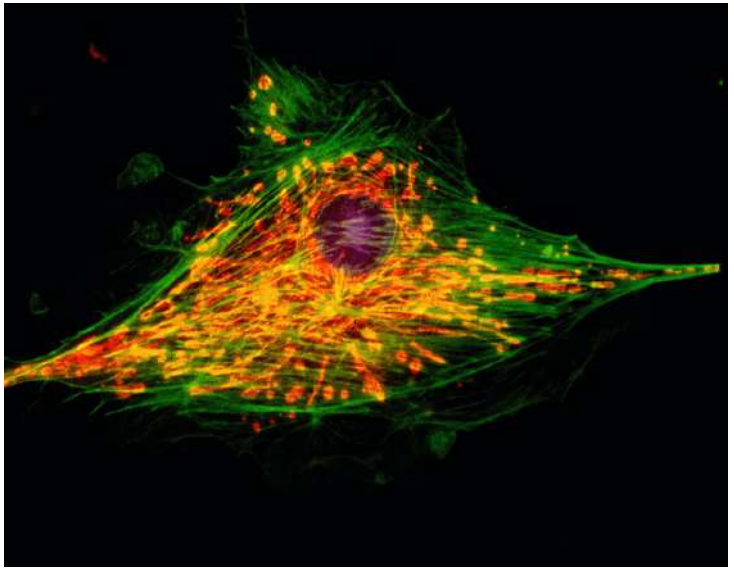
Eukaryotic Cell Structure

The Cell

- ESSENTIAL to the study of biology
- Simplest form of life
- Every organism's basic unit of structure and function
- Named by Robert Hooke in 1665 after observing cork cells (cell walls) under microscope.



The Cell Theory (Schleiden, Schwann, & Virchow)

- All living things are composed of cell(s).
- Cells are the structural & functional units in living organisms.
- Cells come from other living cells. (Virchow added after Pasteur disproved the idea of spontaneous generation/abiogenesis.)

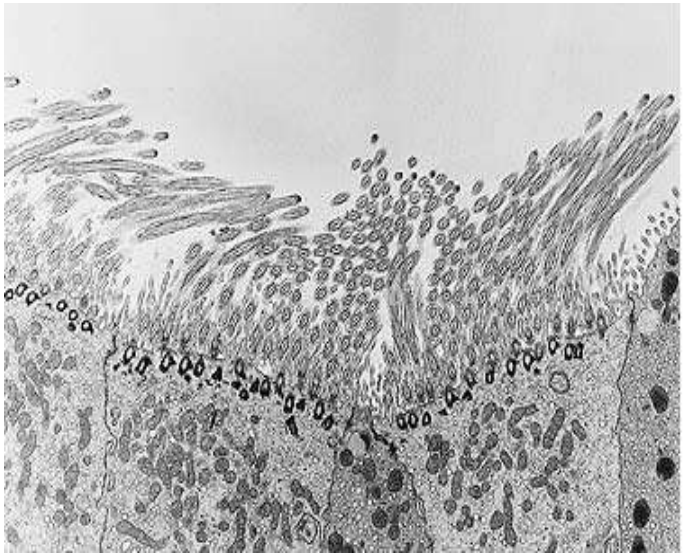
Microscopes

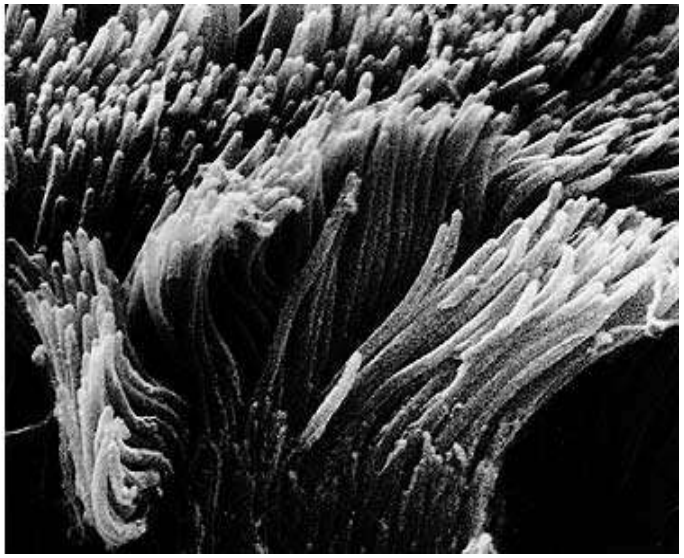
- The discovery of cells corresponds with the advancement of technology
  - Microscopes!
  - Simplest light microscope was invented by Anton van Leeuwenhoek in the 1600s (observed & drew “animalcules”

Microscopes

- 2 major types of microscopes
  - Light microscope
    - Visible light is passed through the specimen and then through glass lenses
  - Electron microscope
    - Focuses a beam of electrons through the specimen/ cannot be used to observe living cells.
    - Transmission EM:
      - Used mainly to study the internal structure of cells
      - 2D image
      - Highest magnification (200,000 x)
    - Scanning EM:
      - Used mainly for detailed study of the surface of a specimen
      - 3D image (100,000 x)

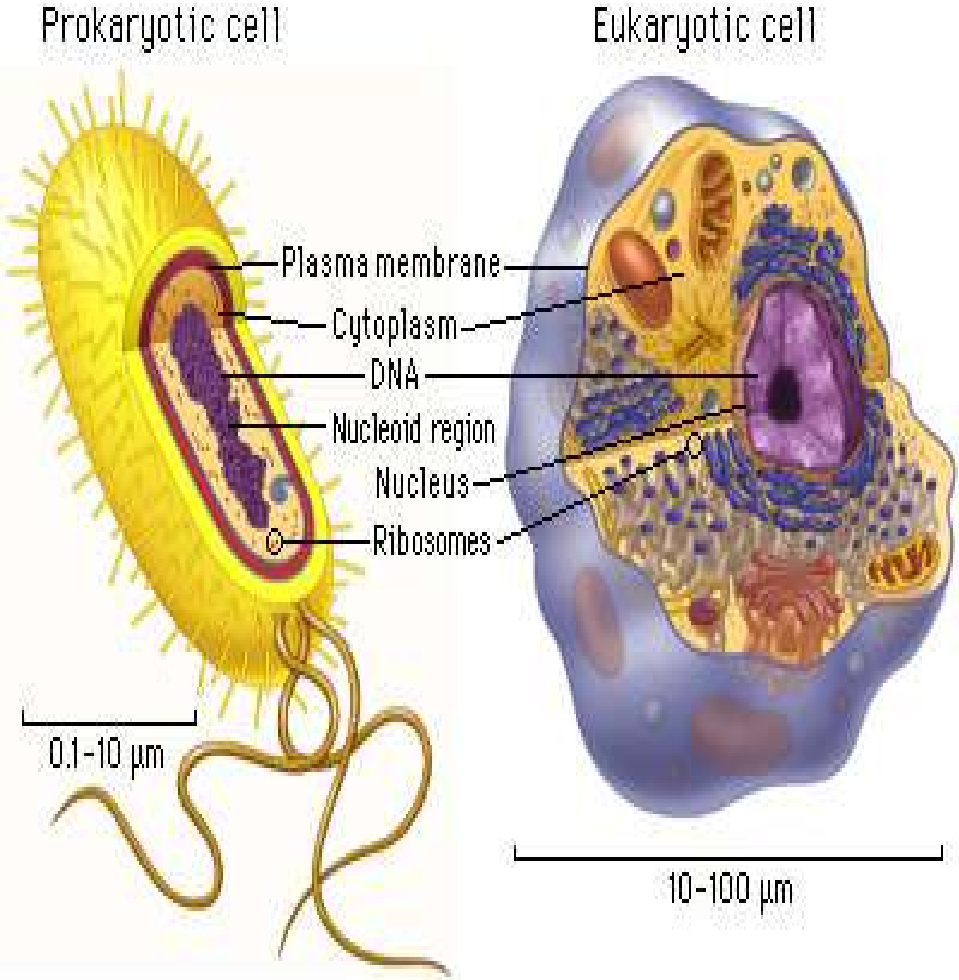
TEM & SEM





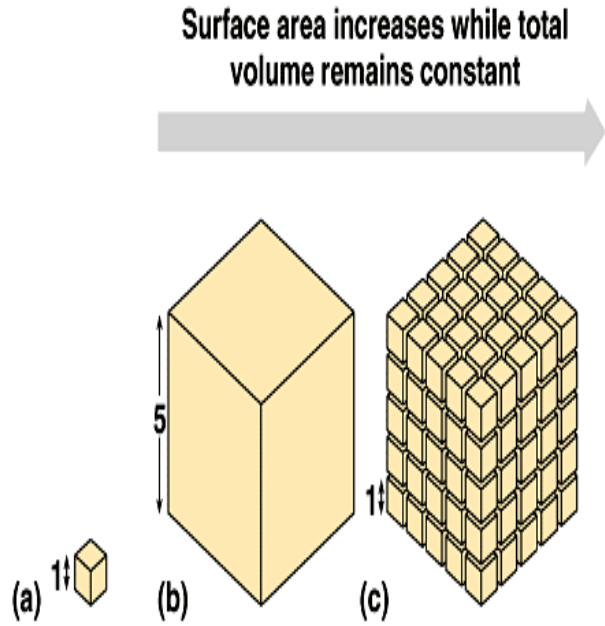
Prokaryotic vs. Eukaryotic Cells

- Prokaryote
  - "before" "nucleus"/ NO NUCLEUS/few organelles
  - Bacteria
  - DNA is concentrated in nucleoid (non membrane-bound)
- Eukaryote
  - "true" "nucleus" / many membranous organelles
  - Protists, plants, fungi, animals
  - Nucleus with nuclear membrane holds DNA



Why so small?

- Metabolism requires that cells stay small
  - As a cell grows, its volume grows proportionately more than its surface area
  - Cells need a high surface area to volume ratio to exchange materials with their environment through plasma membrane.



