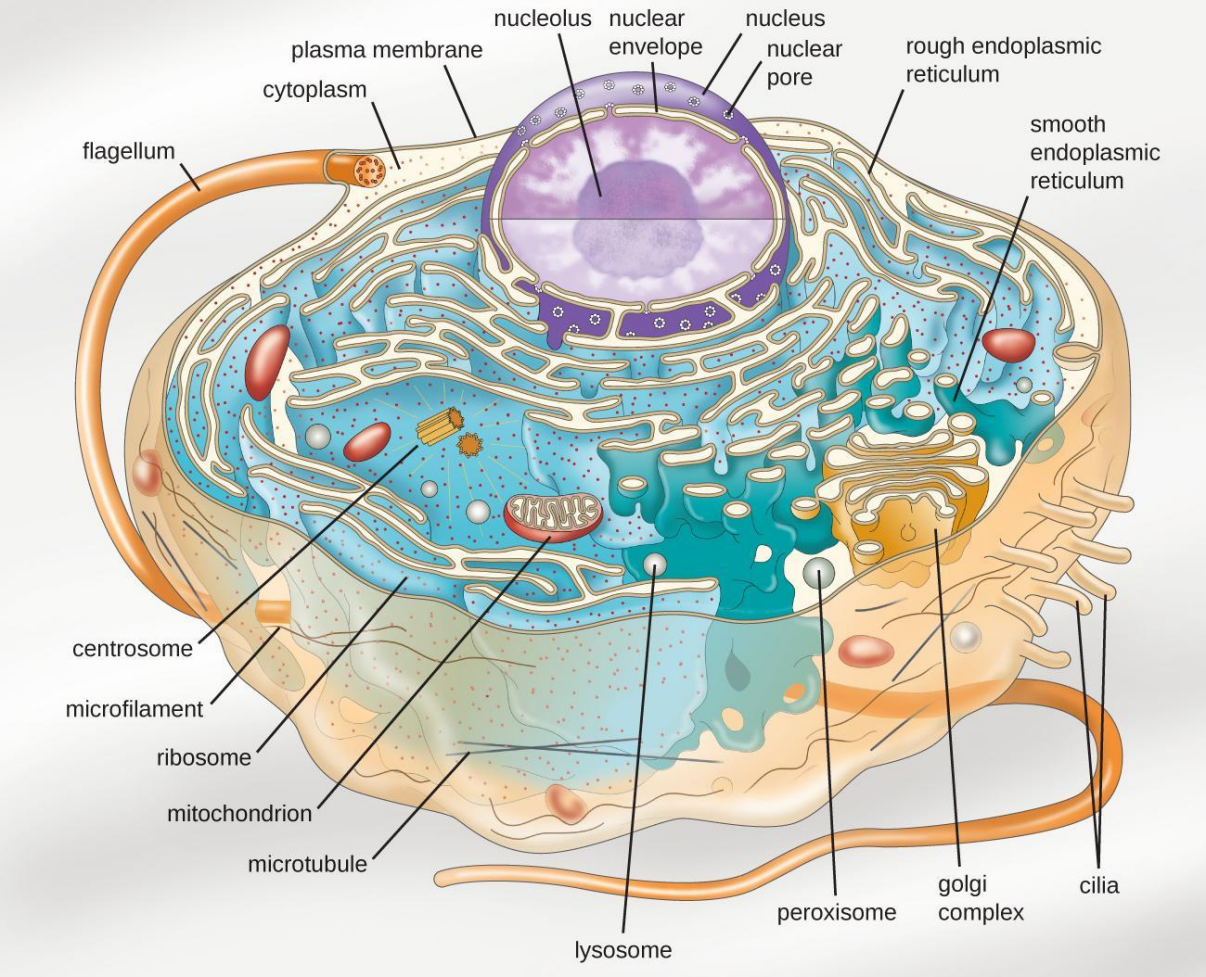
Lecture 11: The eukaryotic cell.



Edited by Marie-Cecile Chalbot, PhD

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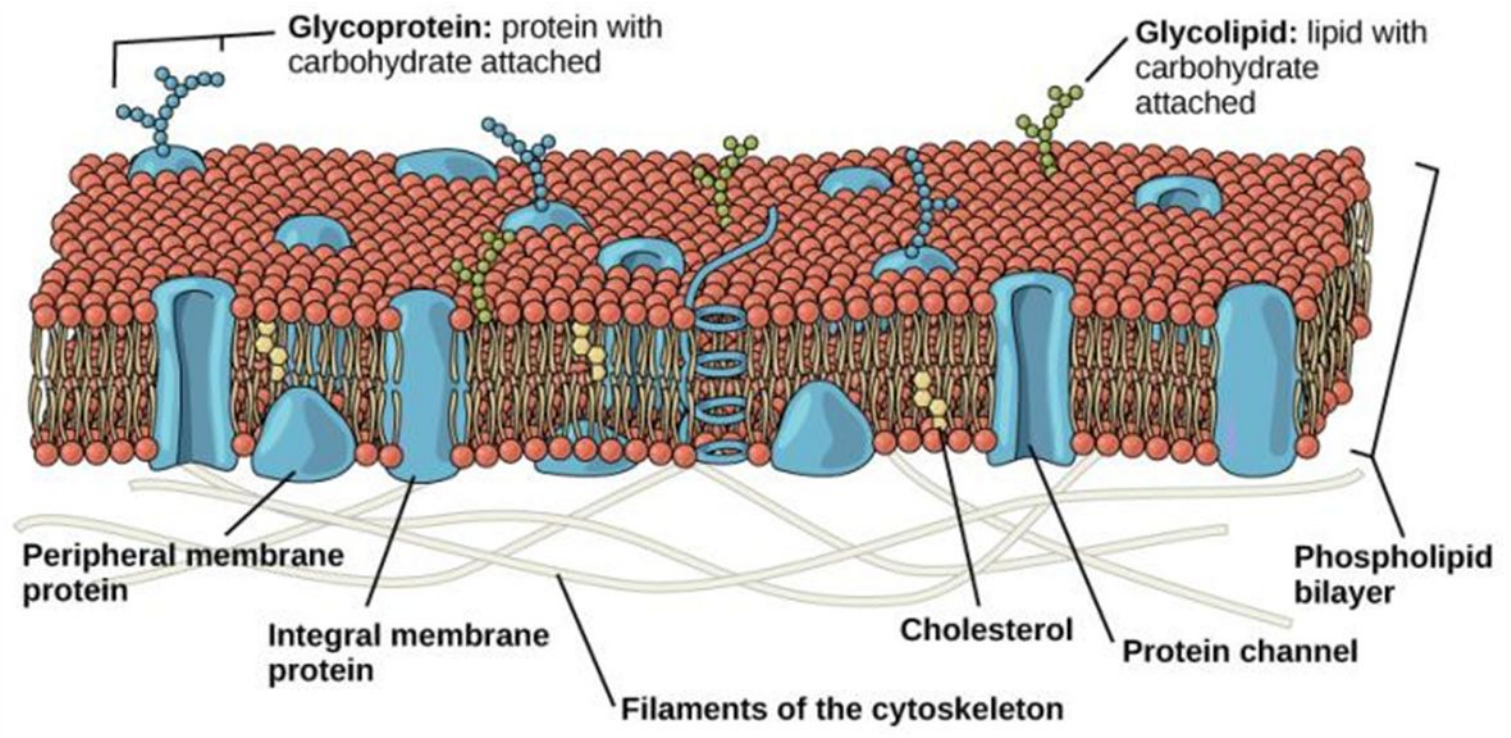
OUTLINE

- Plasma membrane
- Cytoplasm
- Nucleus
- Nucleolus
- Ribosomes
- Mitochondria
- Peroxisomes
- Animal vs plant cells
- The endomembrane system

Eukaryotic plasma membrane



Phospholipid bilayer with embedded proteins.

