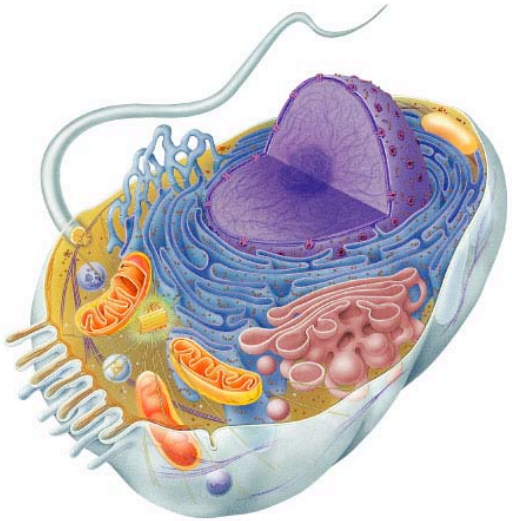
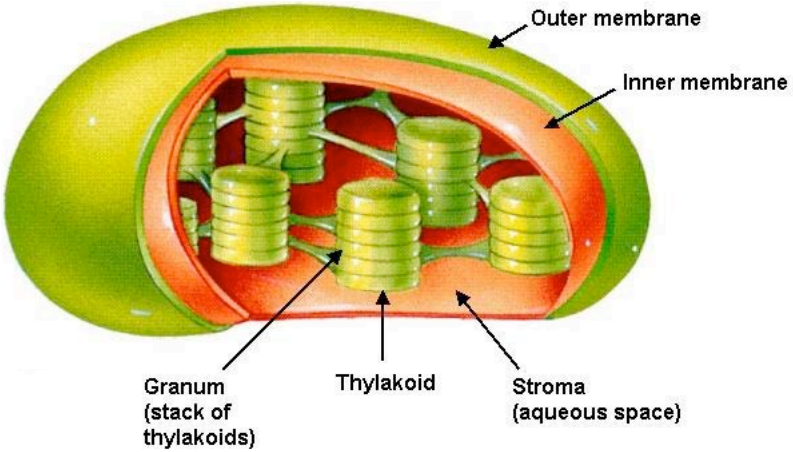
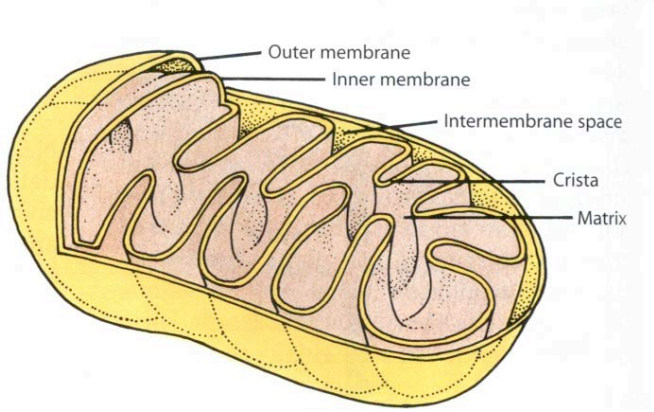
Chapter 7.



The Cell:
Mitochondria & Chloroplasts

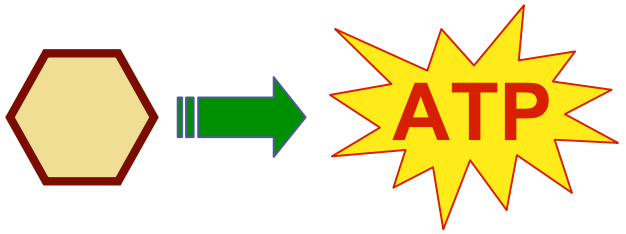




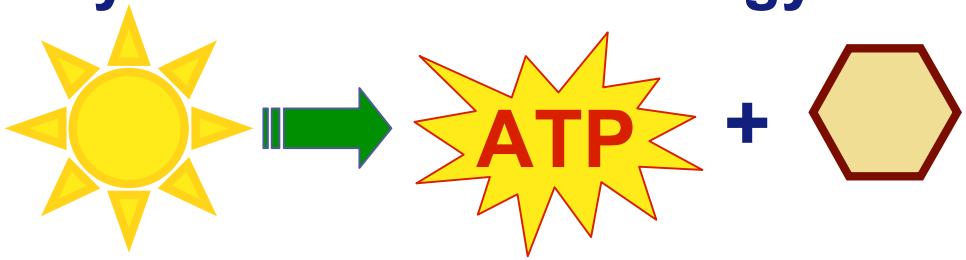
2005-2006

Overview

- **Mitochondria & chloroplasts are the organelles that convert energy to forms that cells can use for work**
  - **mitochondria:**
    from glucose to ATP

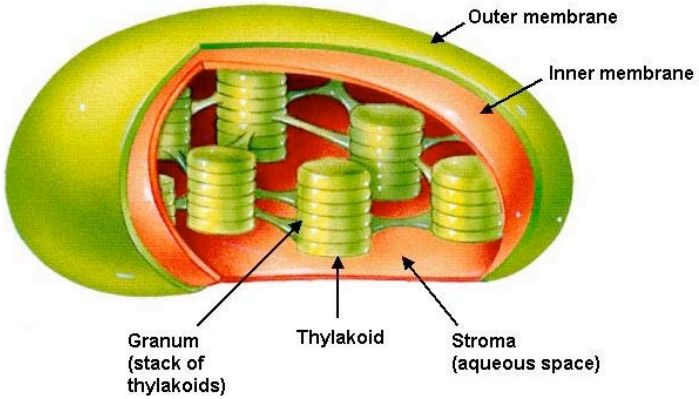


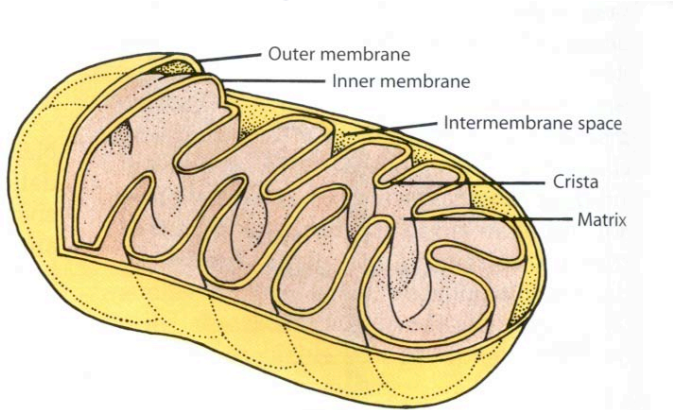
  - **chloroplasts:**
    from sunlight to ATP & carbohydrates
    - **ATP = active energy**
    - **carbohydrates = stored energy**