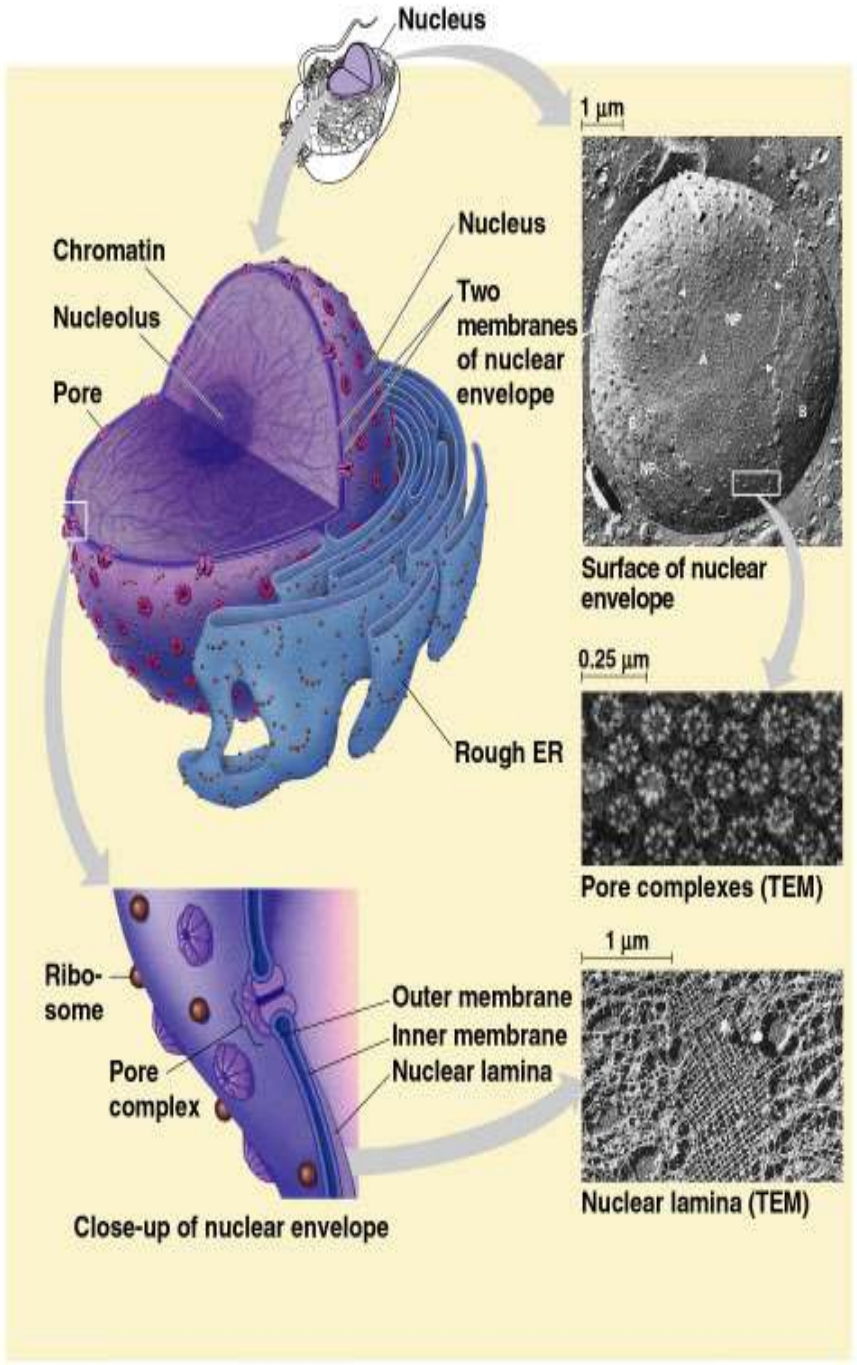
Total surface area (height x width x number of sides x number of boxes)	6	150	750
Total volume (height x width x length x number of boxes)	1	125	125
Surface-to-volume ratio (area ÷ volume)	6	1.2	6

Compartmental Organization of Cells

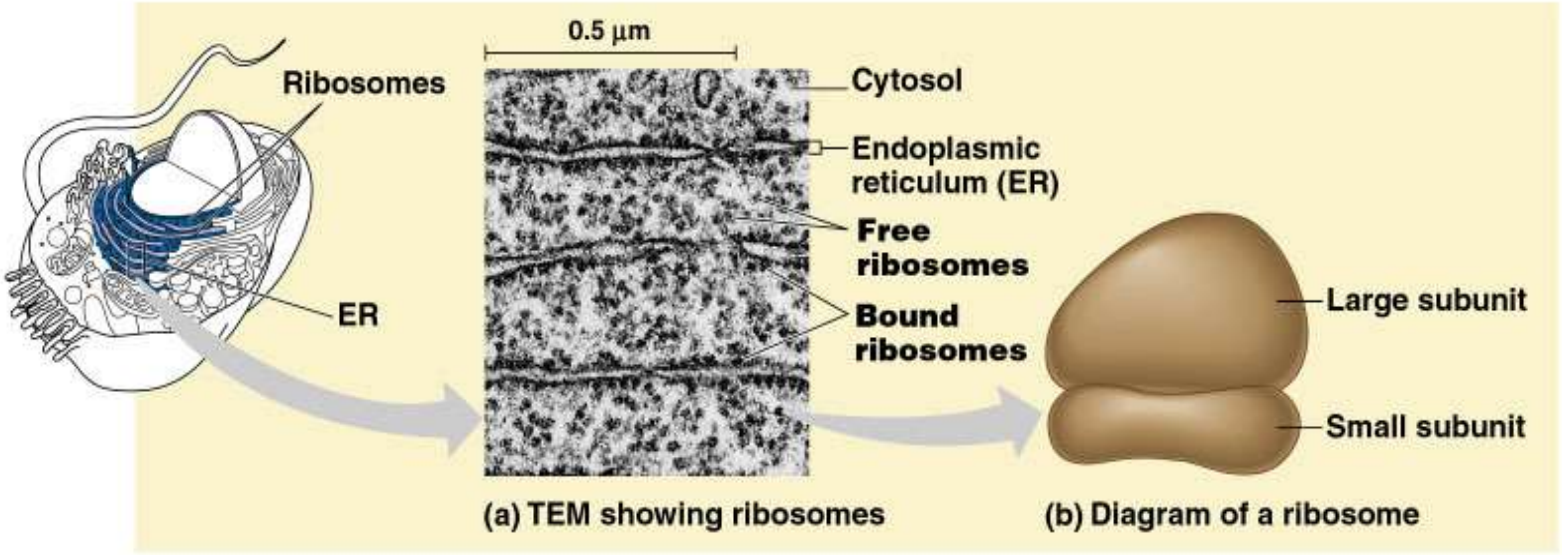
- Compartments (ORGANELLES) provide different local environments (pH, etc.)
  - Incompatible but equally important processes can occur next to each other in different “rooms”

Cellular Organelles

- Nucleus:
  - "control center" of the cell
  - Surrounded by a nuclear envelope
  - Contains DNA
  - Nucleolus: site of ribosome synthesis



Cellular Organelles

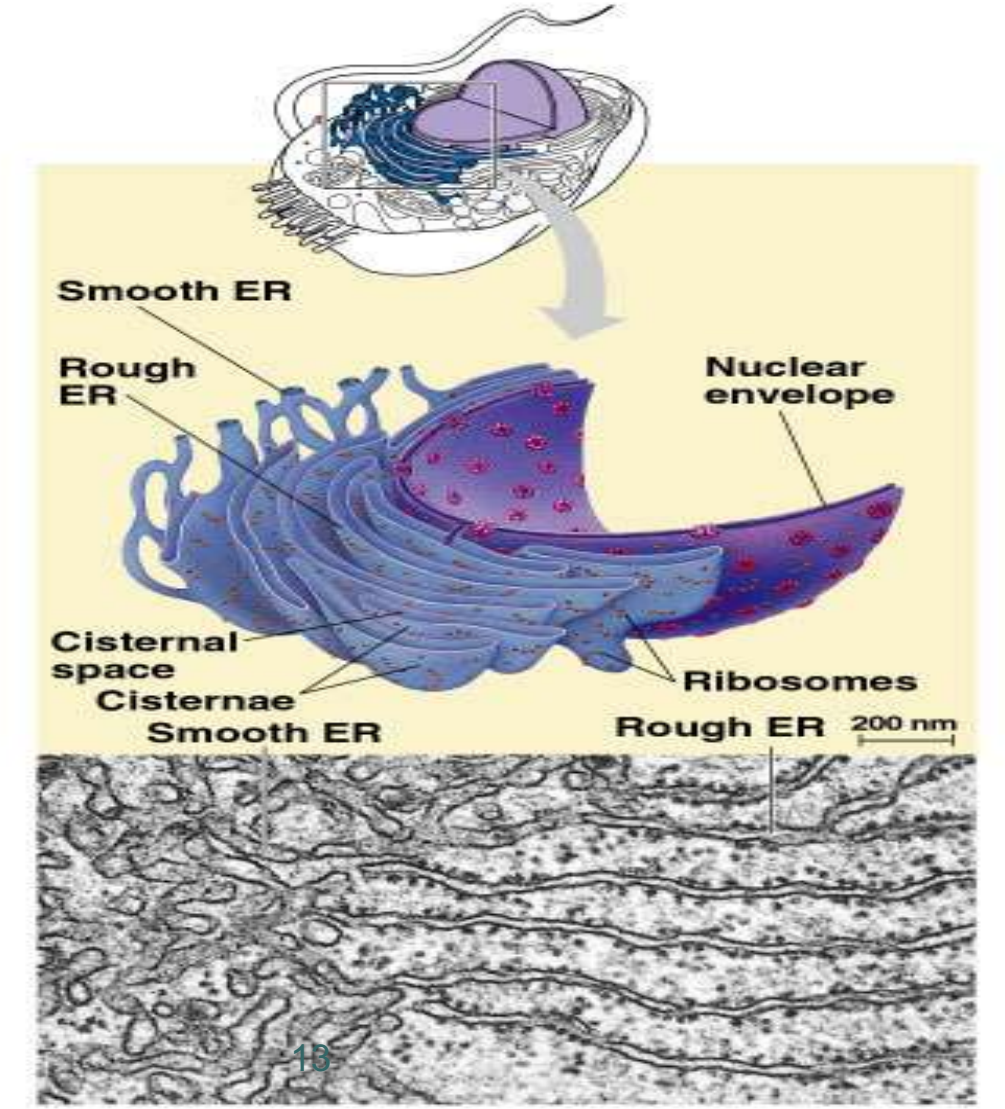


- Ribosomes
  - Site of protein assembly
  - Free and bound ribosomes
    - Free: float through cytoplasm (make proteins for use inside that cell)
    - Bound: attached to Rough ER (make proteins to be transported out of the cell)

Cellular Organelles

- Endoplasmic Reticulum:
  - Made up of membranous tubules and cisternae (sacs)
  - Smooth ER: NO ribosomes attached
    - Synthesis and transport of lipids
    - Controls glucose ←→glycogen conversion in liver & muscles
    - Detoxification of drugs and other poisons
    - Sarcoplasmic reticulum (muscle ER) stores calcium needed in muscle contraction.
  - Rough ER: ribosomes attached
    - Synthesis & transport of proteins

