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Cell Structure and Function

Cells

- **Smallest living unit**
- **Most are microscopic**

Discovery of Cells

- **Robert Hooke (mid-1600s)**
  - Observed sliver of cork
  - Saw "row of empty boxes"
  - Coined the term cell

Cell Theory

- (1839)Theodor Schwann & Matthias Schleiden
  " all living things are made of cells"

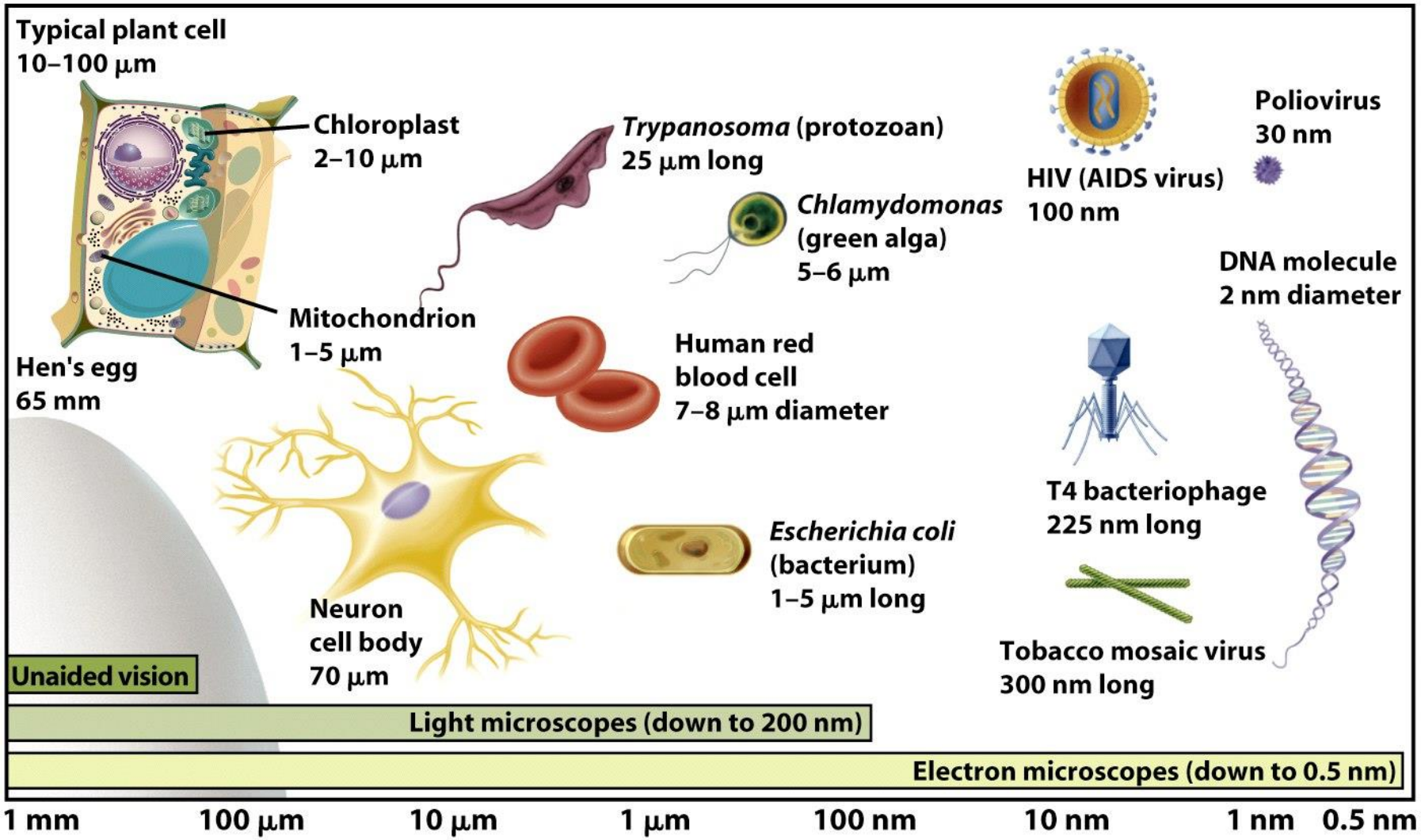
- (50 yrs. later) Rudolf Virchow
  "all cells come from cells"

Principles of Cell Theory

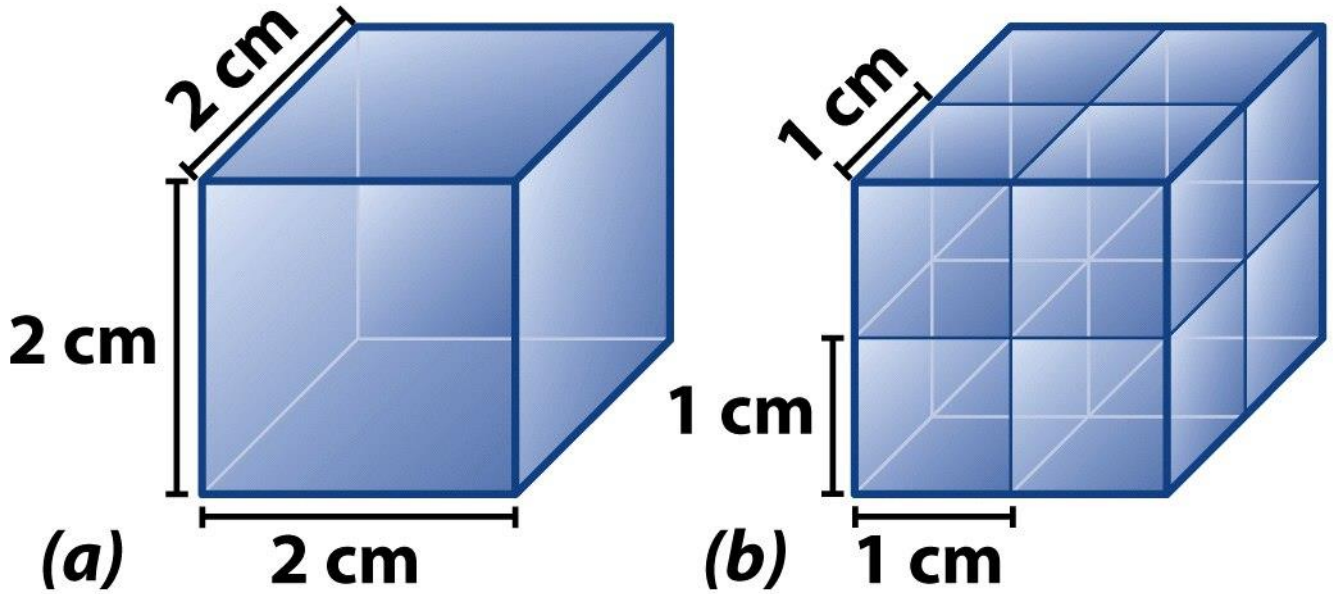
- All living things are made of cells
- Smallest living unit of structure and function of all organisms is the cell
- All cells arise from preexisting cells

(this principle discarded the idea of spontaneous generation)

Cell Size


Typical plant cell
10–100 μm
Chloroplast
2–10 μm
Mitochondrion
1–5 μm
Hen's egg
65 mm
Trypanosoma (protozoan)
25 μm long
Chlamydomonas
(green alga)
5–6 μm
Human red
blood cell
7–8 μm diameter
Neuron
cell body
70 μm
Escherichia coli
(bacterium)
1–5 μm long
HIV (AIDS virus)
100 nm
Poliovirus
30 nm
DNA molecule
2 nm diameter
T4 bacteriophage
225 nm long
Tobacco mosaic virus
300 nm long
Unaided vision
Light microscopes (down to 200 nm)
Electron microscopes (down to 0.5 nm)
1 mm
100 μm
10 μm
1 μm
100 nm
10 nm
1 nm
0.5 nm

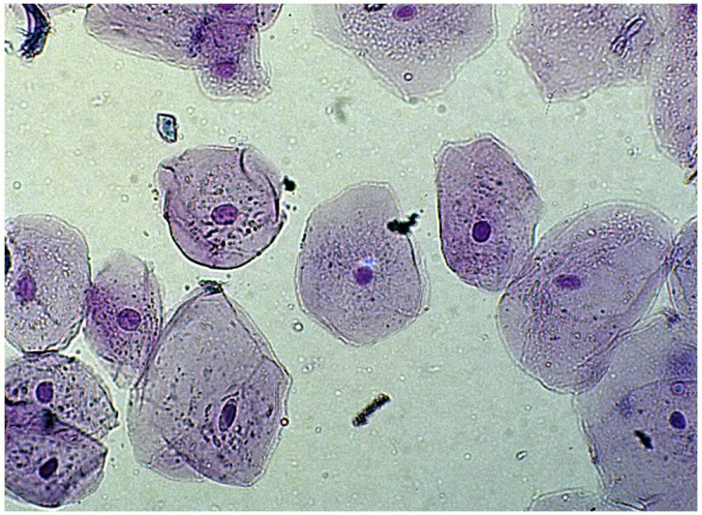
Cells Have Large Surface Area-to-Volume Ratio



Number of cells	1	8
Total surface area	24 cm^2	48 cm^2
Total volume	8 cm^3	8 cm^3
Surface area/volume	24/8 = 3:1	48/8 = 6:1

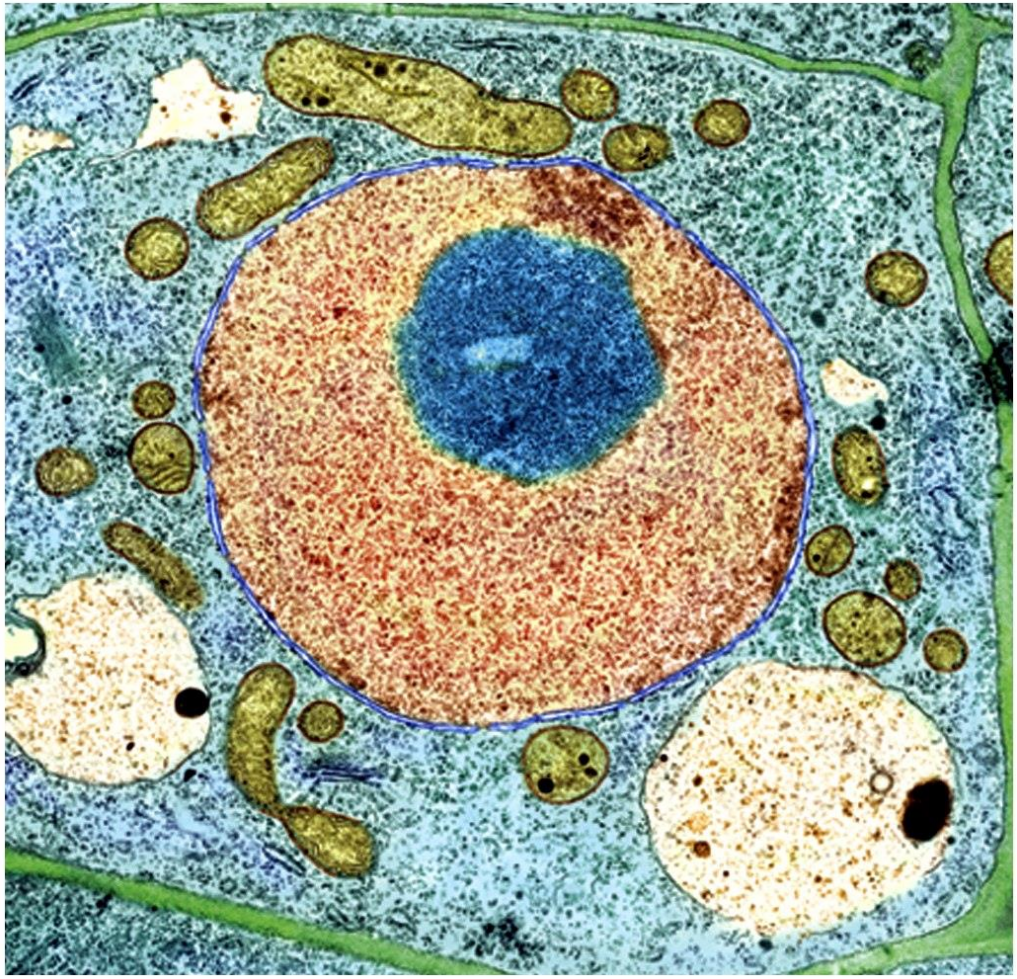
Characteristics of All Cells

- A surrounding membrane
- Protoplasm – cell contents in thick fluid
- Organelles – structures for cell function
- Control center with DNA



