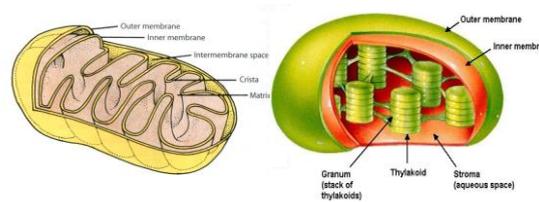
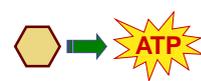


Chapter 5.3 & 5.5

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

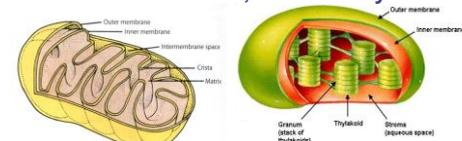


Overview

- 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

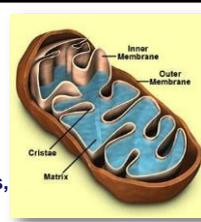
Mitochondria & Chloroplasts

- 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 O₂ = **aerobic respiration**

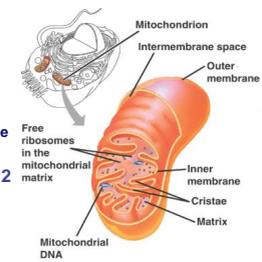


Mitochondria

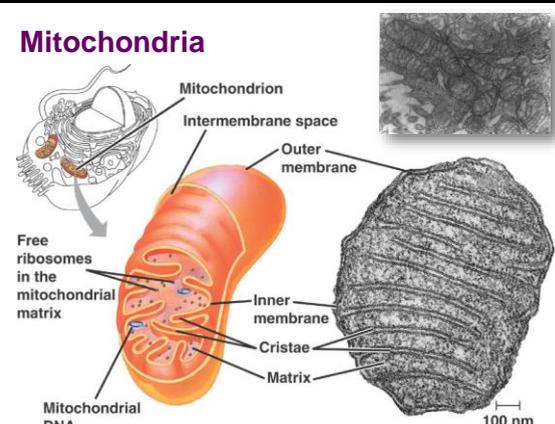
- Structure
 - ♦ 2 membranes
 - smooth outer membrane
 - highly folded inner membrane
 - ♦ the **cristae**
 - ♦ fluid-filled space between 2 membranes
 - ♦ internal fluid-filled space
 - **mitochondrial matrix**
 - DNA, ribosomes & enzymes

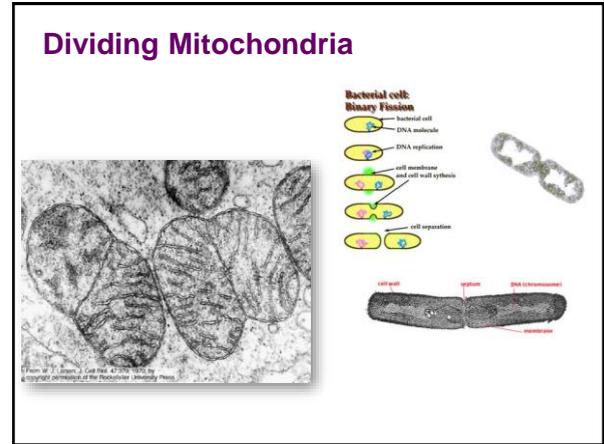
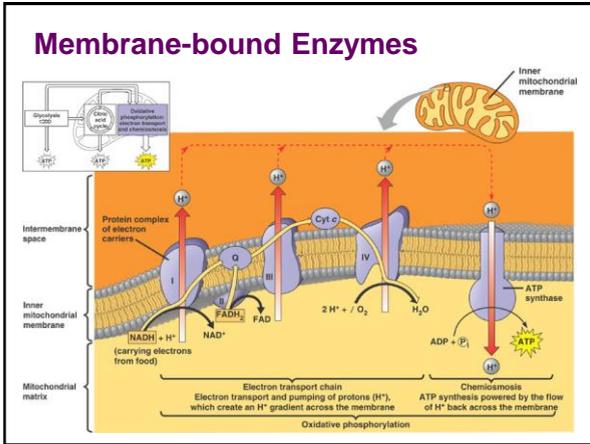
Why 2 membranes?