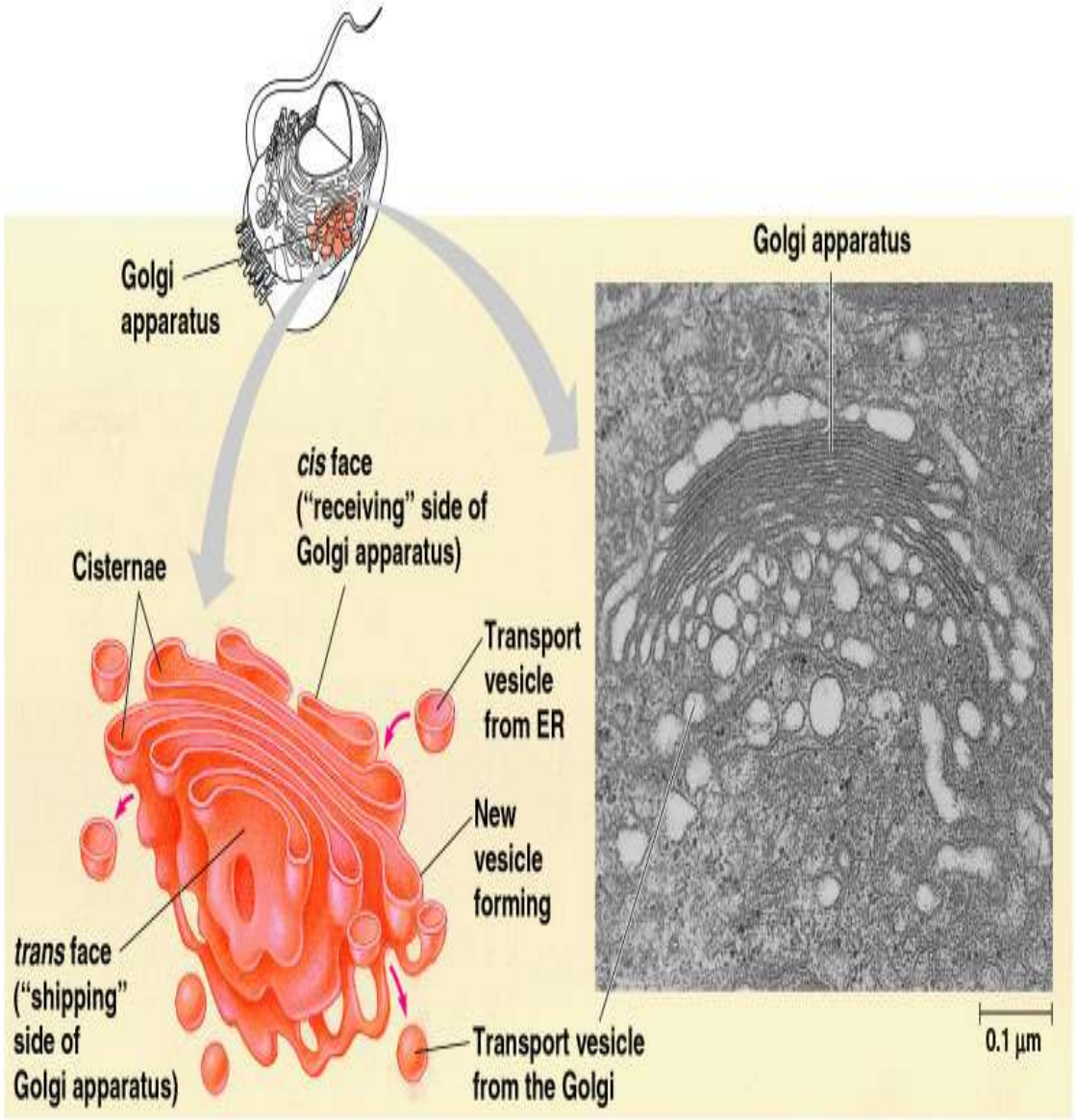
Endomembrane System



⑩ **Smooth and Rough ER**

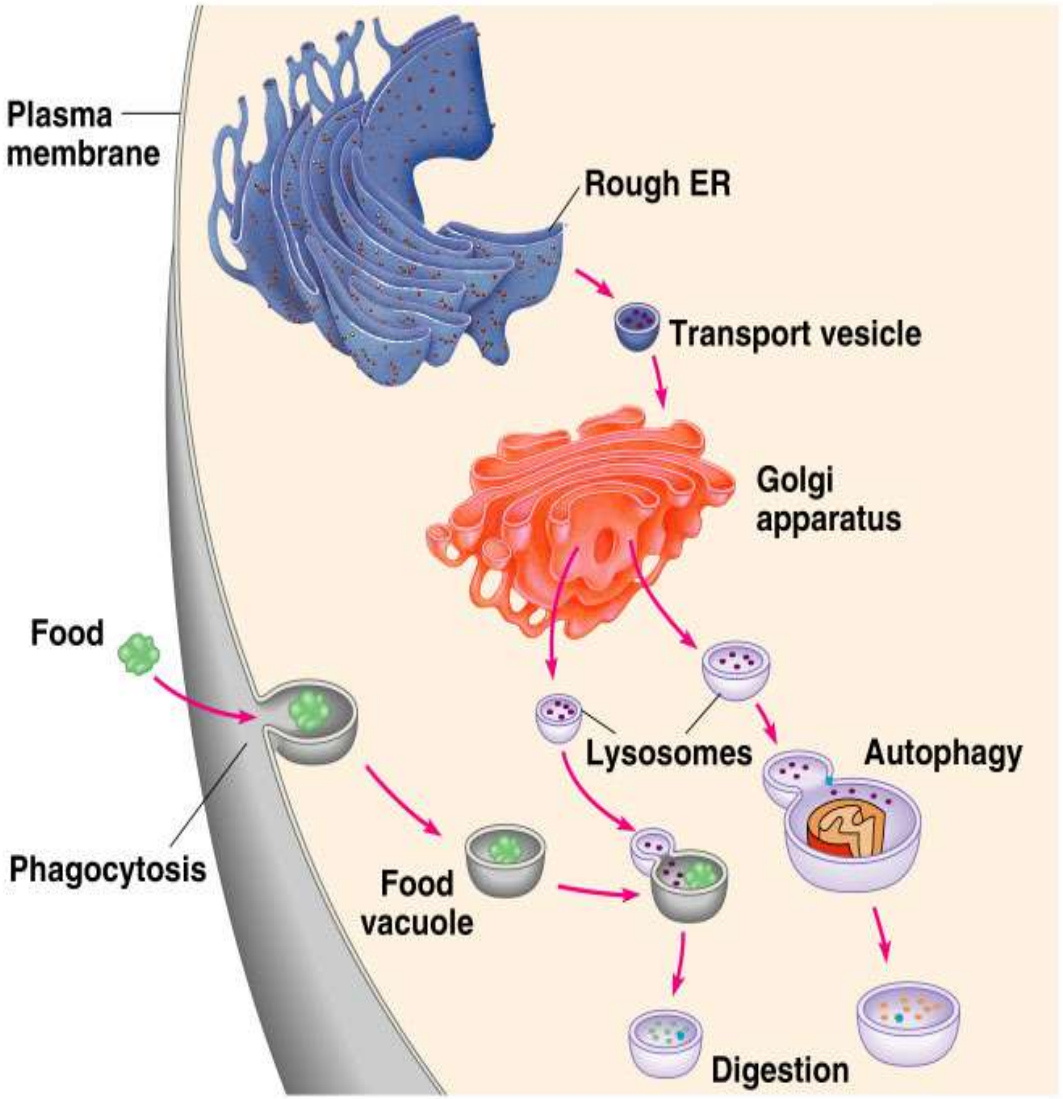
Endomembrane System

- **Golgi Apparatus**:
  - Products of the Endoplasmic Reticulum are modified and stored here
  - Modifies & packages proteins



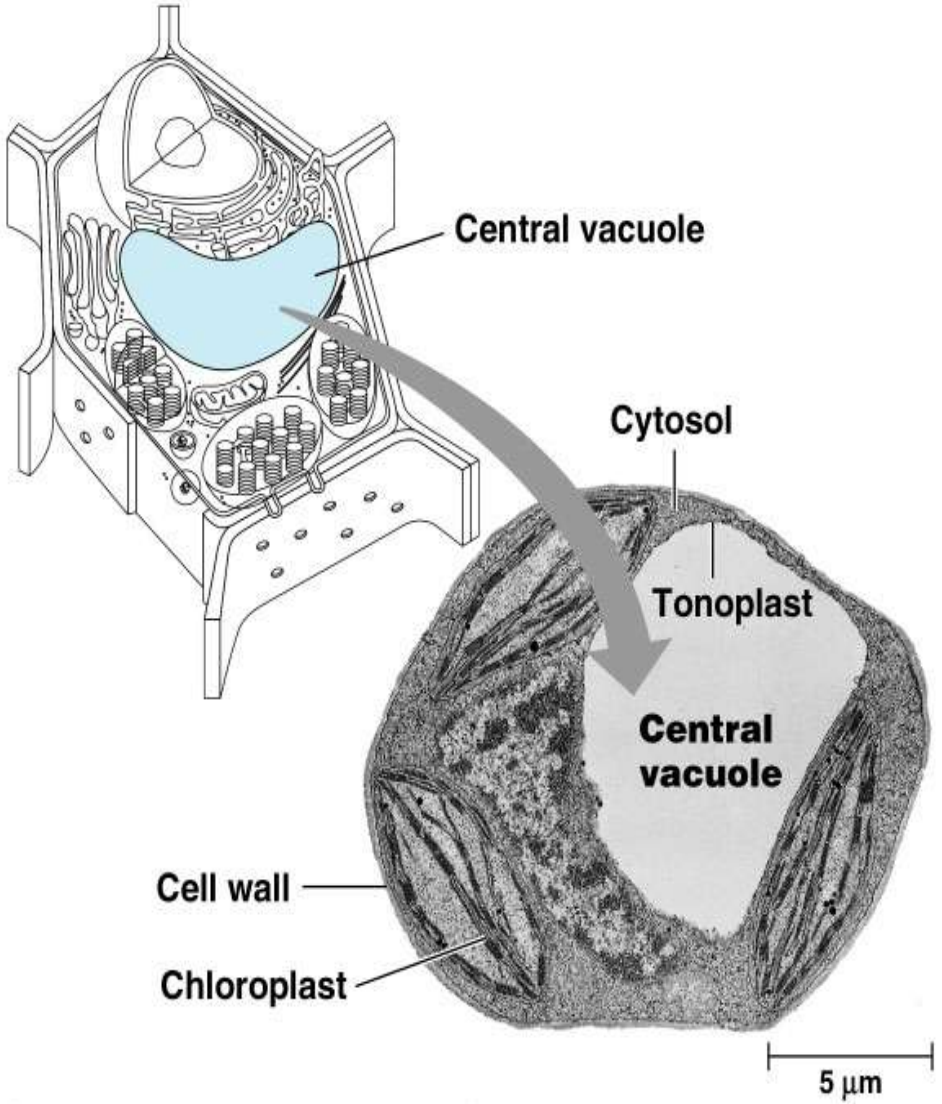
Endomembrane System

- Lysosomes:
  - Used by cells to digest macromolecules
  - Sac of hydrolytic enzymes
  - Apoptosis:
    - Programmed cell death
  - Usually found only in animal cells



