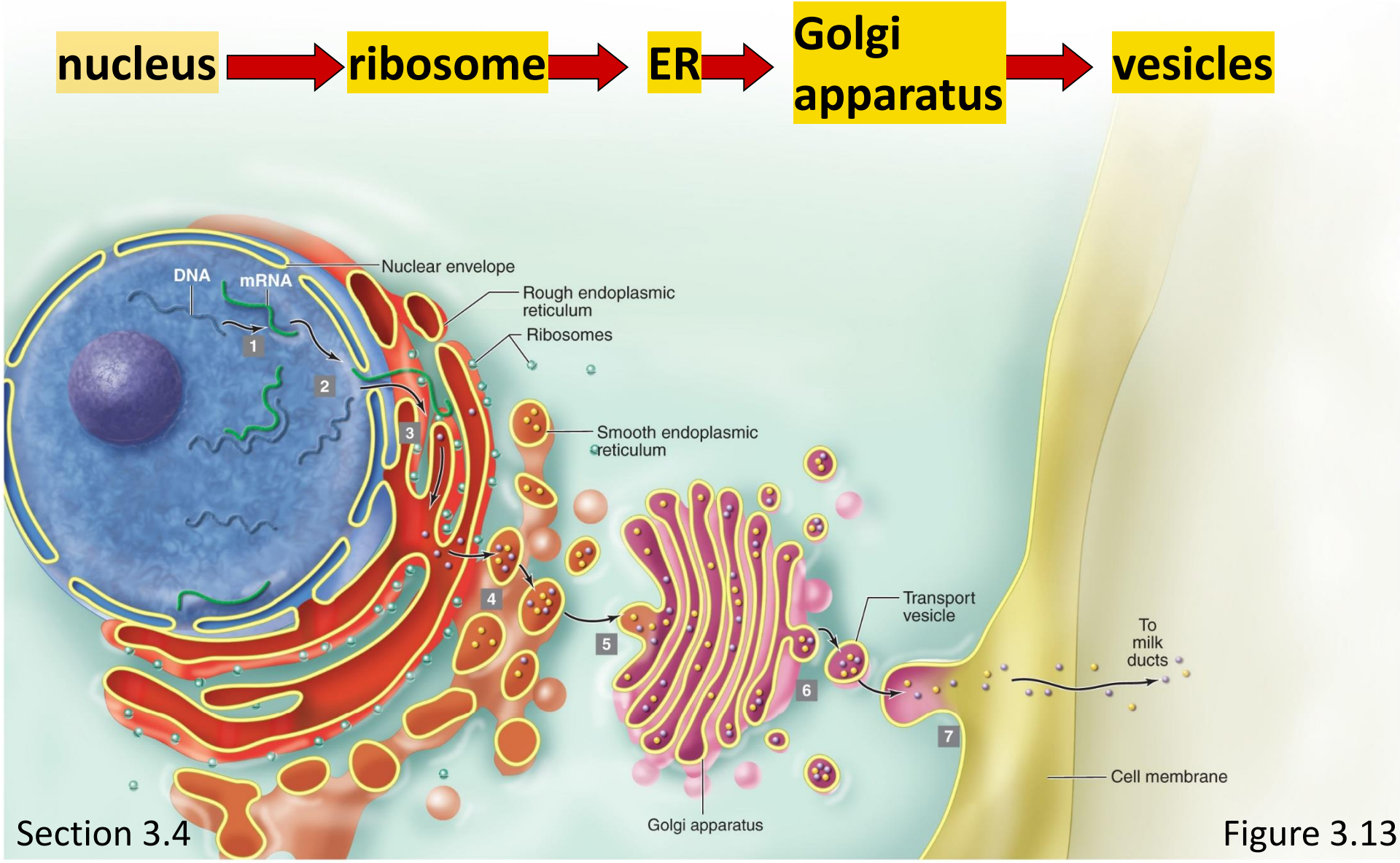
Mastering Concepts

Which organelles interact to produce and secrete a complex substance such as milk?

-Make a quick list in your head
-Compare your list to your partners
-Be prepared to share your list

Milk Production Pathway

nucleus → **ribosome** → **ER** → **Golgi apparatus** → **vesicles**



Section 3.4

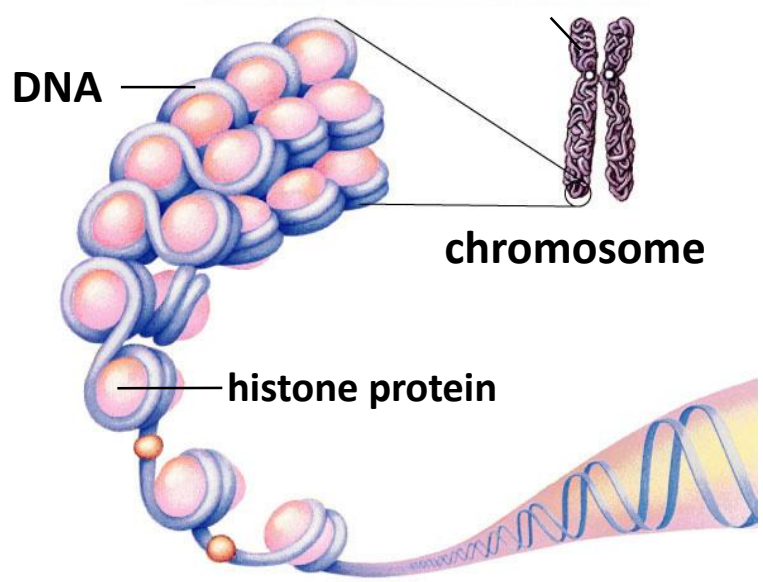
Figure 3.13

Cell Learning Targets

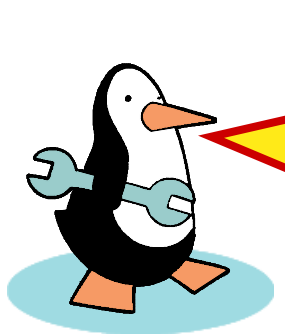
Knowledge Target: A confident scientist can identify all major organelles AND their function in a plant and animal cell

Skill Target: A confident scientist can match all major organelles in a plant and animal cell diagram

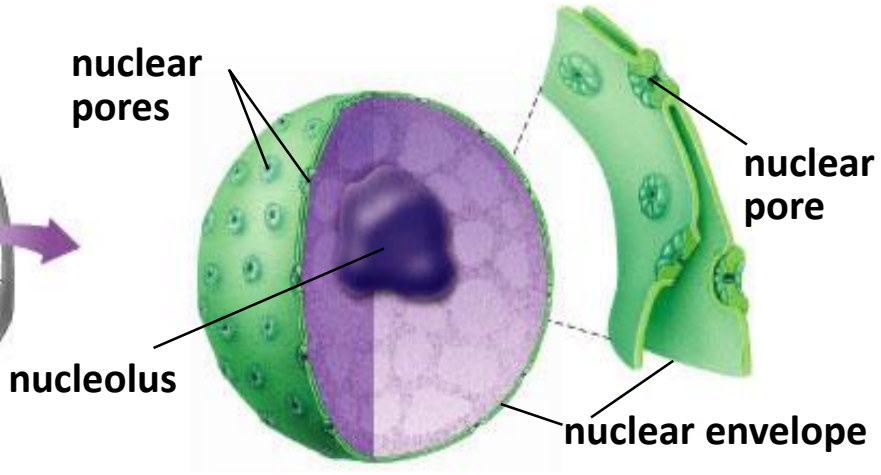
Nucleus

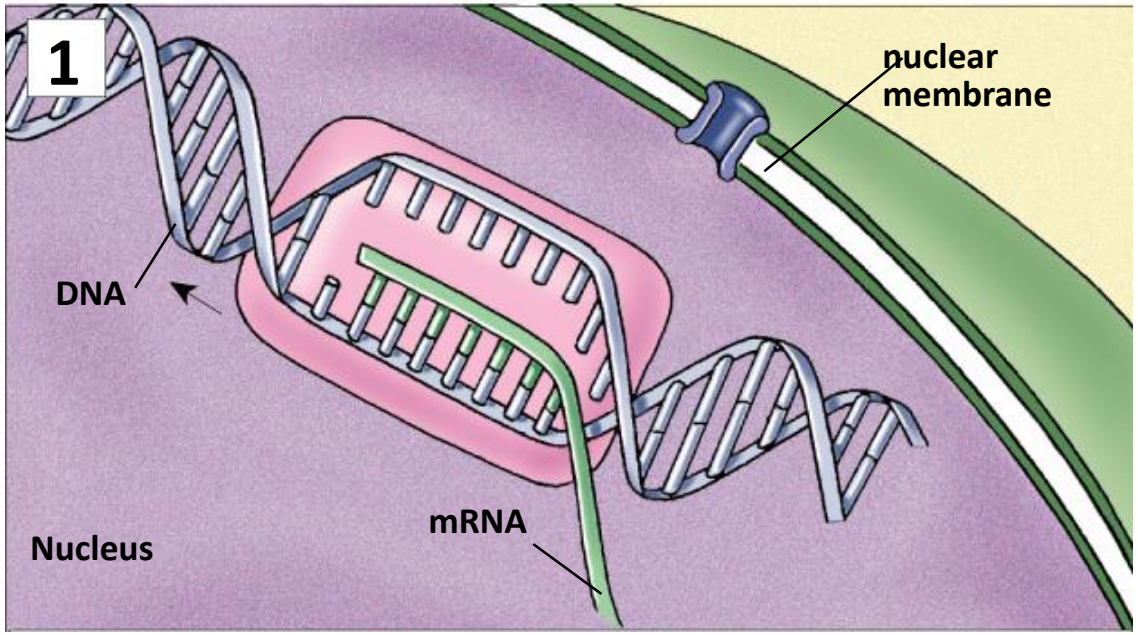


- Function
  - protects DNA
- Structure
  - nuclear envelope
    - double membrane
    - membrane fused in spots to create pores
      - allows large macromolecules to pass through



What kind of molecules need to pass through?



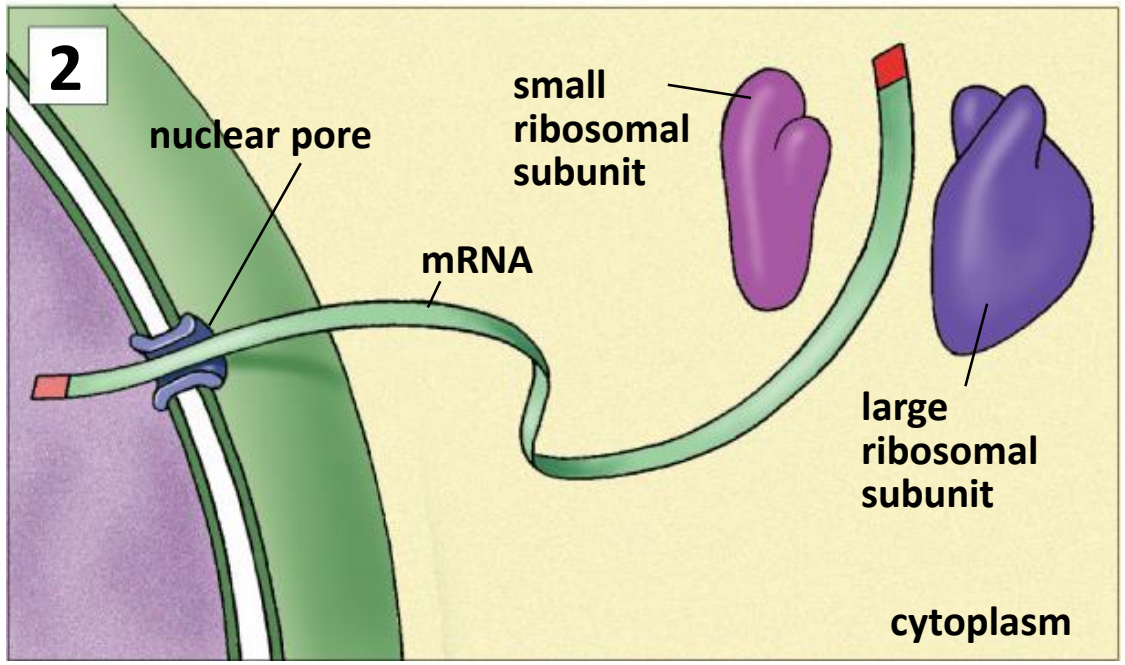


production of mRNA from DNA in nucleus

#transcription

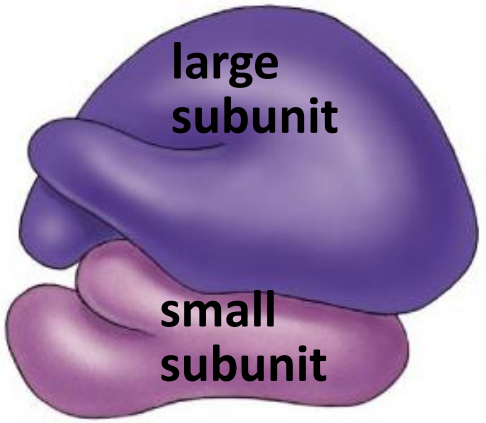
mRNA travels from nucleus to ribosome in cytoplasm through nuclear pore

