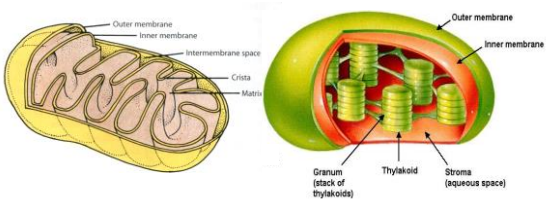
Chapter 5.3 & 5.5

The Cell's Energy System(s): Mitochondria & Chloroplasts

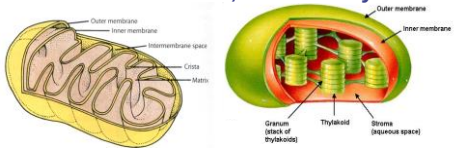


Overview

- 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

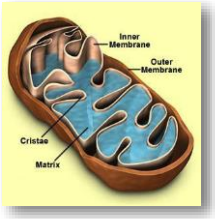
Mitochondria & Chloroplasts

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



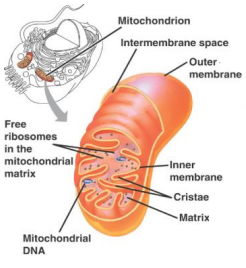
Mitochondria

- Function
  - cellular respiration
  - generate ATP
    - from breakdown of sugars, 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

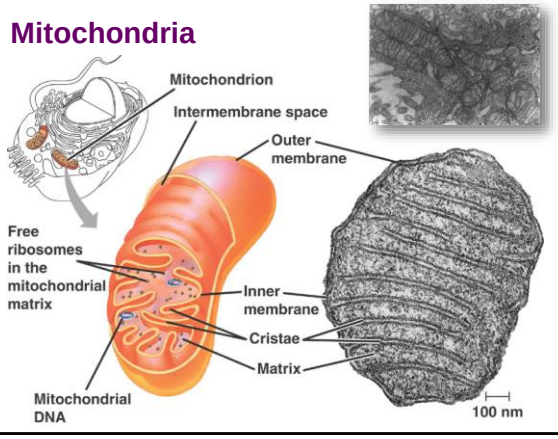
- Structure
  - 2 membranes
    - smooth outer membrane
    - highly folded inner membrane
      - the cristae
  - fluid-filled space between 2 membranes
  - internal fluid-filled space
    - mitochondrial matrix
    - DNA, ribosomes & enzymes



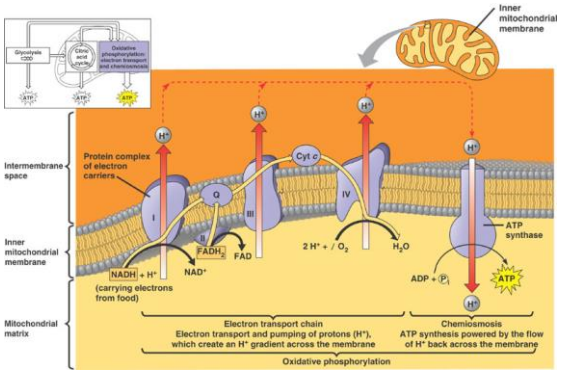
Why 2 membranes?

Increases surface area for membrane-bound enzymes that synthesize ATP!