Cytoplasm: Region between the plasma membrane and the nuclear envelope

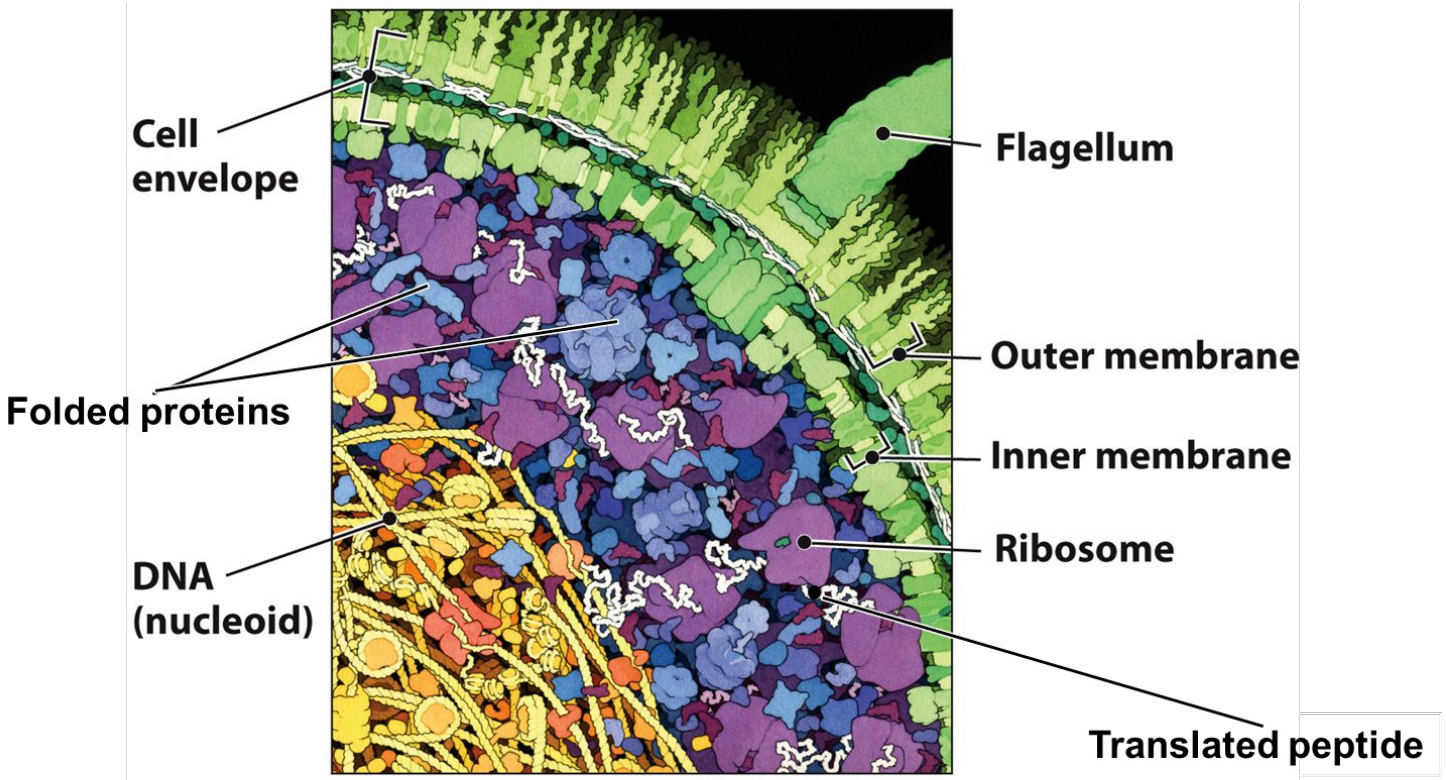
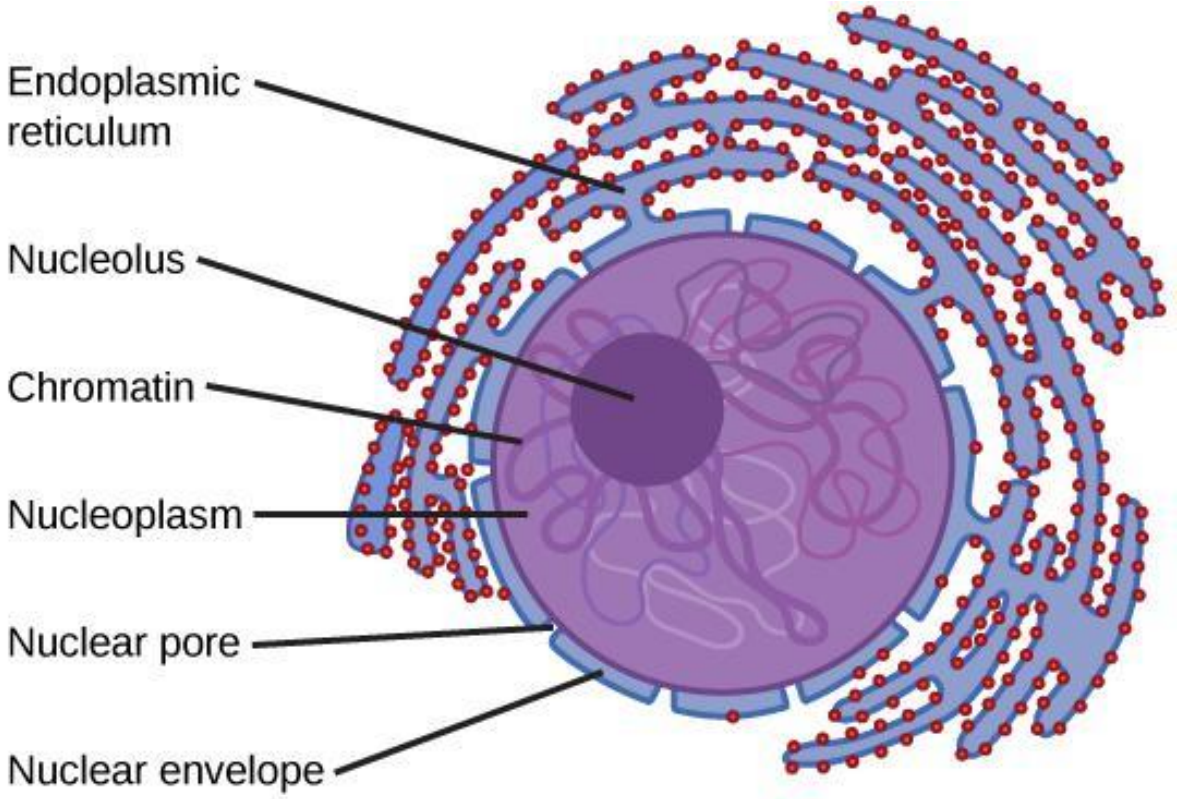


Figure 1-13
Lehninger Principles of Biochemistry, Seventh Edition

- This consists of organelles suspended in gel-like fluid (cytosol) plus the cytoskeleton.
- 70-80% of the cytoplasm is water but it has semi-solid consistency due to proteins within it.

Nucleus

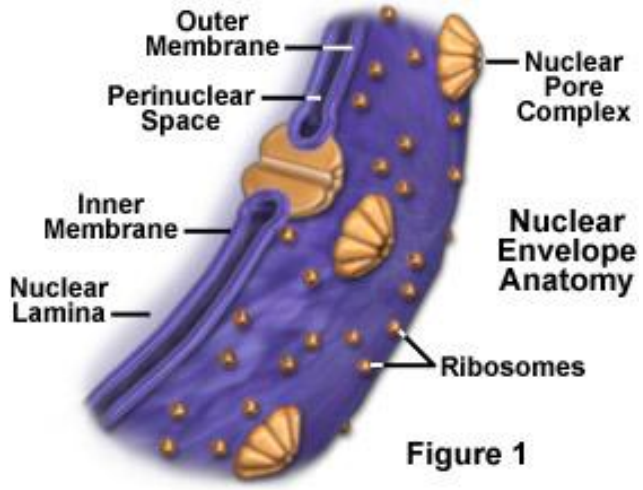
- Usually only one per cell
  - Usually the largest organelle
  - Bigger itself than most prokaryotic cells



Nuclear Envelope

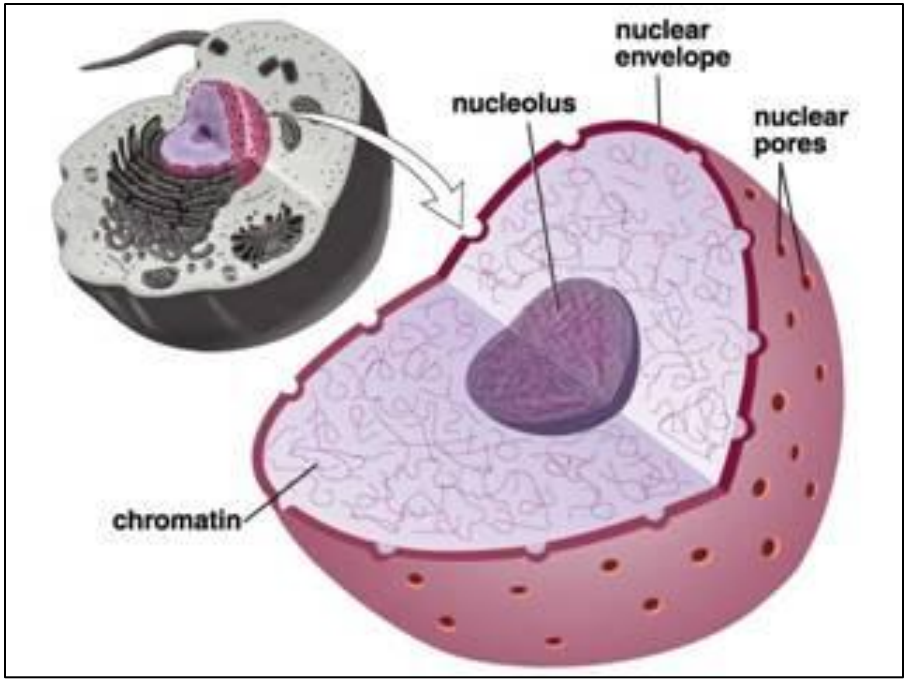
- This is a double membrane
  - Separates DNA from cytoplasm
  - Separates transcription from translation

- Nuclear pores perforate this membrane
  - Connect nucleoplasm to cytoplasm
  - Regulate flow of molecules back & forth
  - Large molecules require nuclear localization signal (NLS) to pass



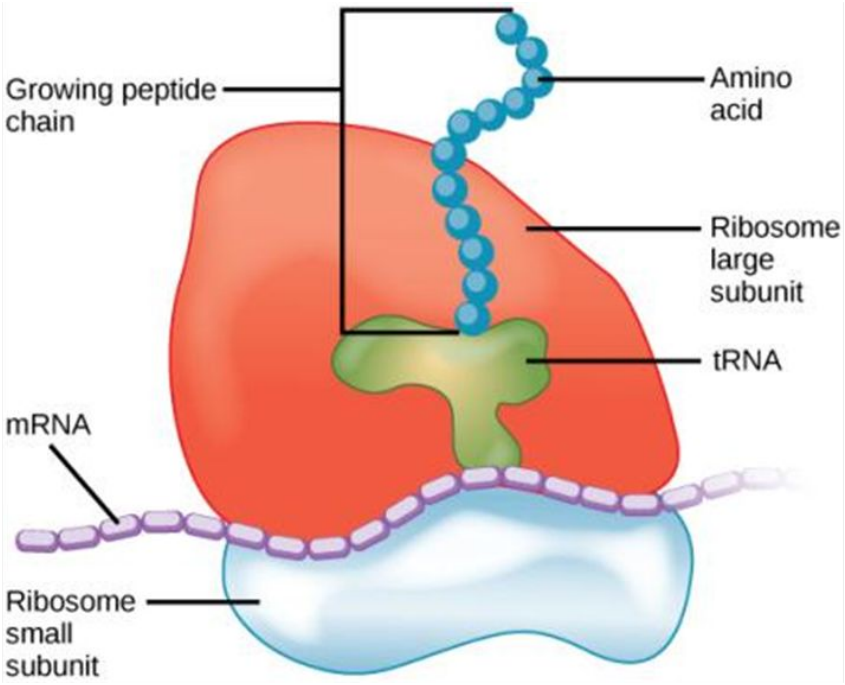
Nucleolus

- This is a region inside nucleus where ribosomes are assembled from RNA & proteins



Ribosomes

- Made of two different-sized subunits
- Slightly larger in eukaryotes
- Made of special RNA (rRNA) and proteins