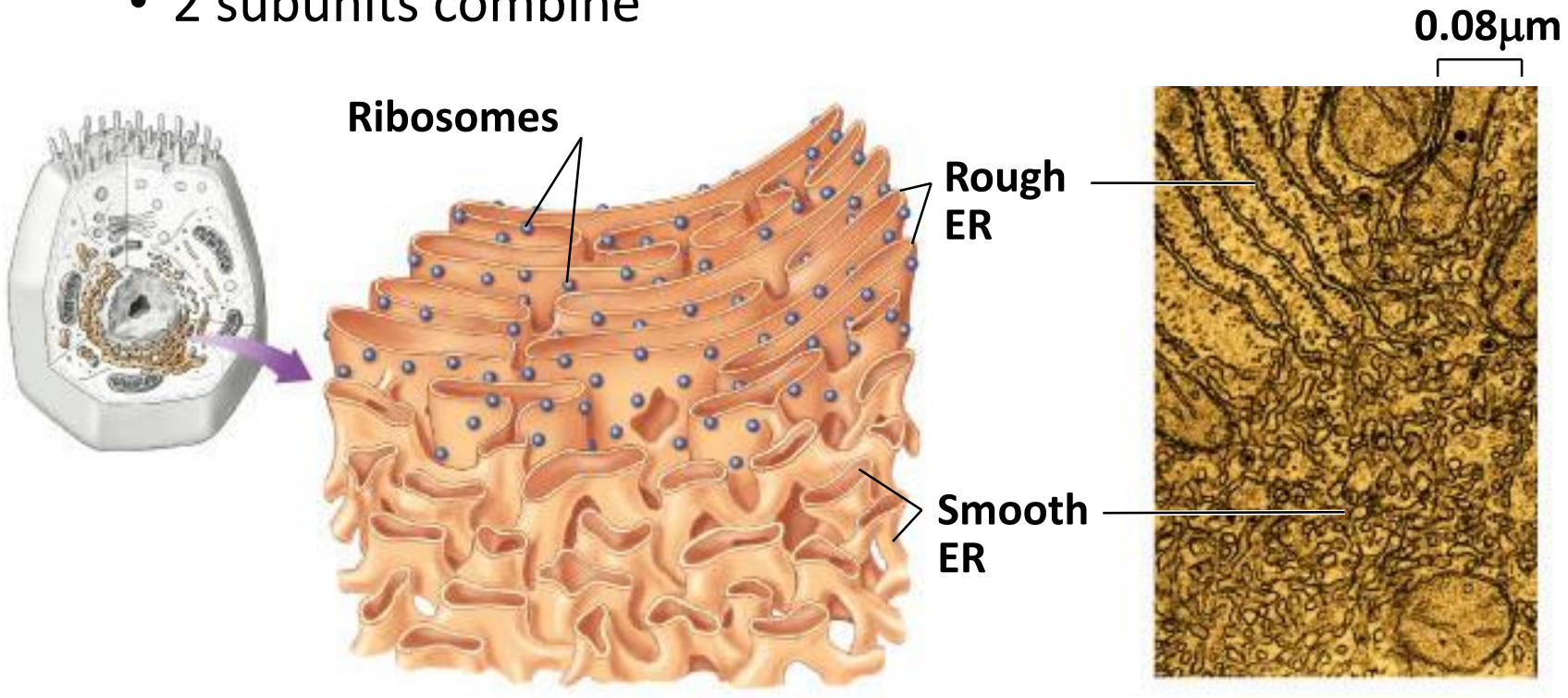
#translation



Ribosomes

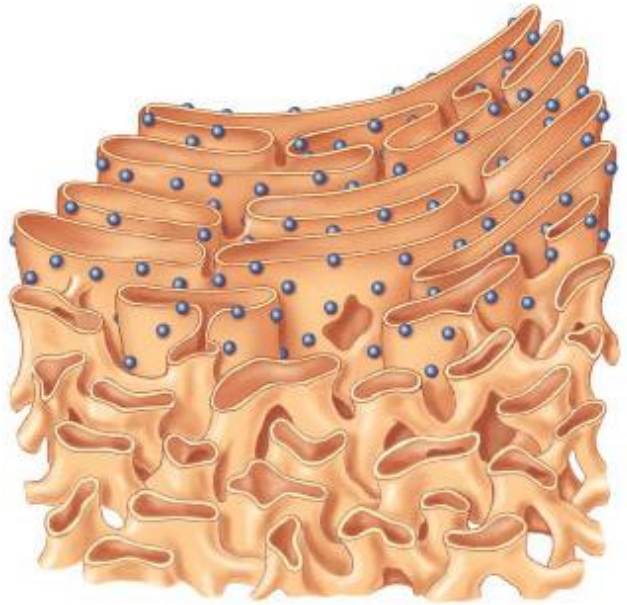
- Function
  - protein production
- Structure
  - rRNA & protein
  - 2 subunits combine

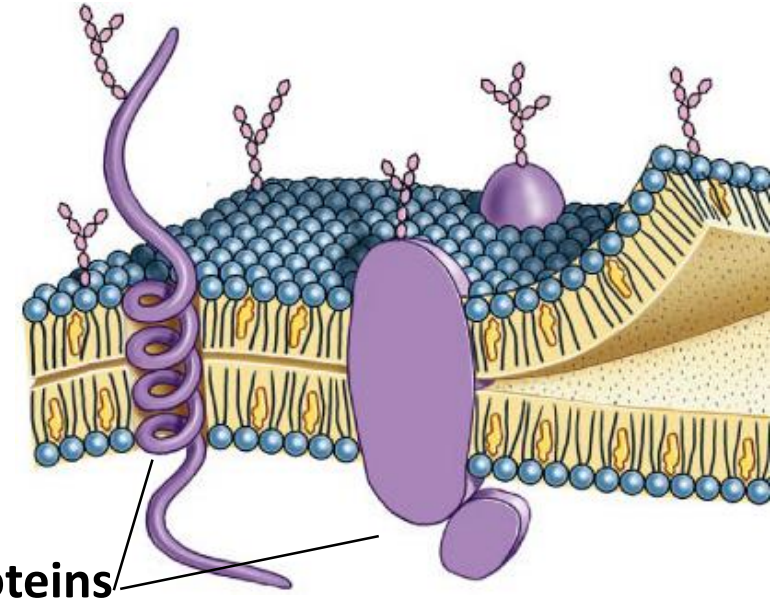




Types of Ribosomes

- Free ribosomes
  - suspended in cytosol
  - synthesize proteins that function in cytosol
- Bound ribosomes
  - attached to endoplasmic reticulum
  - synthesize proteins for export or for membranes



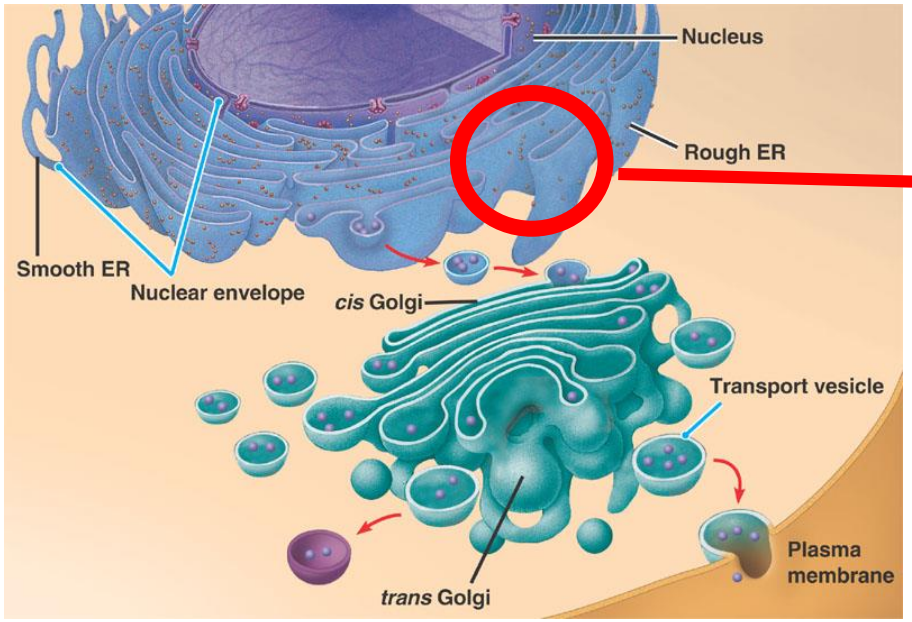


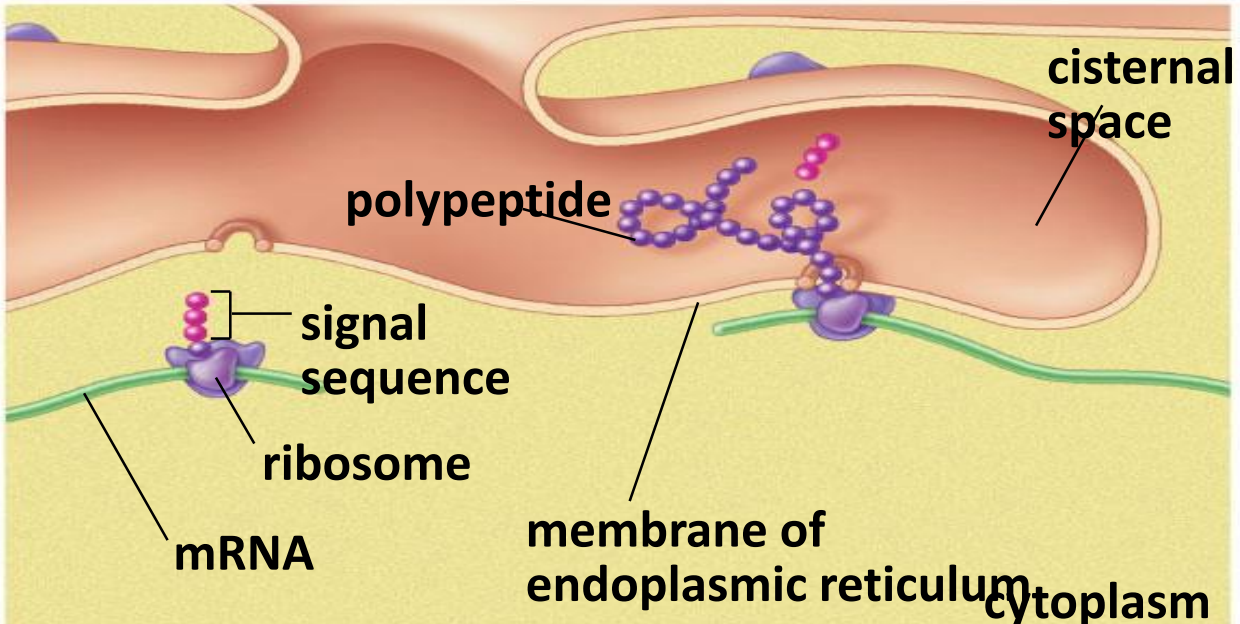
Endoplasmic Reticulum

- Function
  - Processes and transports/secretes proteins to Golgi;