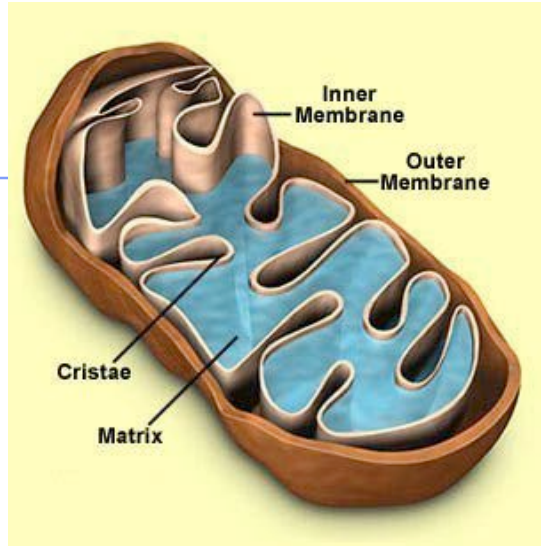
Mitochondria & Chloroplasts

- Important to see the similarities
  - transform energy
    - generate ATP
  - double membranes = 2 membranes
  - semi-autonomous organelles
    - move, change shape, divide
  - internal ribosomes, DNA & enzymes





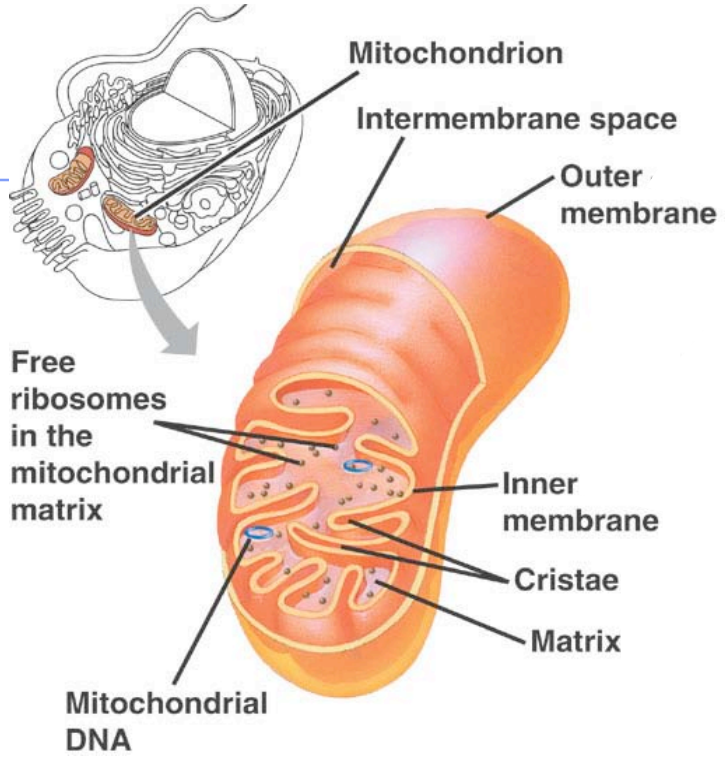
Mitochondria



- **Function**
  - 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

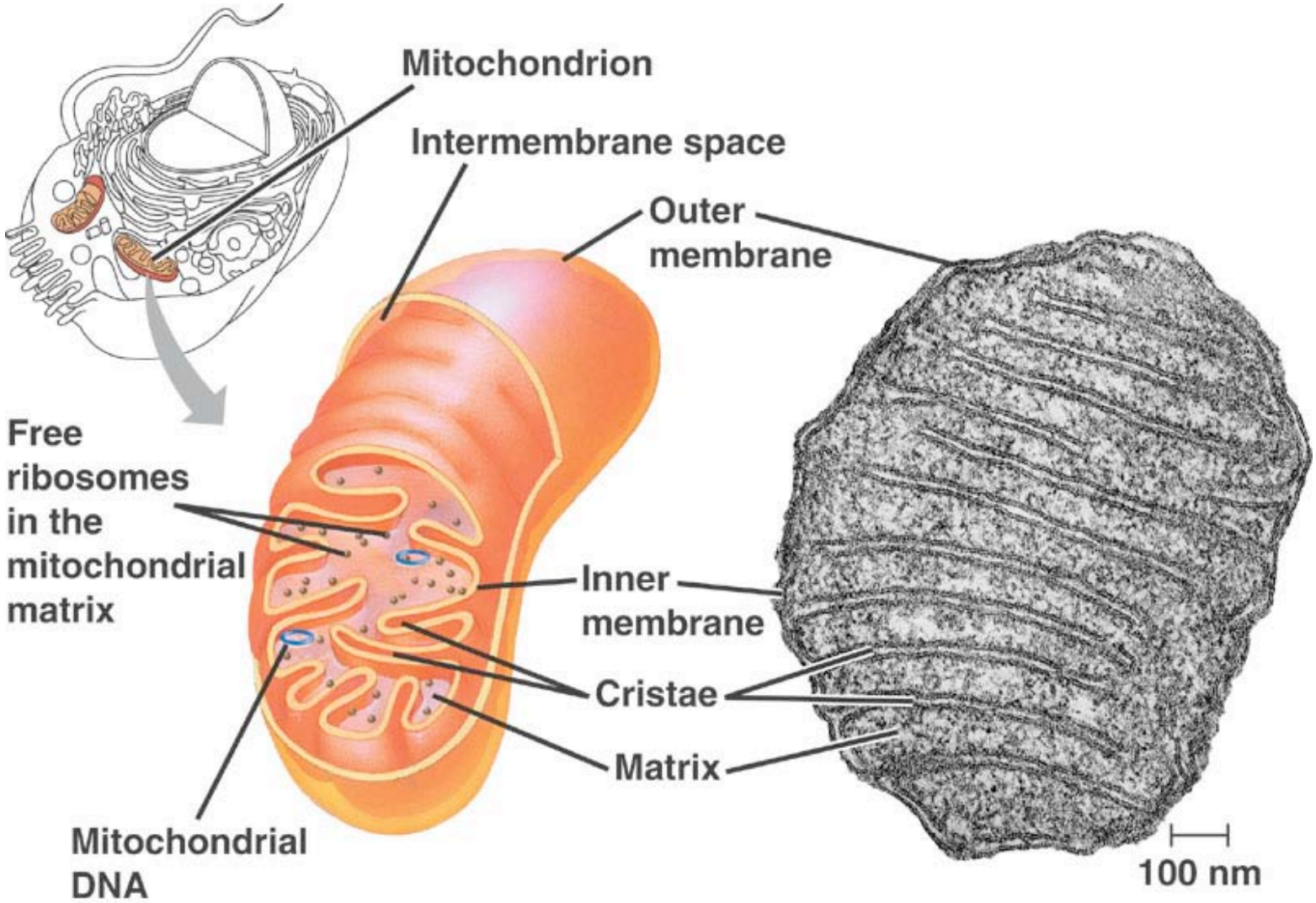
- **Structure**
  - 2 membranes
    - smooth outer membrane
    - highly folded inner membrane
      - the cristae
  - fluid-filled space between 2 membranes
  - internal fluid-filled space
    - mitochondrial matrix
    - DNA, ribosomes & enzymes