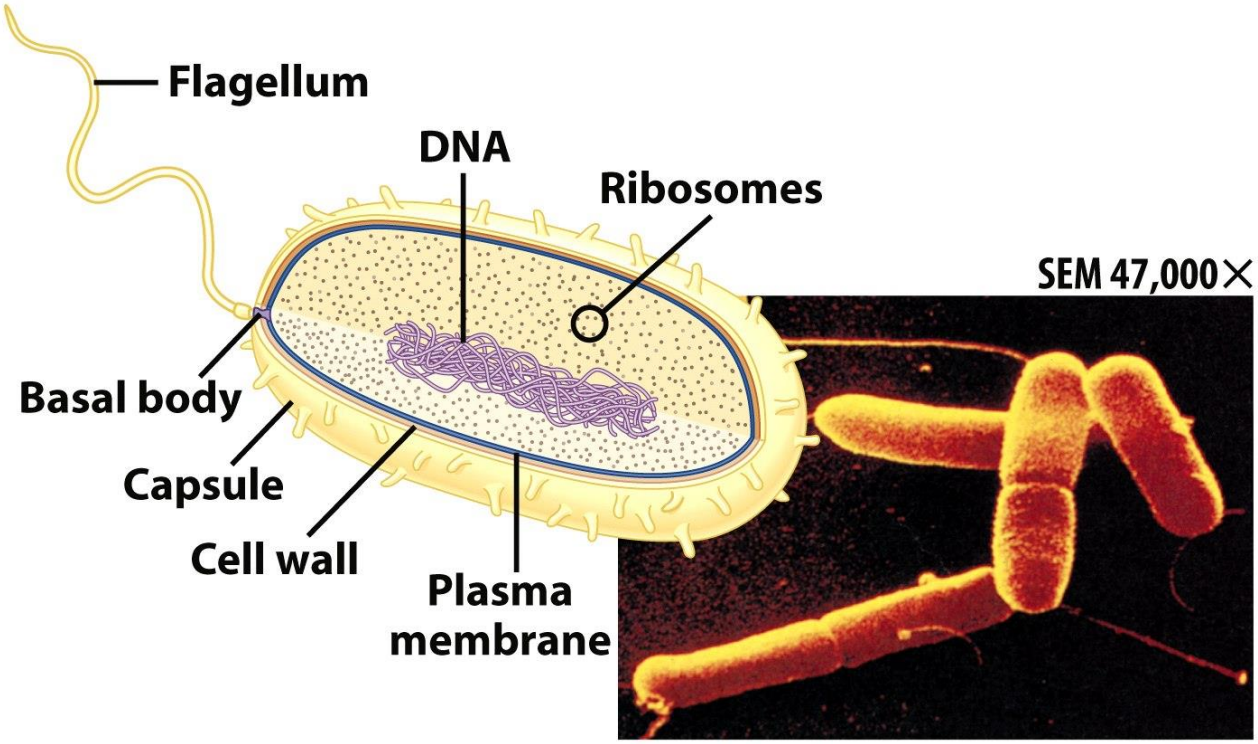
Cell Types

- **Prokaryotic**
- **Eukaryotic**



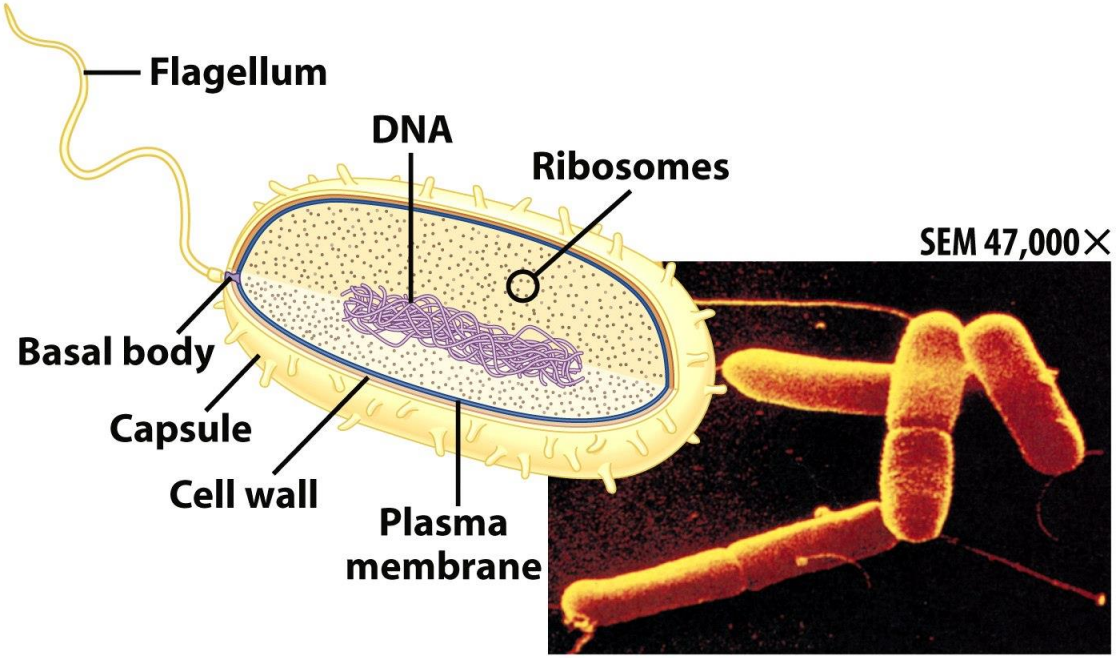
Prokaryotic Cells

- First cell type on earth
- Cell type of Bacteria and Archaea



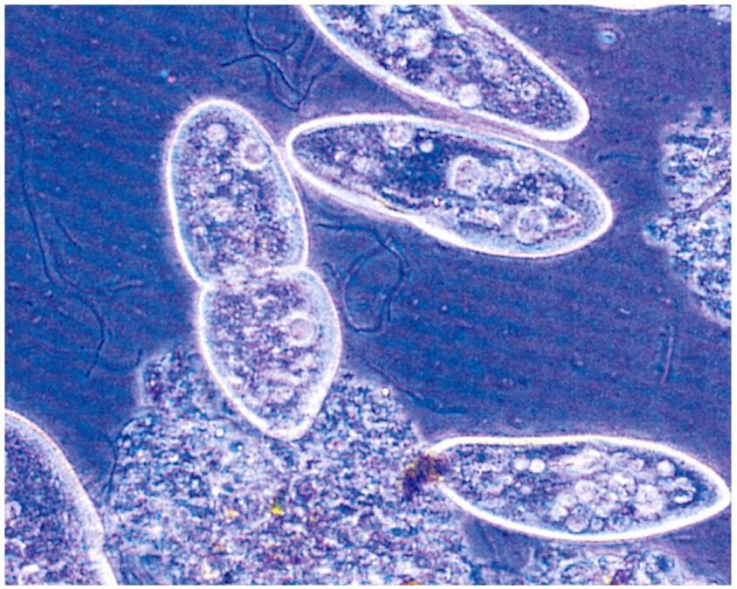
Prokaryotic Cells

- No membrane bound nucleus
- Nucleoid = region of DNA concentration
- Organelles not bound by membranes



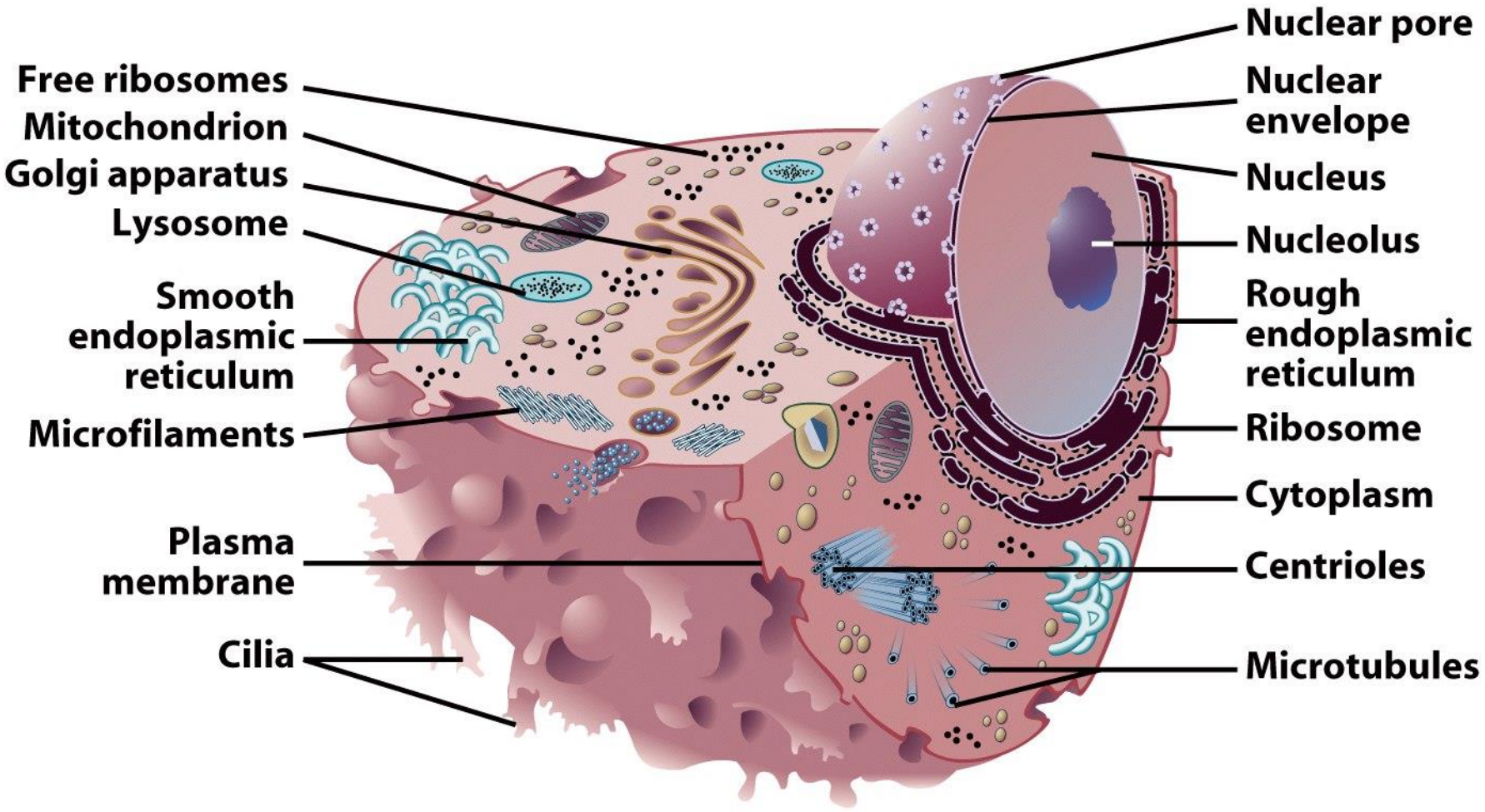
Eukaryotic Cells

- Nucleus bound by membrane
- Include fungi, protists, plant, and animal cells
- Possess many organelles