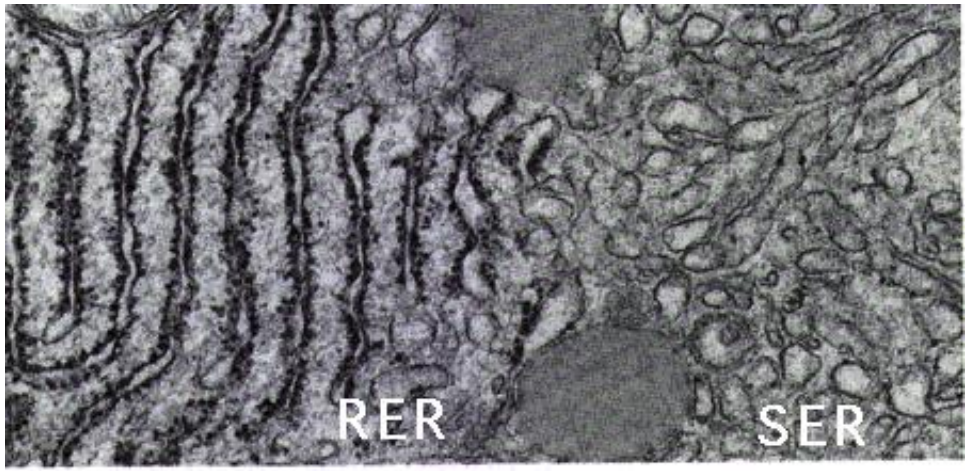
Structure

- membrane connected to nuclear envelope & extends throughout cell

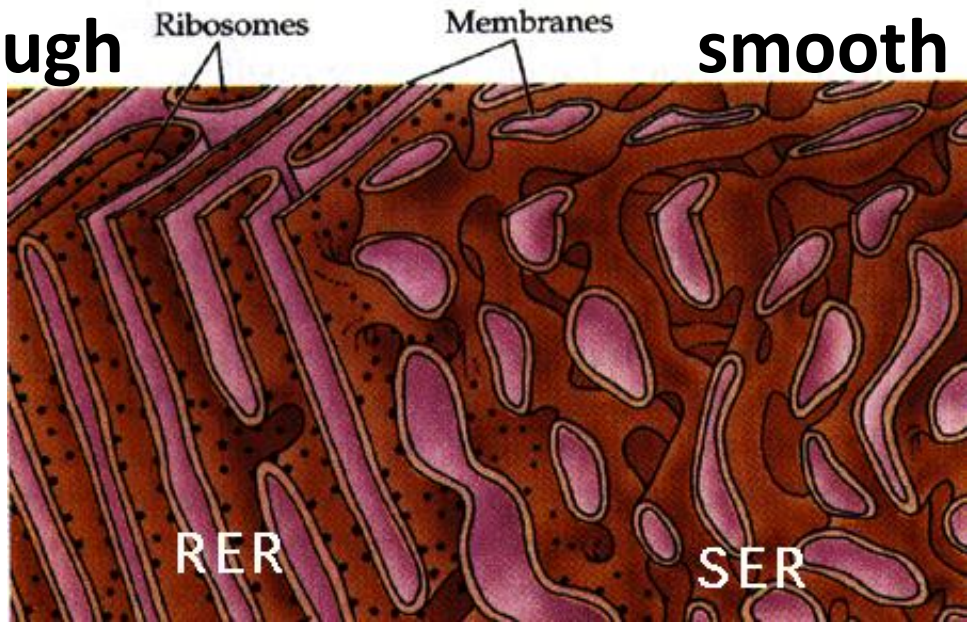


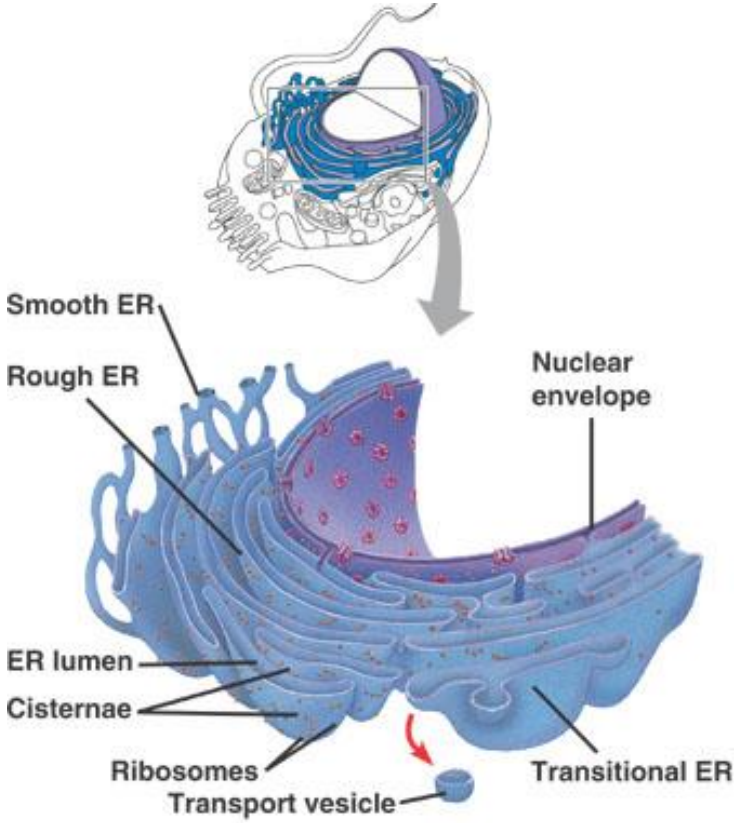


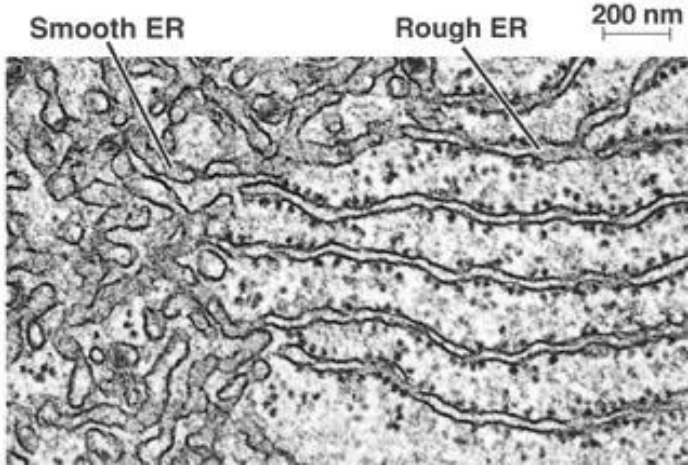
Types of ER



rough **smooth**

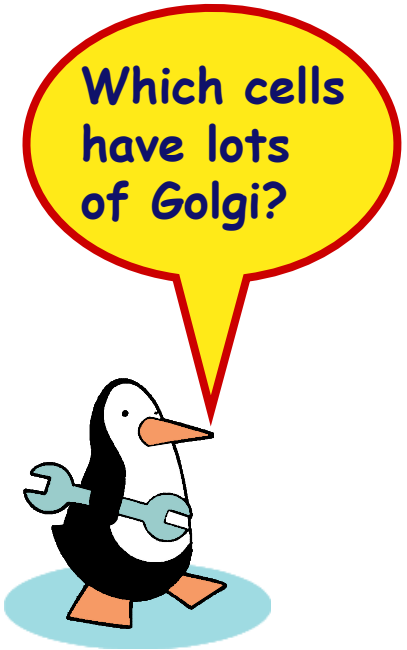


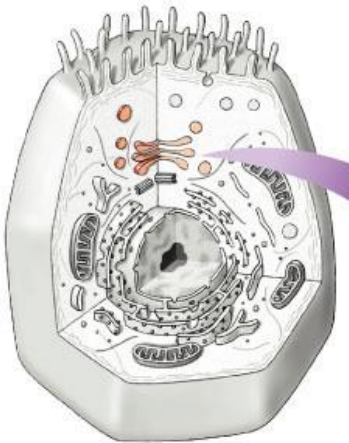


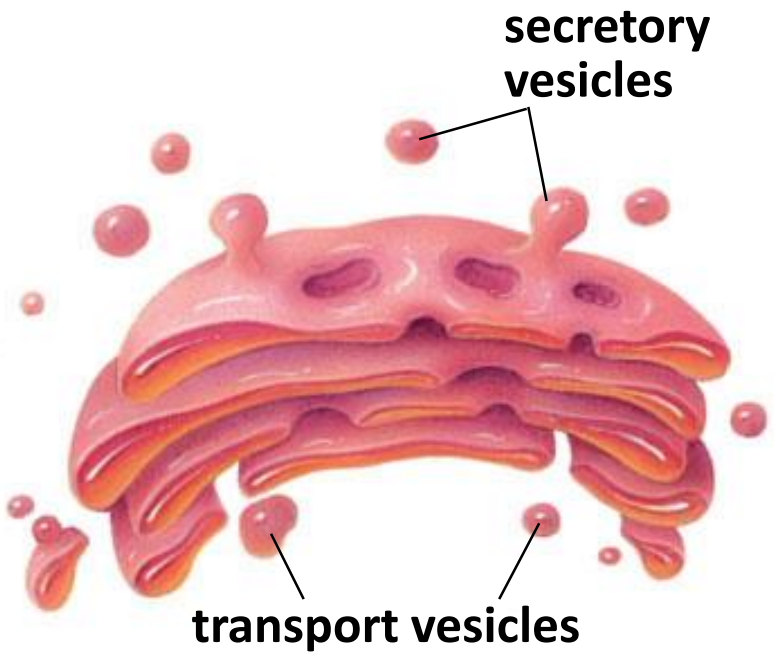


Golgi Apparatus

- Function
  - finishes, sorts, tags & ships cell products
    - like “UPS shipping department”
  - ships products in vesicles
    - membrane sacs
    - “UPS trucks”

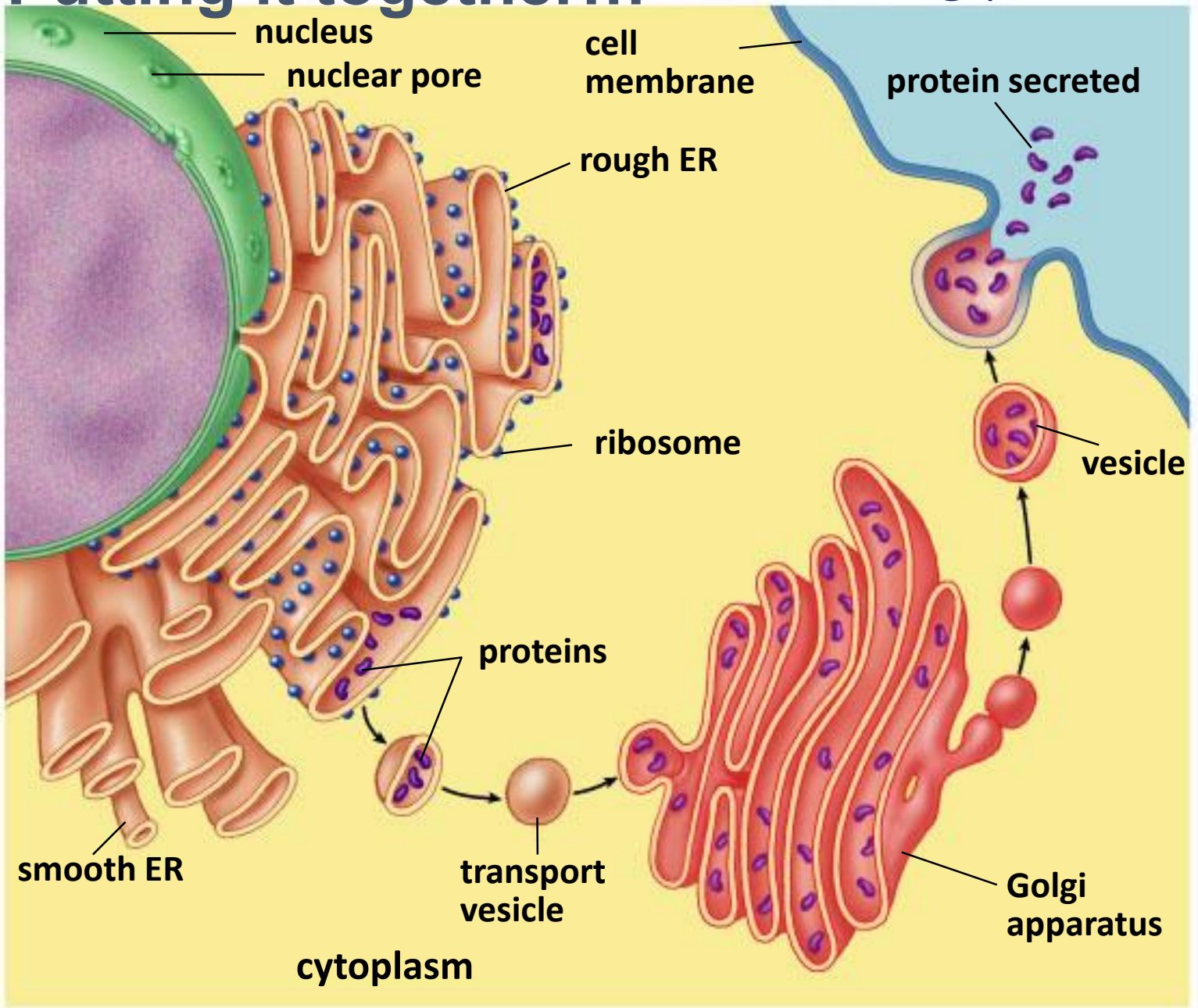






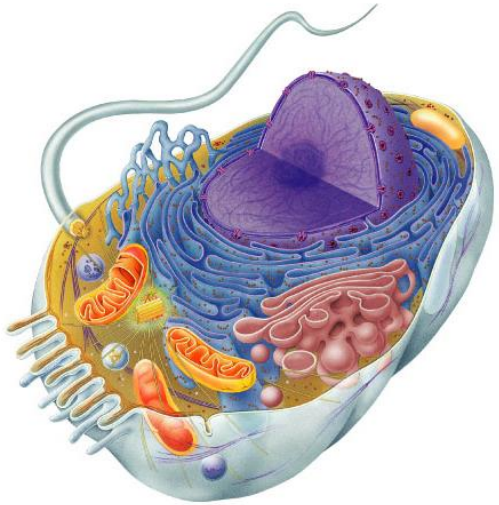
Putting it together…

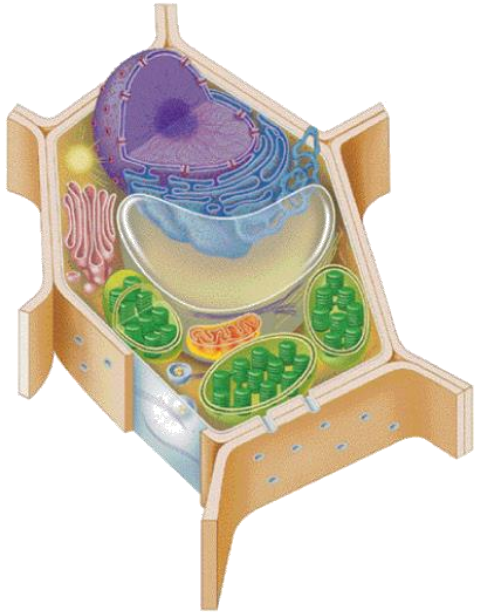
Making proteins



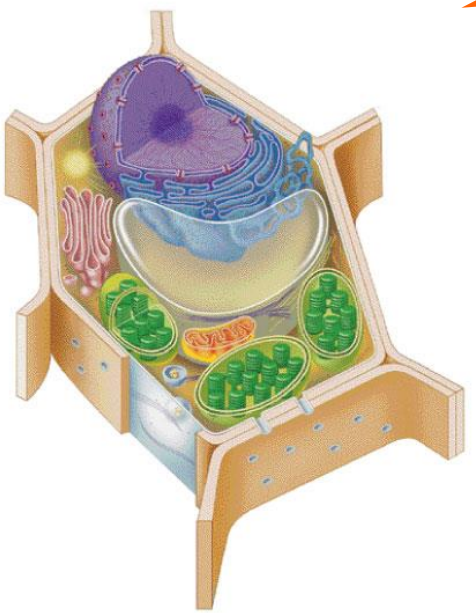
Cells gotta work to live!