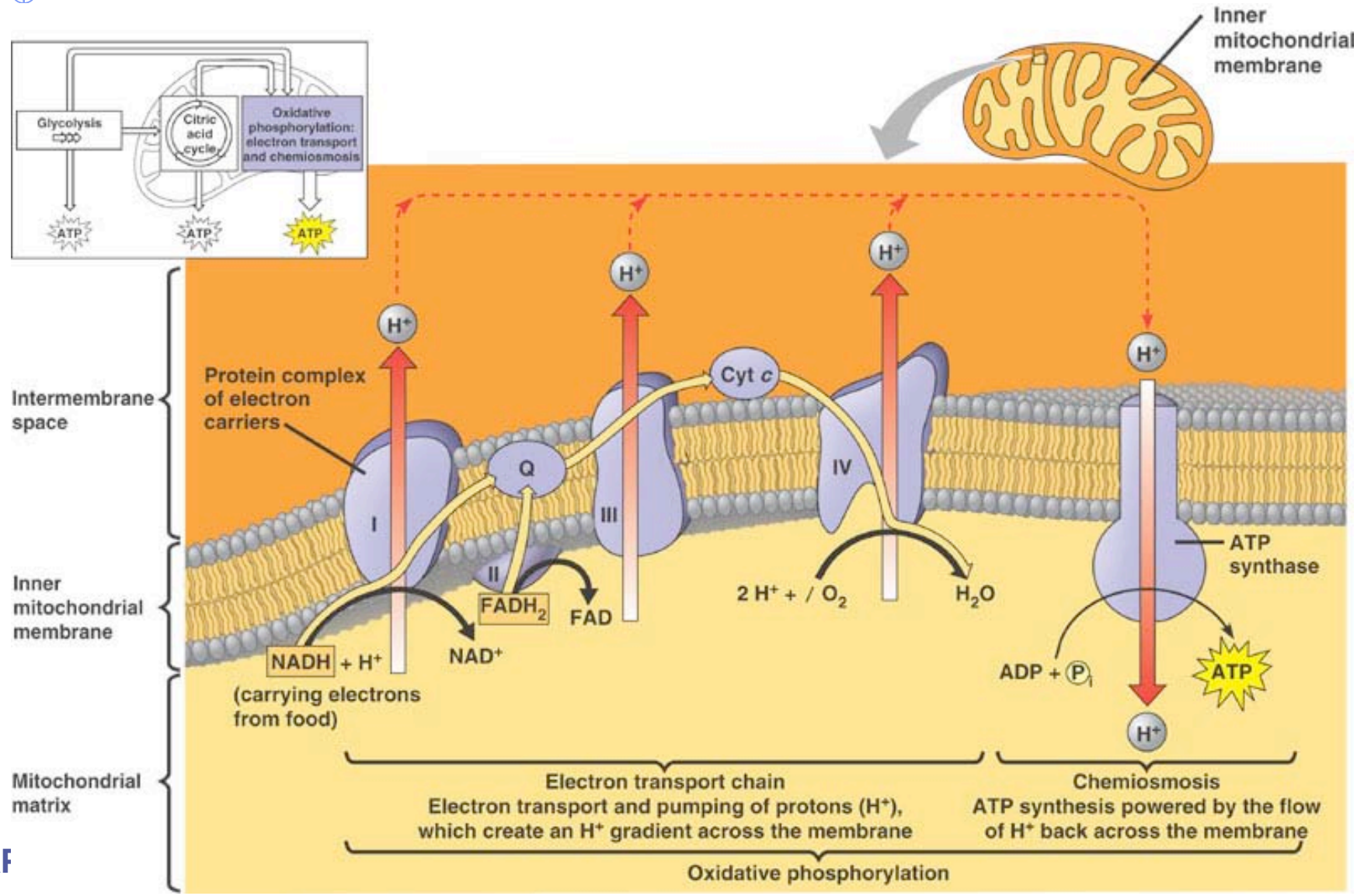
Why 2 membranes?