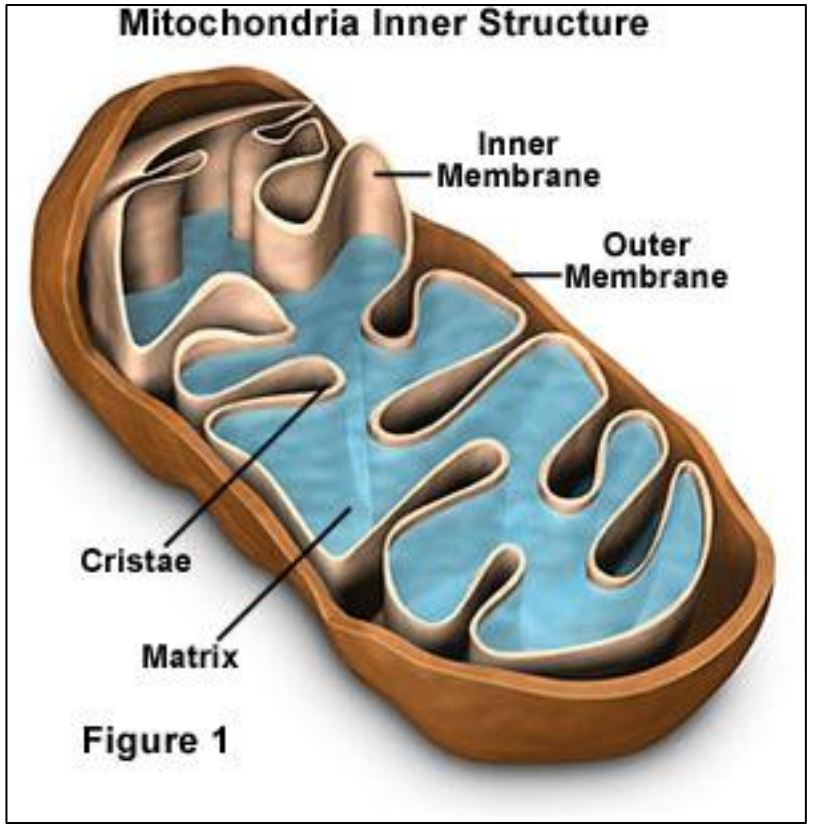


- During protein synthesis, ribosomes assemble amino acids into proteins

Mitochondrion

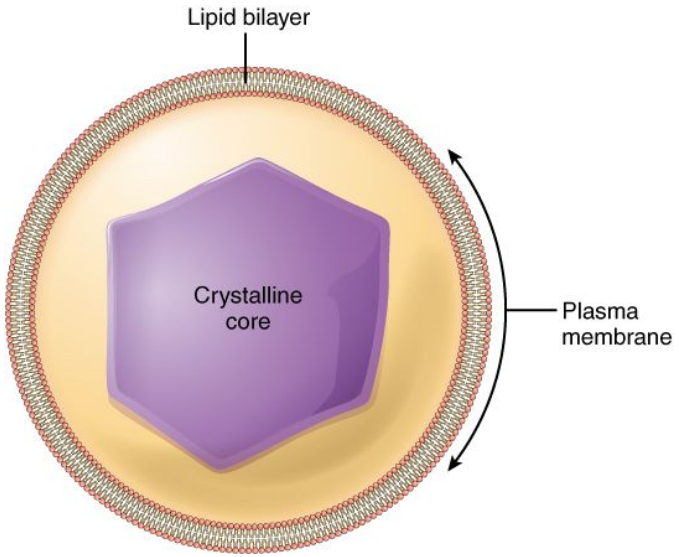
- Site for conversion of stored energy (macromolecule molecular bonds) to more useful form (ATP)
- Site of the Krebs cycle where CO_2 is produced from oxidative decarboxylation of glycolysis products
- Inner membrane is folded
  - Folds are called cristae
  - Increase surface area
  - Area enclosed is the mitochondrial matrix

ATP is formed in the matrix coupled to a gradient of [H+] on both sides of the inner membrane



Peroxisomes

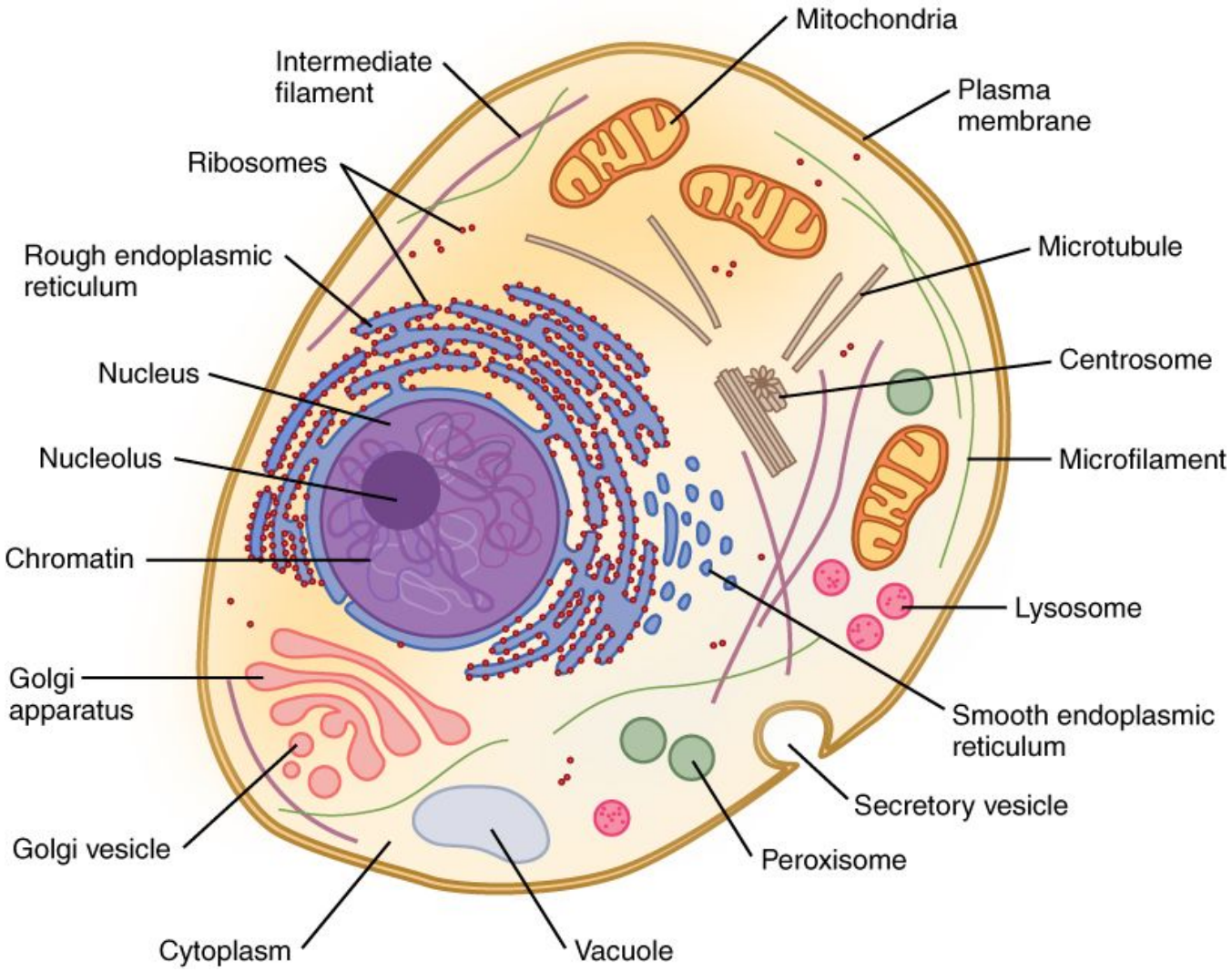
- Peroxisomes are small rounded organelles enclosed by a single membrane
- Reactions that break down fatty acids and amino acids occur here
- Peroxisomes may detoxify poisons



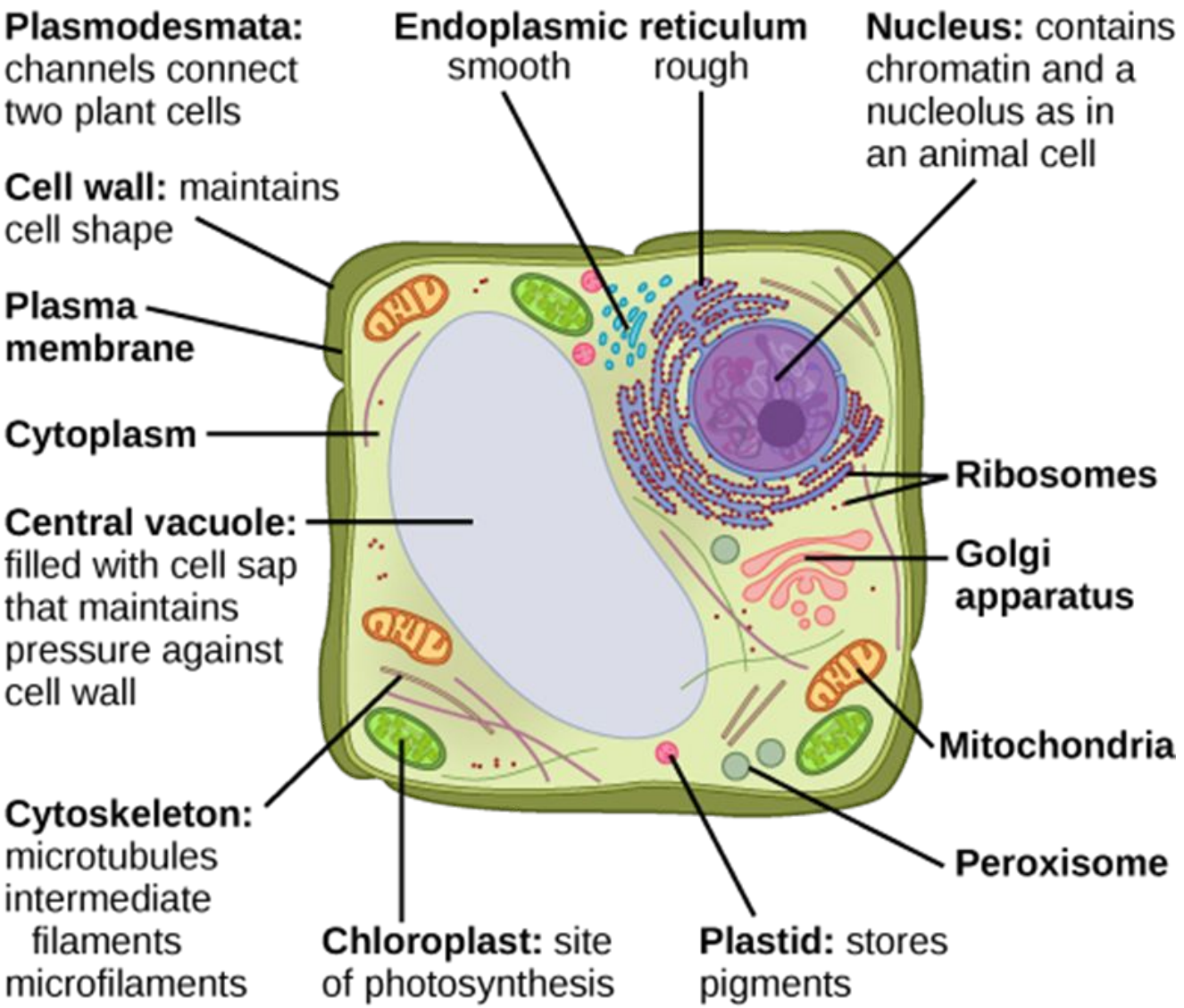
Contrasting Animal and Plant Cells

- Both have microtubule organizing centers (MTOCs), but animal cells also have centrioles associated with the MTOC
  - This complex is called the centrosome
- Animal cells each have a centrosome and lysosomes but plant cells do not
- Plant cells have a cell wall, chloroplasts and other specialized plastids and a large central vacuole - animal cells do not