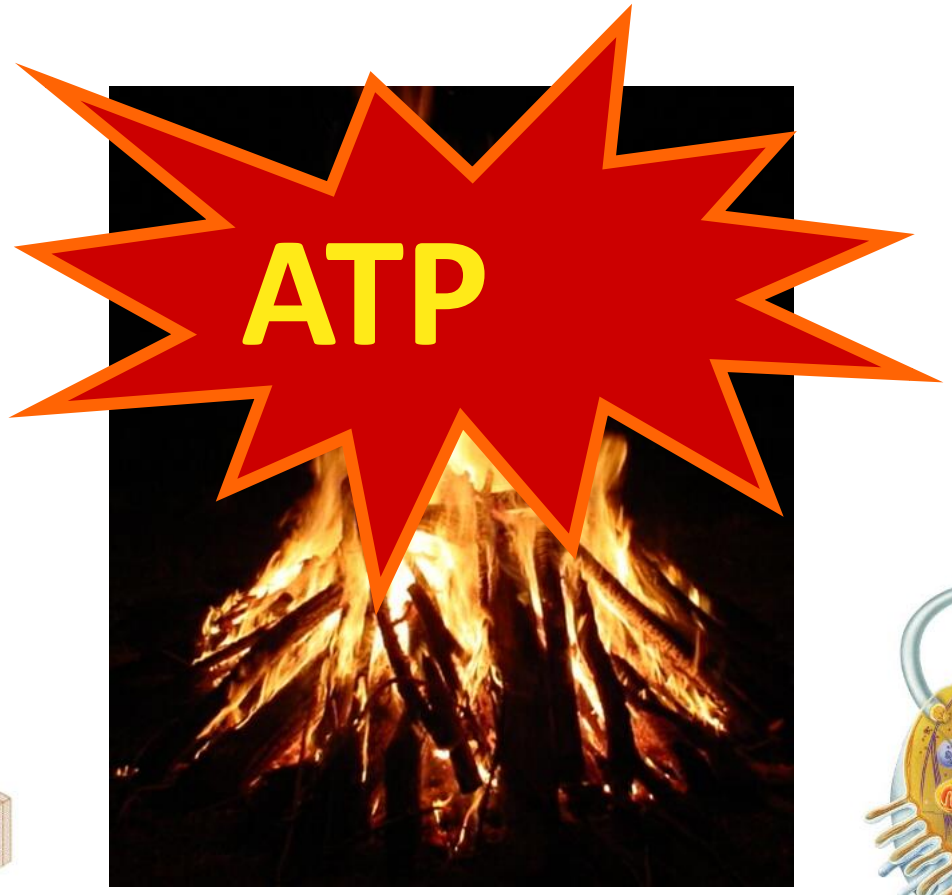
- What jobs do cells have to do?
  - make proteins
    - proteins control every cell function
  - make energy
    - for daily life
    - for growth
  - make more cells
    - growth
    - repair
    - renewal

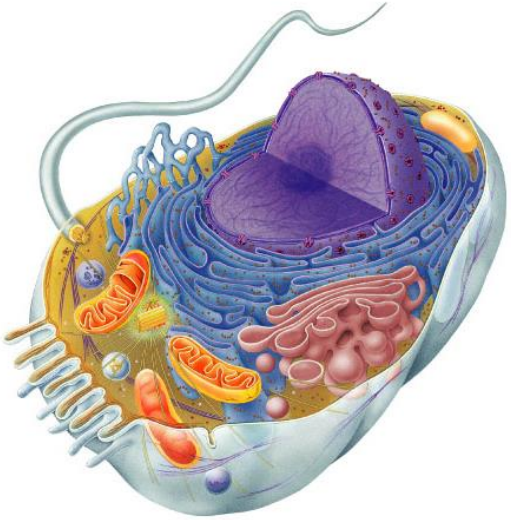




Making Energy

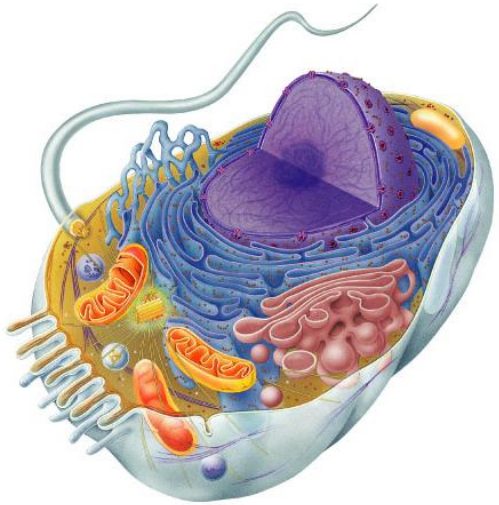


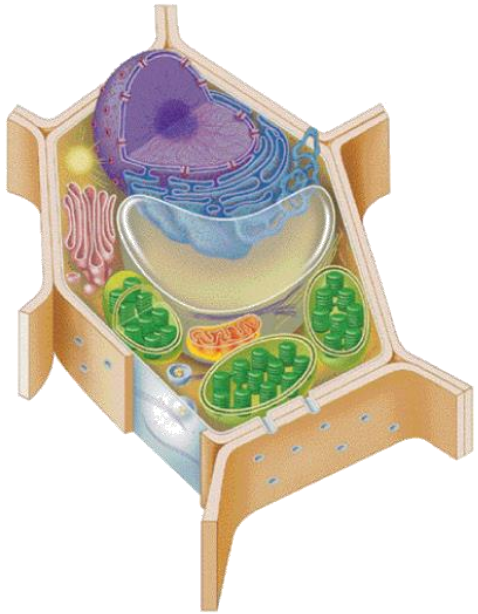




Cells need power!

- How cells make energy
  - take in food & digest it
  - take in oxygen (O_2)
  - make ATP
  - remove waste



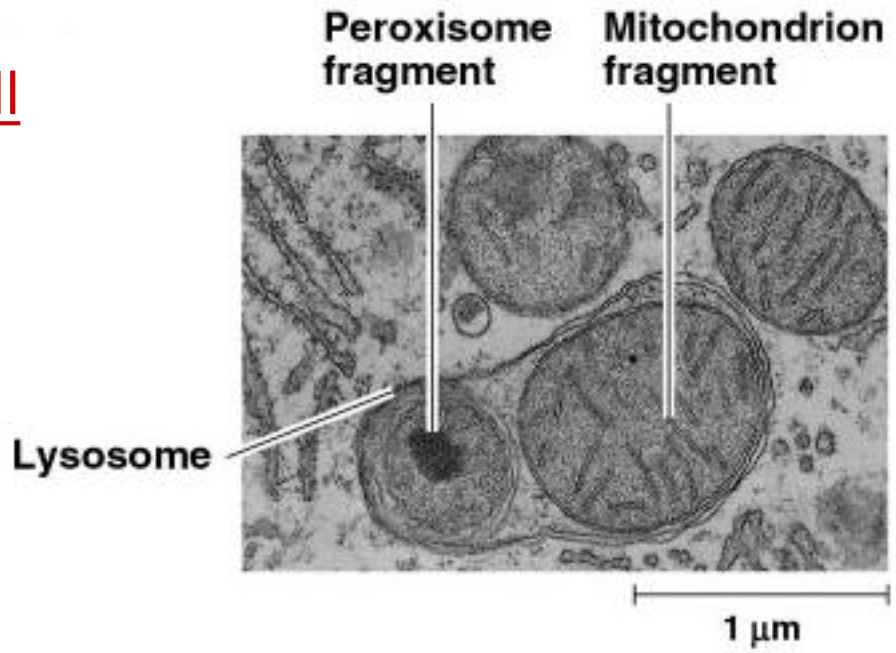


Lysosomes

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

- Function
  - little “stomach” of the cell
    - digests macromolecules
  - “clean up crew” of the cell
    - cleans up broken down organelles

only in animal cells



(b) A lysosome in action

Digging Deep: Lysosomal enzymes

- Lysosomal enzymes work best at pH 5
  - organelle creates custom pH
  - how?
    - proteins in lysosomal membrane pump H^+ ions from the cytosol into lysosome
  - why?
    - enzymes are very sensitive to pH
  - why?
    - enzymes are proteins — pH affects structure
  - why evolve digestive enzymes which function at pH different from cytosol?
    - digestive enzymes won't function well if some leak into cytosol = don't want to digest yourself!

When things go bad…

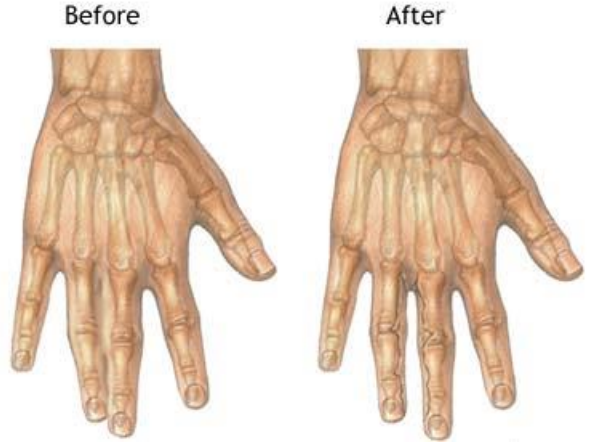
- Diseases of lysosomes are often fatal
  - digestive enzyme not working in lysosome
  - picks up biomolecules, but can't digest one
    - lysosomes fill up with undigested material
  - grow larger & larger until disrupts cell & organ function
    - lysosomal storage diseases
      - more than 40 known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

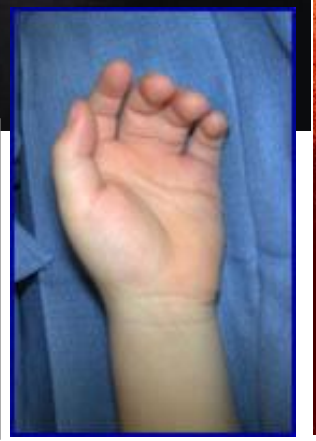
But sometimes cells need to die…

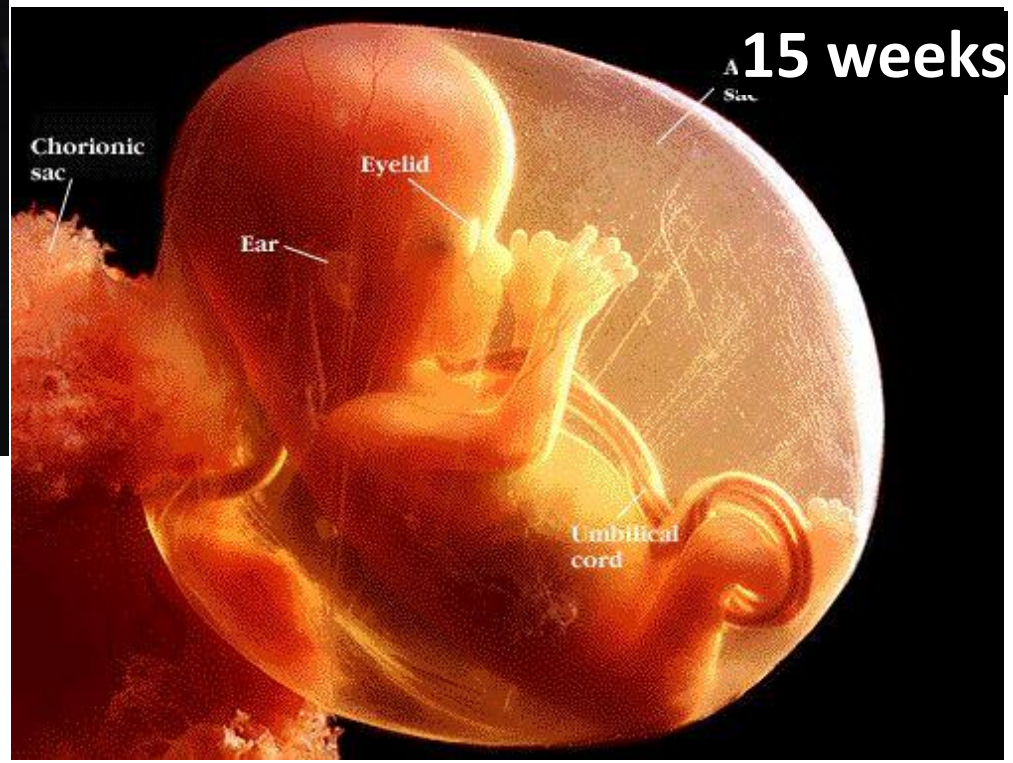
- Lysosomes can be used to kill cells when they are supposed to be destroyed
  - some cells have to die for proper development in an organism
    - **Apoptosis-** programmed cell death
      - "auto-destruct" process
      - lysosomes break open & kill cell
    - ex: tadpole tail gets re-absorbed when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