increase surface area for membrane-bound enzymes that synthesize ATP

Mitochondria

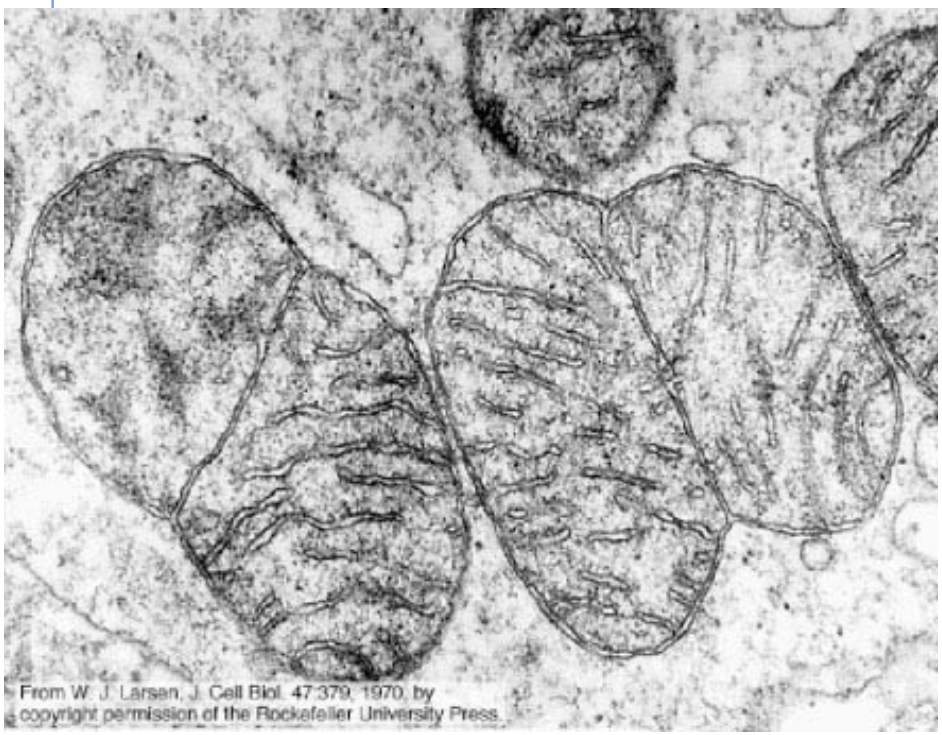


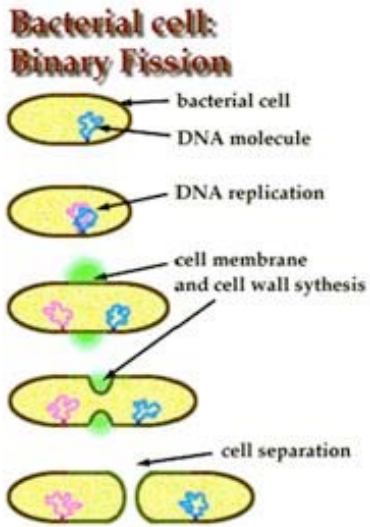
Membrane-bound Enzymes

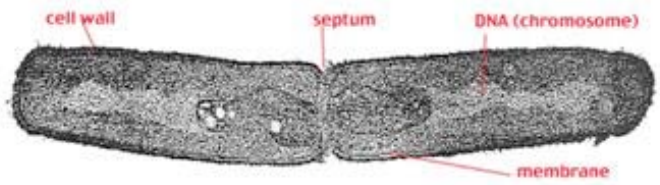


Dividing Mitochondria

Who else divides like that?



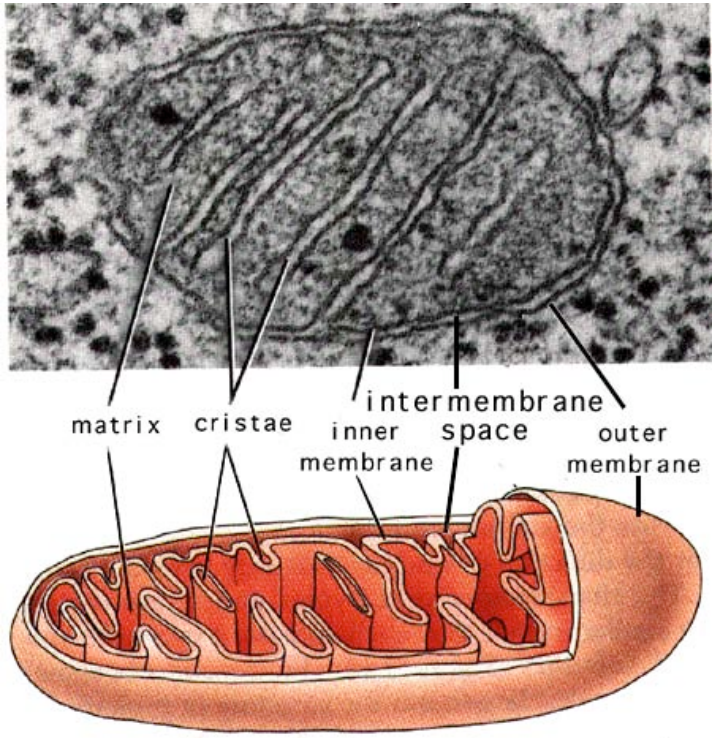




What does this tell us about the evolution of eukaryotes?