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



Mitochondria

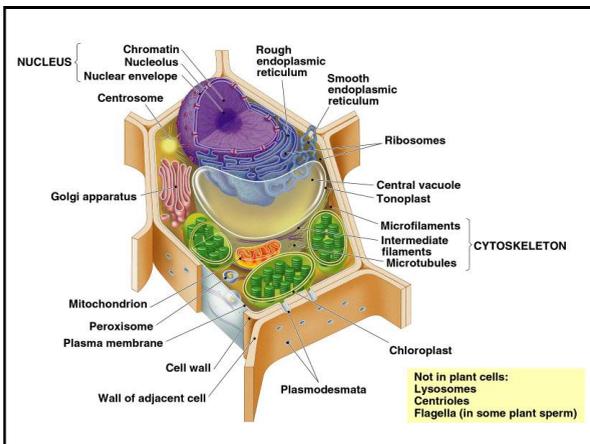
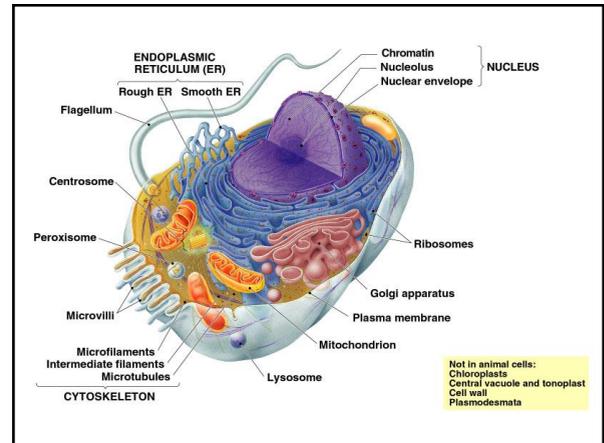




Mitochondria

- 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

matrix, cristae, intermembrane inner space, outer membrane



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

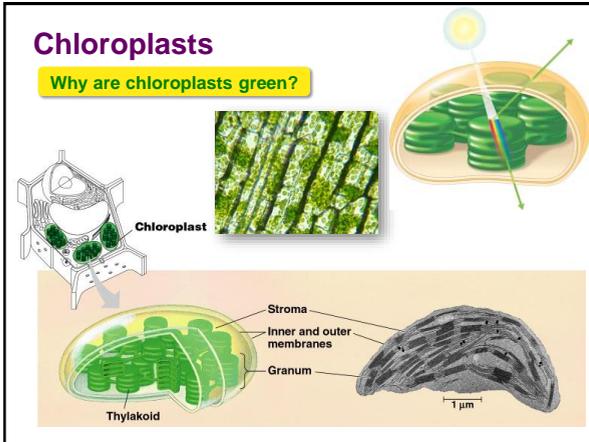
Grana Stacks

Cell Wall

Thylakoid Membranes

Stroma

Chloroplast Envelope Membranes

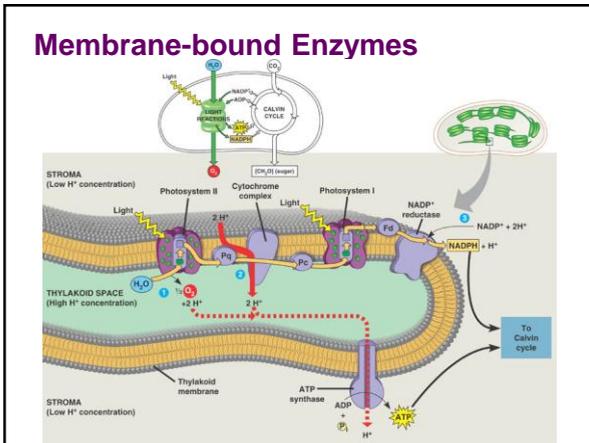


Chloroplasts

- 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



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

Labels: infolding of the plasma membrane, plasma membrane, DNA, cell wall, endoplasmic reticulum (ER), nuclear envelope, nucleus, plasma membrane.

Stages: Prokaryotic cell → Prokaryotic ancestor of eukaryotic cells → Eukaryotic cell

Endosymbiosis

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

Labels: internal membrane system, aerobic bacterium, mitochondrion, Endosymbiosis.

Stages: Ancestral eukaryotic cell → Endosymbiosis → Eukaryotic cell with mitochondrion

Endosymbiosis

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

Labels: chloroplast, photosynthetic bacterium, Endosymbiosis, mitochondrion.

Stages: Eukaryotic cell with chloroplast & mitochondrion

Endosymbiosis theory

Evolution of eukaryotes

Labels: Nuclear envelope, Endoplasmic reticulum, Nucleus, Mitochondrion, Ancestral photosynthetic eukaryote, Plastid, Engulfing of photosynthetic prokaryote, Engulfing of aerobic heterotrophic prokaryote, Ancestral heterotrophic eukaryote, Mitochondrion, Ancestral prokaryote, Cytoplasm, Plasma membrane, DNA, Time.