Fetal development

syndactyly







Apoptosis

- programmed destruction of cells in multi-cellular organisms
  - programmed development
  - control of cell growth

Defective Implications: Cancer cells have mutated to override this cue in cells and thus enables tumor growth

Learning Targets: 3.3

Knowledge Target: A confident scientist can identify the major organelles responsible for performing photosynthesis and in cellular respiration

Knowledge Target: A confident scientist can list the reactants and products of cellular respiration and photosynthesis

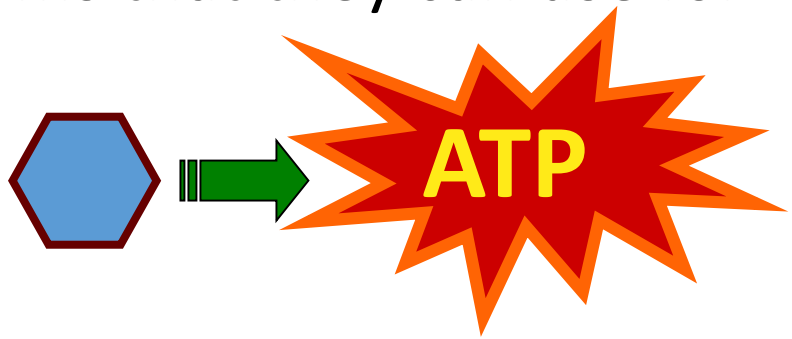
Reason Target: A confident scientist can confidently communicate how photosynthesis and cellular respiration are connected

Skill Target: A confident scientist can identify from reading a passage if a cell is undergoing photosynthesis or cellular respiration

Product Target: A confident scientist can make a flow chart of energy of photosynthesis and cellular respiration

Making Energy

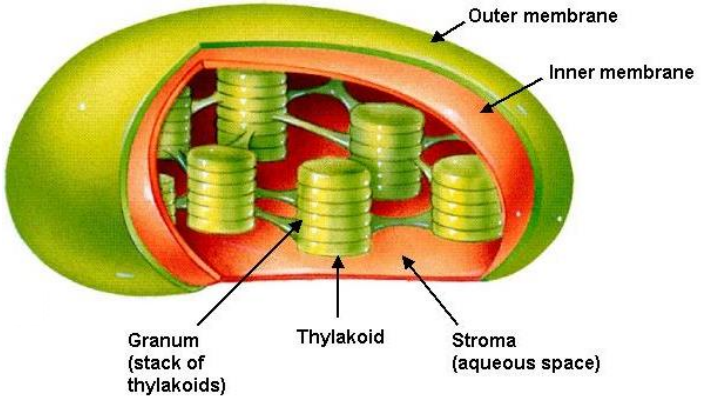
- Cells must convert incoming energy to forms that they can use for work
  - mitochondria:
    from glucose to ATP
  - chloroplasts:
    from sunlight to ATP & carbohydrates
    - ATP = active energy
    - carbohydrates = stored energy

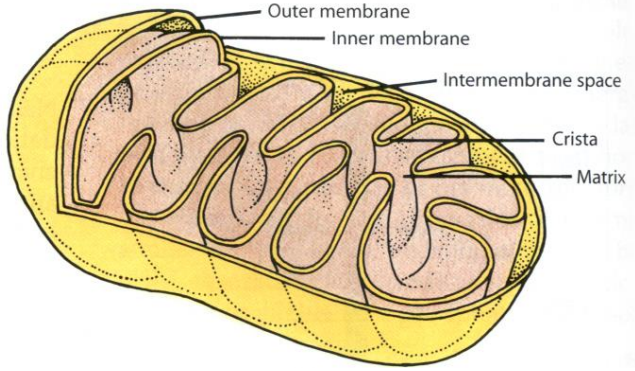


Mitochondria & Chloroplasts

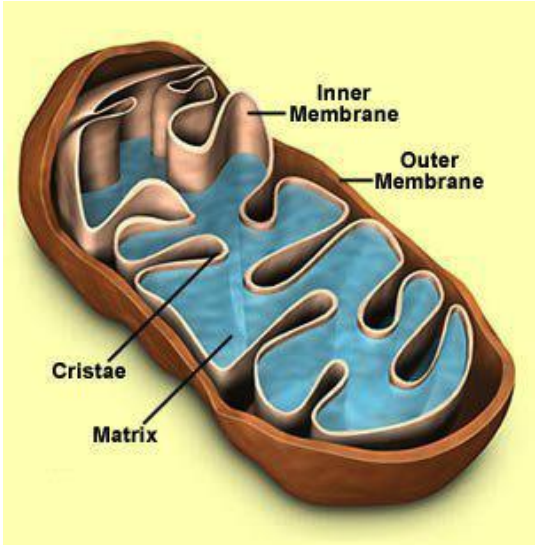
- Very Important to see the similarities
  - Both transform energy and make ATP
  - Both double membranes = 2 membranes
  - Both semi-autonomous organelles
    - move, change shape, divide
  - Both have their own internal ribosomes, DNA & enzymes

More on the last two points later





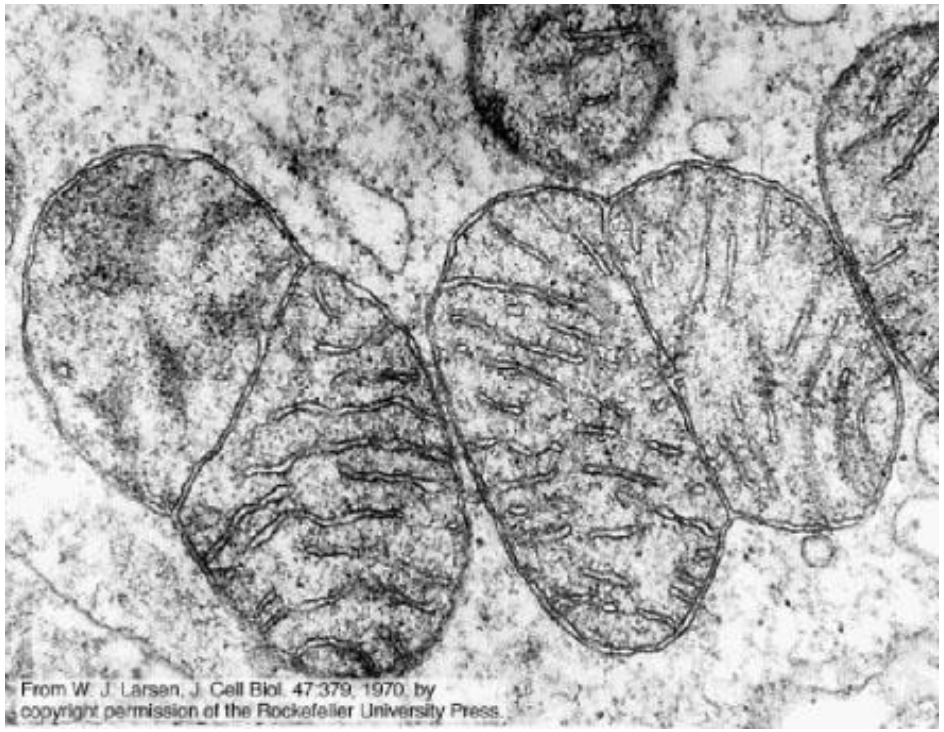
Mitochondria

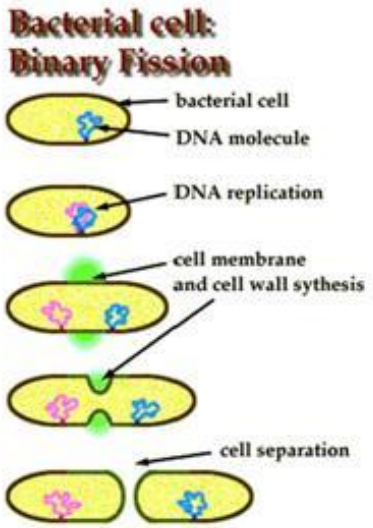


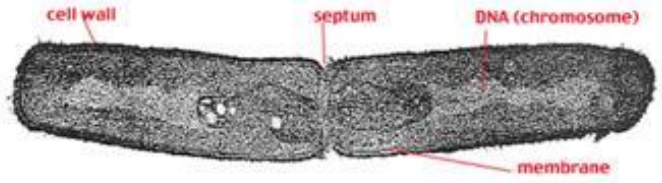
- Function- make energy (ATP)
  - cellular respiration
  - generate ATP
    - from breakdown of sugars, fats & other fuels
    - in the presence of oxygen
      - break down larger molecules into smaller to generate energy = catabolism
      - generate energy in presence of O_2 = aerobic respiration

Mitochondria divide by splitting themselves

Who else divides like that?







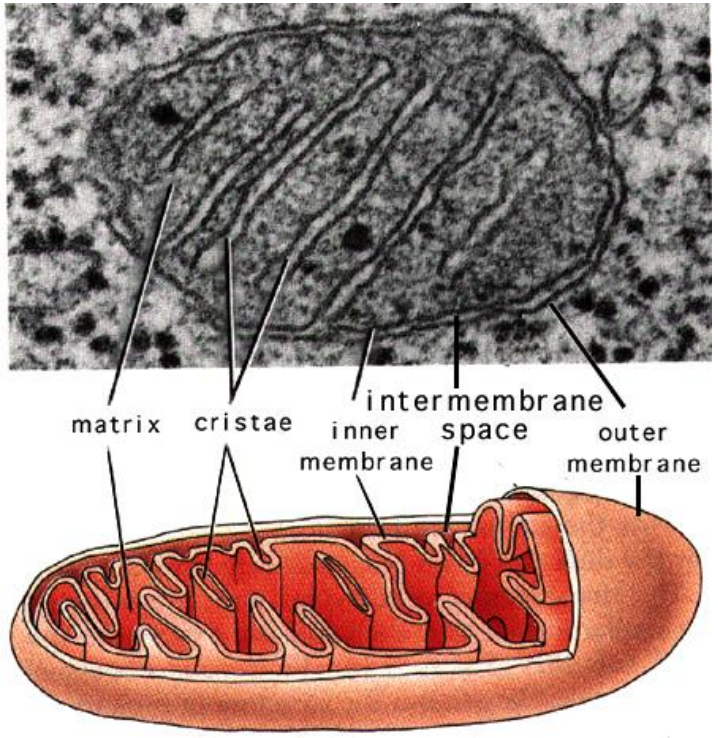
What does this tell us about the evolution of eukaryotes?

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

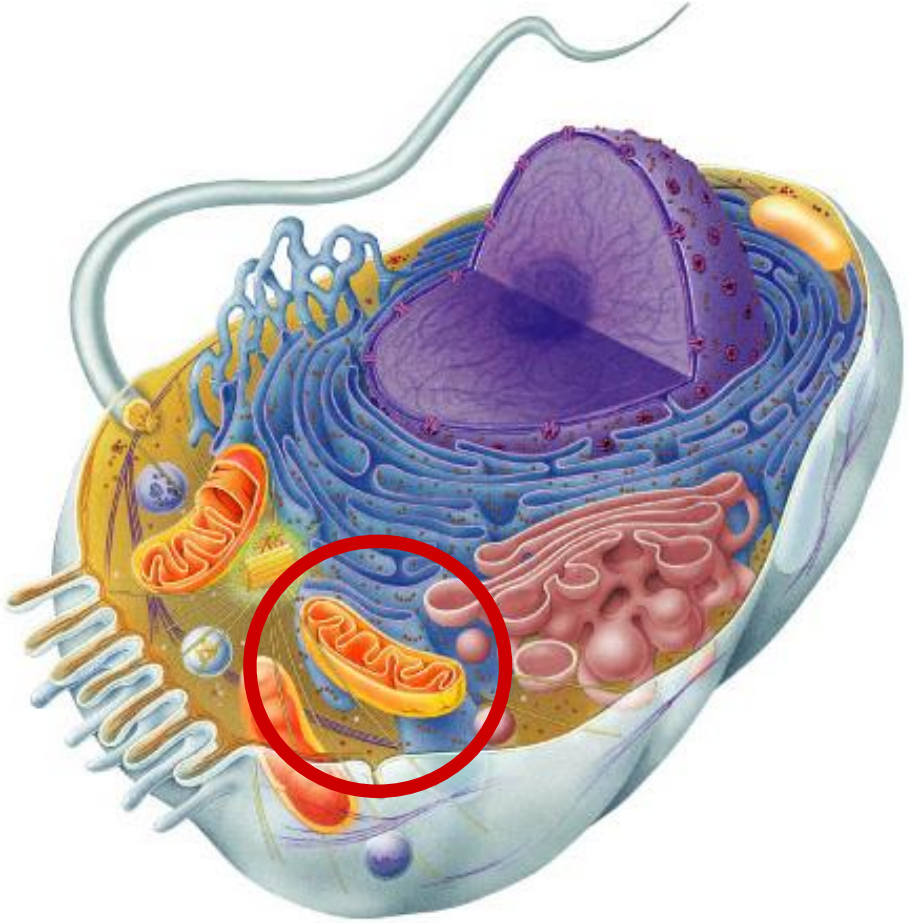
What cells would have a lot of mitochondria?