Animal Cell

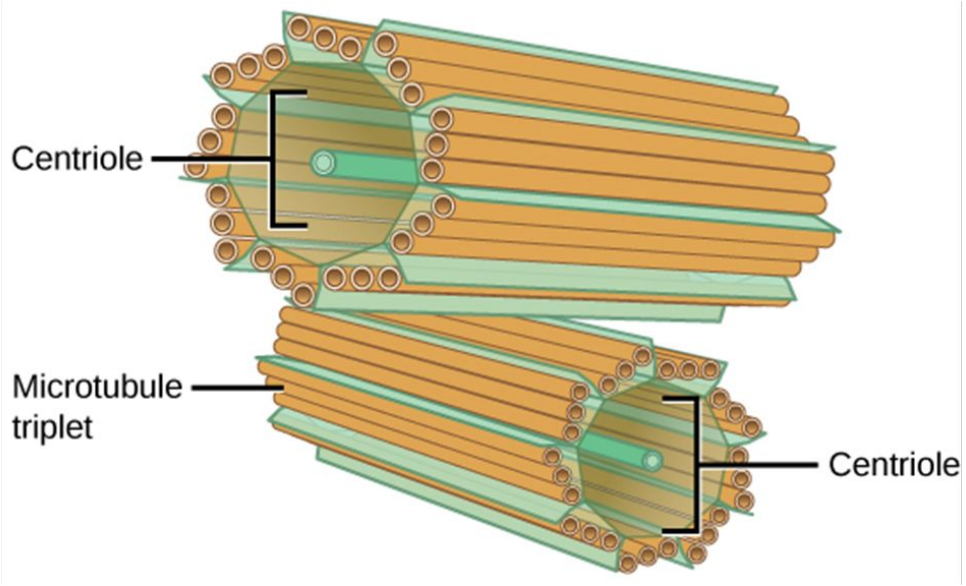

Mitochondria
Intermediate filament
Plasma membrane
Ribosomes
Microtubule
Rough endoplasmic reticulum
Centrosome
Nucleus
Microfilament
Nucleolus
Chromatin
Lysosome
Golgi apparatus
Smooth endoplasmic reticulum
Secretory vesicle
Golgi vesicle
Peroxisome
Cytoplasm
Vacuole

Plant Cell


Plasmodesmata: channels connect two plant cells
Endoplasmic reticulum smooth rough
Nucleus: contains chromatin and a nucleolus as in an animal cell
Cell wall: maintains cell shape
Plasma membrane
Cytoplasm
Central vacuole: filled with cell sap that maintains pressure against cell wall
Ribosomes
Golgi apparatus
Mitochondria
Peroxisome
Cytoskeleton: microtubules intermediate filaments microfilaments
Chloroplast: site of photosynthesis
Plastid: stores pigments

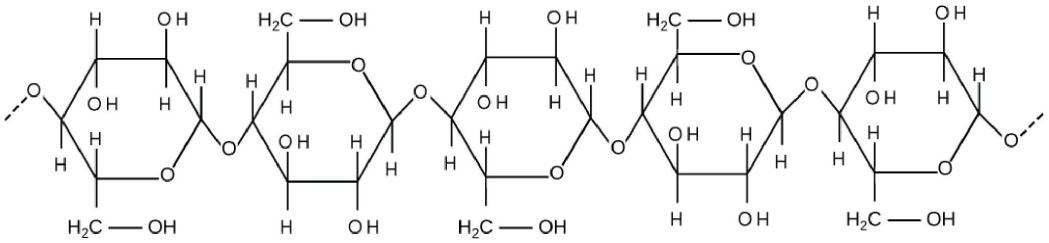
Centrosome

- The centrosome consists of two centrioles that lie at right angles to each other
- Each centriole is a cylinder made up of nine triplets of microtubules
- Nontubulin proteins (indicated by the green lines) hold the microtubule triplets together

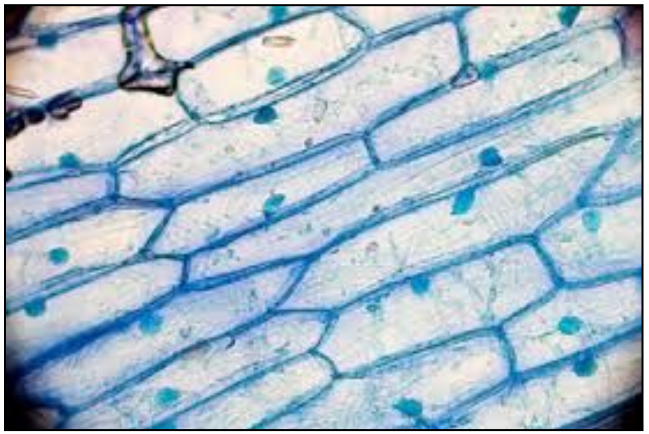


Plant Cell Walls

- The cell wall is a rigid protective structure external to the plasma membrane
- Plant cell walls differ from prokaryotes because they are made up of cellulose rather than peptidoglycan.

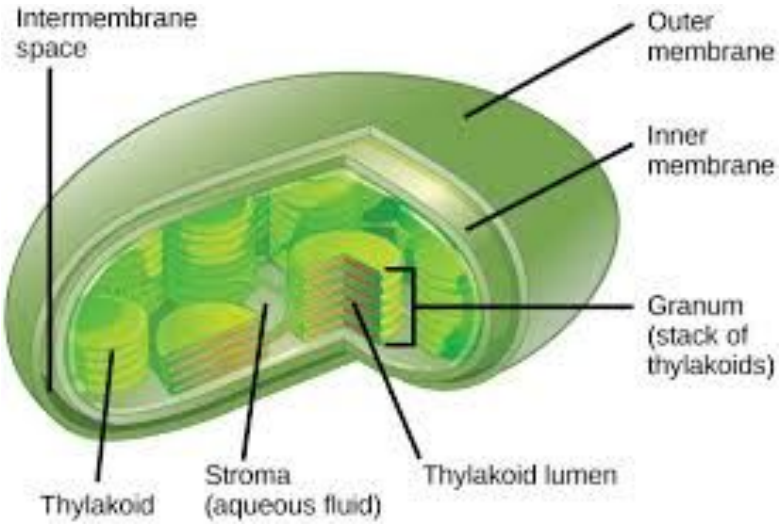


Cellulose molecule



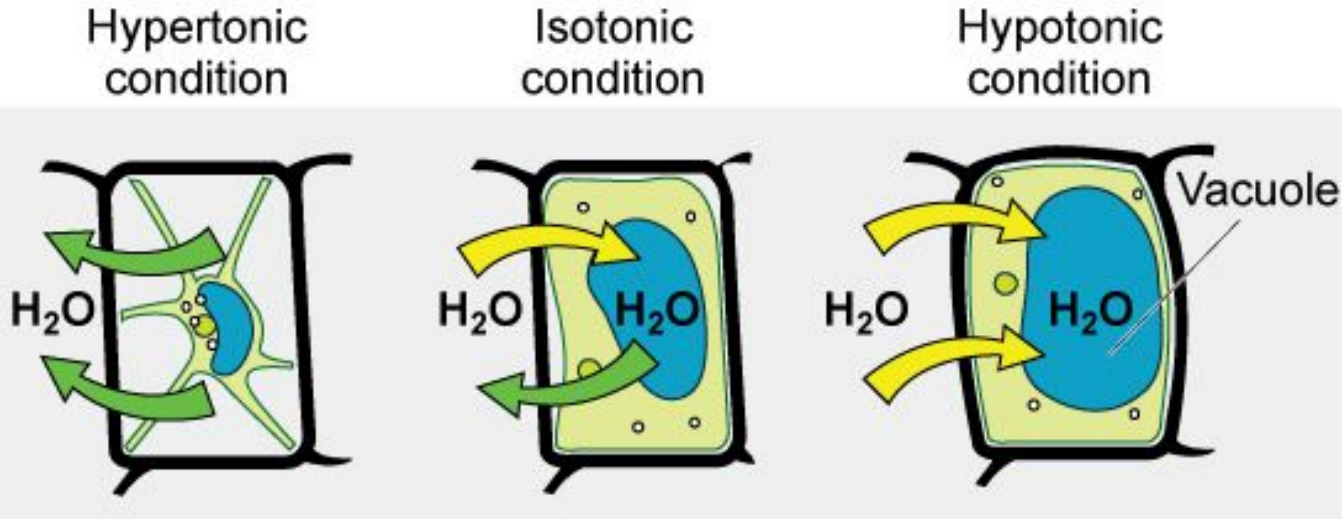
Chloroplasts

- Chloroplasts are double-membrane organelles; have their own ribosomes and DNA like mitochondria
- The inner membrane encloses an aqueous fluid (stroma) that contains a set of interconnected and stacked fluid-filled membrane sacs called thylakoids
- Each stack of thylakoids is a granum (plural = grana).



The Central Vacuole

- Plant cells have a large vacuole that occupies most of the area of the cell
- This central vacuole helps regulate water concentration under changing environmental conditions, and contributes to cell expansion.

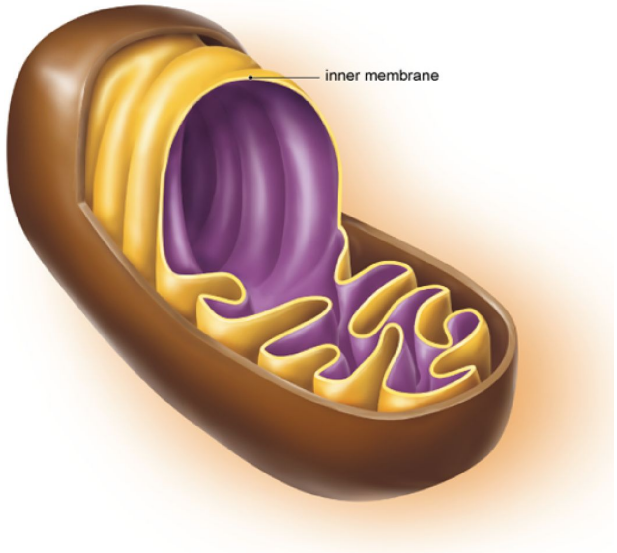


Endosymbiosis

- It is hypothesized that mitochondria and chloroplasts originated as independent prokaryotic organisms.
- These became endosymbionts of the prokaryotic ancestors of the eukaryotes.
- In addition to having their own DNA and ribosomes, the size of these organelles is similar to that of independent prokaryotes.
- Much original research undertaken by Lynn Margulis.