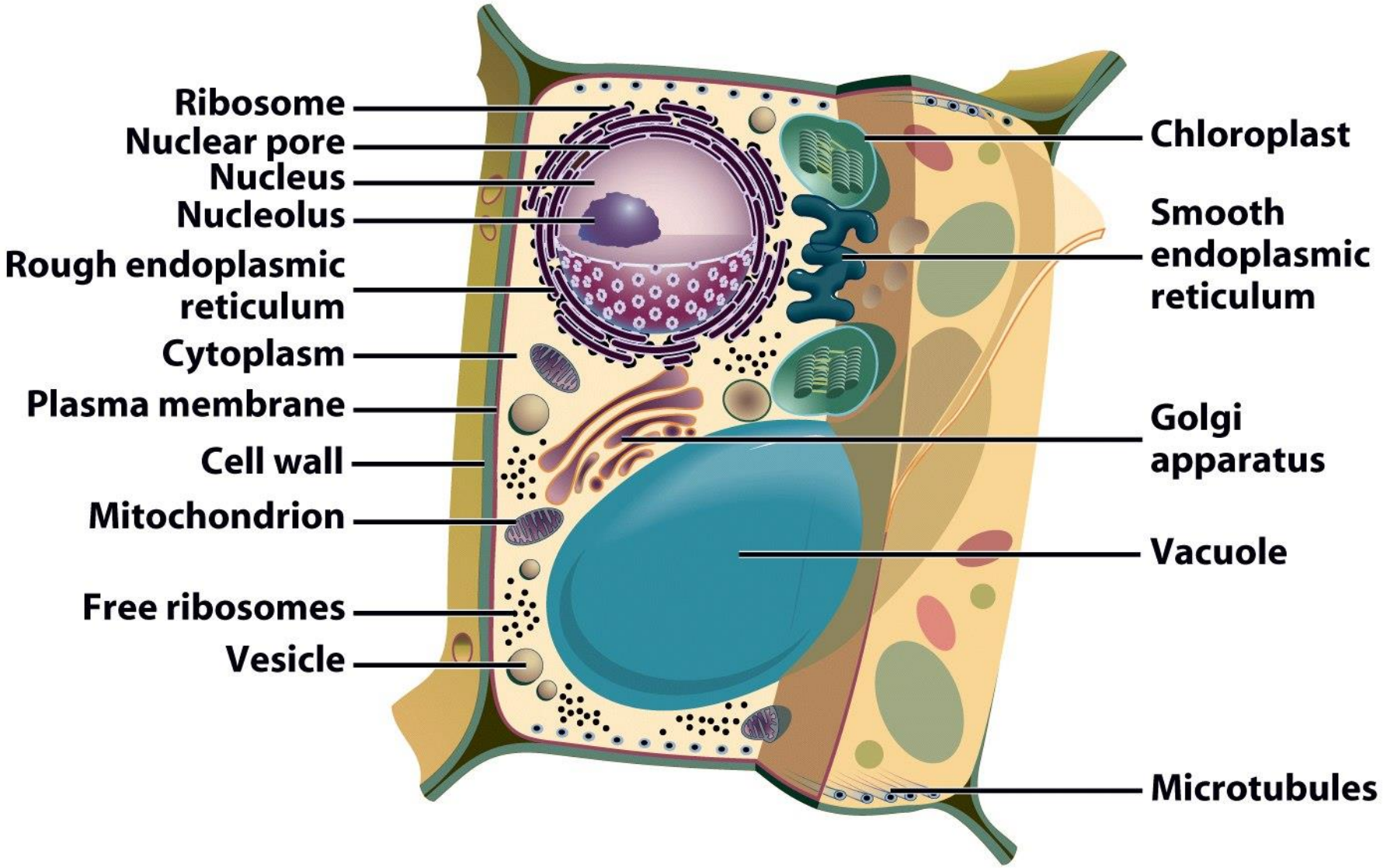


Protozoan

Representative Animal Cell

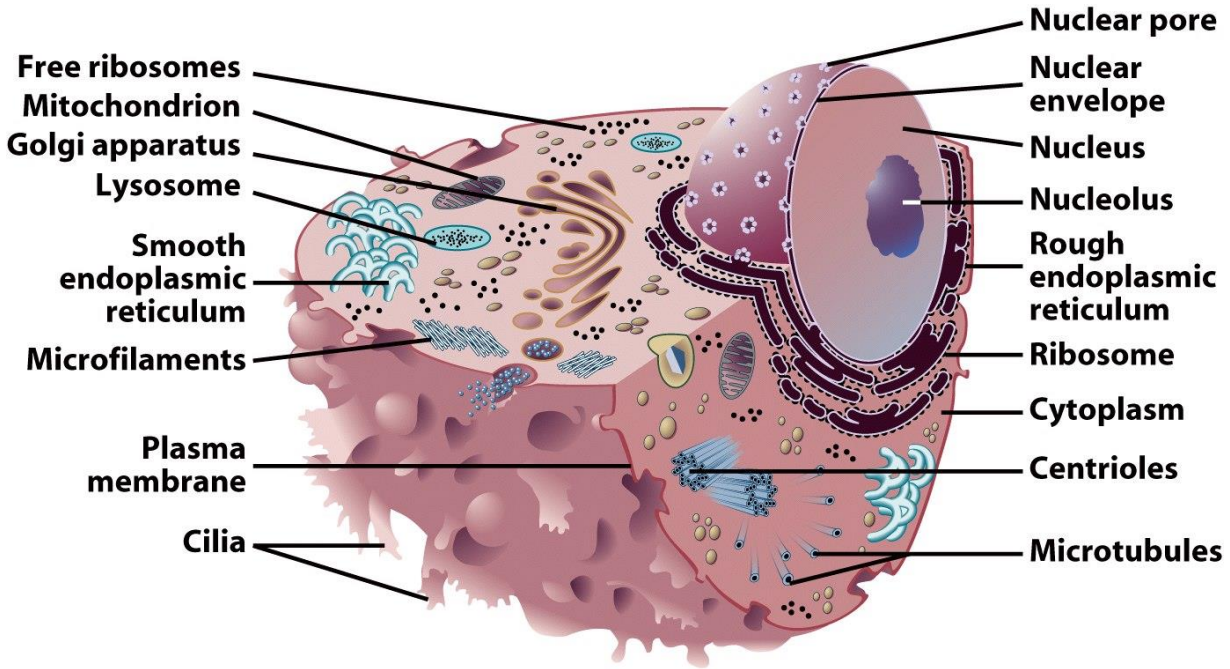


Representative Plant Cell



Organelles

- Cellular machinery
- Two general kinds
  - Derived from membranes
  - Bacteria-like organelles

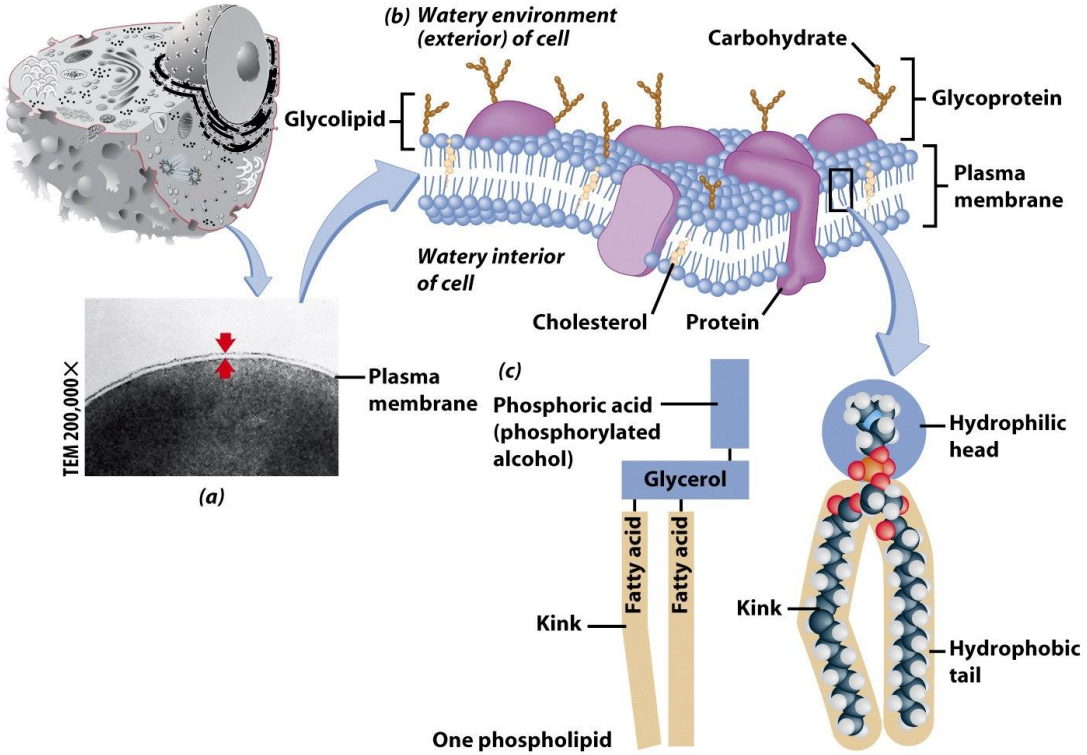


Bacteria-Like Organelles

- Derived from symbiotic bacteria
- Ancient association
- Endosymbiotic theory
  - Evolution of modern cells from cells & symbiotic bacteria