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

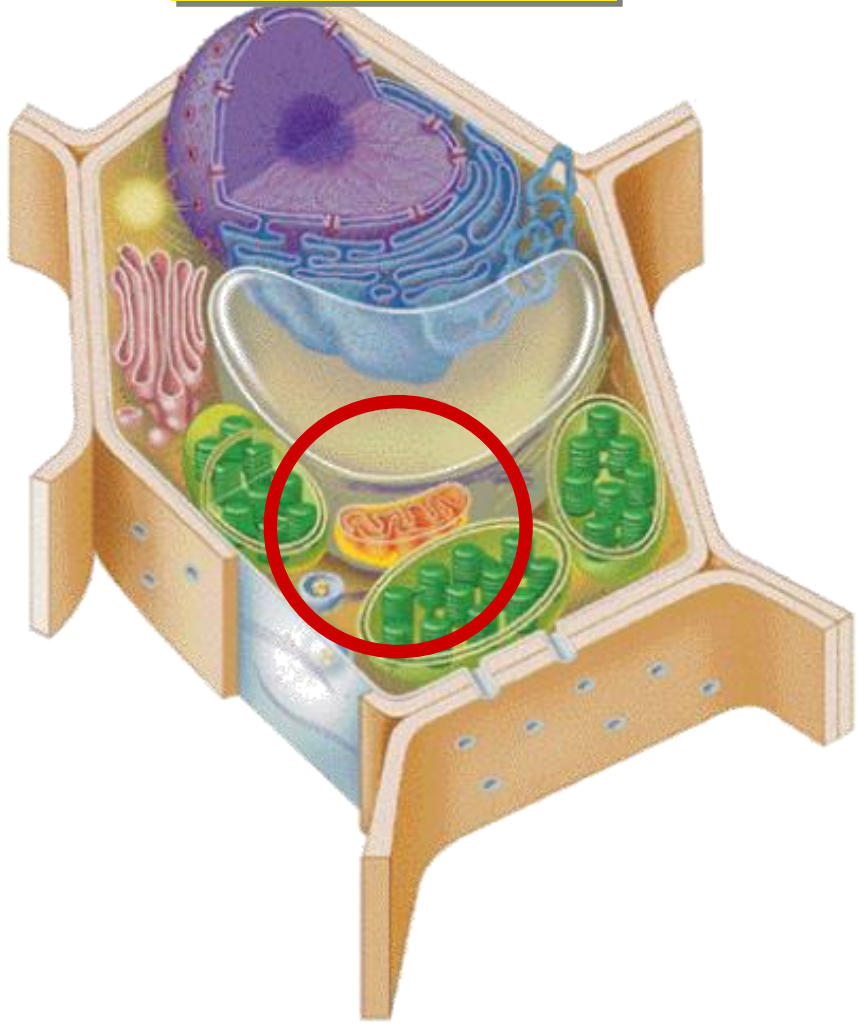


Mitochondria are everywhere!!

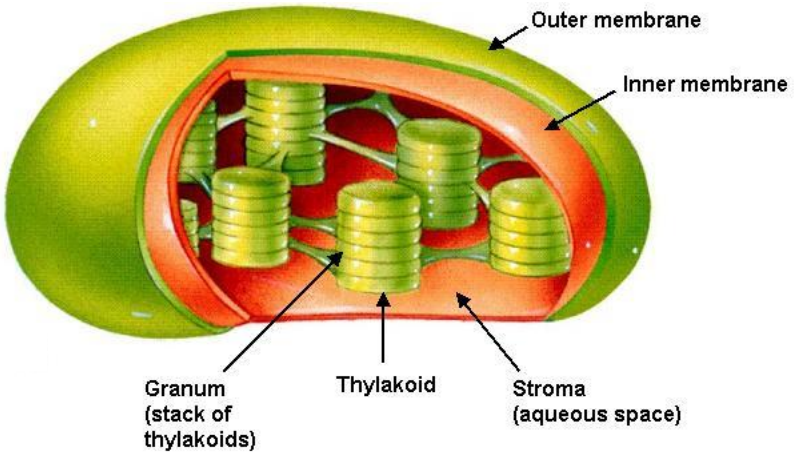
animal cells



plant cells



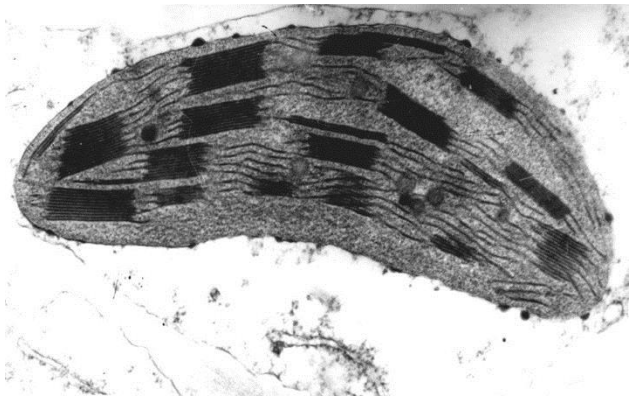
Chloroplasts-Plant Organelles



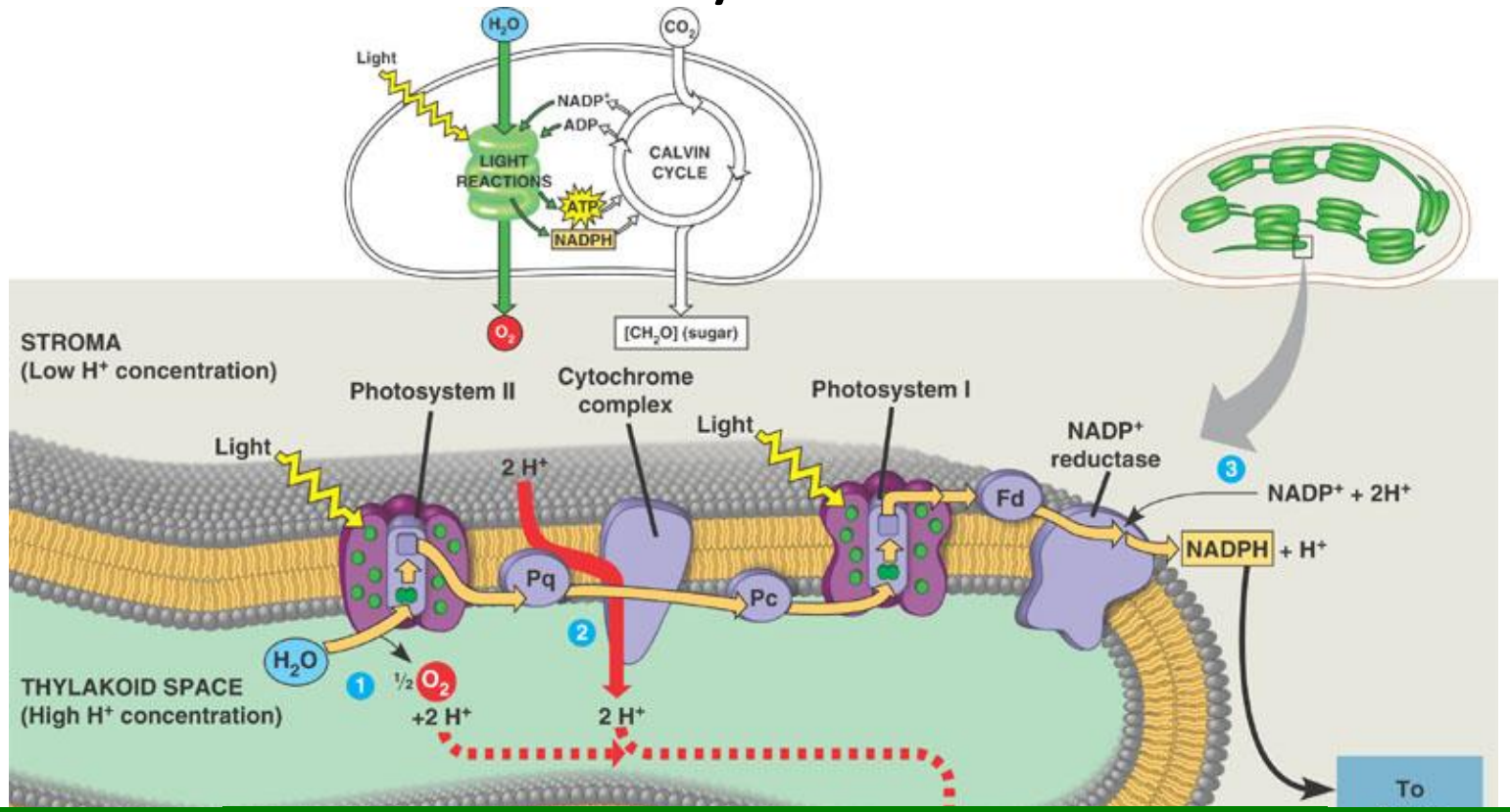
- Structure
  - 2 membranes
  - stroma = internal fluid-filled space
    - DNA, ribosomes & enzymes
    - thylakoids = membranous sacs where ATP is made
    - grana = stacks of thylakoids

Why internal sac membranes?

increase surface area for membrane-bound enzymes that synthesize ATP



Membrane-bound Enzymes

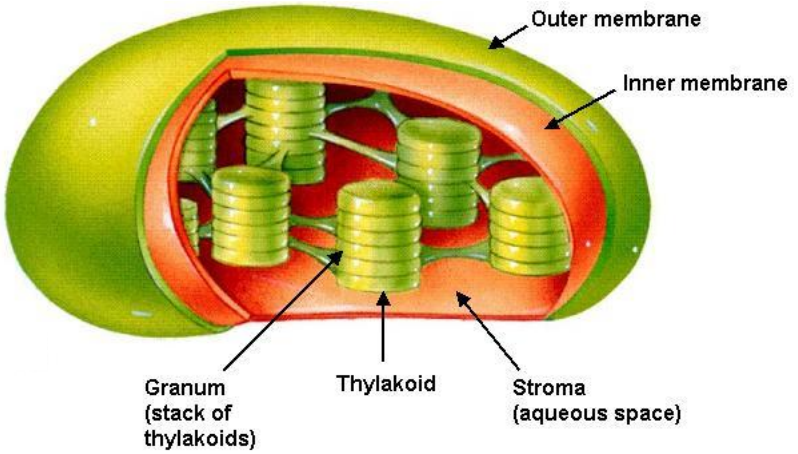


carbon dioxide + water + energy → glucose + oxygen

$6CO_2$ + $6H_2O$ + light energy → $C_6H_{12}O_6$ + $6O_2$

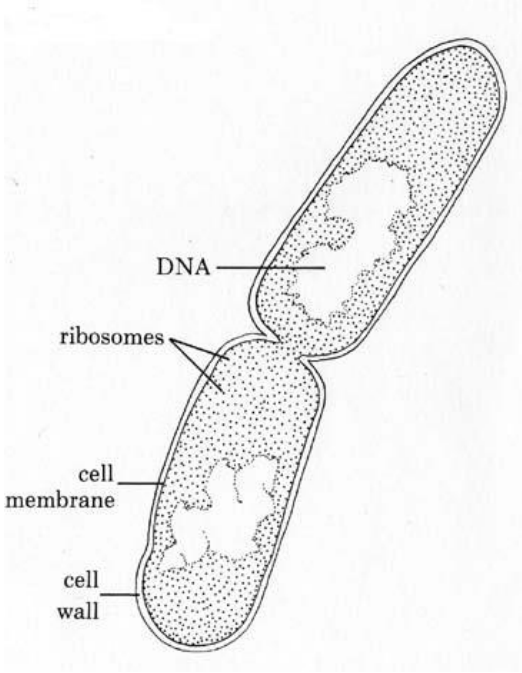
Chloroplasts

- Function- generate Glucose and ATP
  - photosynthesis
  - generate ATP & synthesize sugars
    - transform solar energy into chemical energy
    - produce sugars from CO_2 & H_2O
- Semi-autonomous
    - moving, changing shape & dividing
    - can reproduce by pinching in two



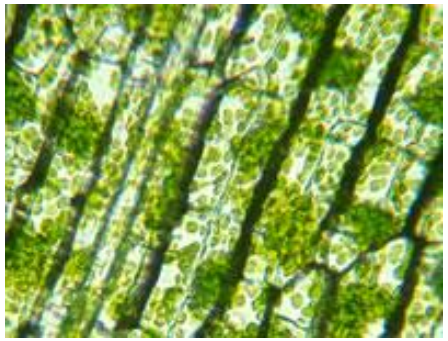
Who else divides like that?