Endomembrane System

- **Vacuoles**:
  - **Food vacuoles** (storage)
  - **Contractile vacuoles** (pump extra water out of cells in freshwater protists)
  - **Central vacuole** (plant cells)
    - Stores organic compounds, inorganic ions (K+, Cl-), and water
    - Surrounded by tonoplast

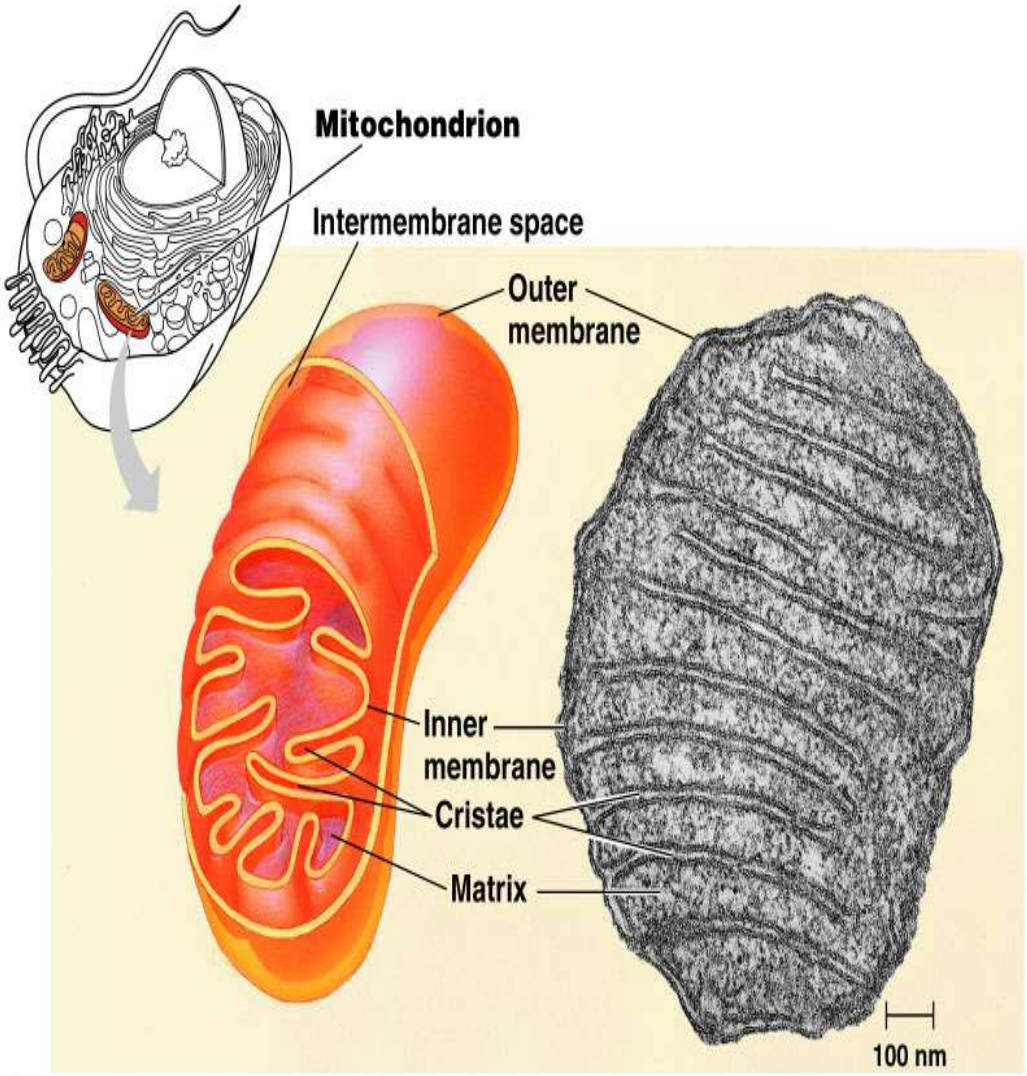


Endomembrane System

- Peroxisomes:
  - Contain enzymes that transfer hydrogen from various substances to oxygen, producing H_2O_2 as a byproduct
  - Various functions:
    - Break fatty acids down into smaller molecules for cellular respiration
    - Detoxify alcohol in liver

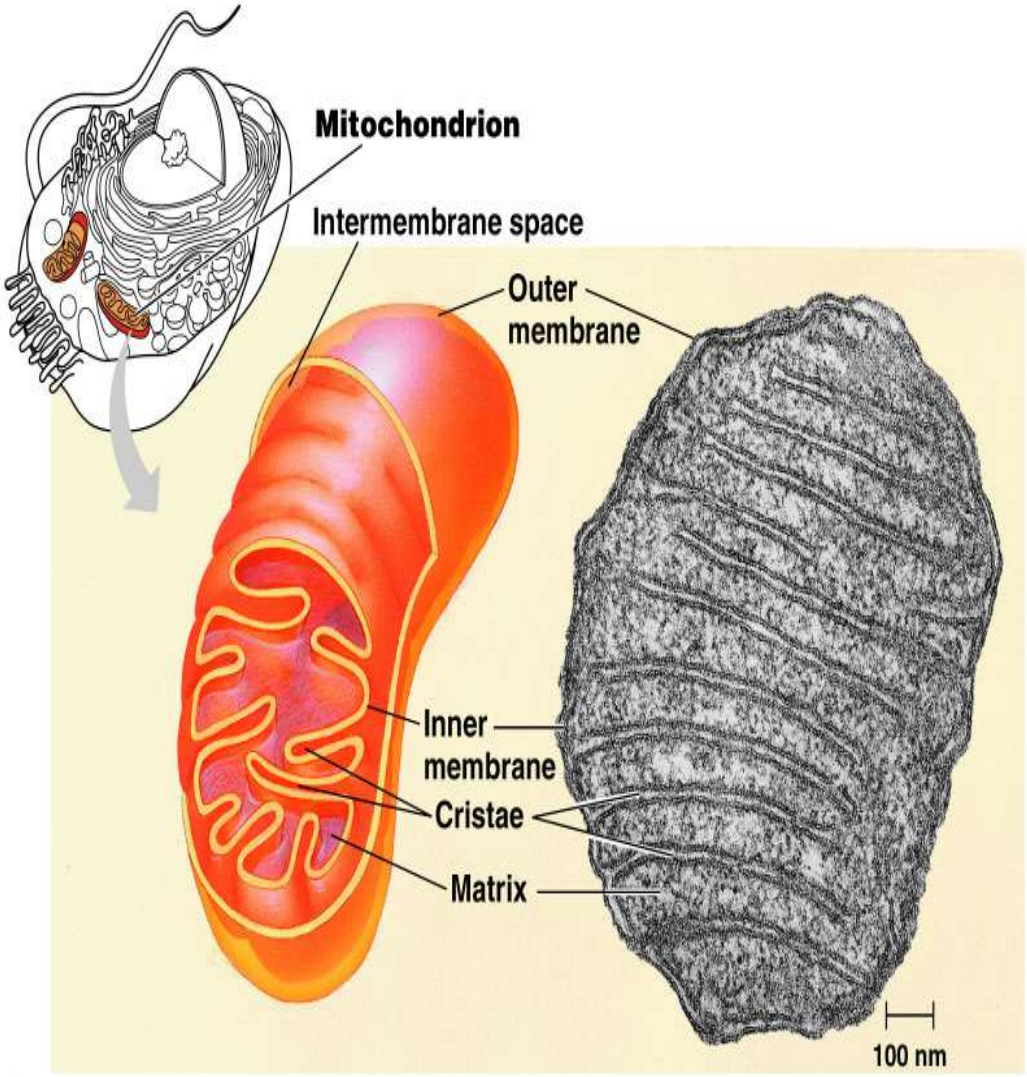
Energy-related organelles

- **Mitochondria**
  - Site of cellular respiration (Energy from the breakdown of organic molecules is used to phosphorylate ADP to produce ATP)
  - "powerhouse of the cell"
  - More metabolic activity = more mitochondria



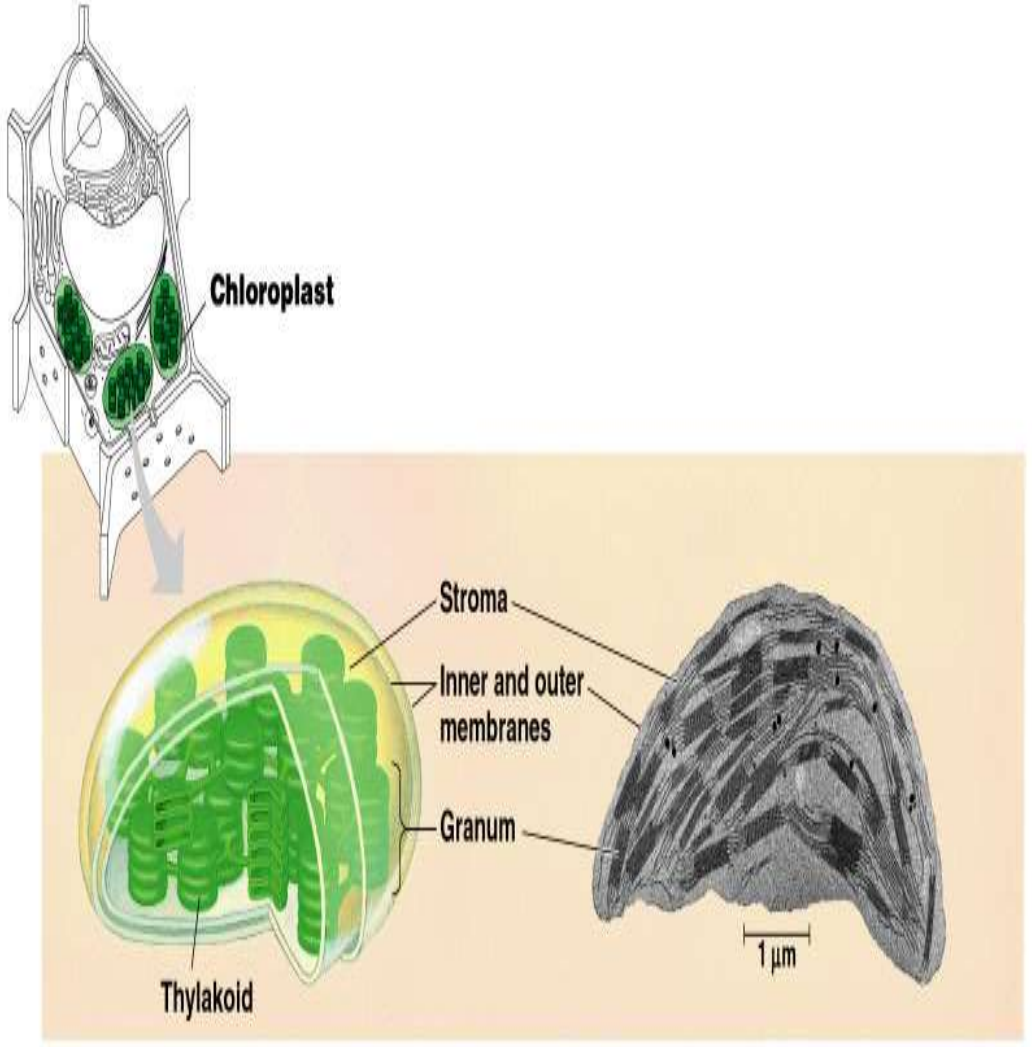
Energy-related organelles

- Mitochondrial Structure:
  - **Outer membrane**
  - **Inner membrane**:
    - **Cristae** = large **surface area** makes more efficient at producing energy
  - **Intermembrane space**
  - **Mitochondrial matrix**