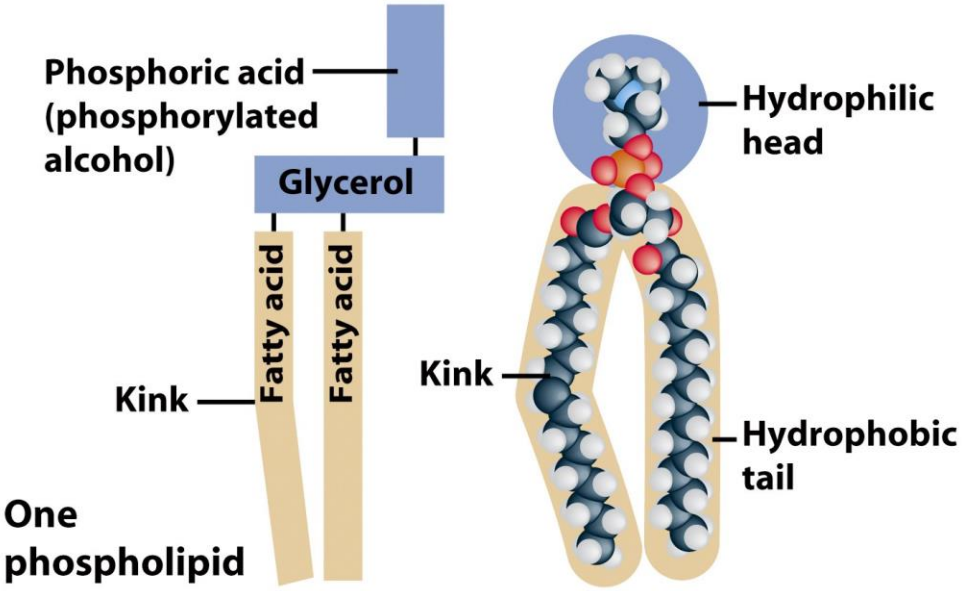
Plasma Membrane

- Contains cell contents
- Double layer of phospholipids & proteins



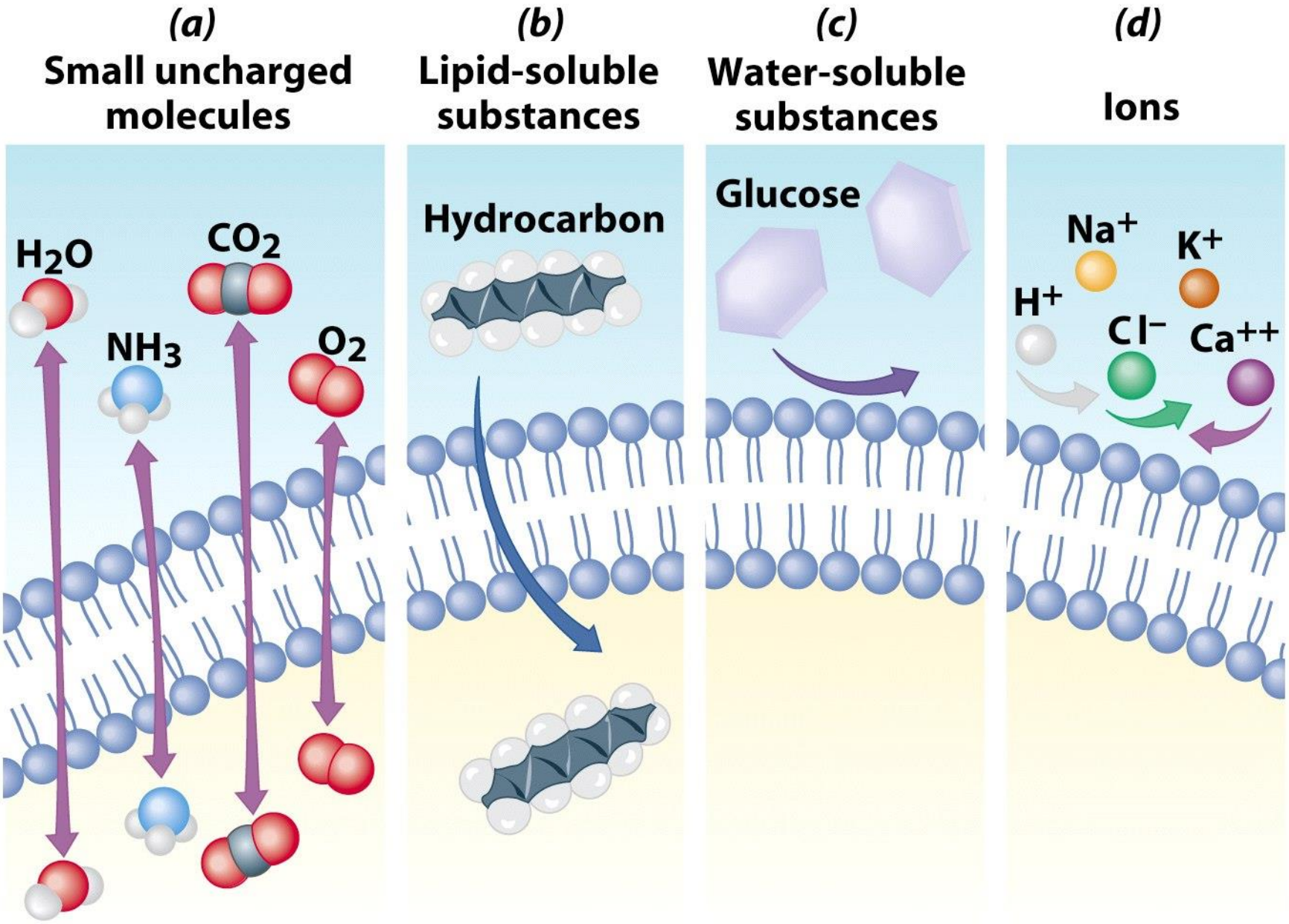
Phospholipids

- Polar
  - Hydrophylic head
  - Hydrophobic tail
- Interacts with water



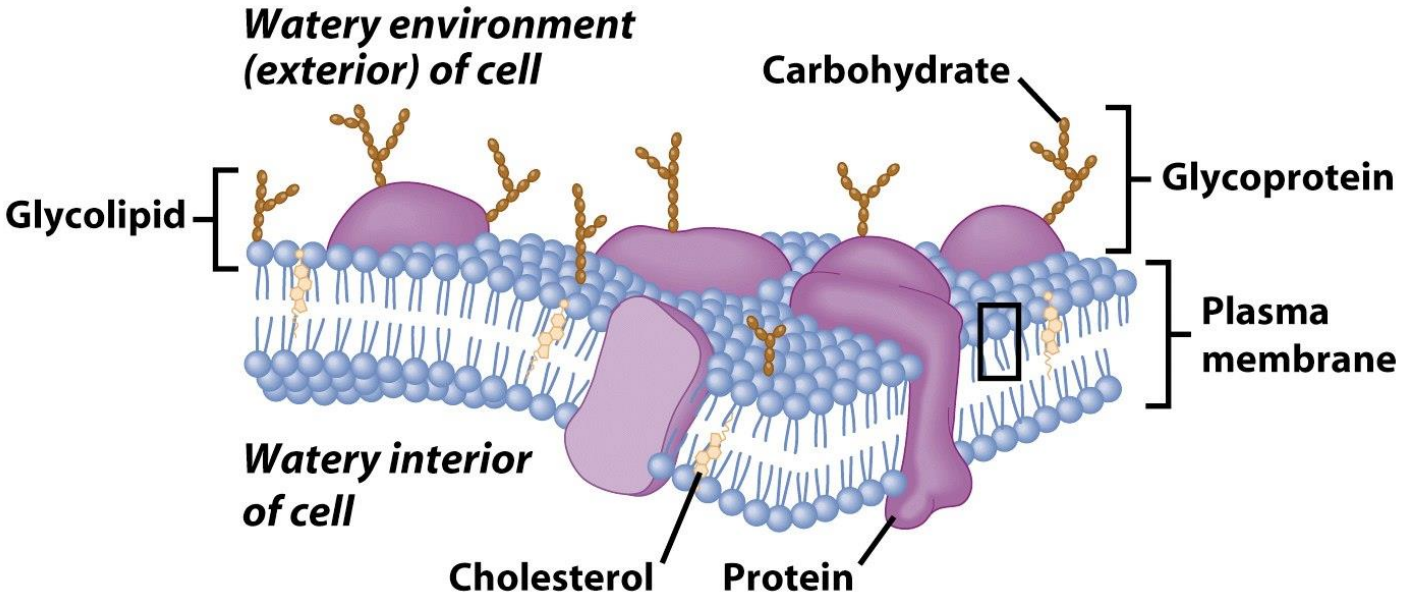
Movement Across the Plasma Membrane

- A few molecules move freely
  - Water, Carbon dioxide, Ammonia, Oxygen
- Carrier proteins transport some molecules
  - Proteins embedded in lipid bilayer
  - Fluid mosaic model – describes fluid nature of a lipid bilayer with proteins


(a)
Small uncharged molecules
(b)
Lipid-soluble substances
(c)
Water-soluble substances
(d)
Ions
H2O
CO2
NH3
O2
Hydrocarbon
Glucose
Na+
K+
H+
Cl−
Ca++

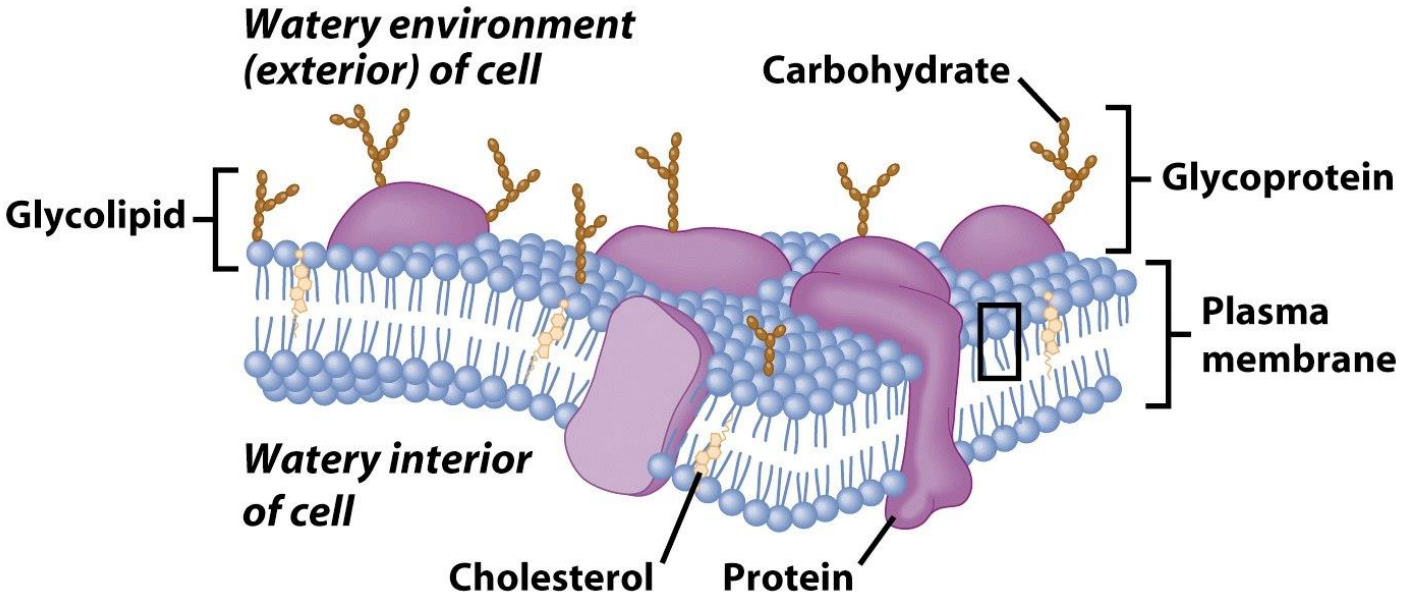
Membrane Proteins

1. Channels or transporters
   – Move molecules in one direction
2. Receptors
   – Recognize certain chemicals



Membrane Proteins

3. Glycoproteins
   – Identify cell type
4. Enzymes
   – Catalyze production of substances



Cell Walls

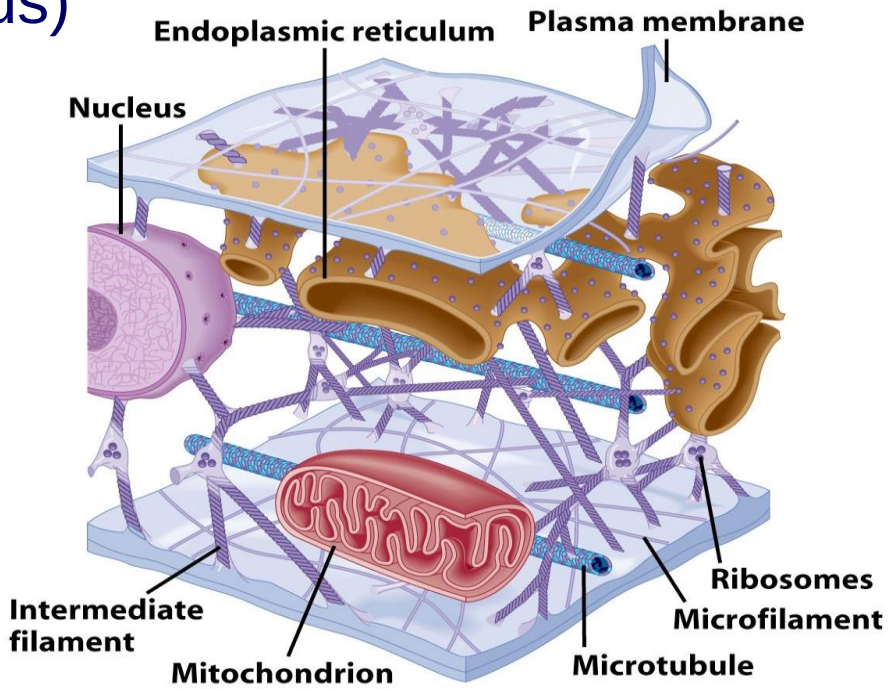
- Found in plants, fungi, & many protists
- Surrounds plasma membrane

Cell Wall Differences

- Plants – mostly cellulose
- Fungi – contain chitin

Cytoplasm

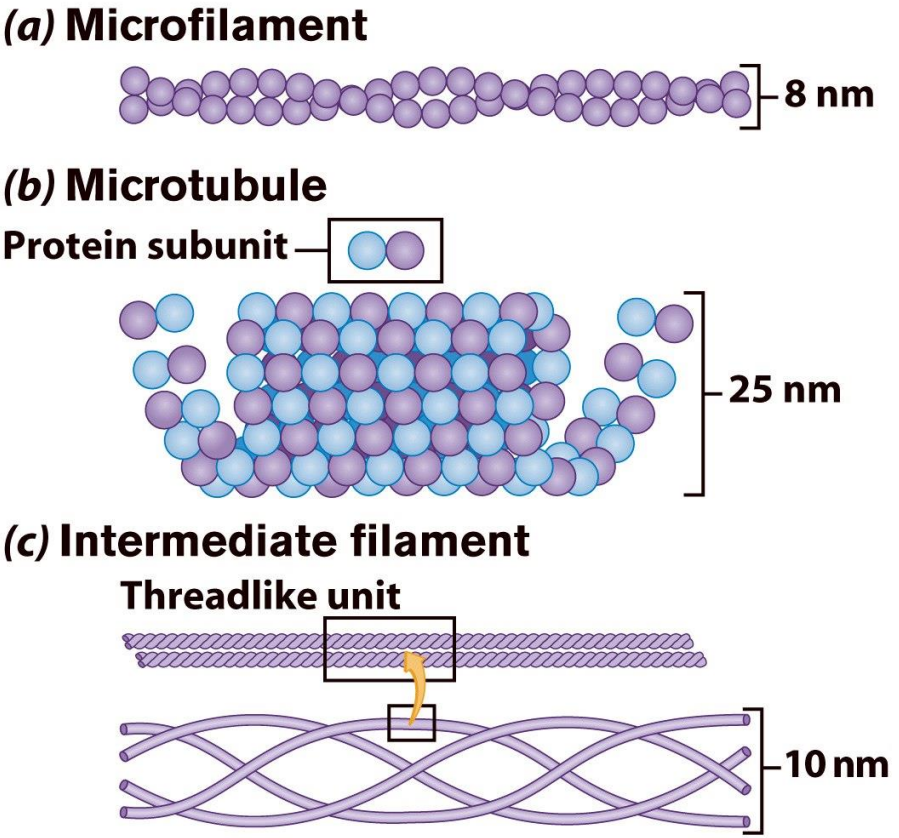
- Viscous fluid containing organelles
- components of cytoplasm
  - Interconnected filaments & fibers
  - Fluid = cytosol
  - Organelles (not nucleus)
  - storage substances

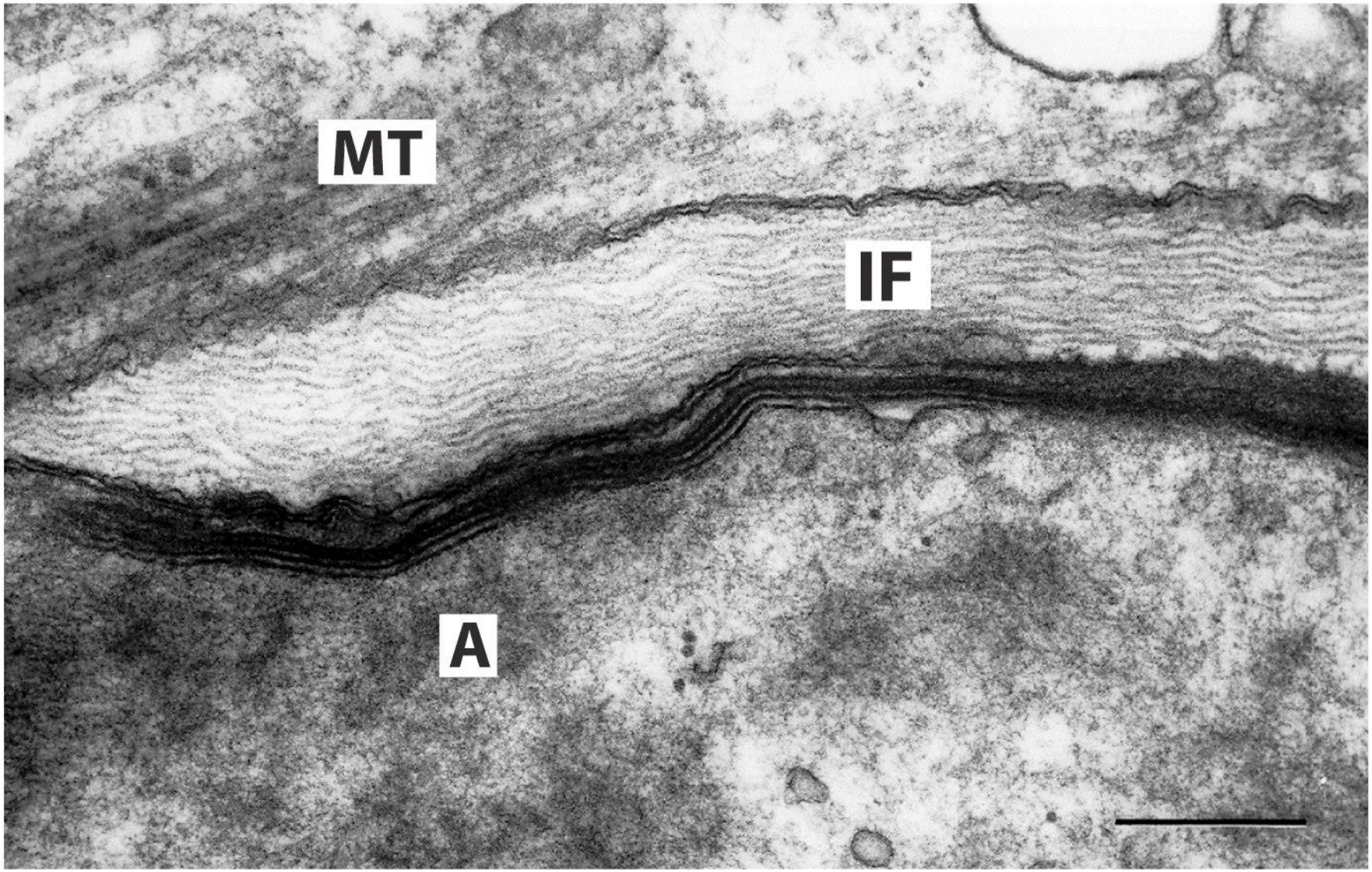


Cytoskeleton

- Filaments & fibers

- Made of 3 fiber types
  - Microfilaments
  - Microtubules
  - Intermediate filaments
- 3 functions:
  - mechanical support
  - anchor organelles
  - help move substances