Questions

1. What function does the nucleolus have?
A. houses the chromatin
B. prepares products for export from the cell
C. contains enzymes for intracellular digestion
D. contains the majority of cellular DNA
E. codes for the synthesis of ribosomal RNA



2. Mitochondria are found in
A. plant cells.
B. animal cells only.
C. both plant cells and animal cells.
D. neither plant or animal cells.
E. animal cells and bacterial cells only.

3. What does the folding of the mitochondrial inner membrane shown here provide?
A. greater ability to allow for osmosis
B. increased surface area for photosynthesis
C. greater ability to remove waste from the cell cytosol
D. greater surface area for ATP production
E. increased space for protein synthesis

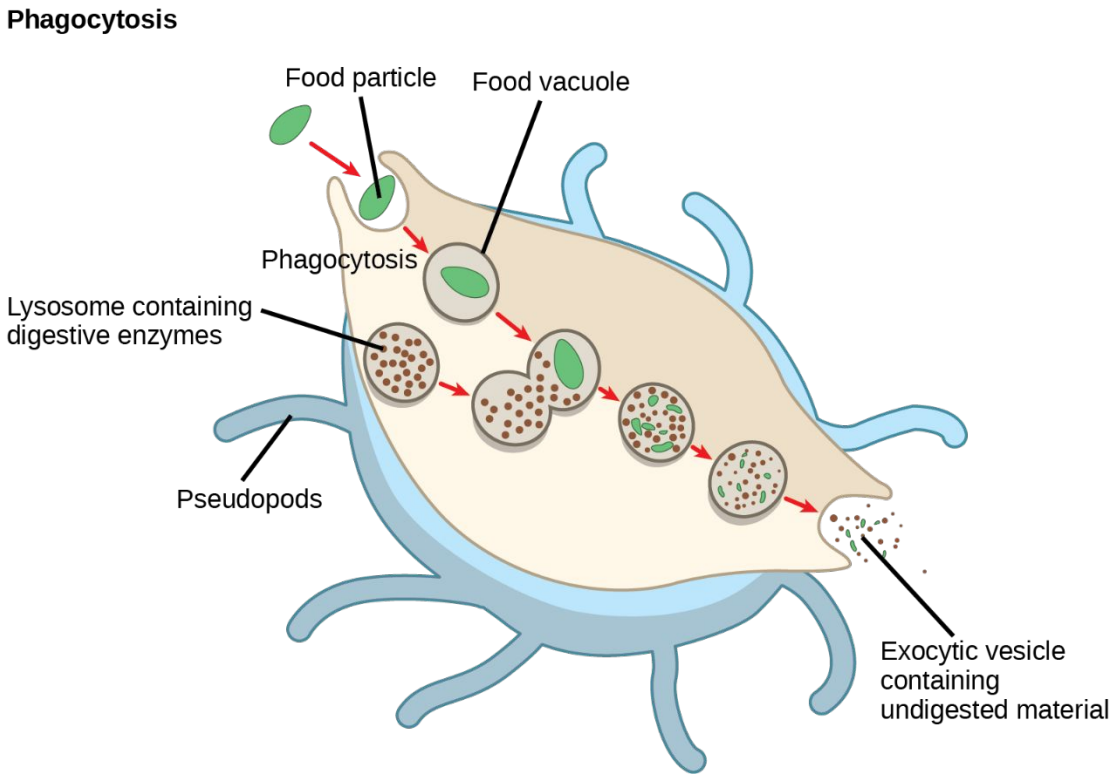
The Endomembrane System

- The endomembrane system consists of internal membranes and organelles in eukaryotic cells that work together to modify, package, and transport lipids and proteins.

- Includes: nuclear envelope, lysosomes, and vesicles, endoplasmic reticulum and Golgi apparatus plus the plasma membrane

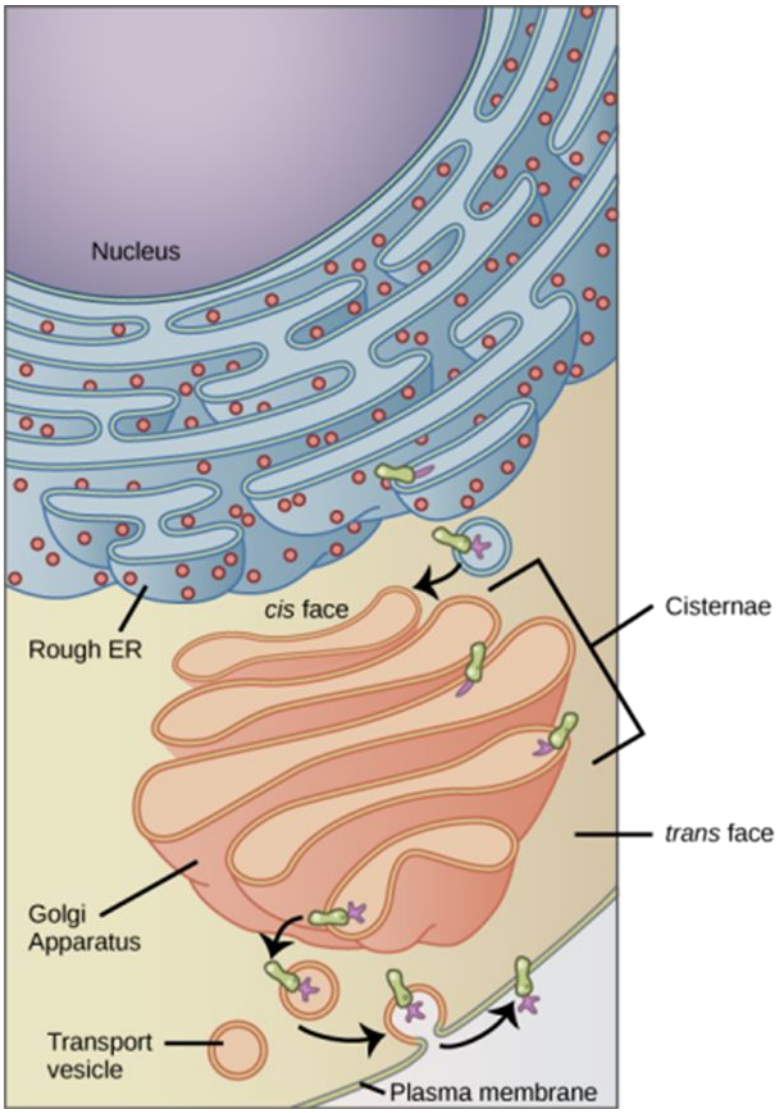
Lysosomes

- Lysosomes in animal cells contain digestive enzymes
- These breakdown large biomolecules and even worn-out organelles



Endoplasmic reticulum (ER)

- Interconnected membranous sacs and tubules.
- Modifies proteins (rough ER) and synthesizes lipids (smooth ER).
- The hollow portion of the ER tubules is called the lumen or cisternal space.
- The membrane of the ER is continuous with the nuclear envelope.

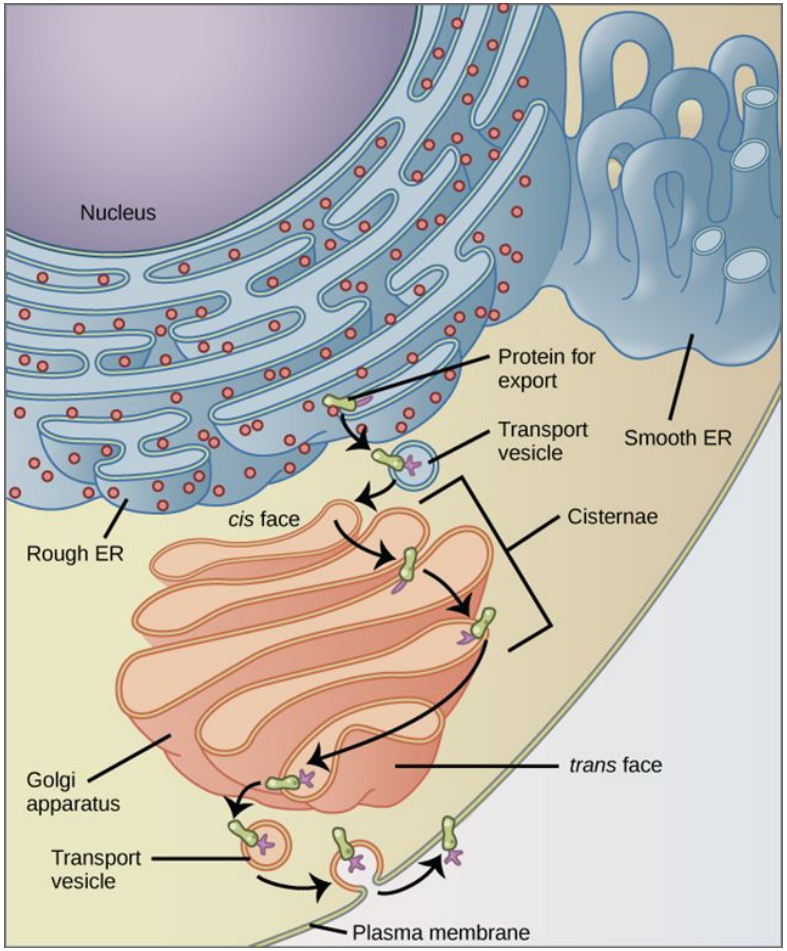


Rough Endoplasmic Reticulum

- Ribosomes attached to the cytoplasmic surface manufacture proteins
- New proteins are modified (by folding or the acquisition of side chains) in the lumen of the RER
- Modified proteins are either incorporated into cellular membranes or secreted from the cell (eg. protein hormones, enzymes)

Rough Endoplasmic Reticulum

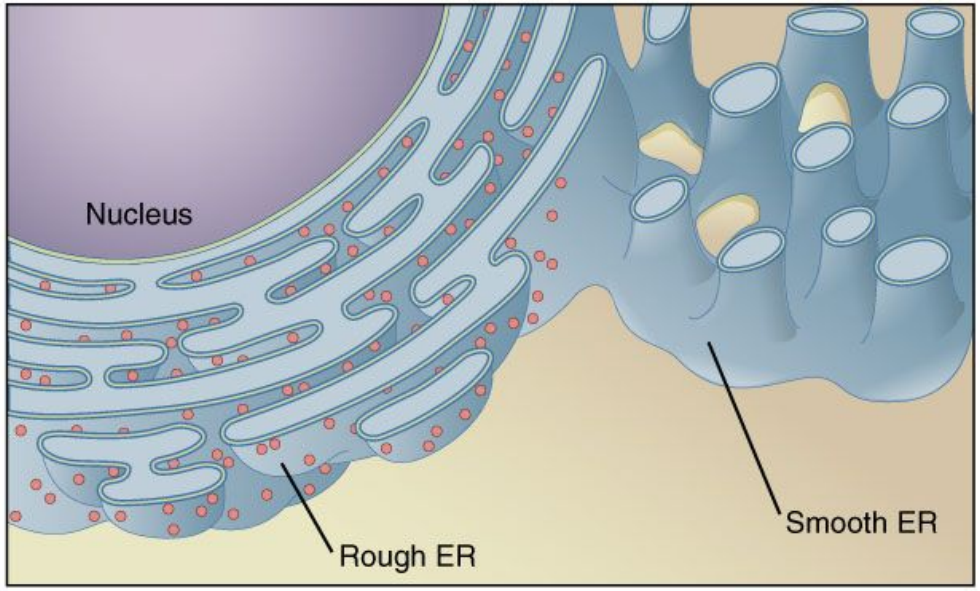
- The RER also makes phospholipids for cellular membranes.
- Phospholipids or modified proteins not destined to stay in the RER reach their destinations via transport vesicles that bud from the RER's membrane.