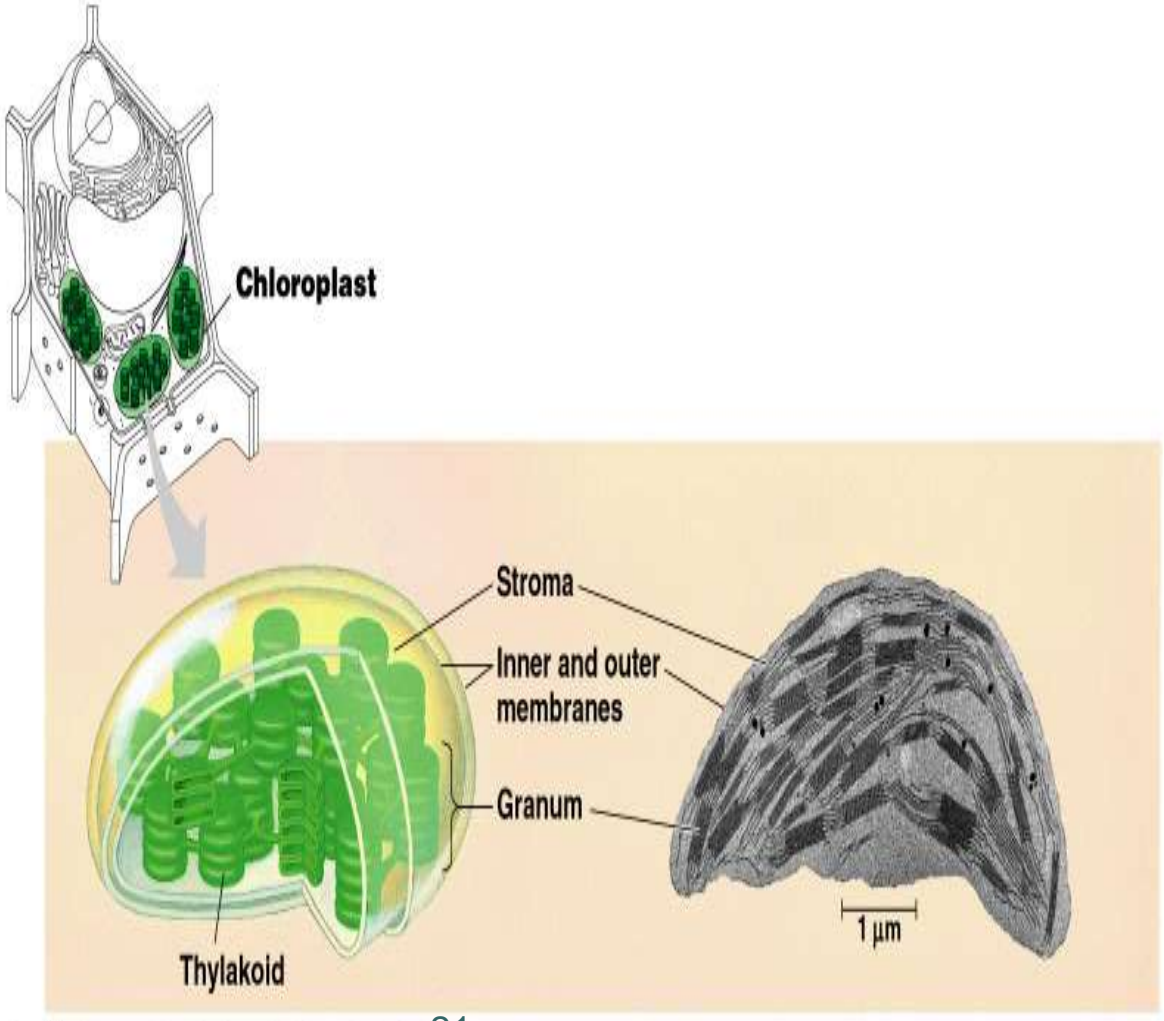


Energy-related organelles

- **Chloroplasts**:
  - Found in plants and eukaryotic algae
  - Site of photosynthesis
  - Contain the green pigment chlorophyll



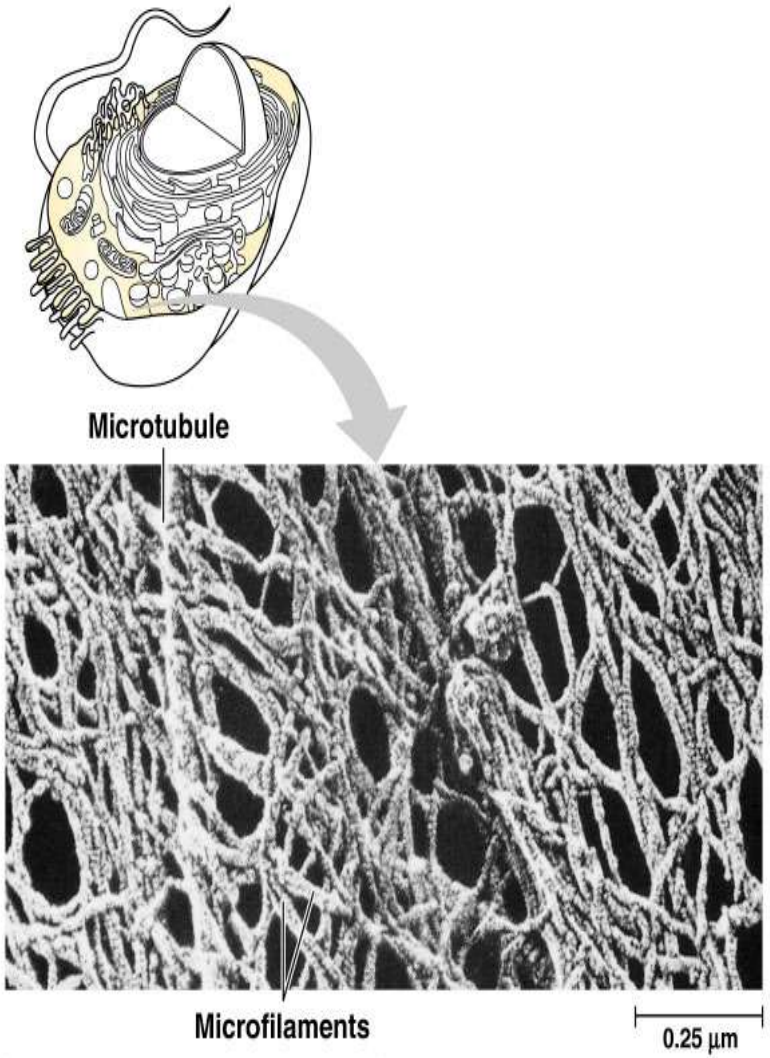
Energy-related organelles



- Chloroplast Structure
  - **Thylakoids**
    - **Grana** = stacks of thylakoids
    - (Light Dependent Phase)
  - **Stroma**
    - Fluid outside the thylakoids
    - (Calvin Cycle)

Cytoskeleton & Related Organelles

- **Cytoskeleton**
  - Maintains shape of cell
  - Responsible for movement of cell and movement of organelles within cell
  - Made of three types of protein fibers:
  - **Microtubules, microfilaments, & intermediate filaments**

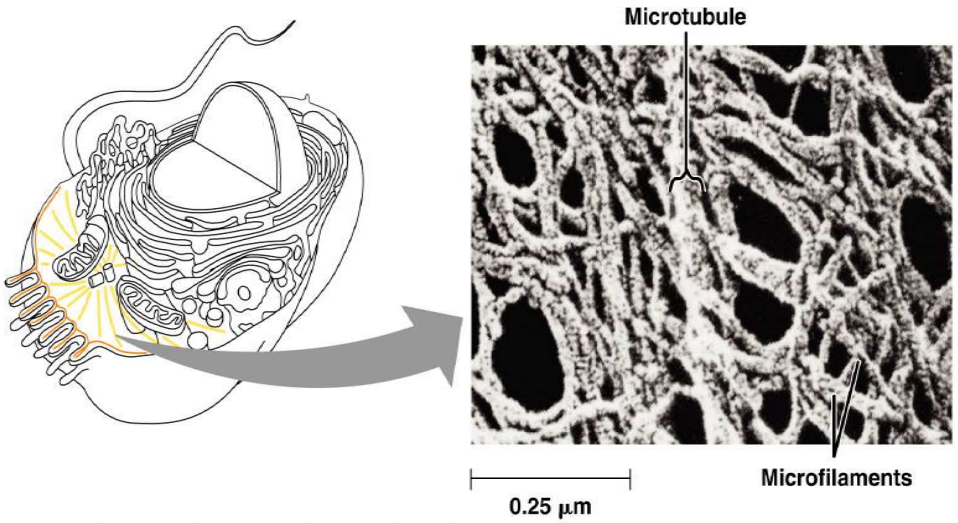


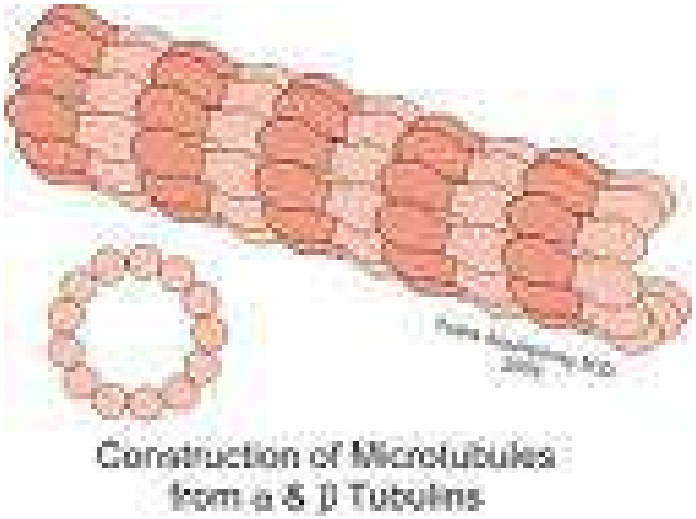
Cytoskeleton & Related Organelles

- Components of Cytoskeleton:
  - **Microtubules** – 25 nm diameter
  - **Intermediate Filaments** – 8 – 12 nm diameter
  - **Microfilaments** – 7 nm diameter