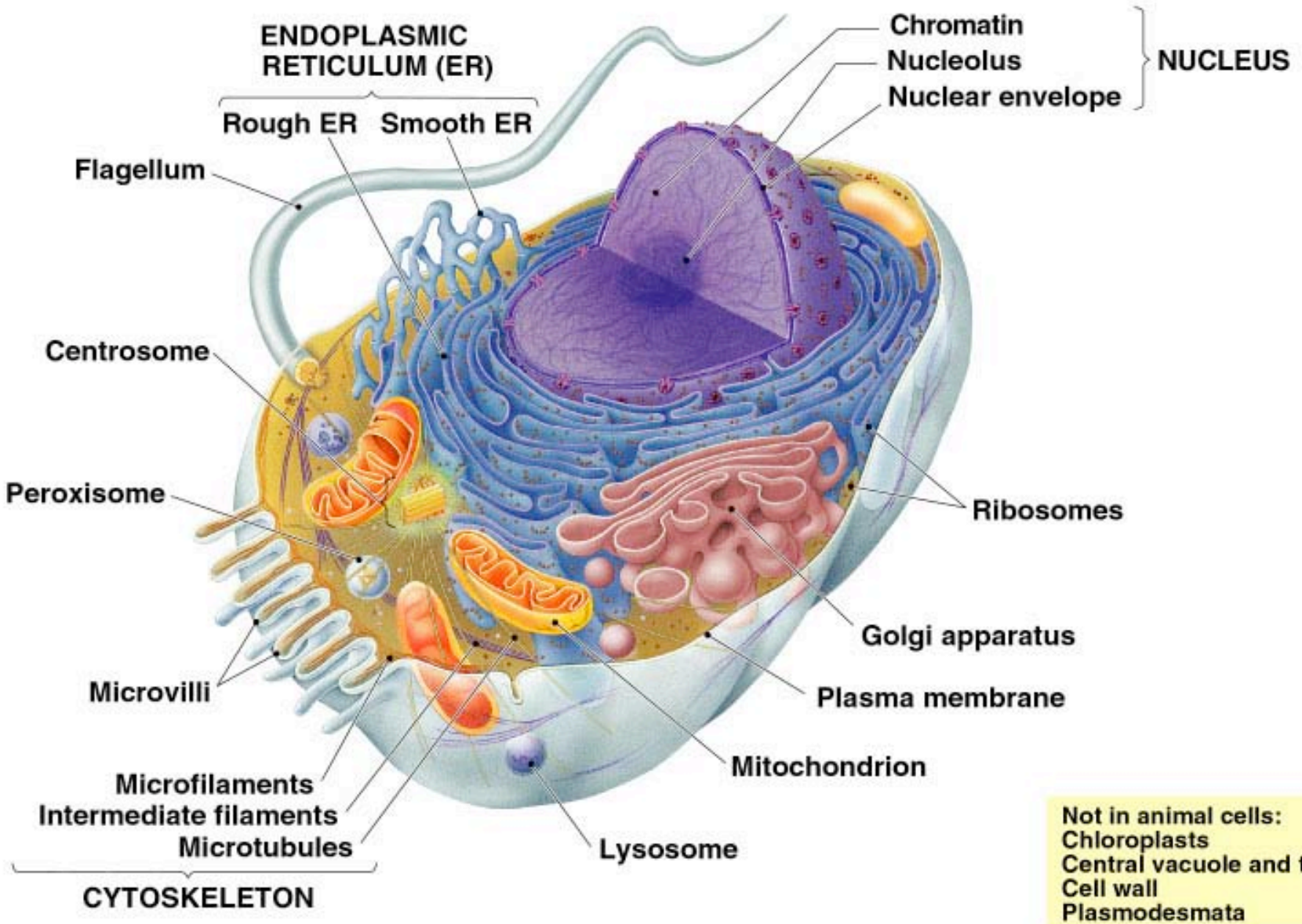
Mitochondria

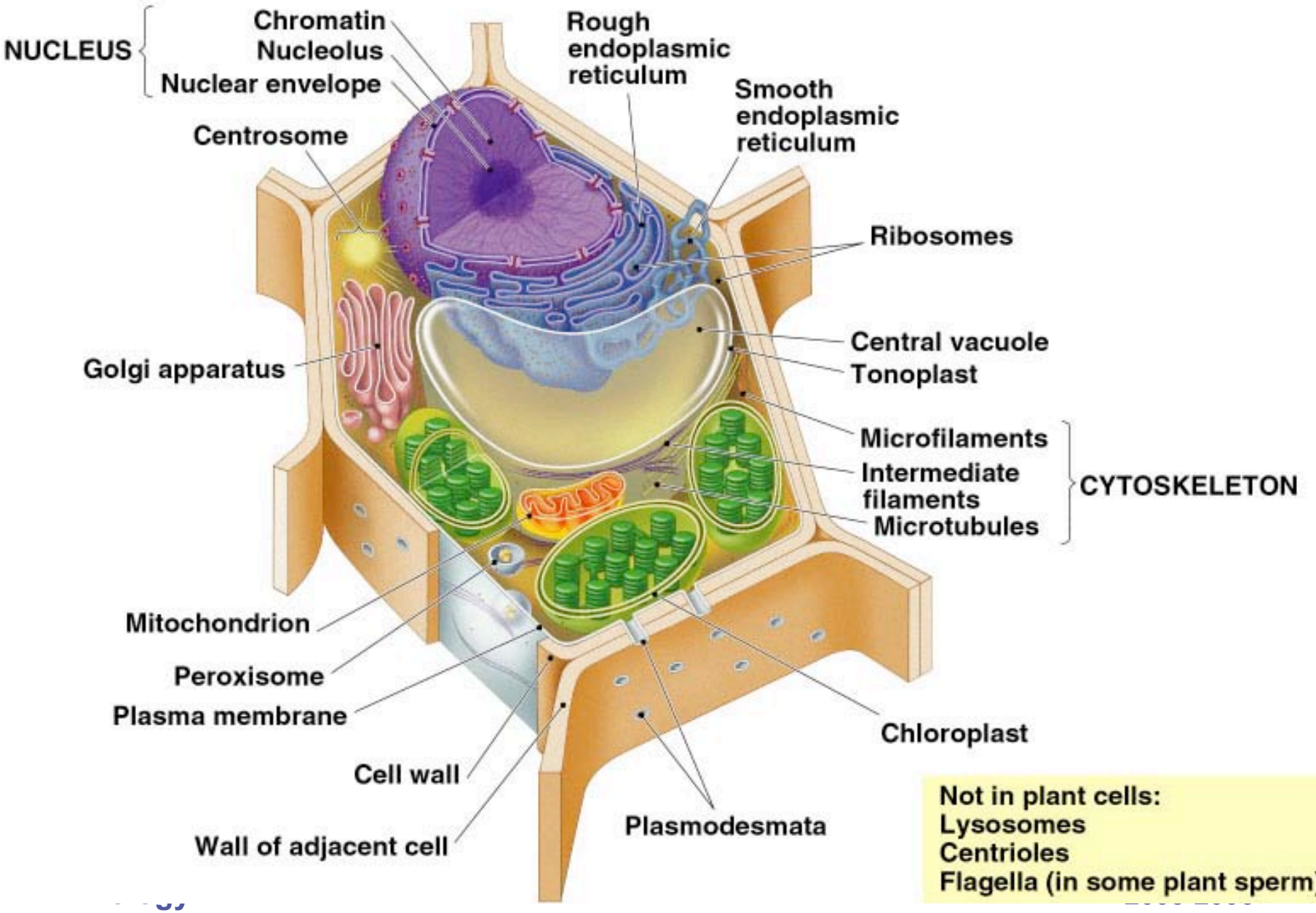
- Almost all eukaryotic cells have mitochondria
  - there may be 1 very large mitochondrion or 100s to 1000s of individual mitochondria
  - number of mitochondria is correlated with aerobic metabolic activity
    - more activity = more energy needed = more mitochondria



What cells would have a lot of mitochondria?