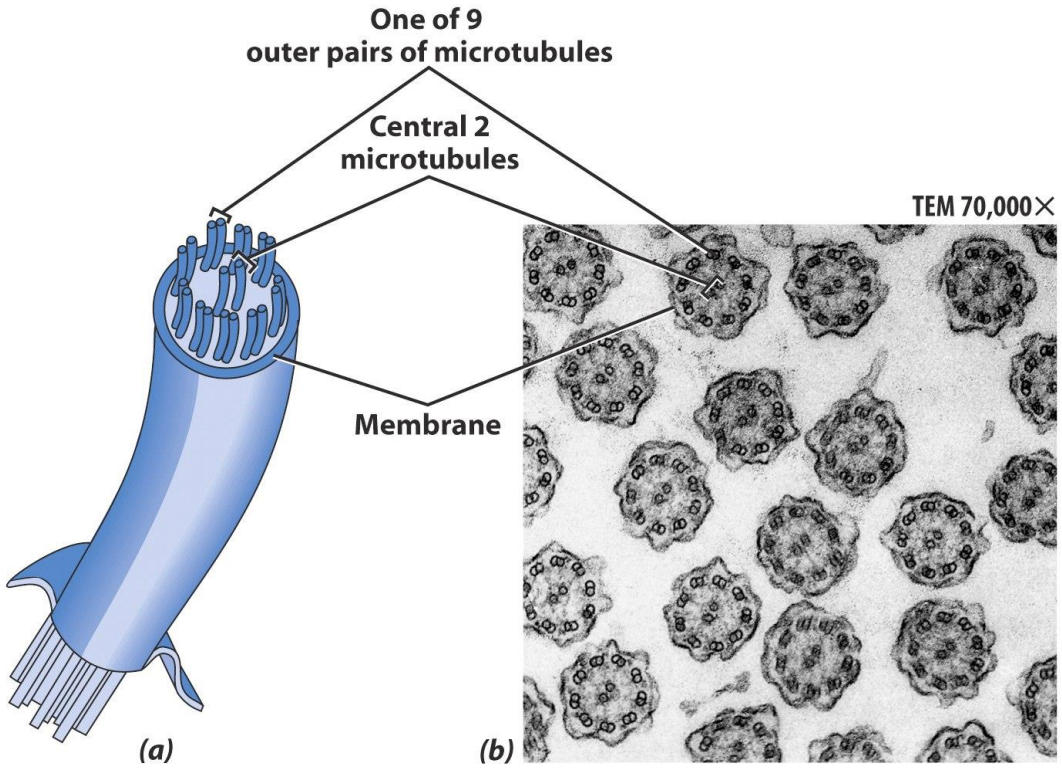
A = actin, IF = intermediate filament, MT = microtubule

Cilia & Flagella

- Provide motility
- Cilia
  - Short
  - Used to move substances outside human cells
- Flagella
  - Whip-like extensions
  - Found on sperm cells
- Basal bodies like centrioles