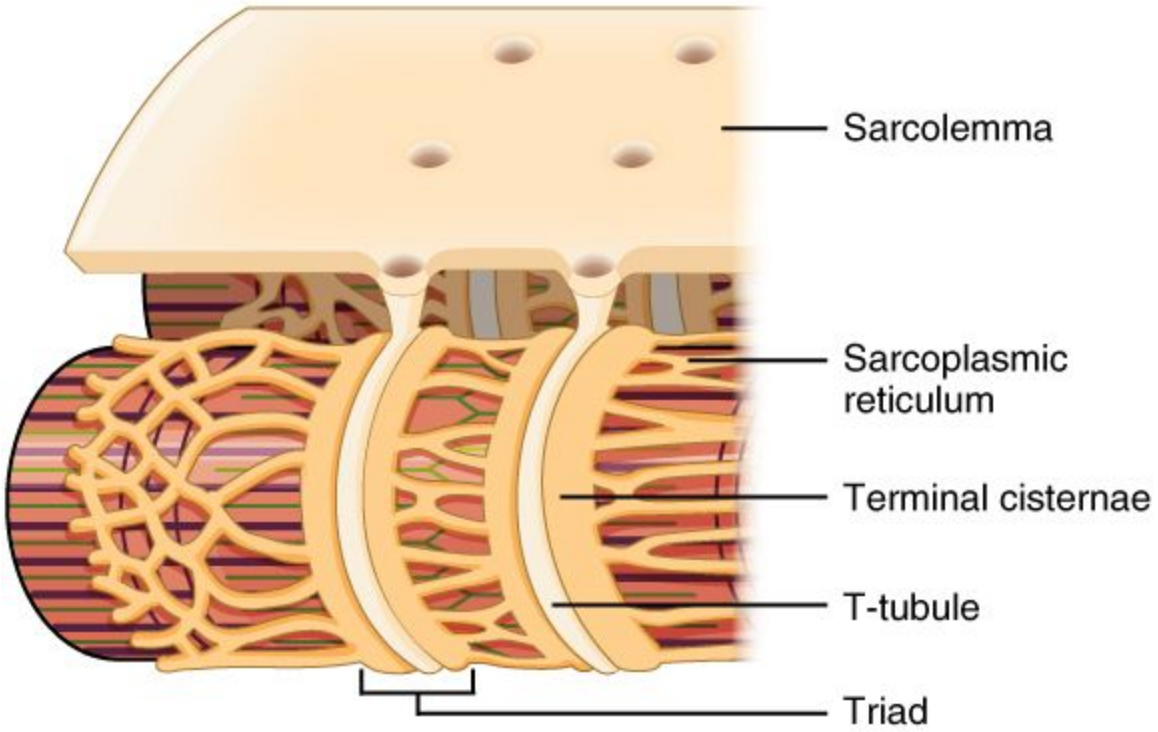
Smooth Endoplasmic Reticulum

The SER is continuous with the RER but has few or no ribosomes on its cytoplasmic surface.

- Synthesis of
  - Carbohydrates
  - Lipids
  - Steroid hormones
- Detoxification of medications and poisons
- Storage of Ca^{++}

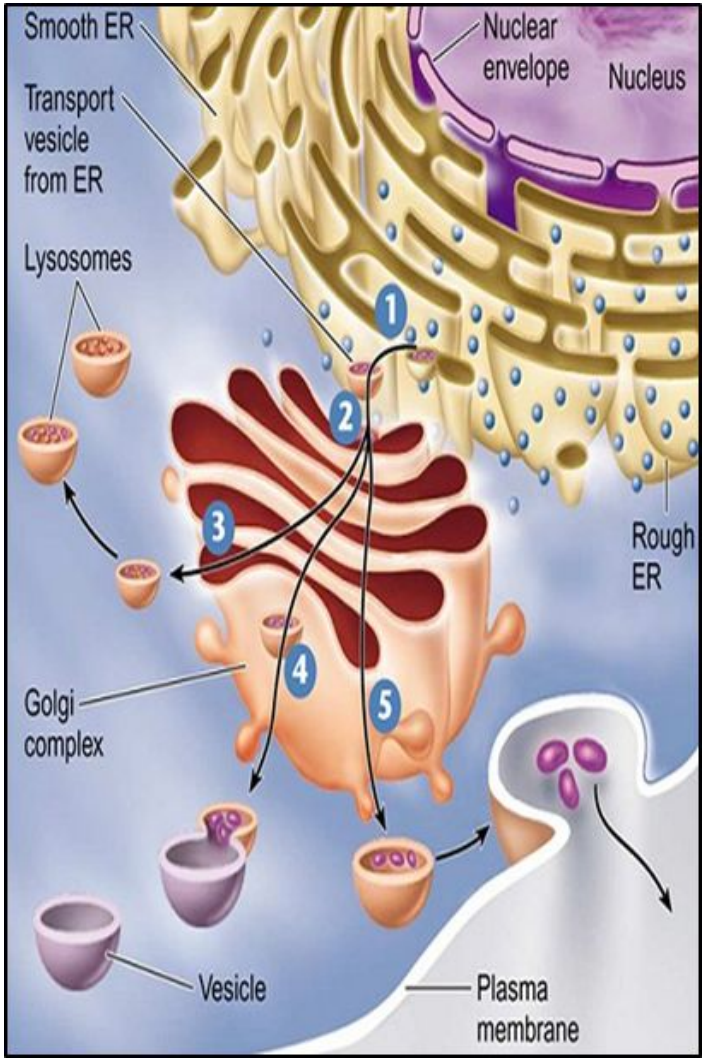


In muscle cells, a specialized SER called the *sarcoplasmic reticulum* stores Ca^{++} needed for the coordinated contractions of the muscle cells.



Golgi Apparatus

- Lipids or proteins within transport vesicles still need to be sorted, packaged, and tagged so that get to the right place
- This occurs in the Golgi apparatus (also called the Golgi body) which consists of a series of flattened membranes



Golgi Apparatus

- The receiving side of the Golgi apparatus is called the *cis* face; the opposite side is the *trans* face.
- Transport vesicles from the ER fuse with the cis face and empty their contents into the lumen of the Golgi apparatus.
- As the proteins and lipids travel through the Golgi, they are further modified so they can be sorted.
- This often involves adding short chains of sugar molecules

The Cytoskeleton

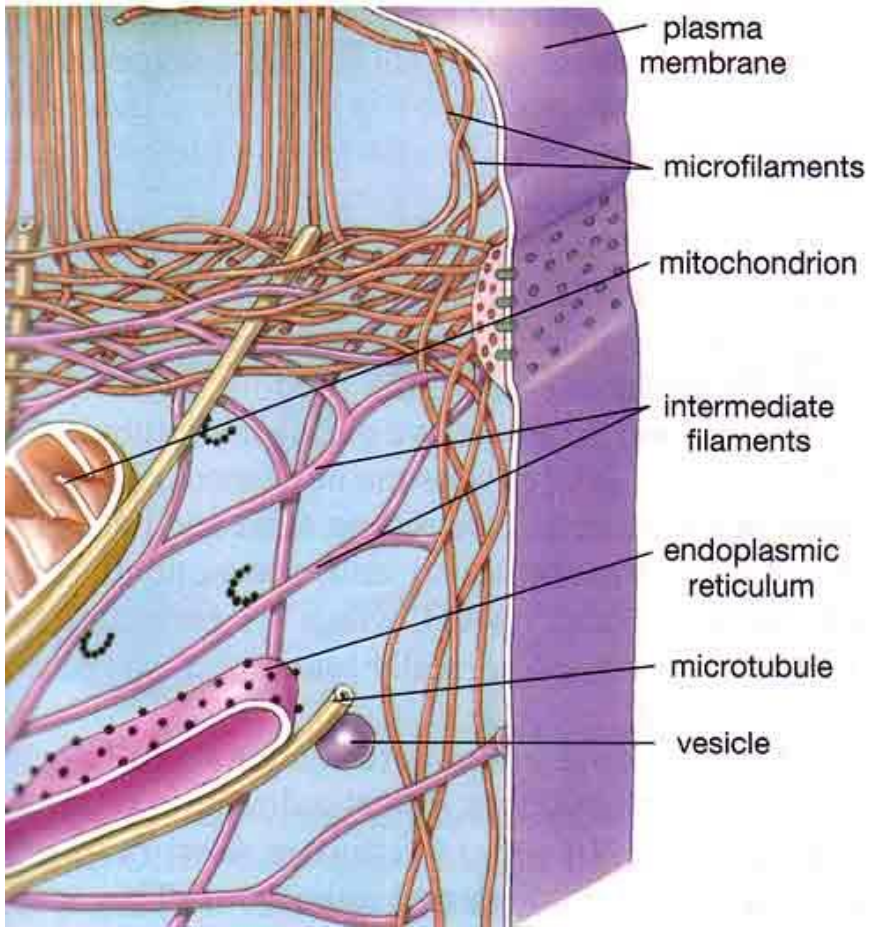
The cytoskeleton is a network of protein fibers with several functions

- It helps maintain the shape of the cell;
- Hold some organelles in specific positions
- Allows movement of cytoplasm and vesicles within the cell:
- Enables cells within multicellular organisms to move