Cytoskeleton & Related Organelles

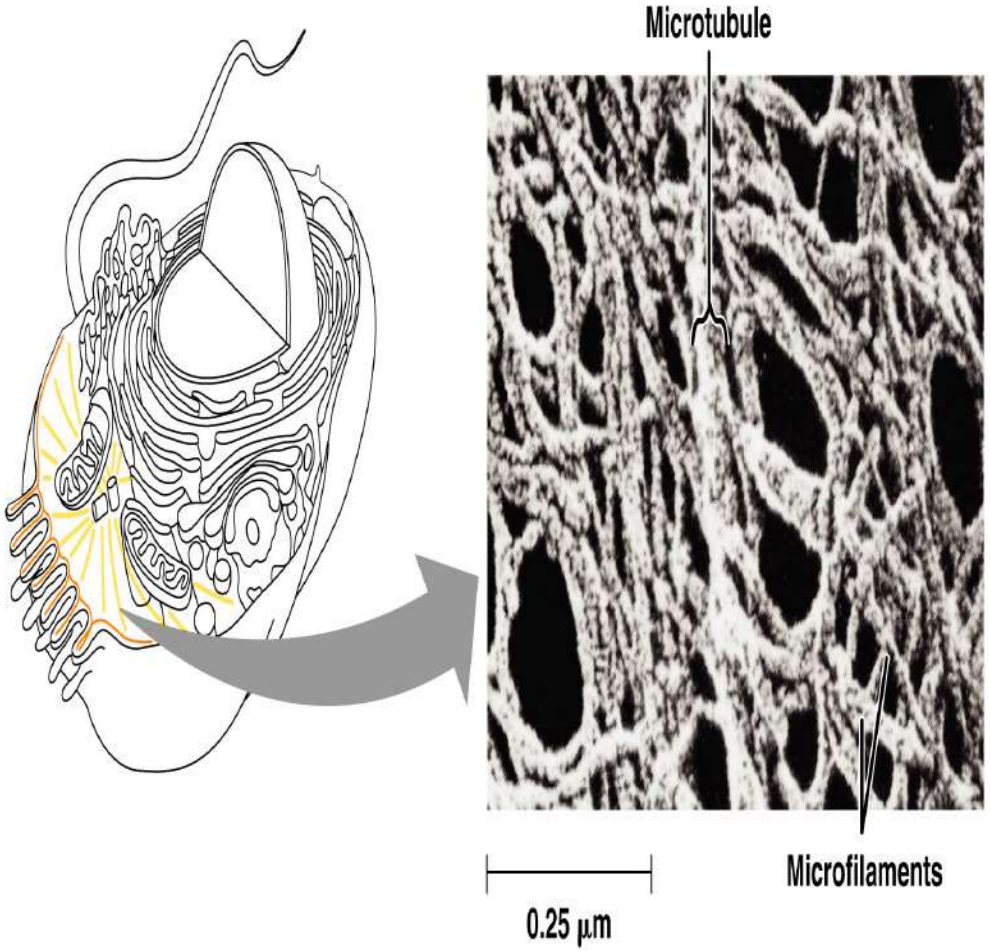
- **Microtubules**
  - Hollow tubes
  - Made up of **A- and B-tubulin**
  - Responsible for:
    - Cell motility
      - cilia/flagella
    - Chromosome movements (mitosis)
      - centrioles
    - Movement of organelles
    - Maintenance of cell shape




Construction of Microtubules from α & β Tubulins

Cytoskeleton & Related Organelles

- **Intermediate Filaments**
  - Made up of fibrous proteins
  - Made up of **keratin**
  - Responsible for:
    - Structural support
    - Maintenance of cell shape
    - Anchors nucleus & certain organelles

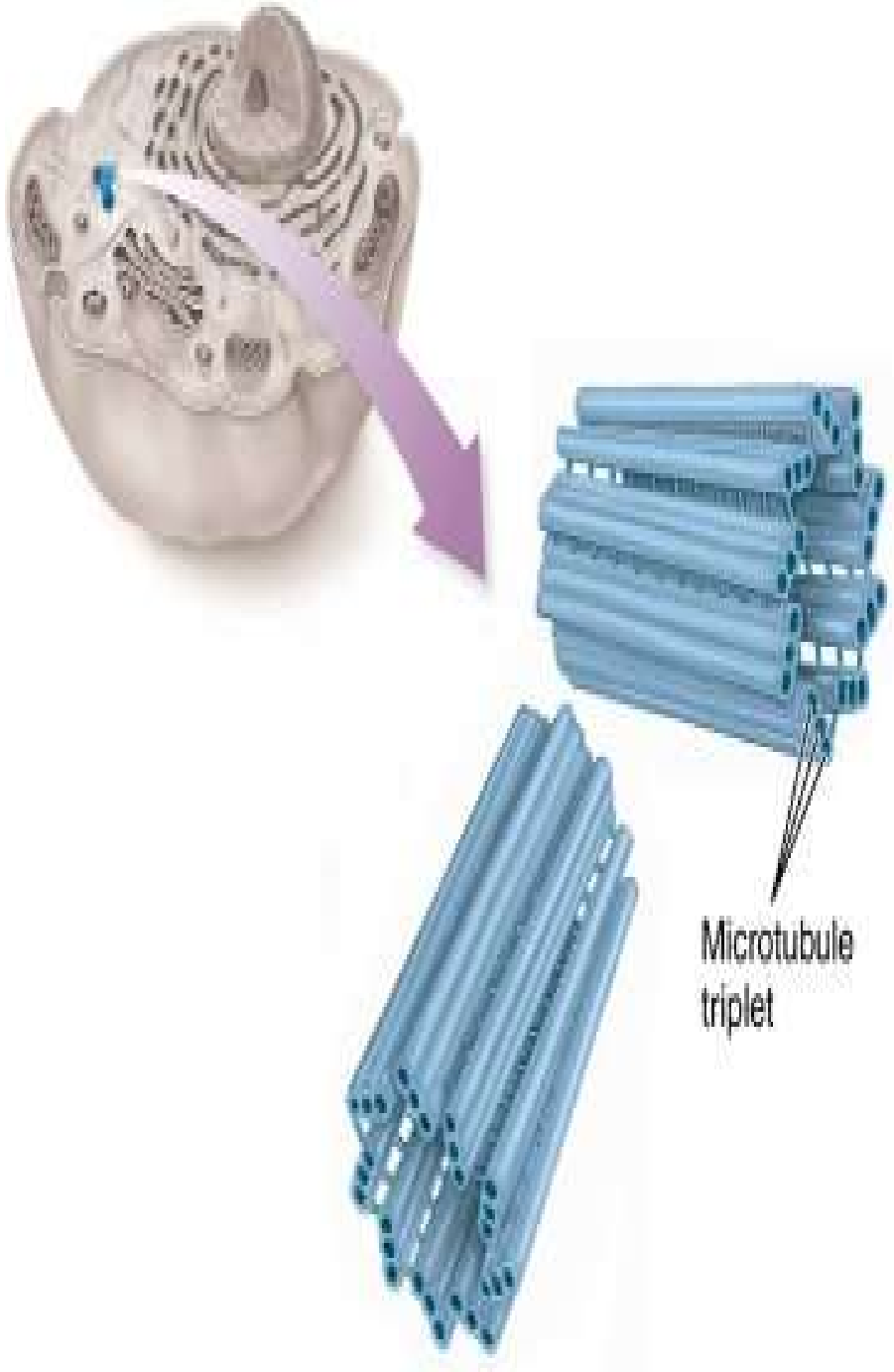


Cytoskeleton & Related Organelles

- Microfilaments
  - Made up of 2 intertwined strands of **actin**
  - Responsible for:
    - Muscle contraction
    - Cytoplasmic streaming
    - Cell motility (pseudopodia)
    - Cell division (cleavage furrow)
    - Maintenance of/changes in cell shape

Centrioles

- Only found in animal cells
- Visible only during cell division
- 9+0 arrangement of microtubules
- May give rise to cilia & flagella
- May be involved in formation of spindle fibers in animal cells, but not plants!



Flagella and Cilia

- Structures for cell motility
- Flagella (long & few in #)
- Cilia (short & numerous)
- 9 + 2 internal structure
- Basal body has 9+0 structure like centrioles