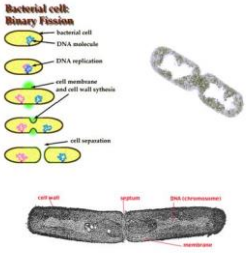
Mitochondria



Membrane-bound Enzymes

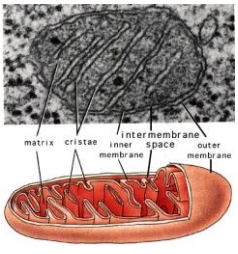


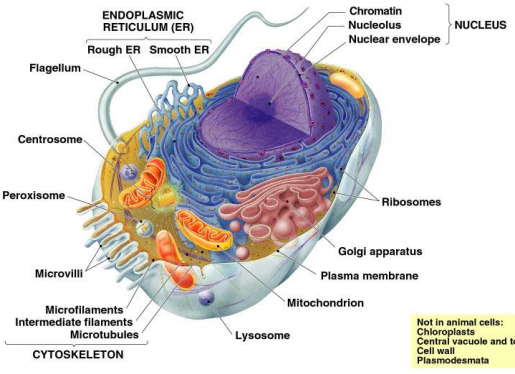
Dividing Mitochondria

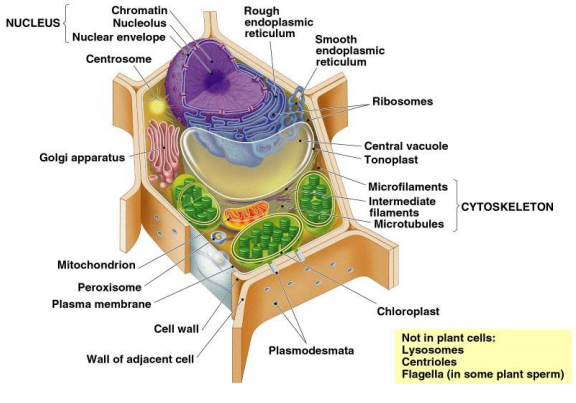


Mitochondria

- 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

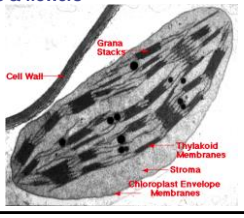






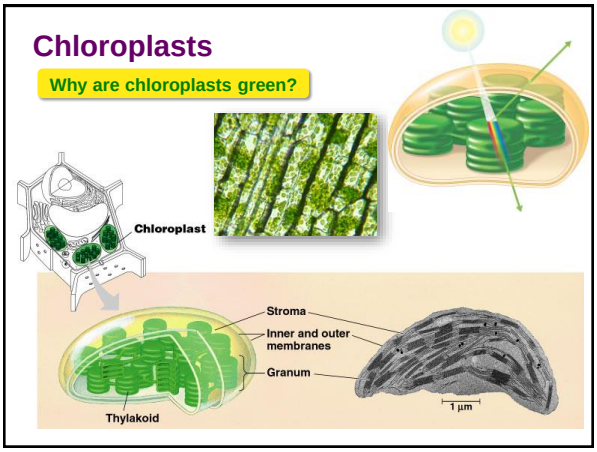
Chloroplasts

- 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

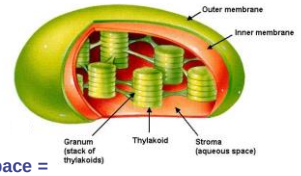


Chloroplasts

Why are chloroplasts green?



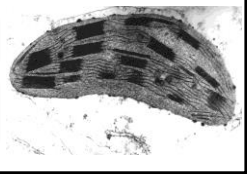
Chloroplasts



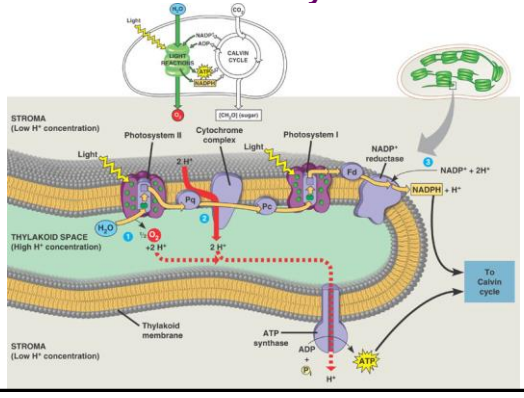
- Structure
  - 2 membranes
    - outer membrane
    - inner membrane
  - internal fluid-filled space = stroma
    - DNA, ribosomes & enzymes
    - thylakoids = membranous sacs where ATP is made
    - grana = stacks of thylakoids

Why many internal sac membranes?

Increases surface area for membrane-bound enzymes that synthesize ATP



Membrane-bound Enzymes

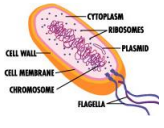


Chloroplasts

- 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

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



Endosymbiosis Theory

1981 | NOPE

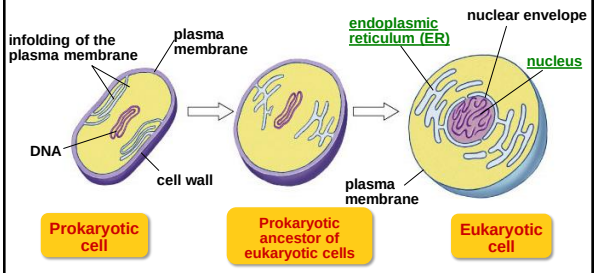
- Mitochondria & chloroplasts were once free living bacteria
  - engulfed by ancestral eukaryote
- Endosymbiont
  - cell that lives within another cell (host)
    - as a partnership
    - evolutionary advantage for both
      - one supplies energy
      - the other supplies raw materials & protection

Lynn Margulis
U of M, Amherst

First Eukaryotes

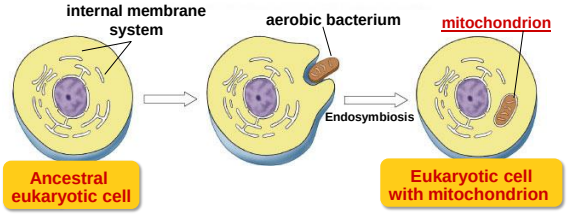
~2 bya

- Development of internal membranes
  - create internal micro-environments
  - advantage: specialization = increase efficiency



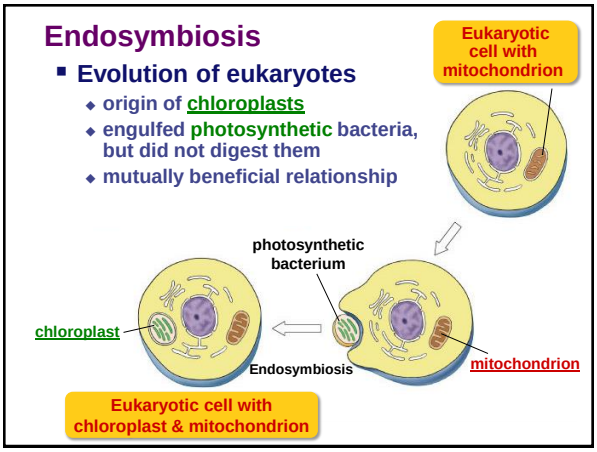
Endosymbiosis

- Evolution of eukaryotes
  - origin of mitochondria
  - engulfed aerobic bacteria, but did not digest them
  - mutually beneficial relationship



Endosymbiosis

- Evolution of eukaryotes
  - origin of chloroplasts
  - engulfed photosynthetic bacteria, but did not digest them
  - mutually beneficial relationship



Endosymbiosis theory