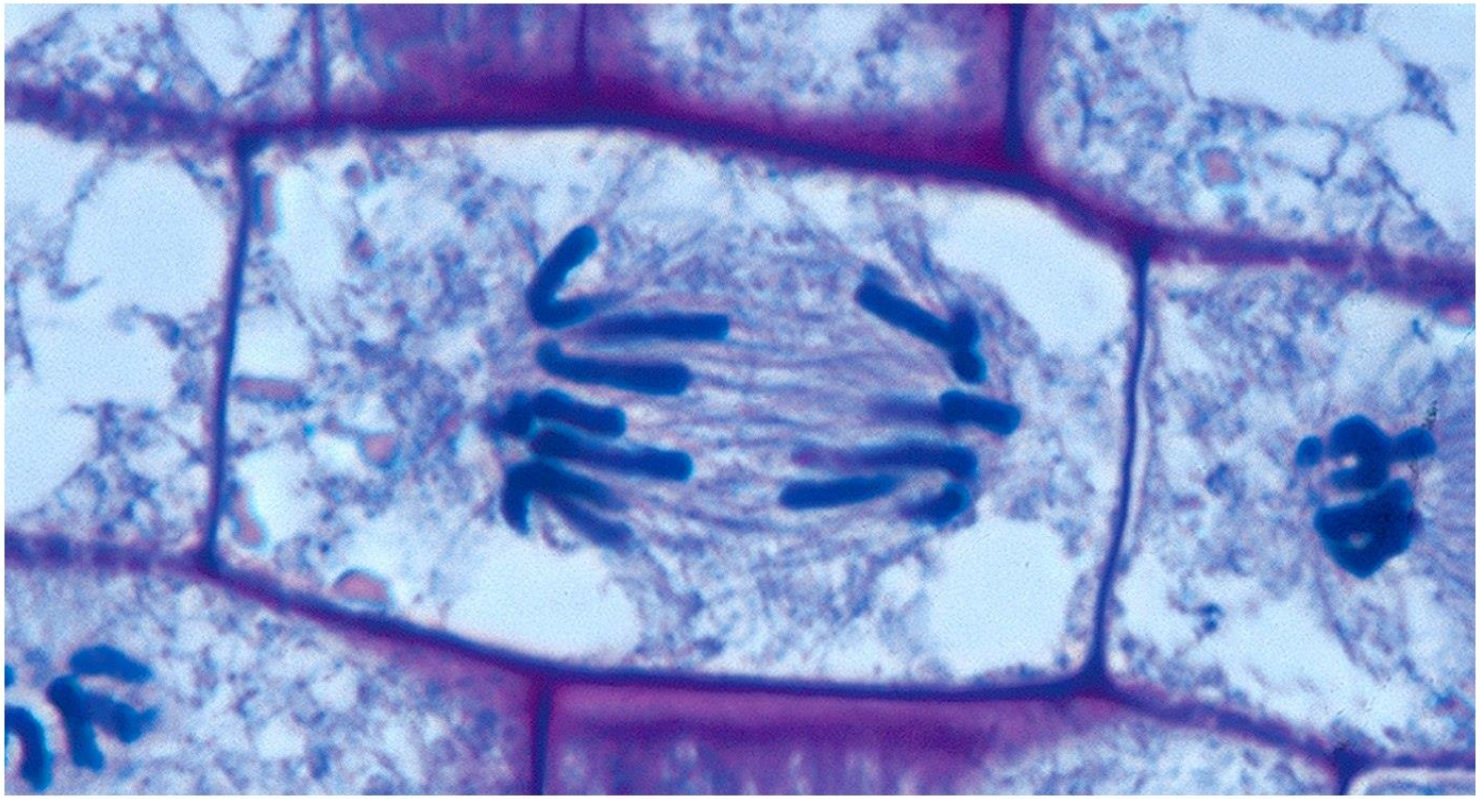
Cilia & Flagella Structure

- Bundles of microtubules
- With plasma membrane



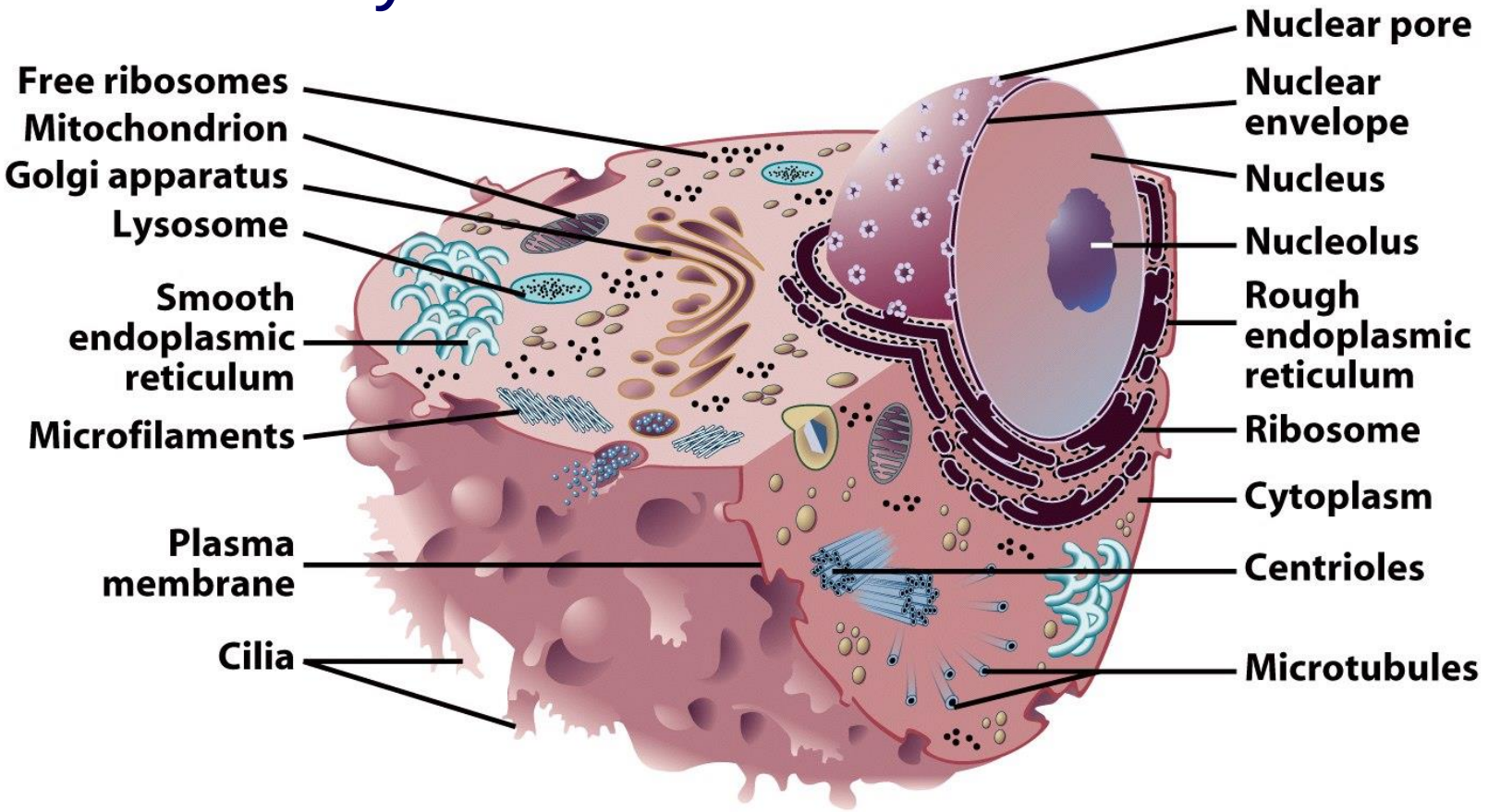
Centrioles

- Pairs of microtubular structures
- Play a role in cell division



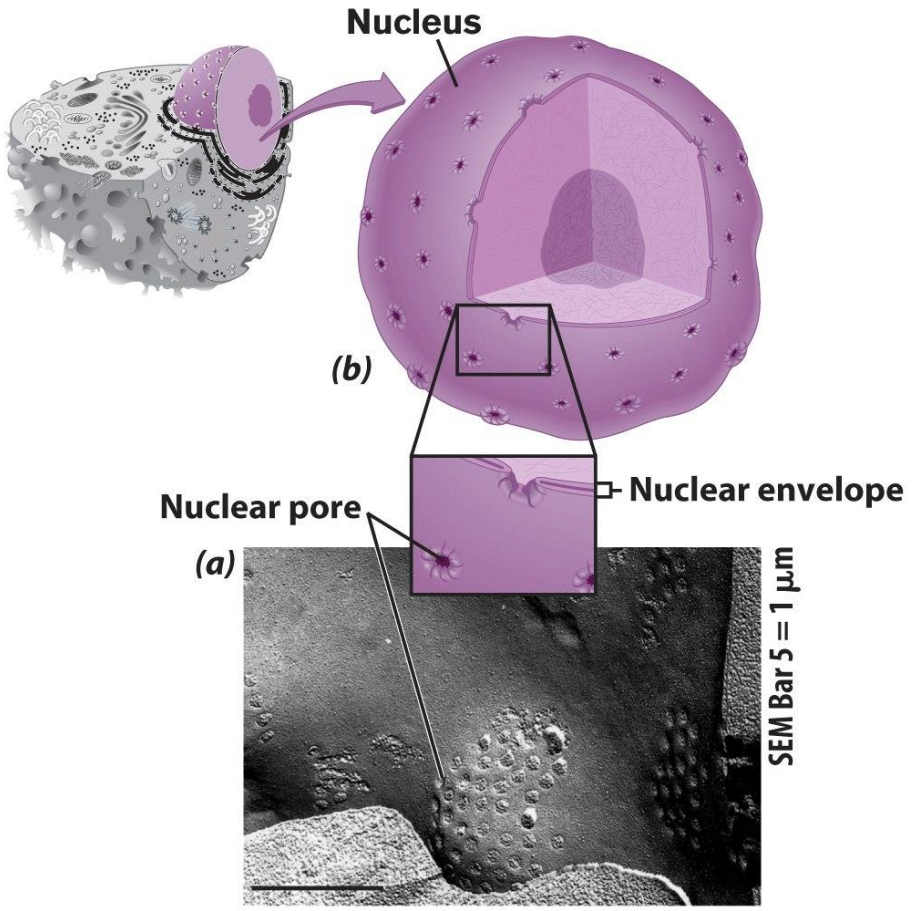
Membranous Organelles

- Functional components within cytoplasm
- Bound by membranes



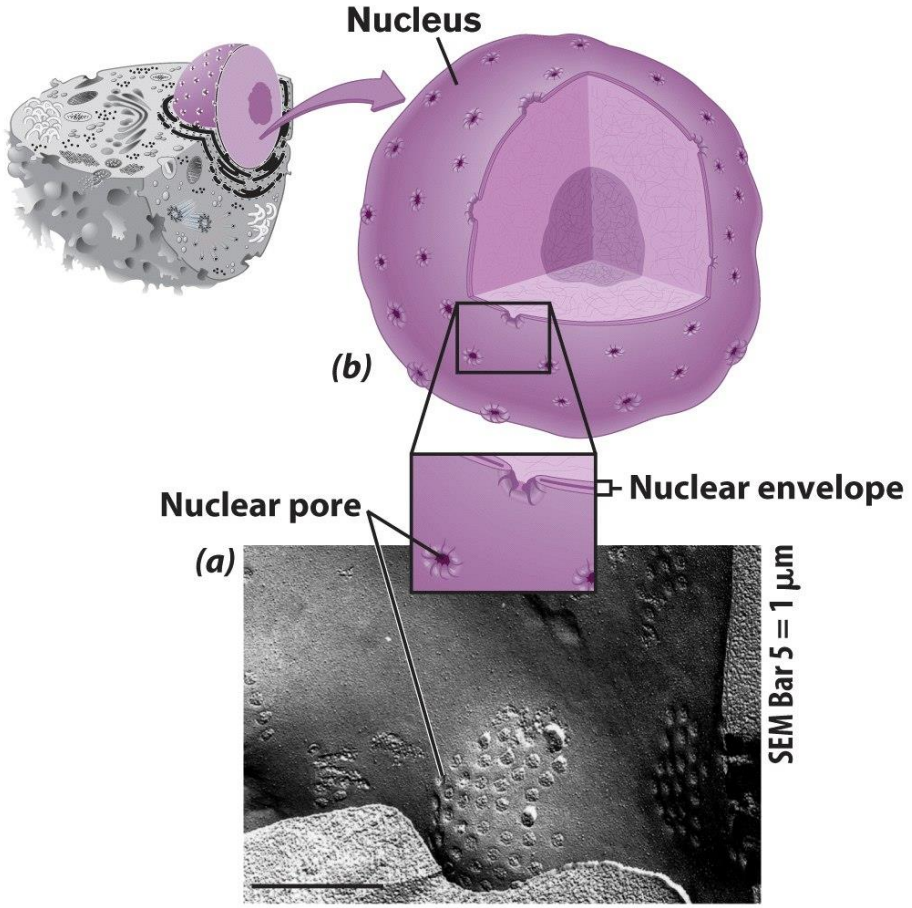
Nucleus

- Control center of cell
- Double membrane
- Contains
  - Chromosomes
  - Nucleolus



Nuclear Envelope

- Separates nucleus from rest of cell
- Double membrane
- Has pores

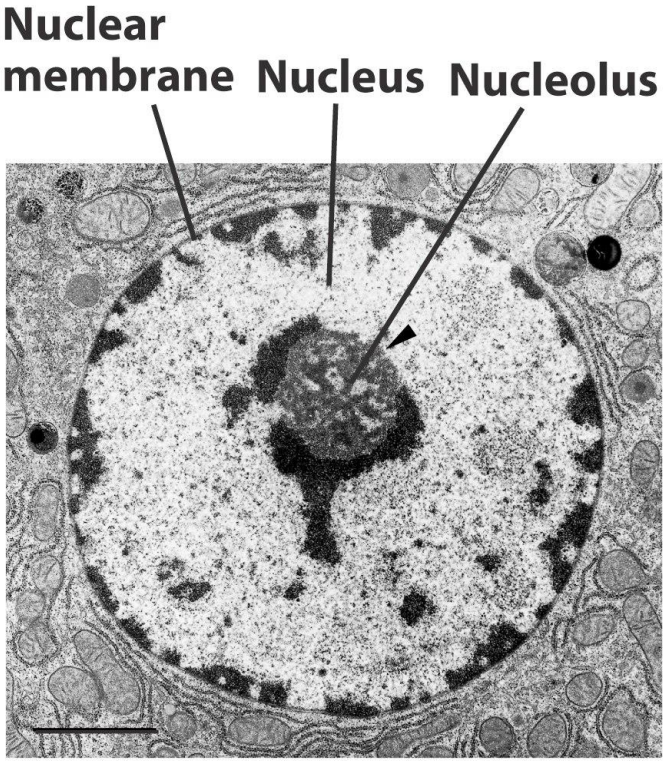


DNA

- Hereditary material
- Chromosomes
  - DNA
  - Protiens
  - Form for cell division
- Chromatin

Nucleolus

- Most cells have 2 or more
- Directs synthesis of RNA
- Forms ribosomes

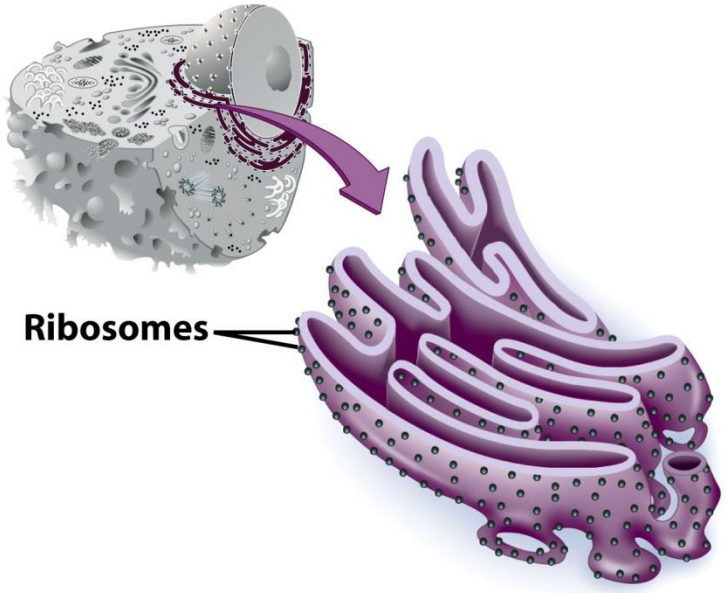


Endoplasmic Reticulum

- Helps move substances within cells
- Network of interconnected membranes
- Two types
  - Rough endoplasmic reticulum
  - Smooth endoplasmic reticulum

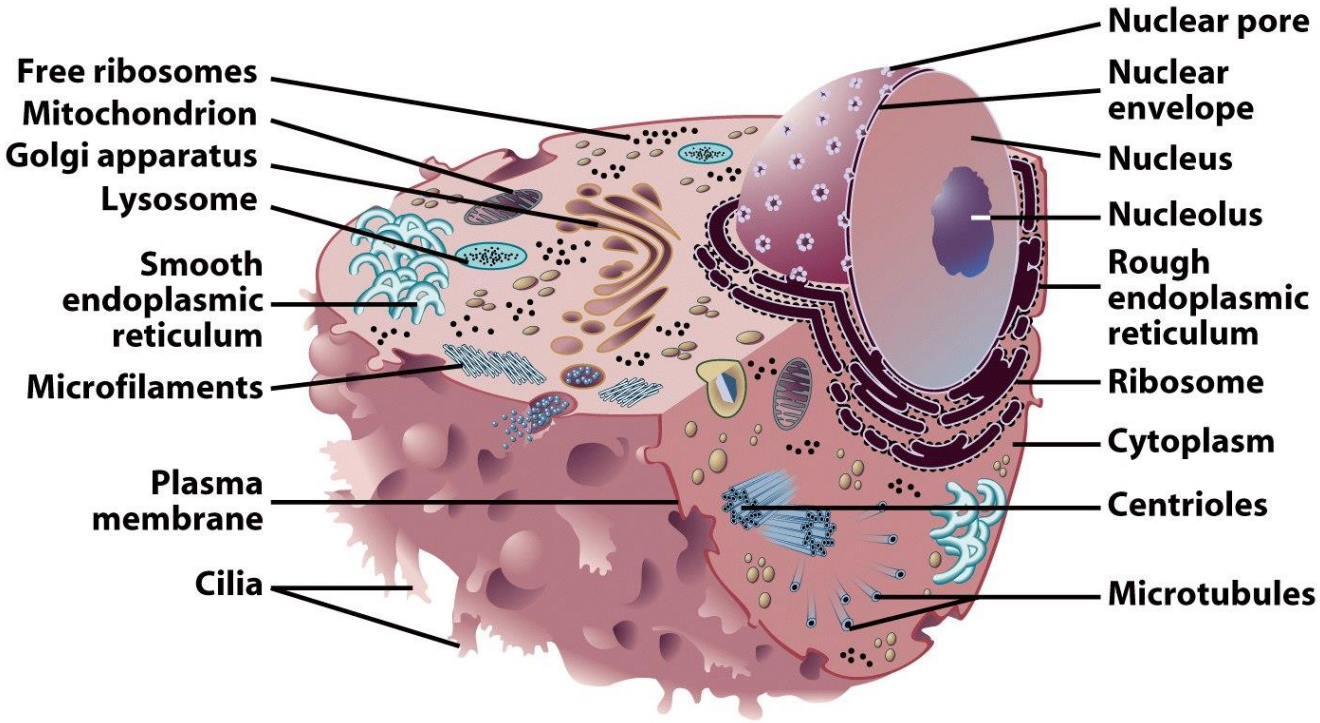
Rough Endoplasmic Reticulum

- Ribosomes attached to surface
  - Manufacture protiens
  - Not all ribosomes attached to rough ER
- May modify proteins from ribosomes



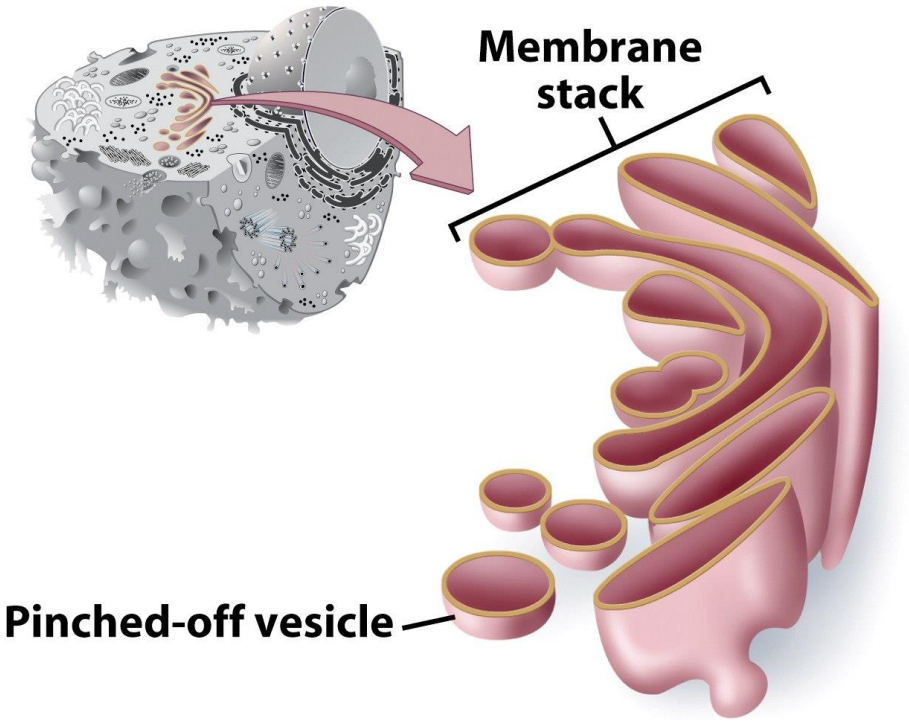
Smooth Endoplasmic Reticulum

- No attached ribosomes
- Has enzymes that help build molecules
  - Carbohydrates
  - Lipids



Golgi Apparatus

- Involved in synthesis of plant cell wall
- Packaging & shipping station of cell