Three Components of Cytoskeleton

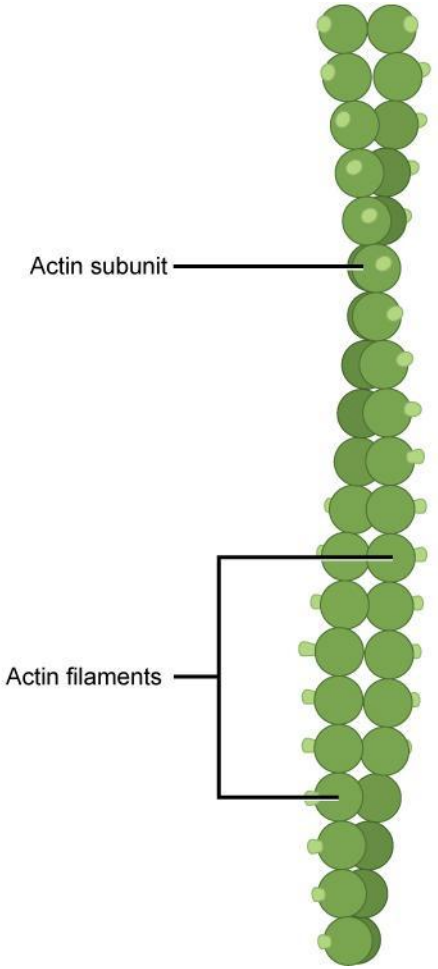
- Microfilaments
- Intermediate filaments
- Microtubules

- Different sizes; different functions



Microfilaments

- Involved in movement
  - Whole cell or internal parts
- Determine & stabilize shape
- Made from actin monomers



Microtubules

- Form rigid internal skeleton for some cells
- Provide framework for motor proteins to move structures within cell
- Made of tubulin dimers
  - 13 chains of dimers surround central cavity of microtubule

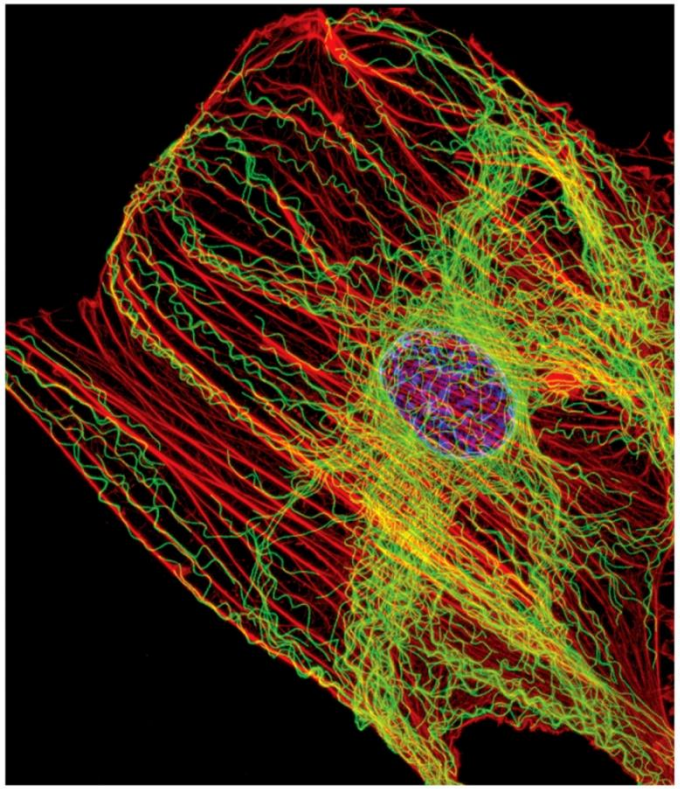


Figure 1-10a
Lehninger Principles of Biochemistry, Seventh Edition

In this cultured fibroblast cell, bundles of actin filaments are stained red; microtubules, radiating from the cell center, are stained green; and chromosomes (in the nucleus) are stained blue.

Cilia & Flagella

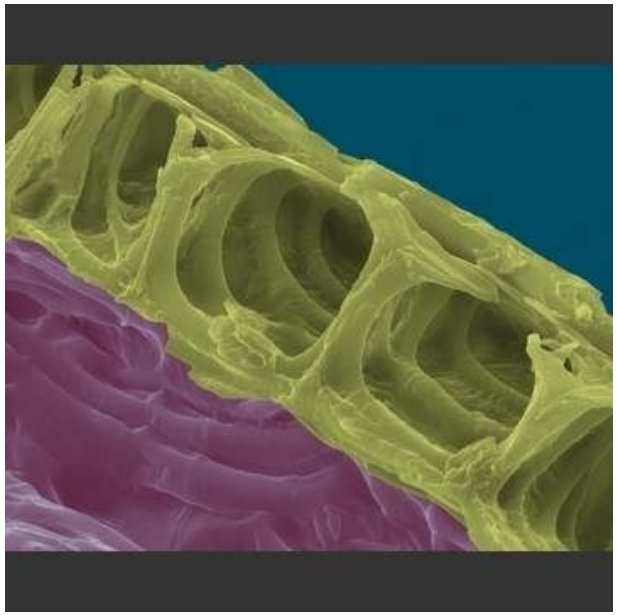
- Ultrastructure
  - Same 9+2 array of microtubules
    - 9 doublets on outside
    - 2 unfused in center
    - Spokes connect doublets to middle
- Cilia shorter and more numerous
- Beating patterns differ

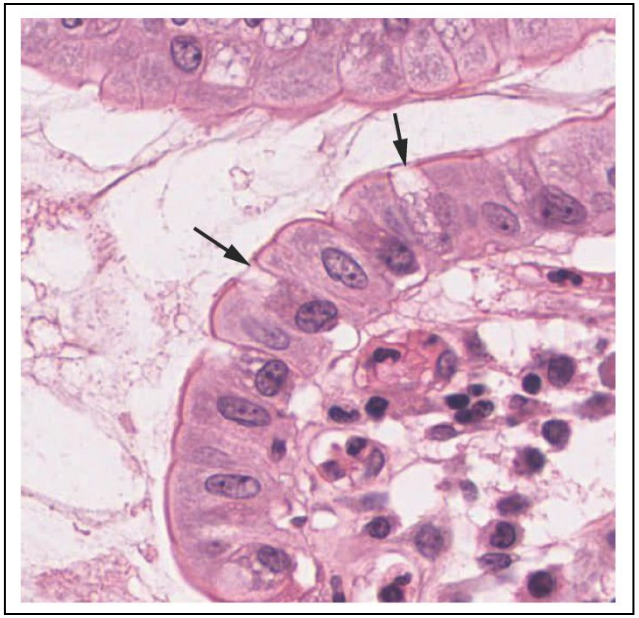
Extracellular Structures

- Plant cell wall
  - Support
  - Barrier to infection
  - Plasmodesmata connect cells
- Extracellular matrix in animals
  - 3 components
    - Collagens & other fibrous proteins
    - Glycoproteins called proteoglycans
    - Linking proteins

Intercellular Junctions

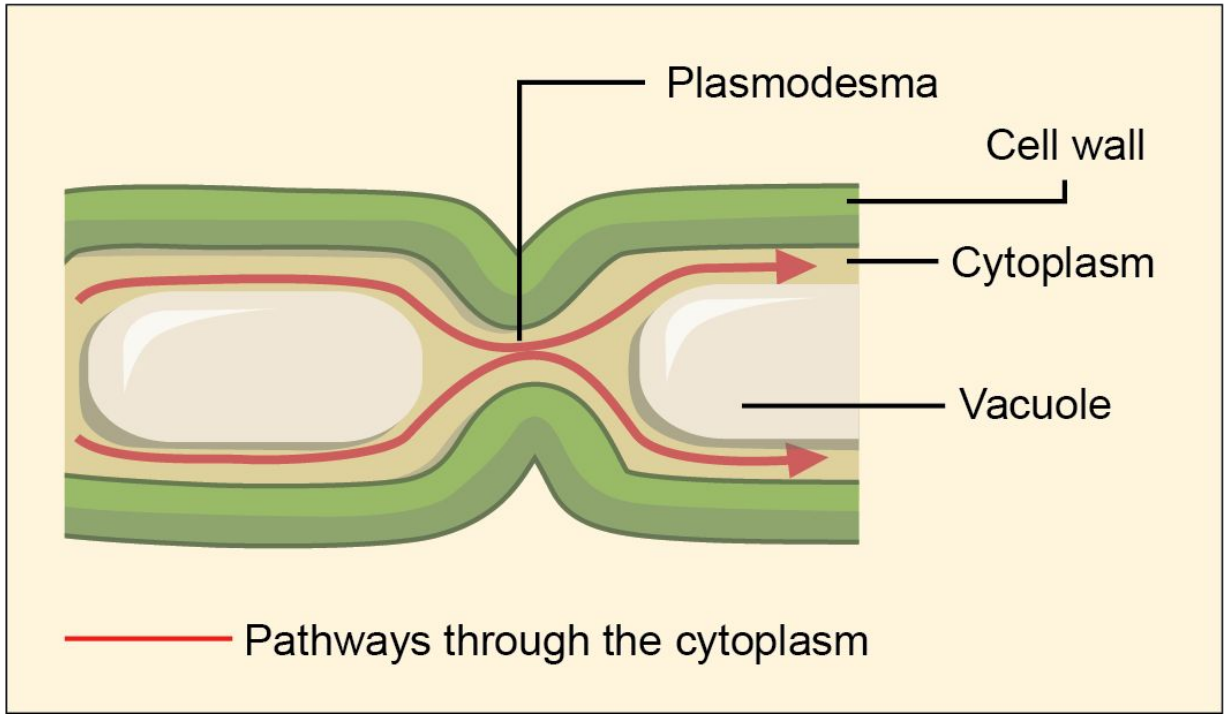
- Intercellular junctions provide direct channels of communication between cells
- Plants and animals do this differently