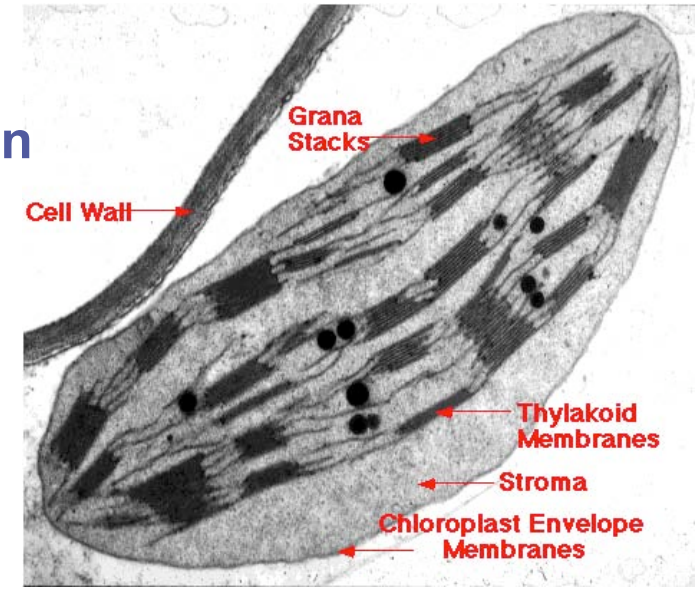
active cells:
- **muscle cells**
- **nerve cells**


ENDOPLASMIC RETICULUM (ER)
Rough ER
Smooth ER
Flagellum
Centrosome
Peroxisome
Microvilli
Microfilaments
Intermediate filaments
Microtubules
CYTOSKELETON
Chromatin
Nucleolus
Nuclear envelope
NUCLEUS
Ribosomes
Golgi apparatus
Plasma membrane
Mitochondrion
Lysosome
Not in animal cells:
Chloroplasts
Central vacuole and tonoplast
Cell wall
Plasmodesmata


NUCLEUS
Chromatin
Nucleolus
Nuclear envelope
Centrosome
Rough endoplasmic reticulum
Smooth endoplasmic reticulum
Ribosomes
Central vacuole
Tonoplast
Golgi apparatus
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)

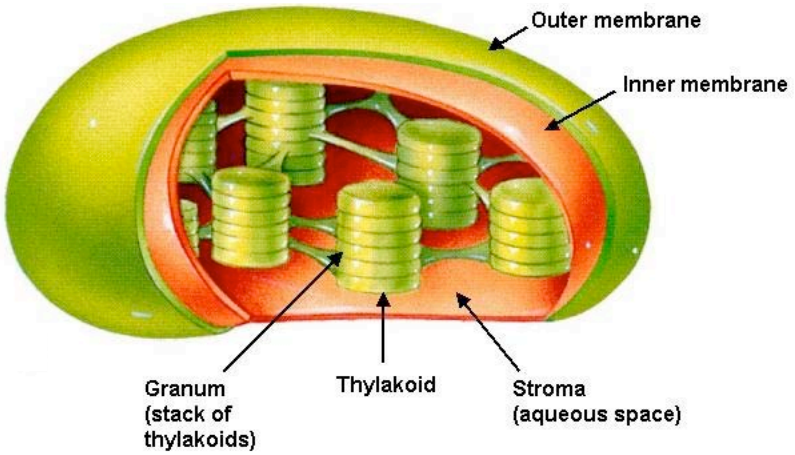
Chloroplasts

- 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



Chloroplasts

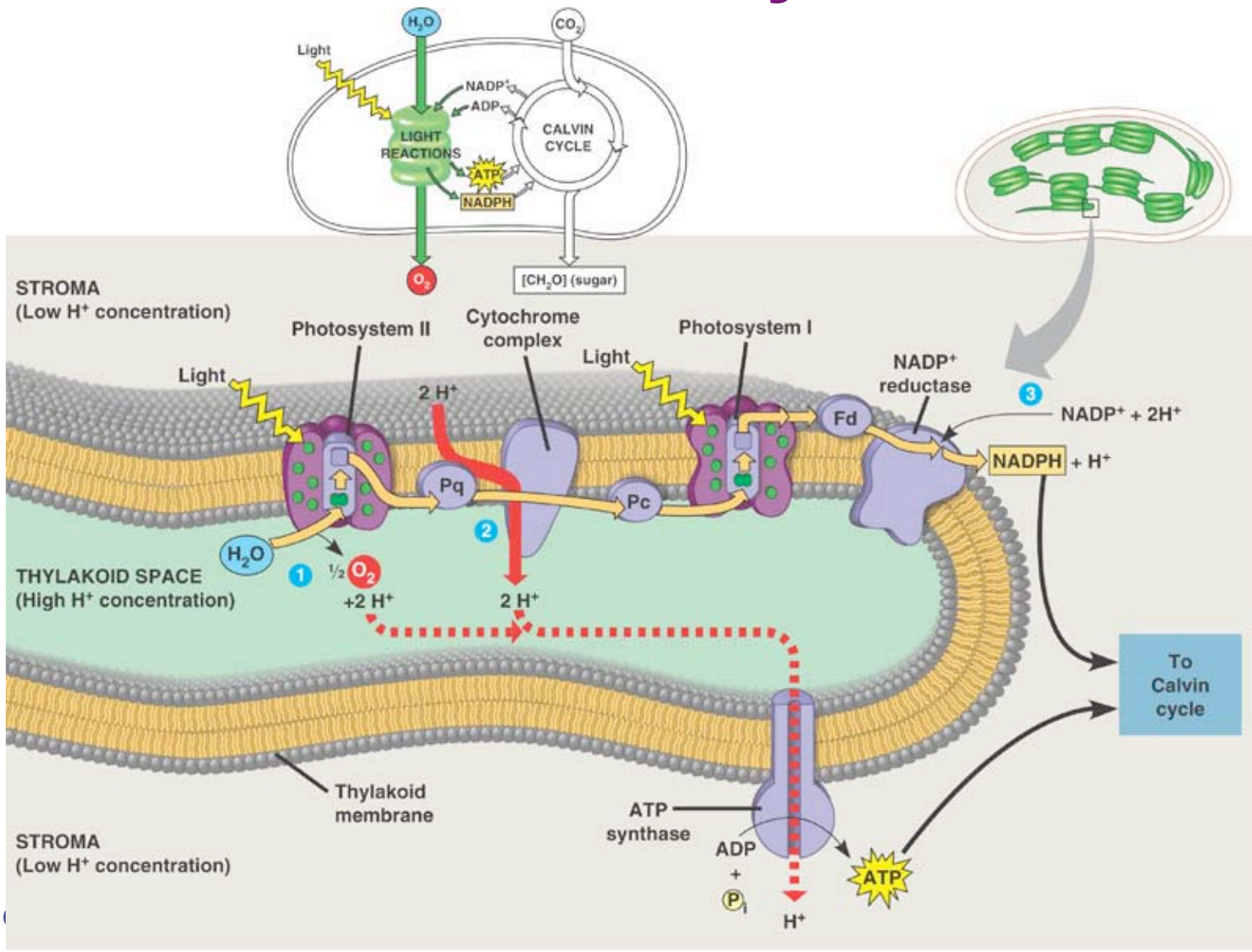
- **Structure**
  - 2 membranes
    - outer membrane
    - inner membrane
  - internal fluid-filled space = stroma
    - DNA, ribosomes & enzymes
    - thylakoids = membranous sacs where ATP is made
    - grana = stacks of thylakoids