Golgi Apparatus Function

1. Molecules come in vesicles

2. Vesicles fuse with Golgi membrane

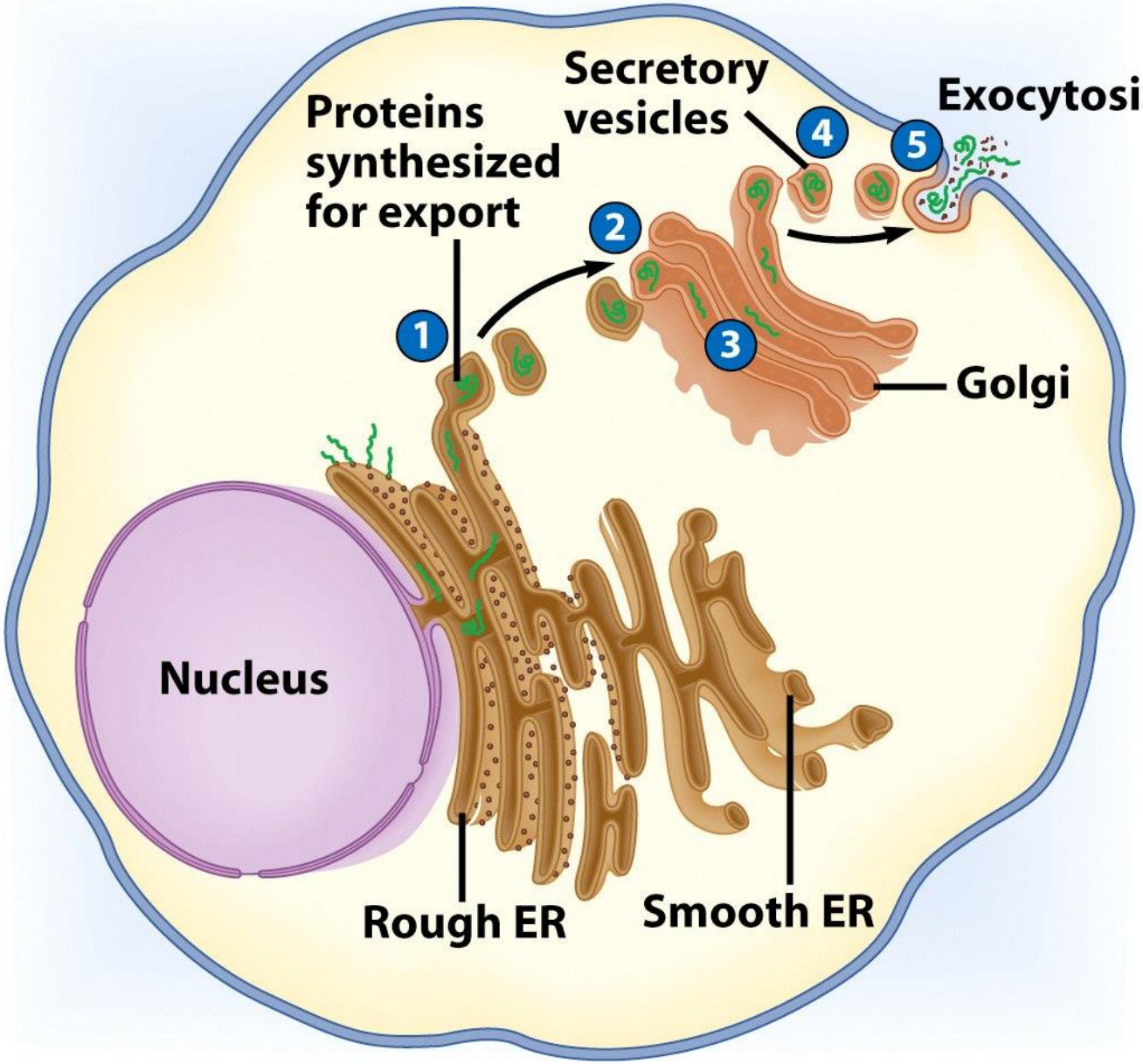
3. Molecules may be modified by Golgi

Golgi Apparatus Function (Continued)

4. Molecules pinched-off in separate vesicle

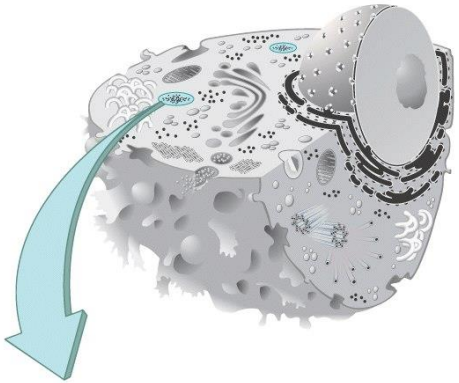
5. Vesicle leaves Golgi apparatus

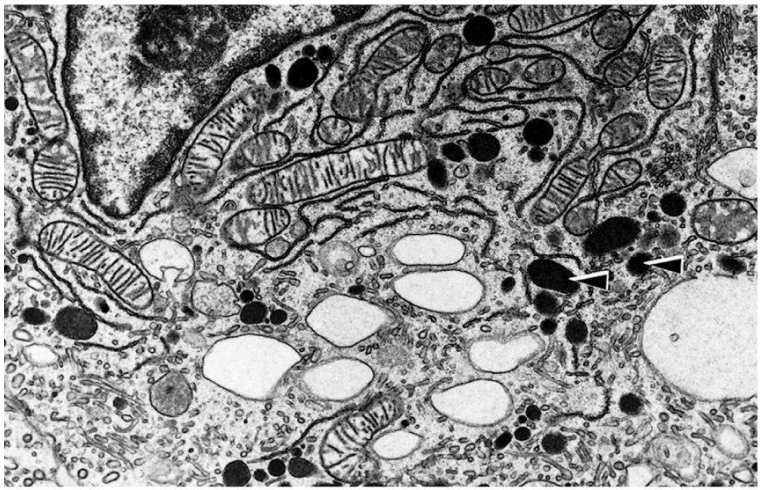
6. Vesicles may combine with plasma membrane to secrete contents


Proteins synthesized for export
Secretory vesicles
Exocytosis
1
2
3
4
5
Golgi
Nucleus
Rough ER
Smooth ER

Lysosomes

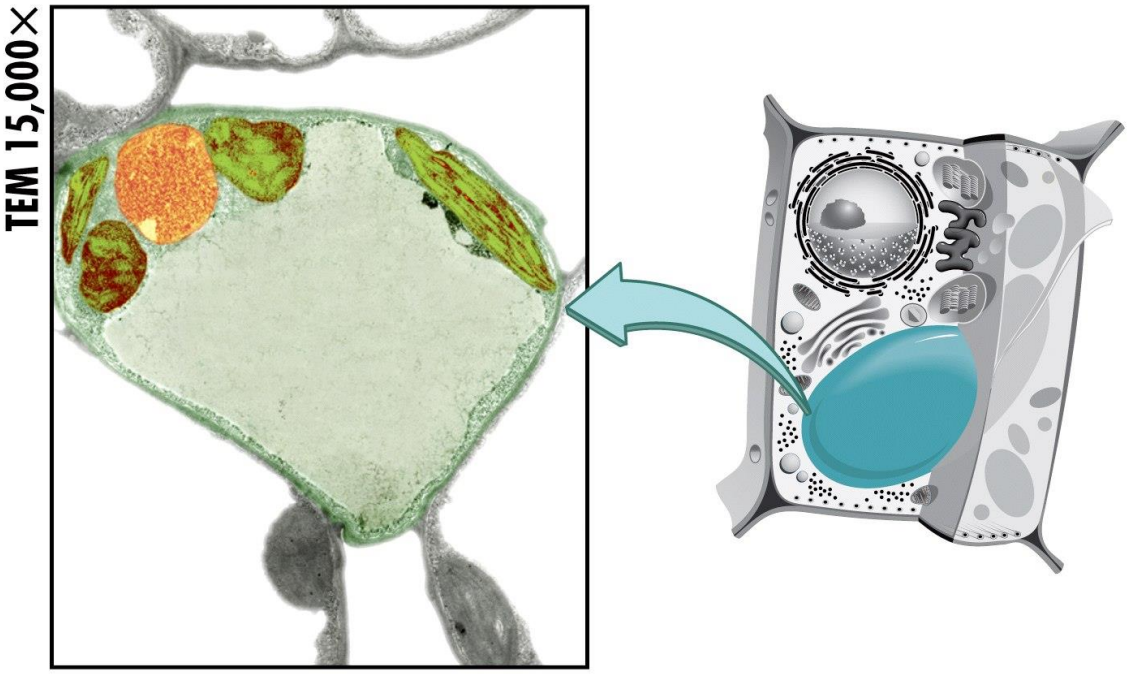
- Contain digestive enzymes
- Functions
  - Aid in cell renewal
  - Break down old cell parts
  - Digests invaders





Vacuoles

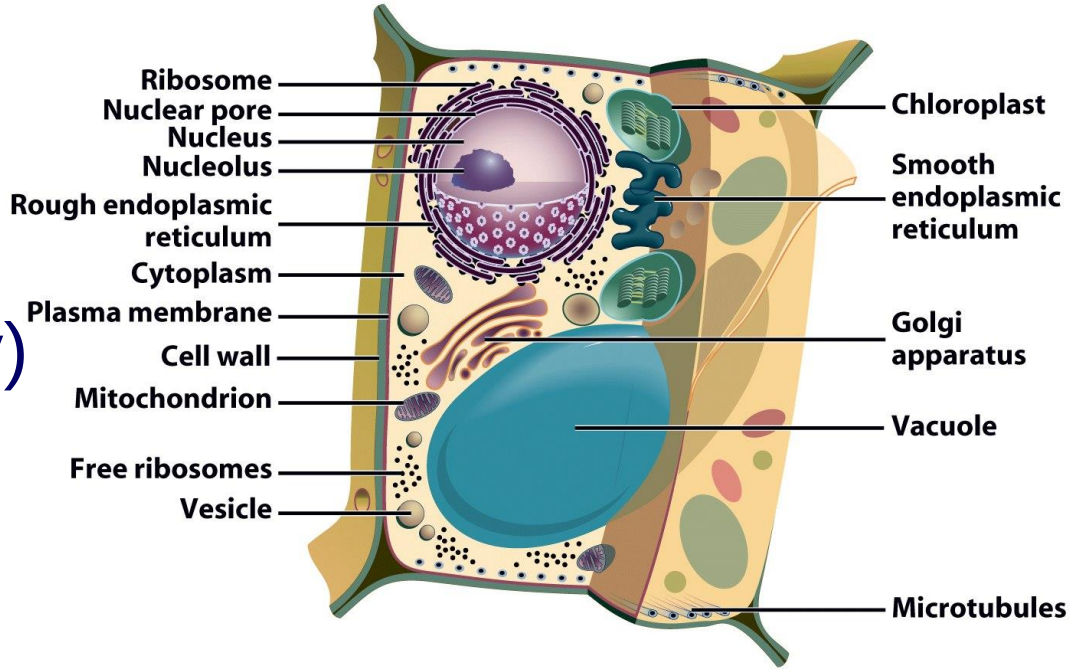
- Membrane bound storage sacs
- More common in plants than animals
- Contents
  - Water
  - Food
  - wastes



Bacteria-Like Organelles

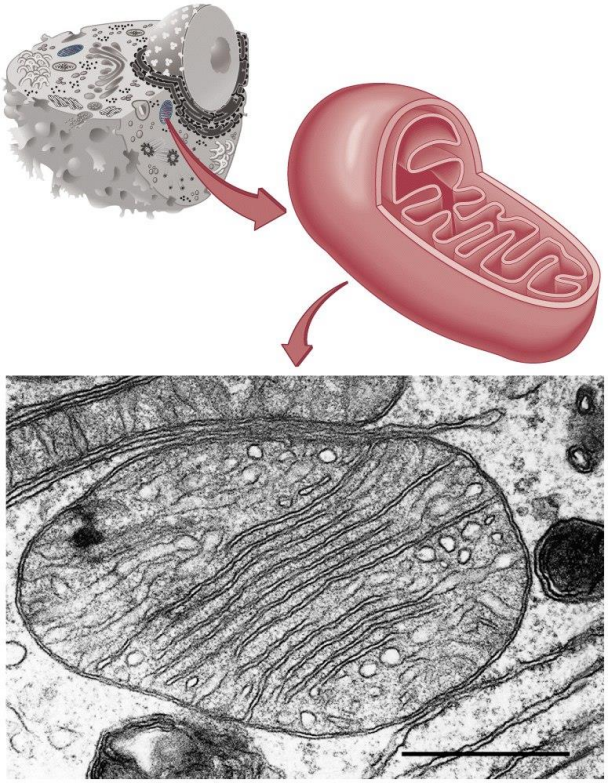
- Release & store energy

- Types
  - Mitochondria (release energy)
  - Chloroplasts (store energy)