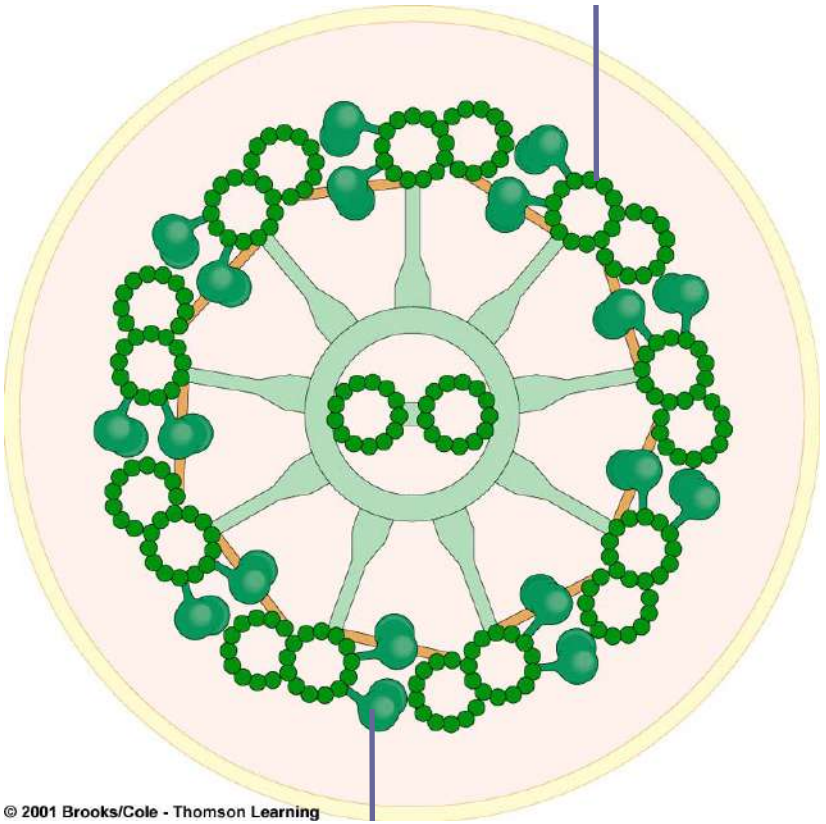


Figure 4.25
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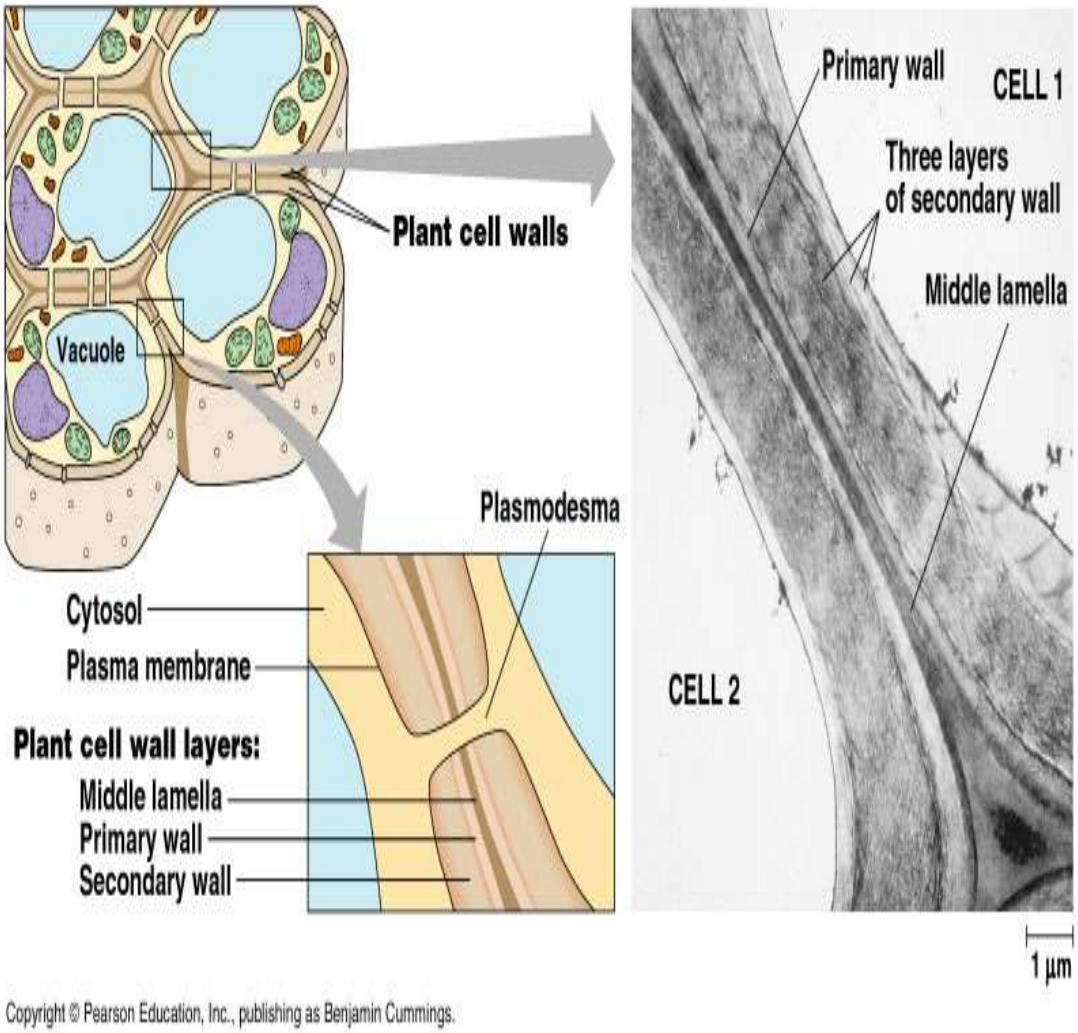
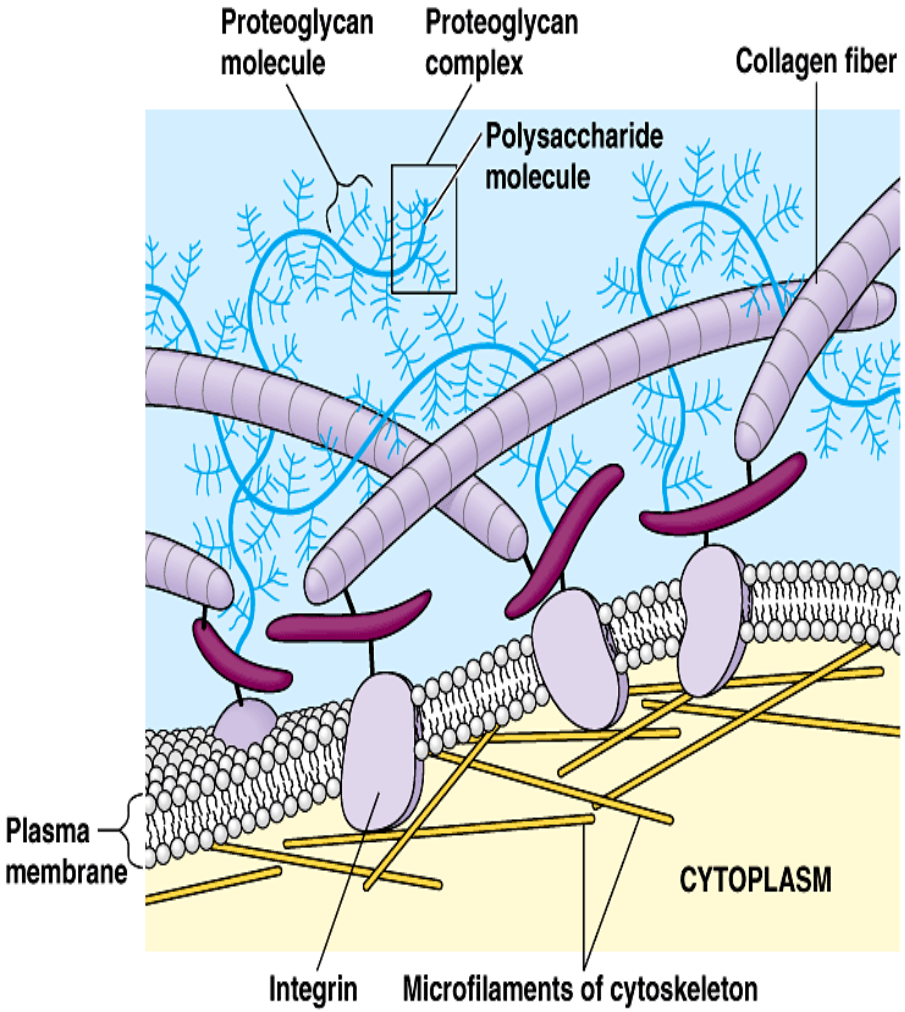
Cellular Organelles

- Cell Wall
  - Found only in plant cells
  - Protects the cell Maintains cell shape
  - Prevents excessive uptake of water
  - Holds plant up against gravity
  - Primary Cell Wall-thin; cellulose
  - Secondary Cell Wall-thicker; found in woody plants



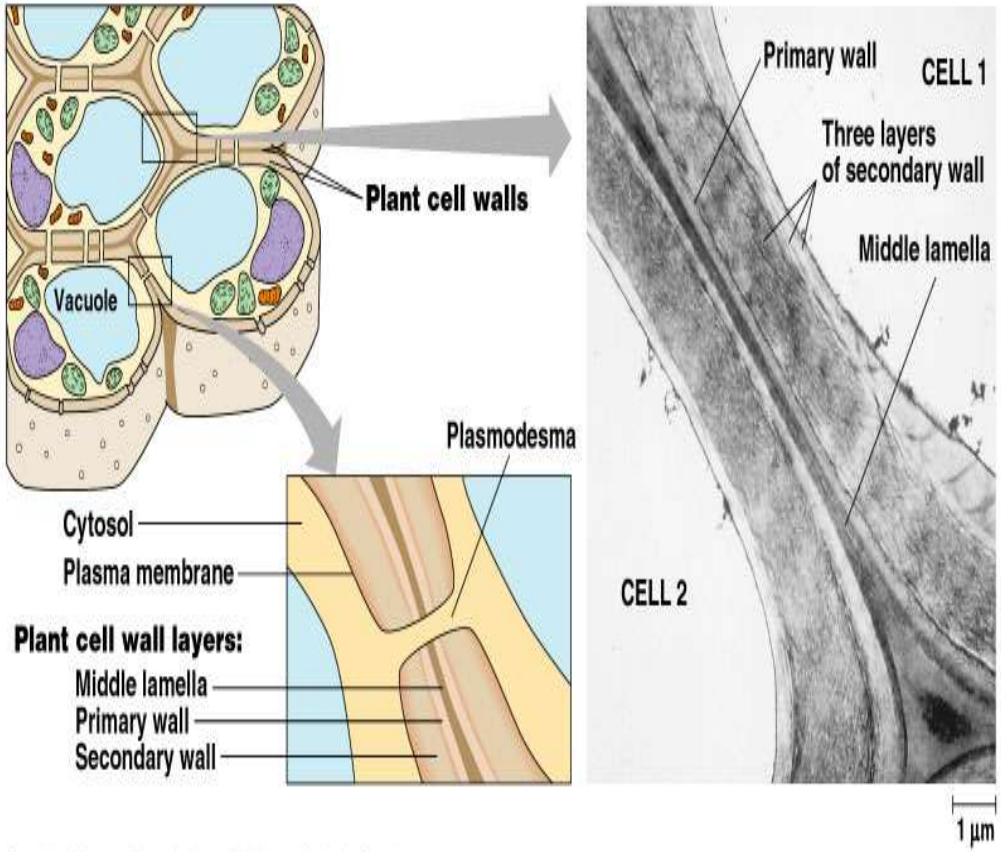
Cellular Organelles



- Extracellular Matrix:
  - Found in animal cells
  - Made up of glycoproteins (collagen) & proteoglycans
    - Proteins + carbohydrates
  - Provides support and anchorage for cells
  - Differs from one cell type to another