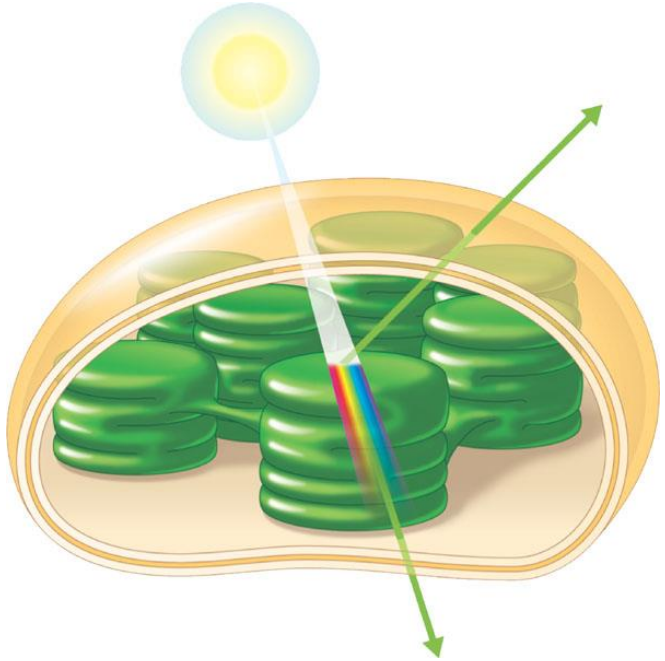
bacteria!

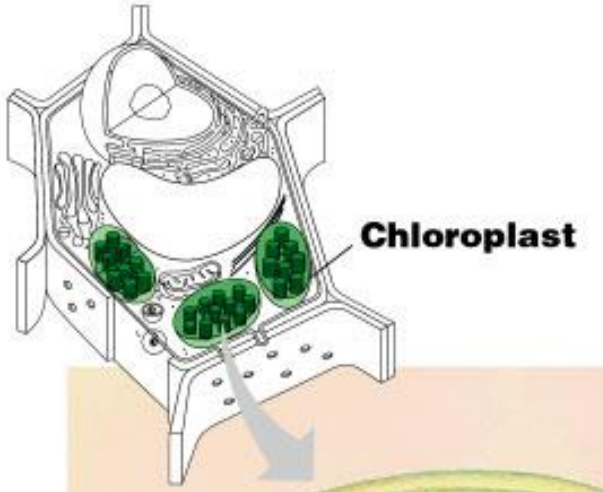


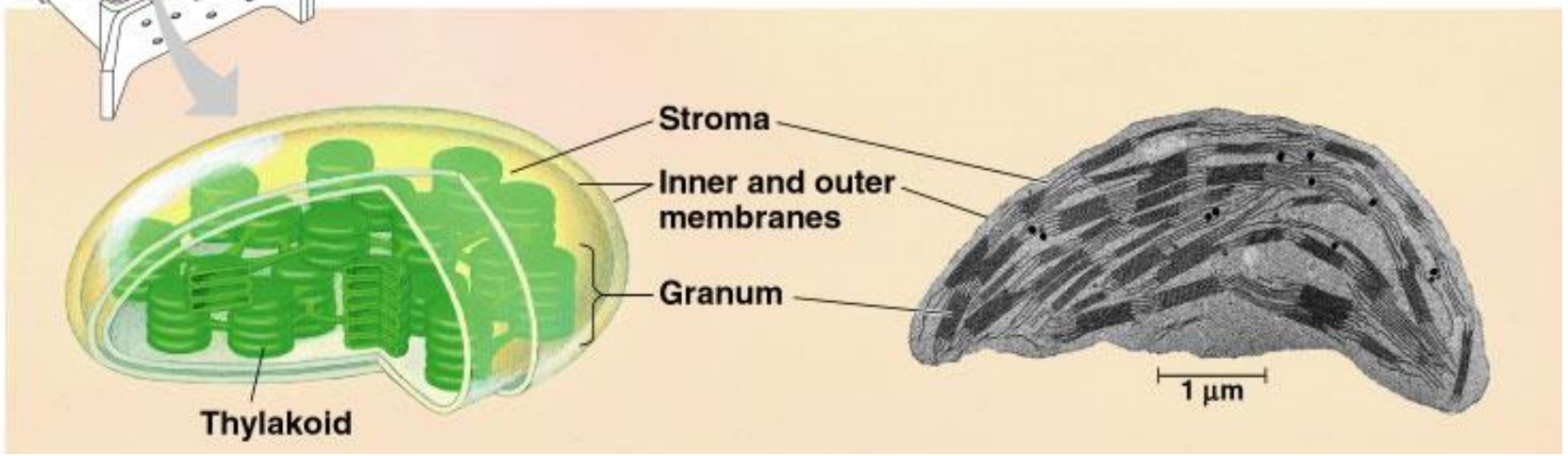
Chloroplasts

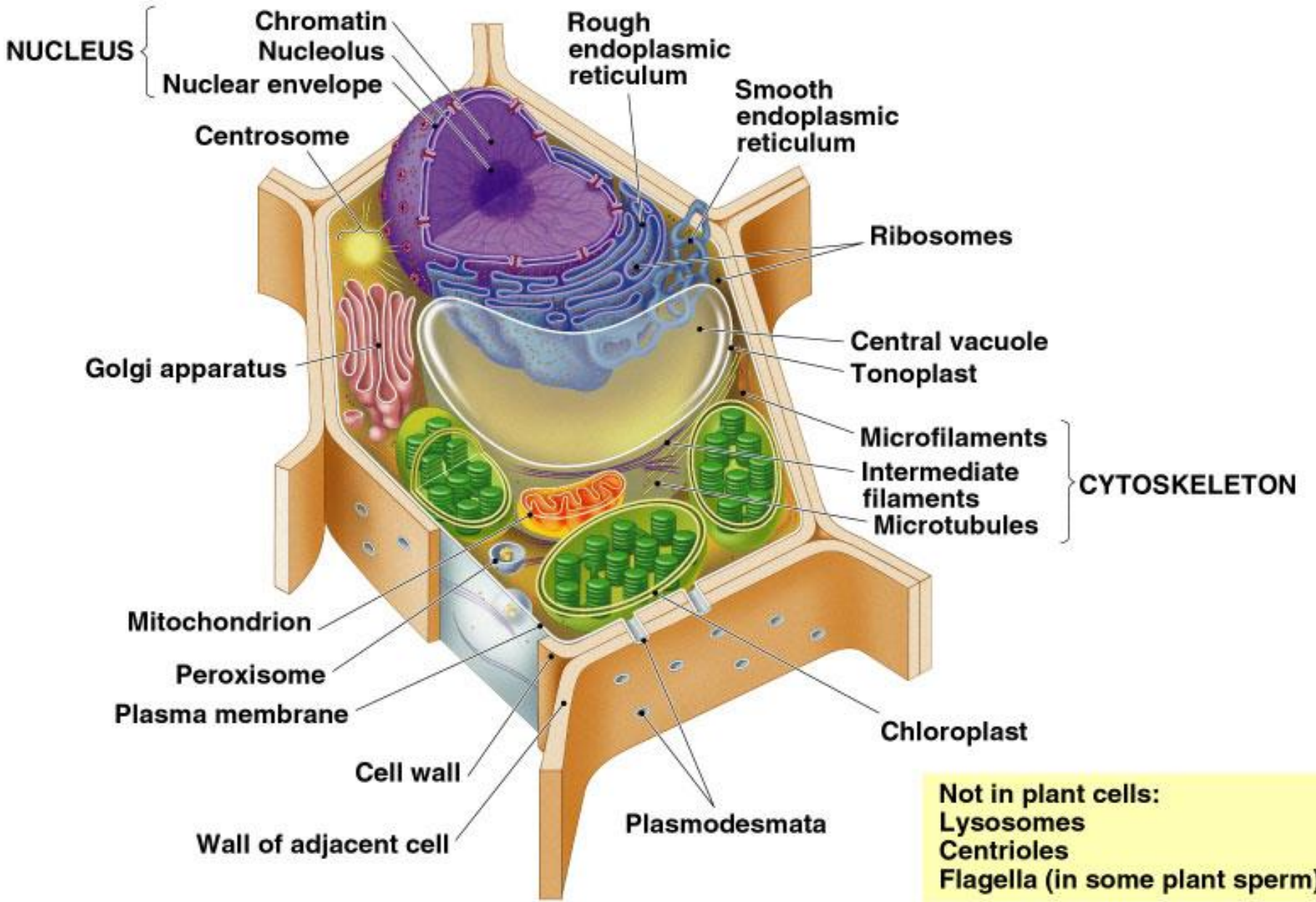
Why are chloroplasts green?









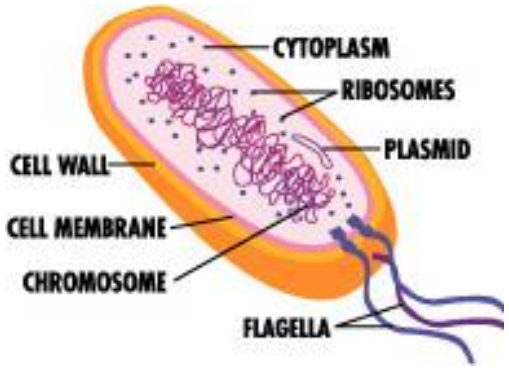

NUCLEUS
Chromatin
Nucleolus
Nuclear envelope
Centrosome
Rough endoplasmic reticulum
Smooth endoplasmic reticulum
Ribosomes
Golgi apparatus
Central vacuole
Tonoplast
Microfilaments
Intermediate filaments
Microtubules
CYTOSKELETON
Mitochondrion
Peroxisome
Plasma membrane
Cell wall
Wall of adjacent cell
Plasmodesmata
Chloroplast
Not in plant cells:
Lysosomes
Centrioles
Flagella (in some plant sperm)

Mitochondria & chloroplasts are different

- Organelles not part of endomembrane system
- Grow & reproduce
  - semi-autonomous organelles
- Proteins primarily from free ribosomes in cytosol & a few from their own ribosomes
- Own circular chromosome
  - directs synthesis of proteins produced by own internal ribosomes
    - ribosomes like bacterial ribosomes

Who else has a circular chromosome not bound within a nucleus?

bacteria



1981 | ??

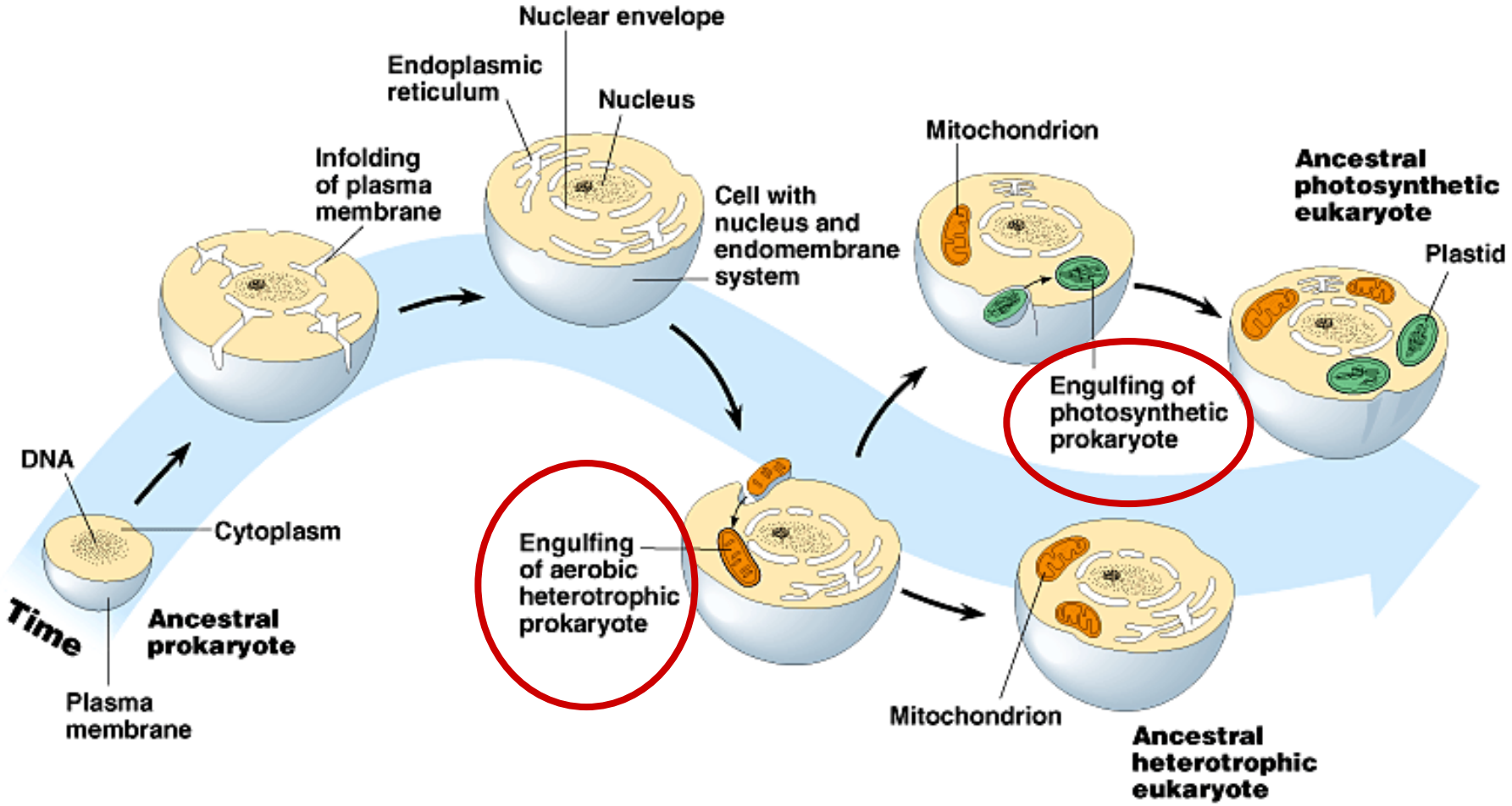
Endosymbiosis theory

- Mitochondria & chloroplasts were once free living bacteria
  - engulfed by ancestral eukaryote
- Endosymbiont
  - cell that lives within another cell (host)
    - as a partnership
    - evolutionary advantage for both
      - one supplies energy
      - the other supplies raw materials & protection