Why internal sac membranes?

increase surface area for membrane-bound enzymes that synthesize ATP

Membrane-bound Enzymes

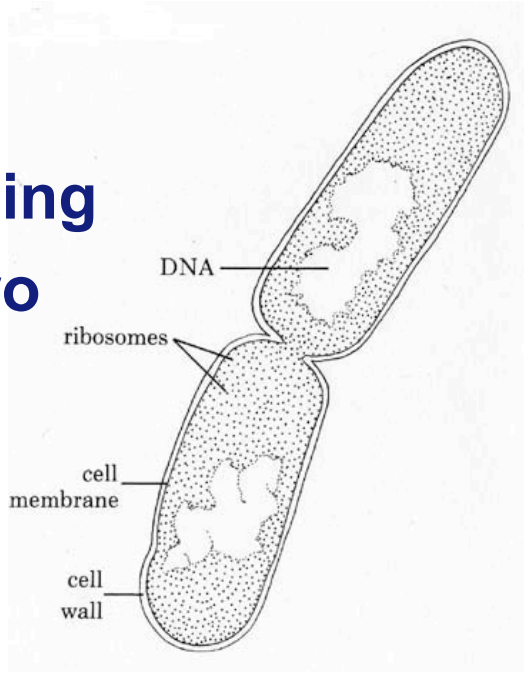


Chloroplasts

- **Function**
  - **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**

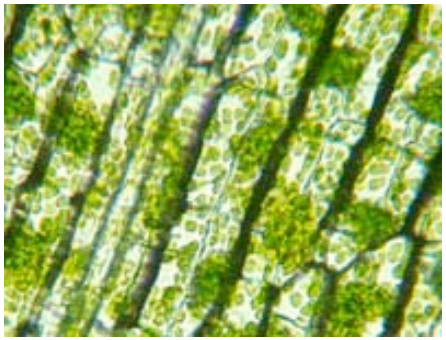
Who else divides like that?

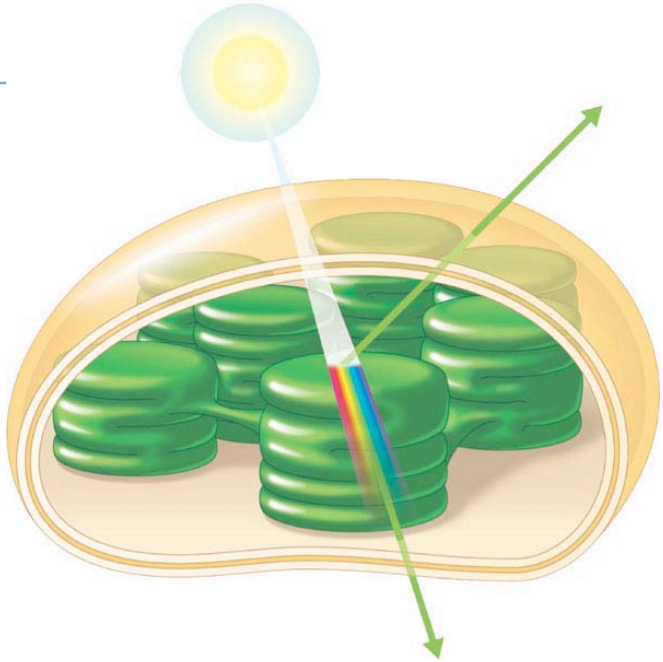
bacteria!