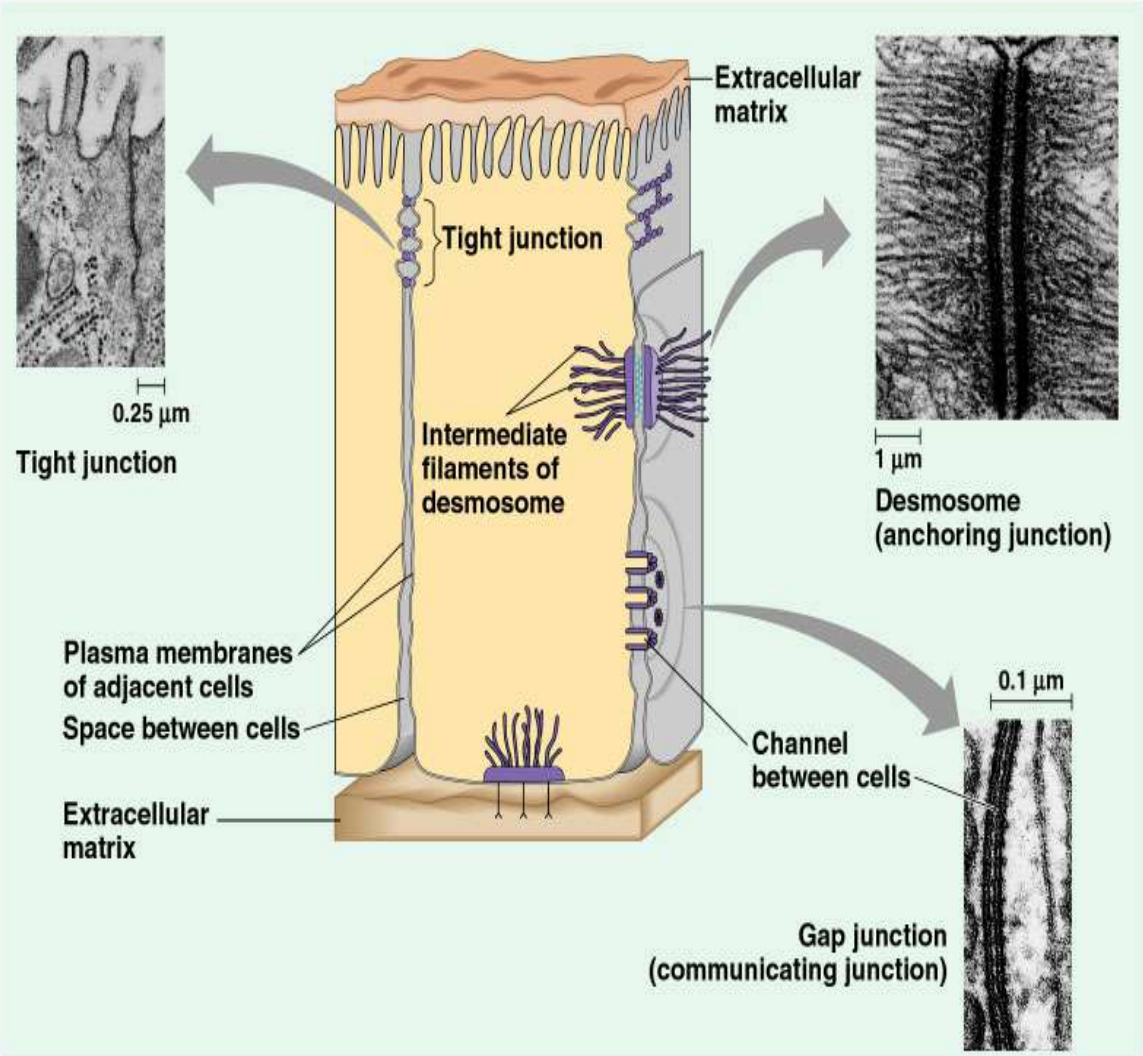
Intercellular Junctions

- Neighboring cells are connected to one another
- Plant cells:
  - Plasmodesmata:
    - Channels in the cell wall through which strands of cytoplasm pass through and connect the living contents of adjacent cells

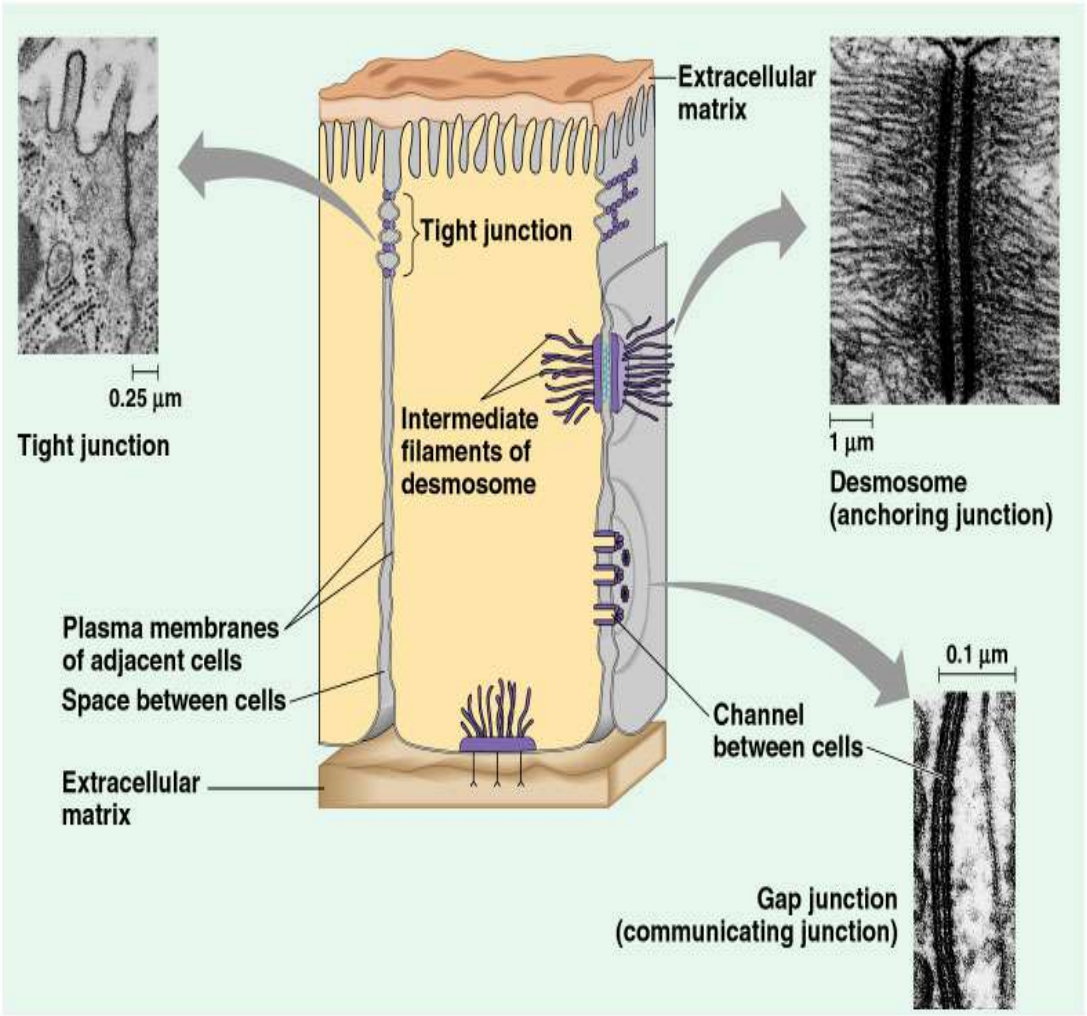


Intercellular Junctions (Animal Cells)

- **Tight junctions-**membrane proteins interlock
- **Desmosomes, (anchoring junction**)-intermediate filaments “sew” membranes together
- **Gap junctions-** channels align allowing materials to flow between cells



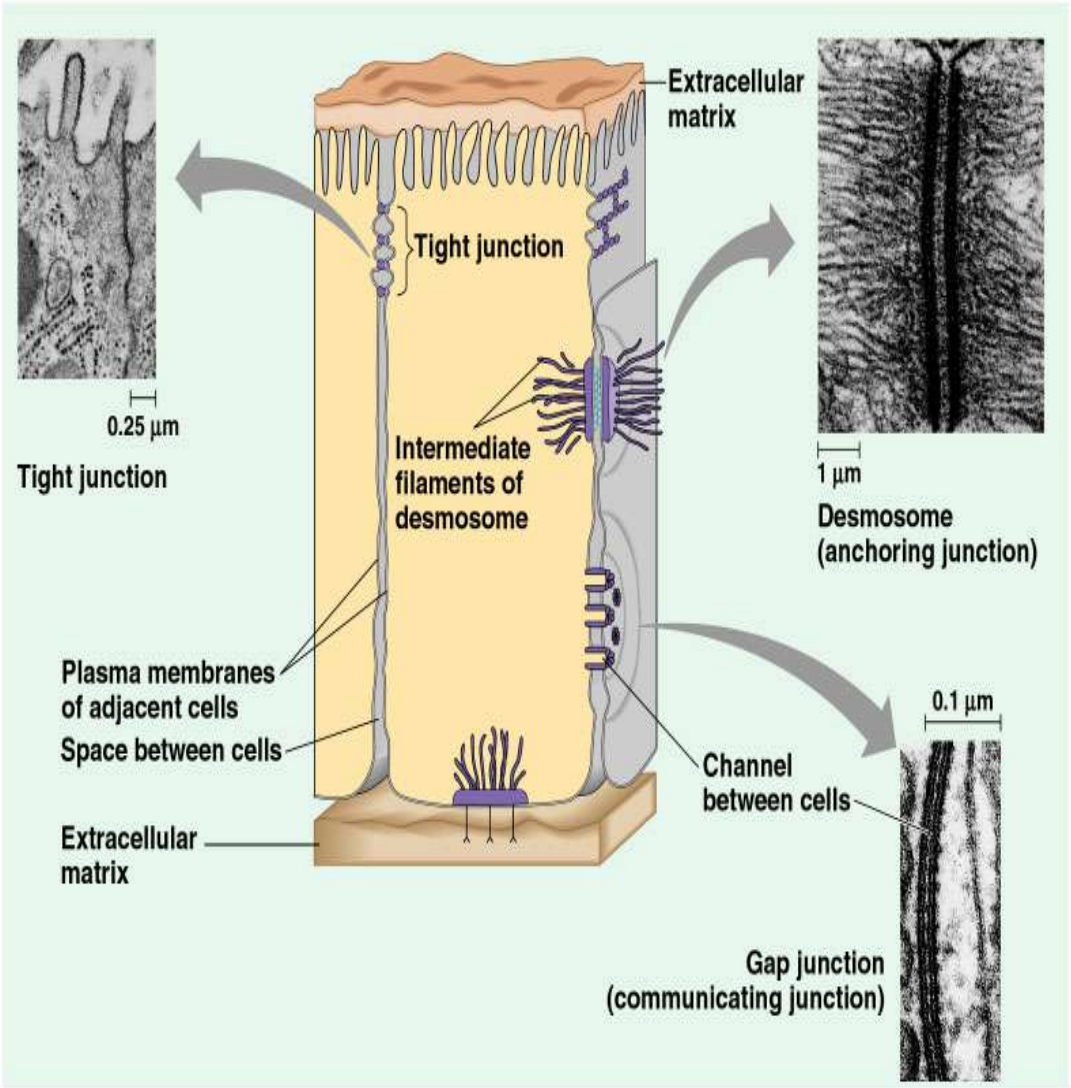
Intercellular Junctions



- **Tight junctions**:
  - Membranes of neighboring cells are fused
  - Form a continuous "belt" around a cell
  - Example: junction between epidermis o the skin

Intercellular Junctions

- **Desmosomes**
  - Anchoring junctions
  - Act as rivets
  - Muscle cells are held together by desmosomes.
  - What happens when a muscle is torn?



Intercellular Junctions

- **Gap junctions**
  - Communicating junctions
  - Cytoplasmic channels between adjacent cells
  - Salts, sugars, AAs, etc. can pass through