Lynn Margulis
U of M, Amherst

Endosymbiosis theory

Evolution of eukaryotes



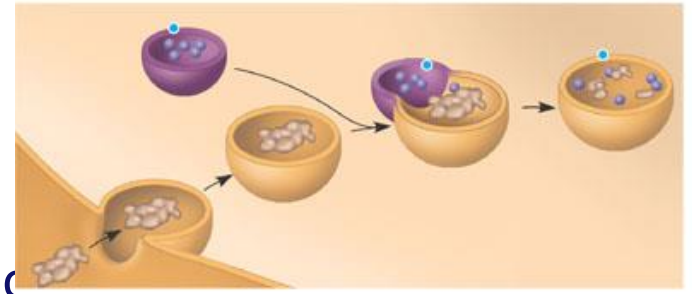
Endosymbiosis theory: Evidence

Evolution of eukaryotes

- New mitochondria are formed through a process similar to how bacteria divide (**e.g. binary fission**)
- If cell's mitochondria or chloroplast are removed, the cell cannot create new ones
- Transport proteins are found on the outer membranes of mitochondria and chloroplast are also found in bacterial cells
- Both mitochondria and plastids contain single circular DNA that is different from that of the cell nucleus and that is similar to that of bacteria (both in their size and structure)
- The genomes, including the specific genes, are basically similar between mitochondria and the Rickettsial bacteria
- Decreased genome sizes show increased dependability

Vacuoles & vesicles

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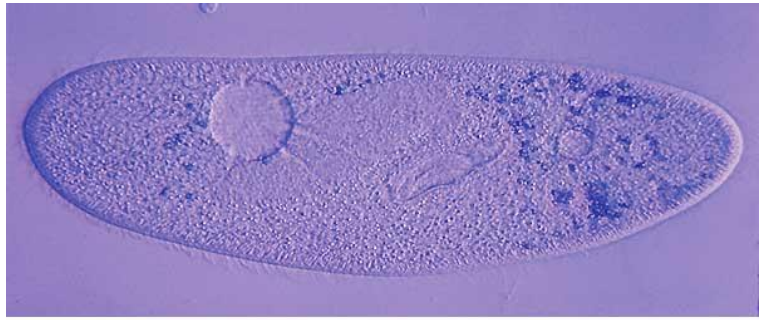
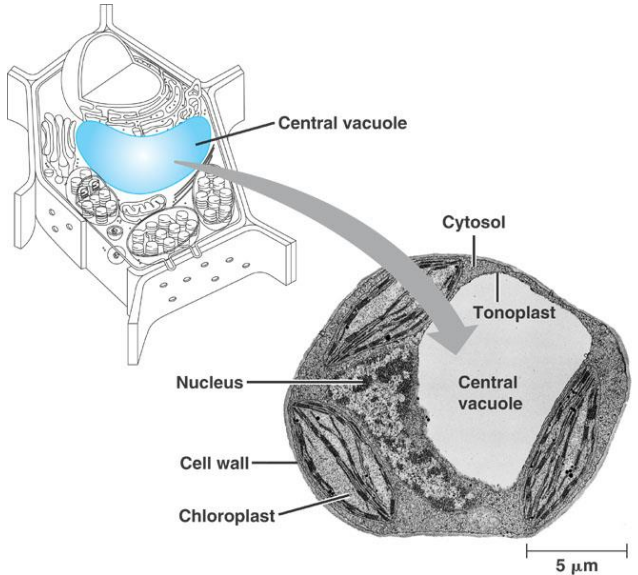
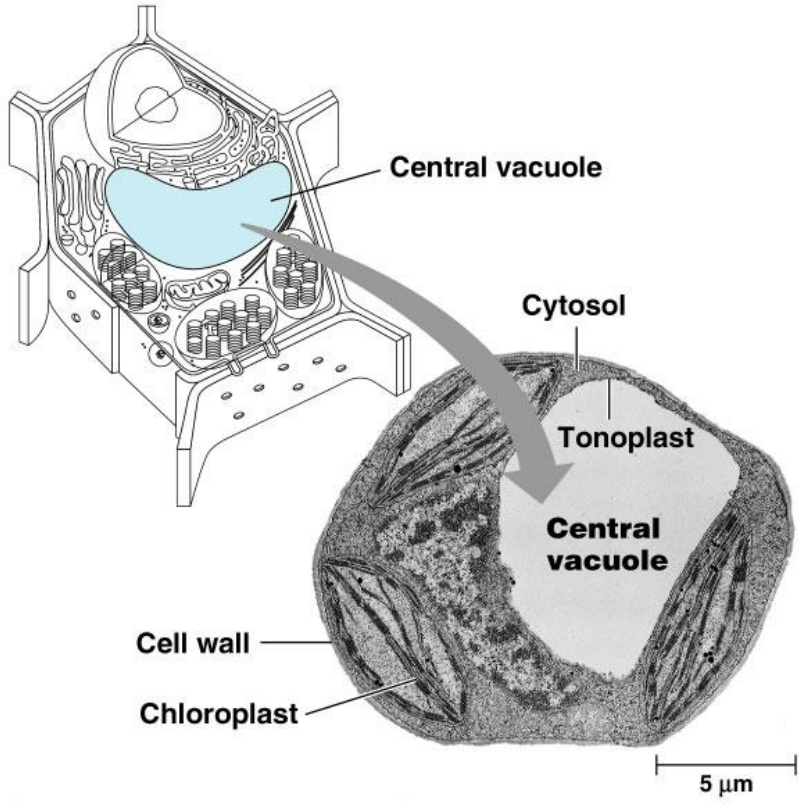


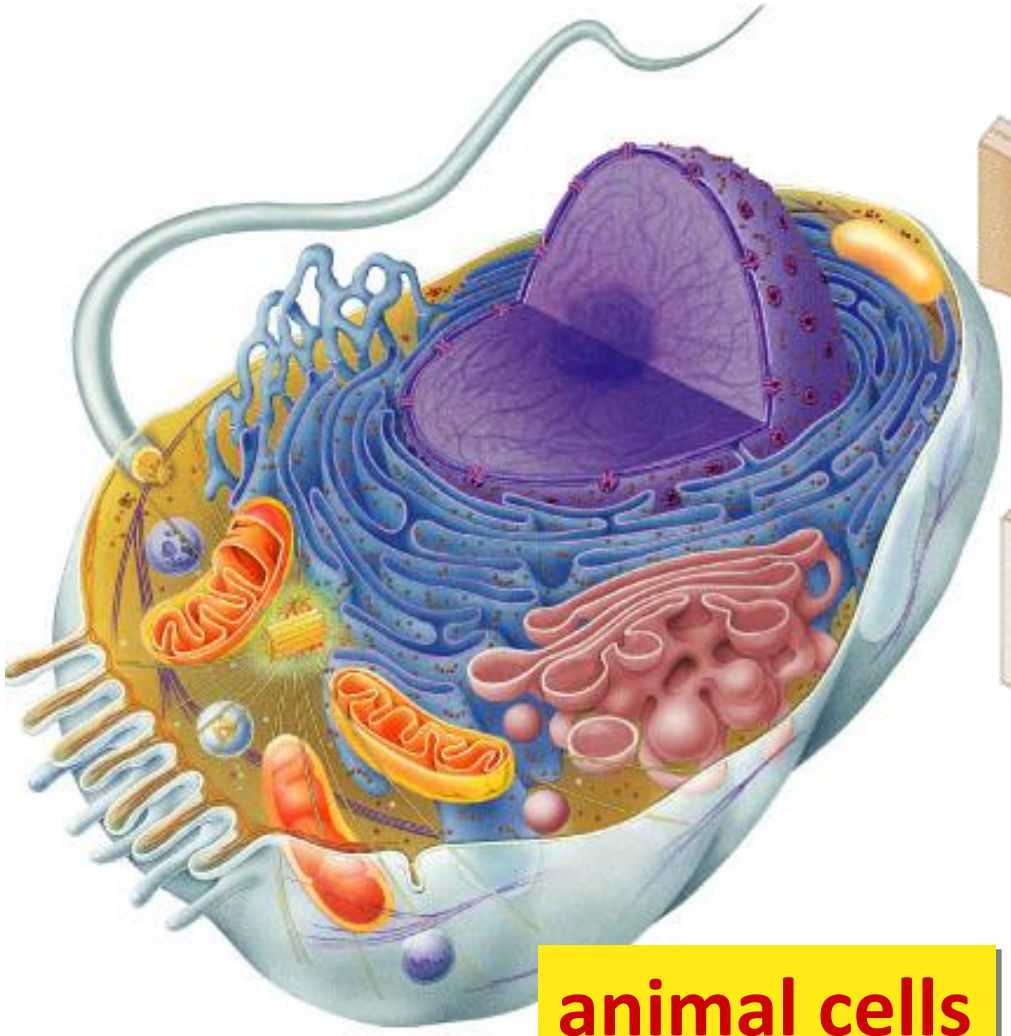


Vacuoles in plants

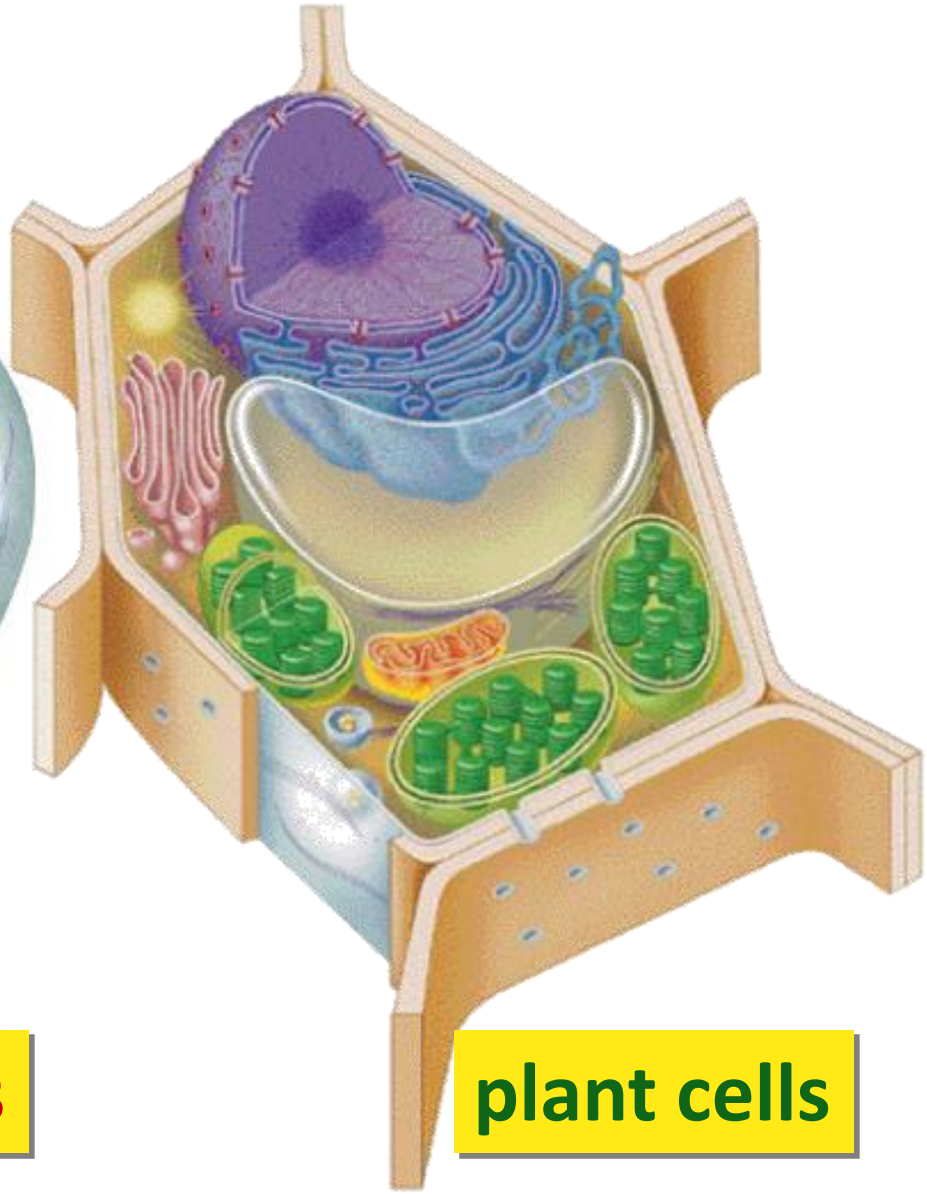
- Functions
  - storage
    - stockpiling proteins or inorganic ions
    - depositing metabolic byproducts
    - storing pigments
    - storing defensive compounds against herbivores
    - selective membrane
      - control what comes in or goes out



Putting it all together



animal cells



plant cells