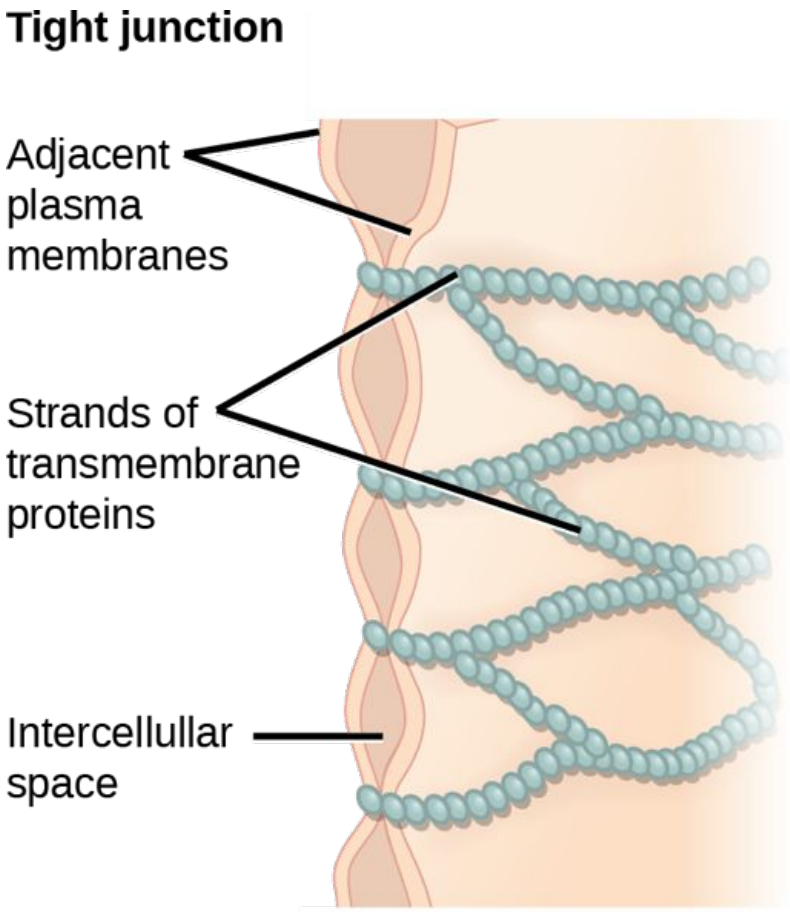
Plasmodesmata

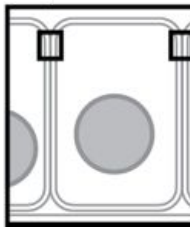
- Plasmodesmata are channels that pass between cell walls in plants to connect cytoplasm and allow materials to move from cell to cell



Tight Junctions

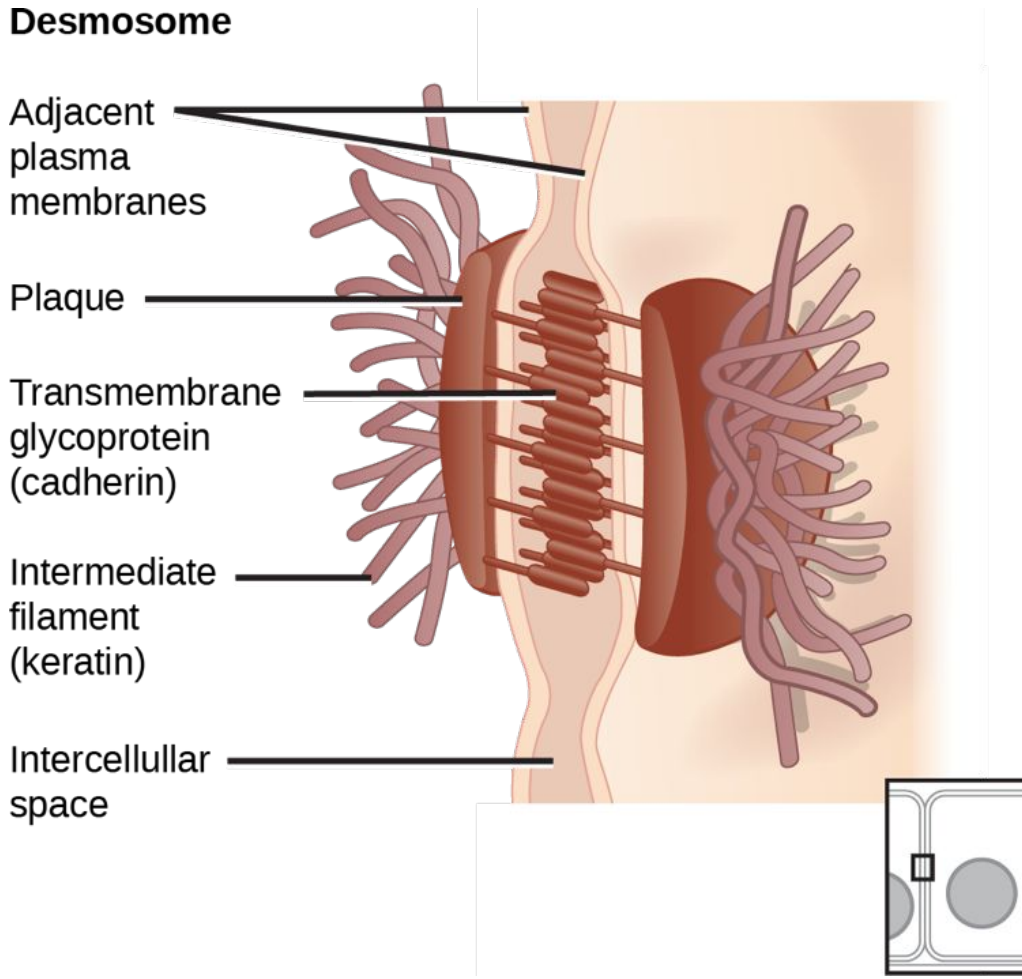
- Tight Junctions are watertight seals between animal cells that prevent materials from leaking between cells
- These are found in epithelial cells that line internal organs and cavities.





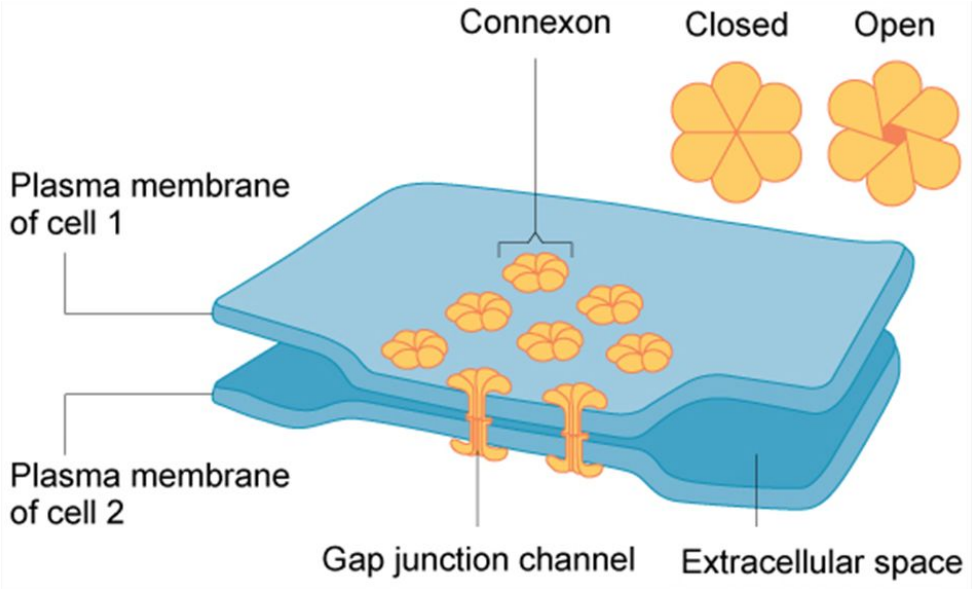
Desmosomes

- Desmosomes are short proteins in the plasma membrane (cadherins) that act as spot welds
- These join adjacent cells in tissues that stretch (*eg*. heart, lungs, muscles)
- Only present animals

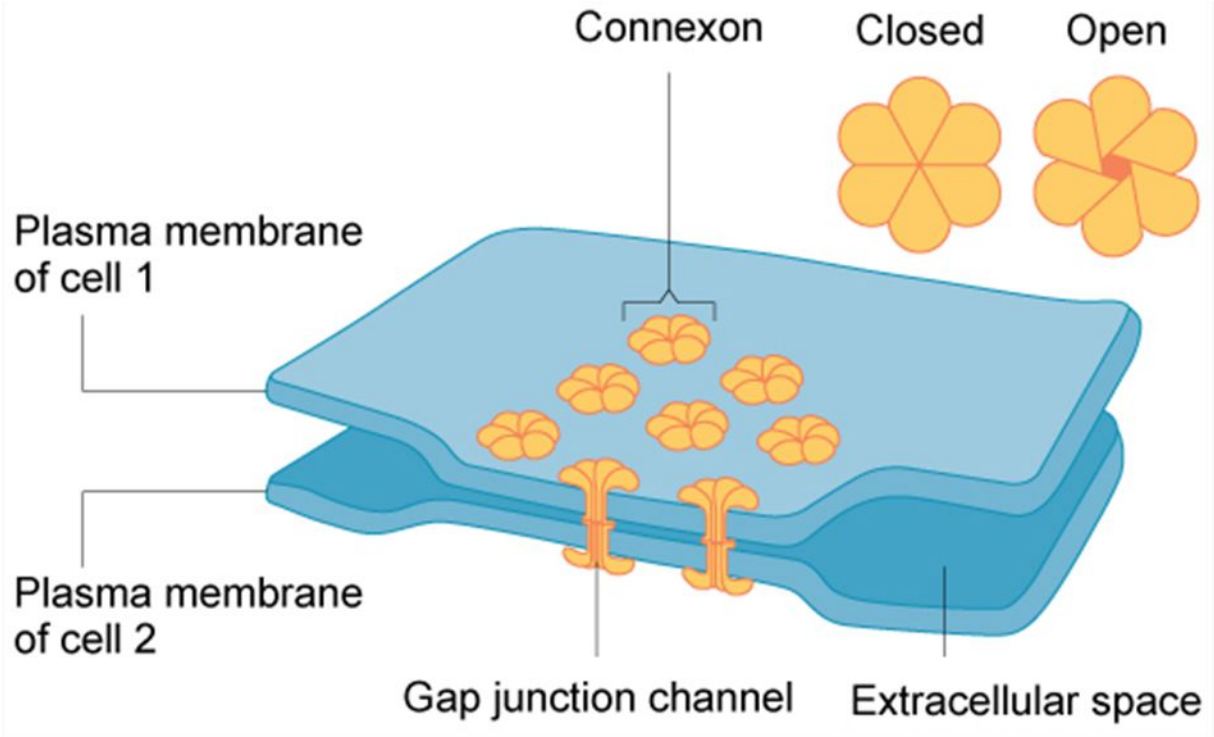


Gap Junctions connect animal cells

- They resemble plasmodesmata in plants because they form channels that allow ions, nutrients and other material to move between cells
- Gap junctions develop when 6 proteins (=connexins) form an elongated doughnut-like structure (connexon) in the plasma membrane
- When connexons of adjacent cells are aligned, it completes the channel



Gap Junctions



- A gap junction is a protein-lined pore that allows water and small molecules to pass between adjacent animal cells. (credit: modification of work by Mariana Ruiz Villareal)

REVIEW

1. Describe the basic structure and function of each of the following cell components: cytoplasm, vacuole, ribosome, endoplasmic reticulum, Golgi complex, lysozome, peroxisome, chloroplast and mitochondrion.
2. Name the three main layers of the plant cell wall and list the chemical components of each layer.
3. Contrast intercellular structures of plants and animals
4. Describe the general structure and function of the nucleus.
5. List the components of the cytoskeleton and describe its general role in the cell.