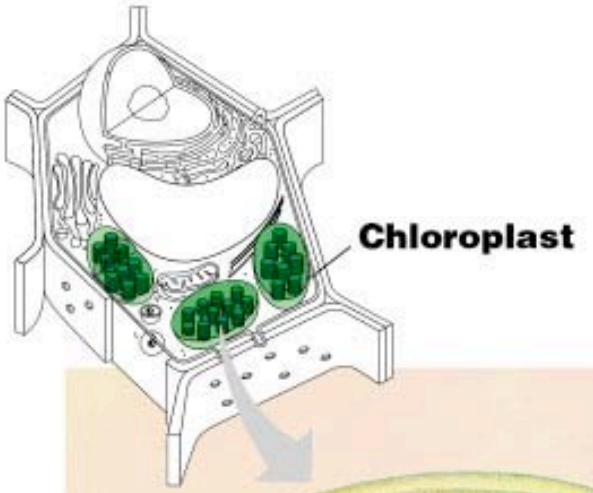


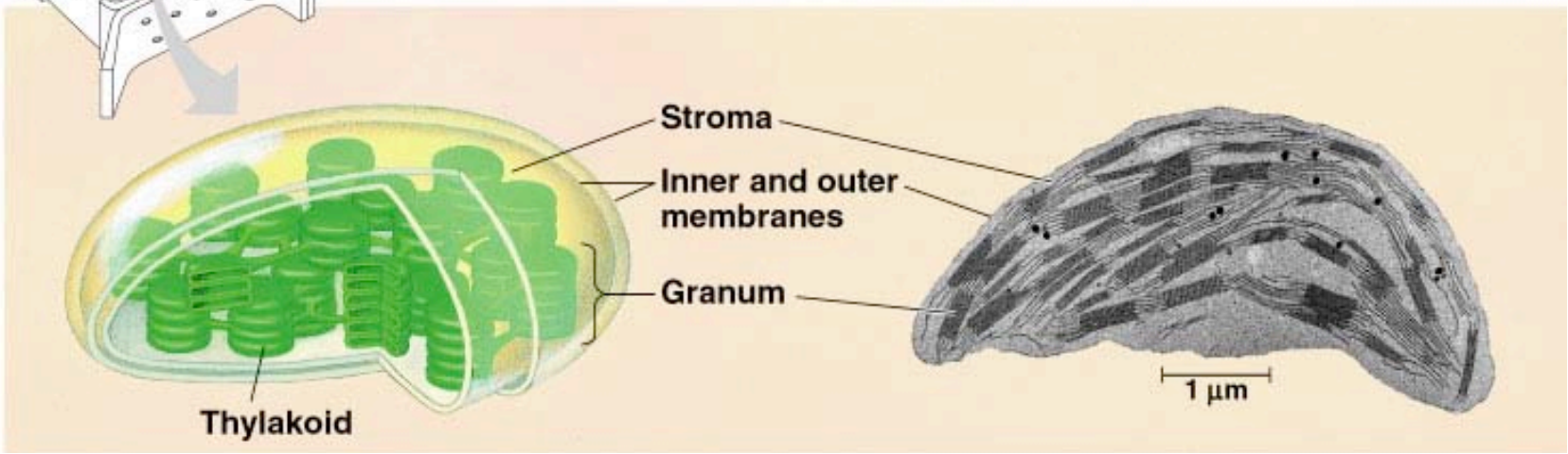
Chloroplasts

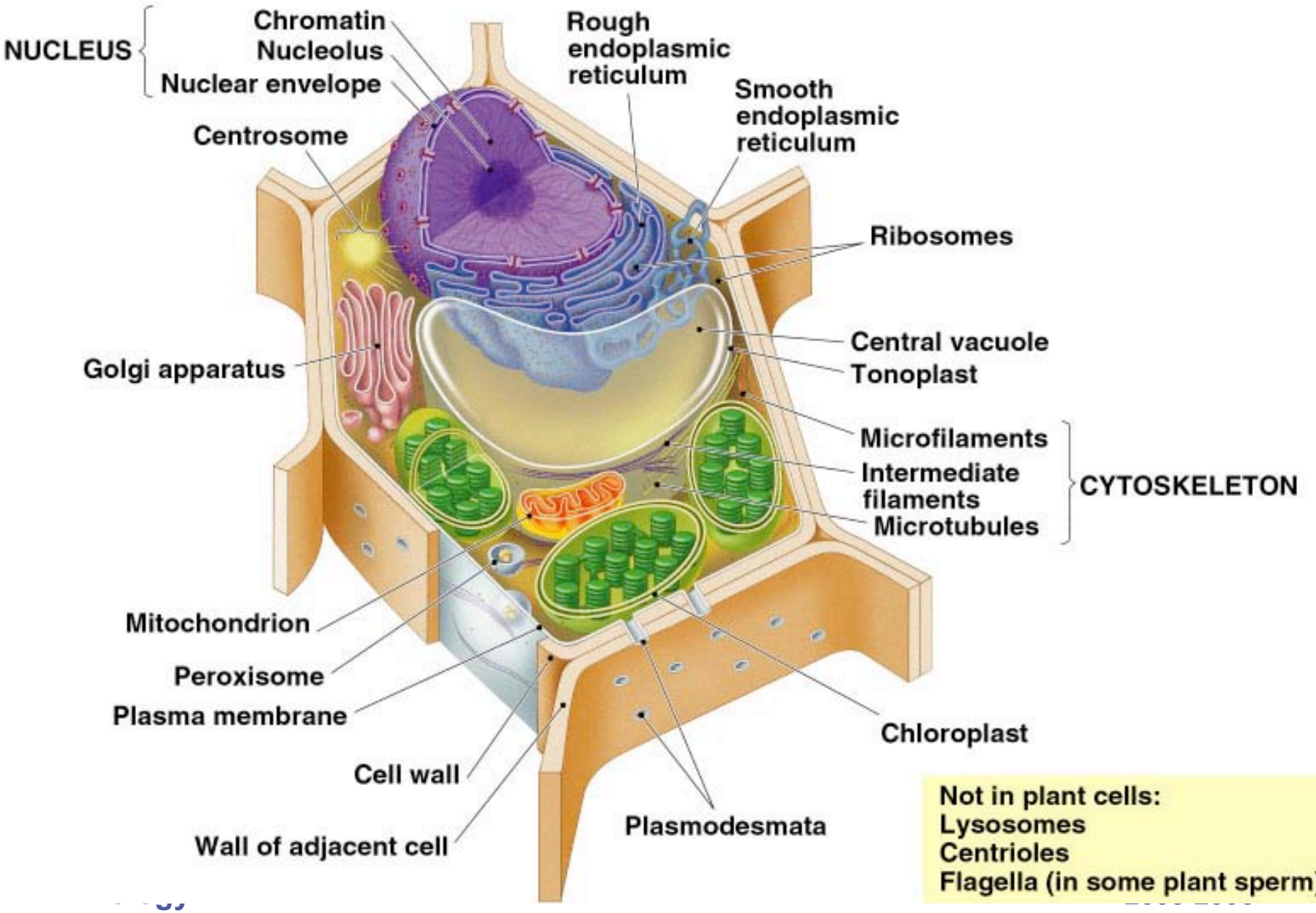
Why are chloroplasts green?










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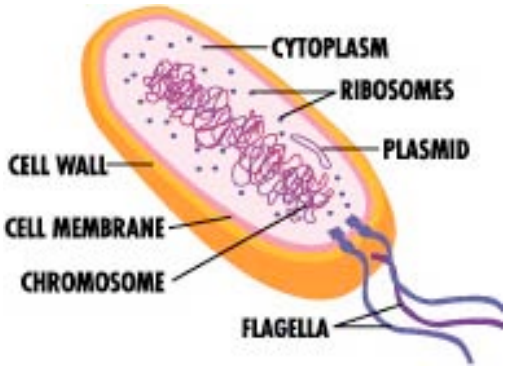
Central vacuole
Tonoplast
Golgi apparatus
Microfilaments
Intermediate filaments
Microtubules
CYTOSKELETON
Mitochondrion
Peroxisome
Plasma membrane
Cell wall
Wall of adjacent cell
Plasmodesmata
Chloroplast
Not in plant cells:
Lysosomes
Centrioles
Flagella (in some plant sperm)

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

Who else has a circular chromosome no 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