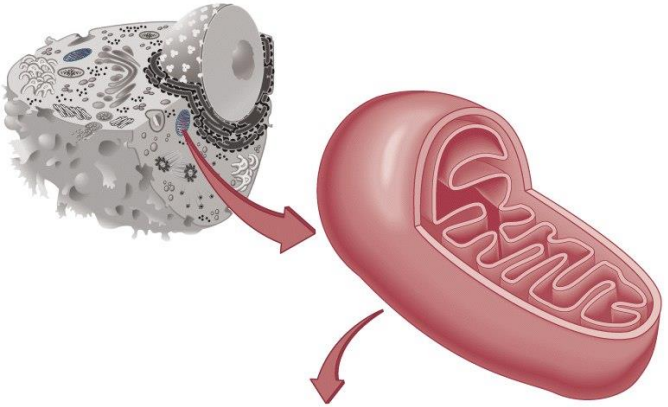
Mitochondria

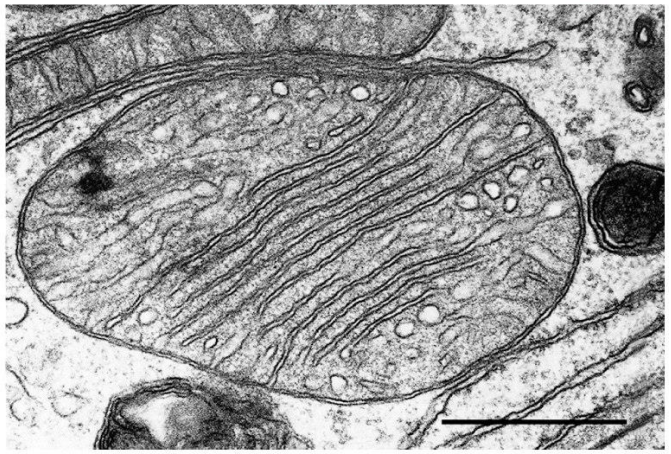
- Have their own DNA
- Bound by double membrane



Mitochondria

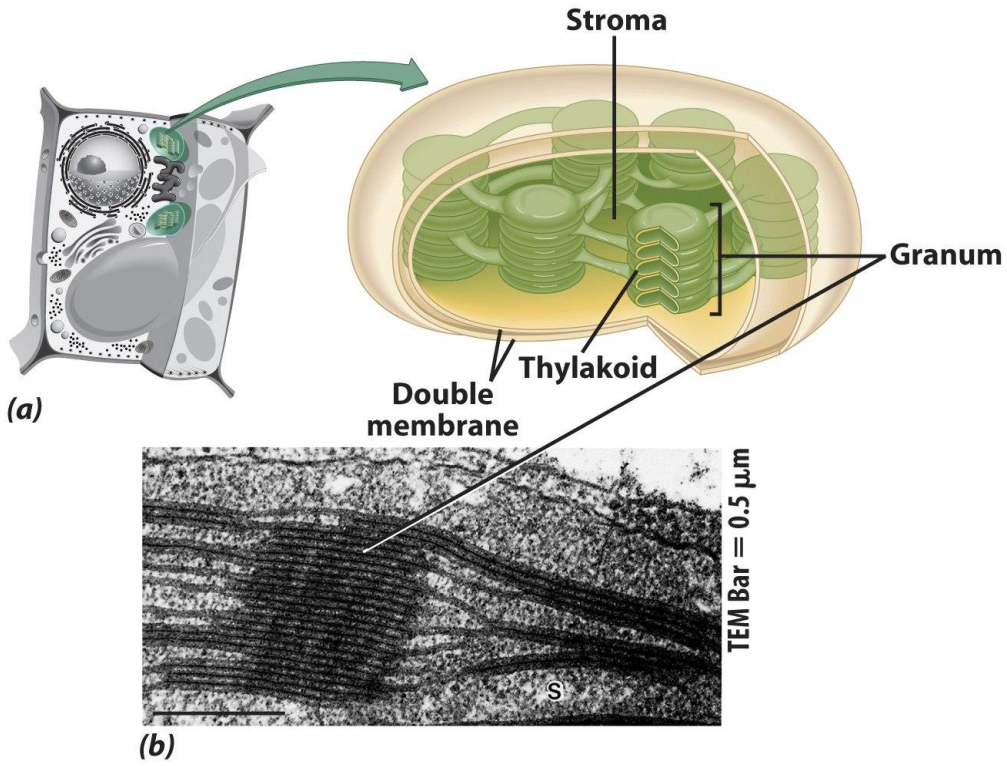
- Break down fuel molecules (cellular respiration)
  - Glucose
  - Fatty acids
- Release energy
  - ATP





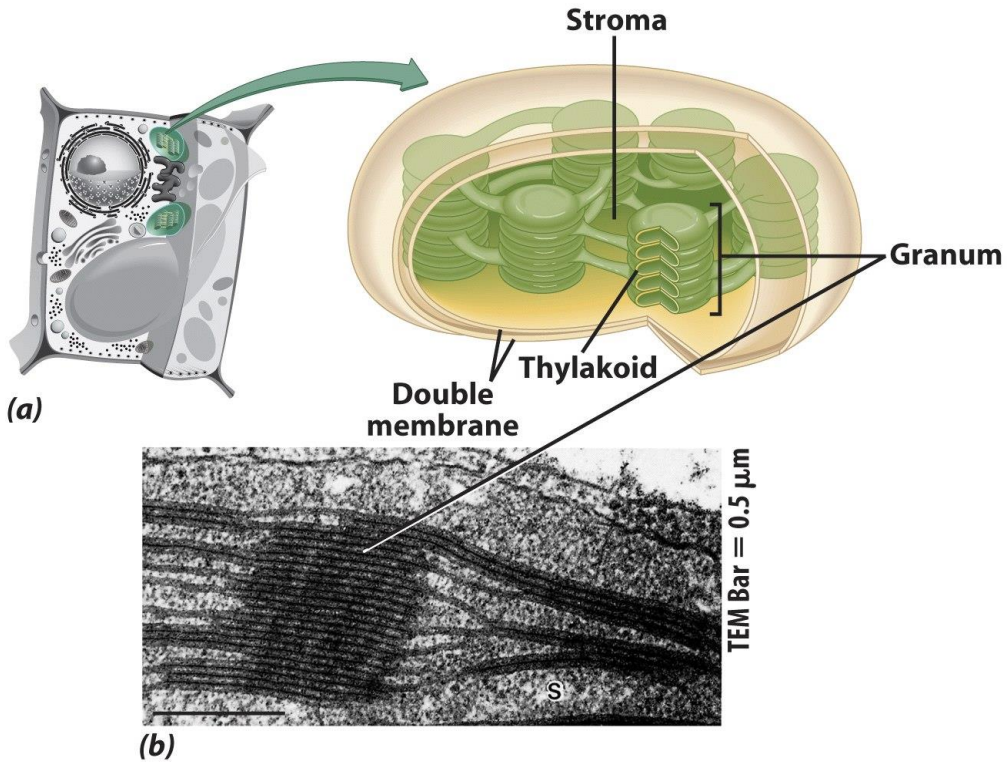
Chloroplasts

- Derived form photosynthetic bacteria
- Solar energy capturing organelle



Photosynthesis

- Takes place in the chloroplast
- Makes cellular food – glucose



Review of Eukaryotic Cells

TABLE 5.1 Eukaryotic Cell Structures and Their Functions

Structure	Description	Function
Exterior Structures		
Cell wall	Outer layer of cellulose or chitin, or absent	Protection, support
Plasma membrane	Lipid bilayer in which proteins are embedded	Regulation of what passes in and out of cell, cell-to-cell recognition
Flagella (cilia)	Cellular extensions with 9 + 2 arrangement of pairs of microtubules	Motility or moving fluids over surfaces

Review of Eukaryotic Cells

TABLE 5.1 Eukaryotic Cell Structures and Their Functions

Structure	Description	Function
Interior Structures and Organelles		
Endoplasmic reticulum (ER)	Network of internal membranes	Formation of compartments and vesicles; modification and transport of proteins; synthesis of carbohydrates and lipids
Ribosomes	Small, complex assemblies of protein and RNA, often bound to ER	Sites of protein synthesis
Nucleus	Spherical structure bounded by a double membrane, site of chromosomes	Control center of cell
Chromosomes	Long threads of DNA associated with protein	Sites of hereditary information
Nucleolus	Site within nucleus of rRNA synthesis	Synthesis and assembly of ribosomes
Golgi apparatus	Stacks of flattened vesicles	Packaging of proteins for export from cell
Lysosomes	Membranous sacs containing digestive enzymes found in animal cells	Digestion of various molecules
Cytoskeleton	Network of protein filaments, fibers, and tubules	Structural support, cell movement
Mitochondria	Bacteria like elements with inner membrane highly folded	"Power plant" of the cell
Chloroplasts	Bacterialike elements with inner membrane forming sacs containing chlorophyll, found in plant cells and algae	Site of photosynthesis

TABLE 5.2 A Comparison of Bacterial, Animal, and Plant Cells

	Bacterium	Animal	Plant
Exterior Structures			
Cell wall	Present (protein polysaccharide)	*Absent*	Present (cellulose)
Plasma membrane	Present	Present	Present
Flagella (cilia)	Sometimes present	Sometimes present	Sperm of a few species possess flagella
Interior Structures and Organelles			
Endoplasmic reticulum	*Absent*	Usually present	Usually present
Microtubules	*Absent*	Present	Present
Centrioles	*Absent*	Present	*Absent*
Golgi apparatus	*Absent*	Present	Present
Nucleus	*Absent*	Present	Present
Mitochondria	*Absent*	Present	Present
Chloroplasts	*Absent*	*Absent*	Present
Chromosomes	A single circle of naked DNA	Multiple units, DNA associated with protein	Multiple units, DNA associated with protein
Ribosomes	Present	Present	Present
Lysosomes	*Absent*	Present	Present
Vacuoles	*Absent*	*Absent* or small	Usually a large single vacuole in mature cell

Molecule Movement & Cells

- Passive Transport
- Active Transport
- Endocytosis
  (phagocytosis & pinocytosis)
- Exocytosis

Passive Transport

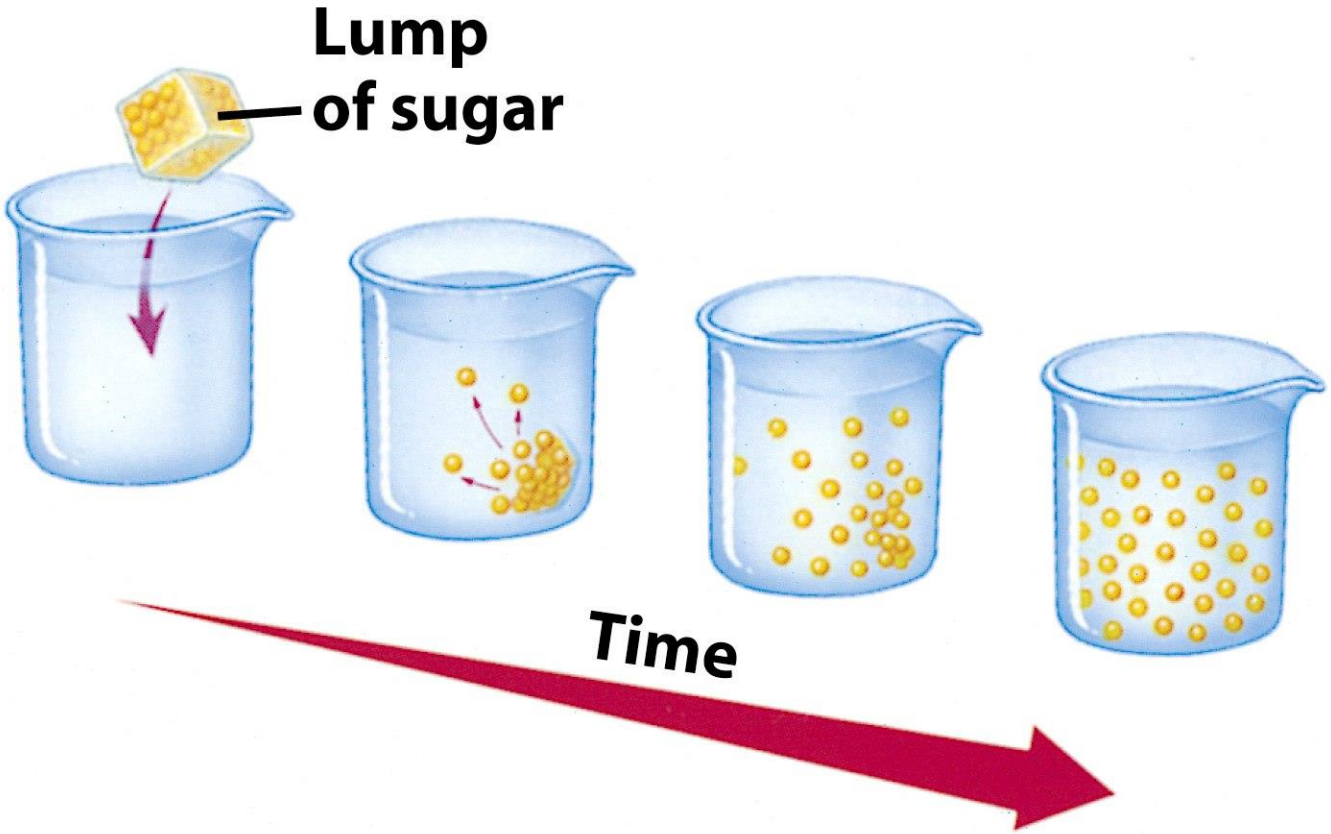
- No energy required
- Move due to gradient
  - differences in concentration, pressure, charge
- Move to equalize gradient
  - High moves toward low

Types of Passive Transport

1. Diffusion
2. Osmosis
3. Facilitated diffusion

Diffusion

- Molecules move to equalize concentration

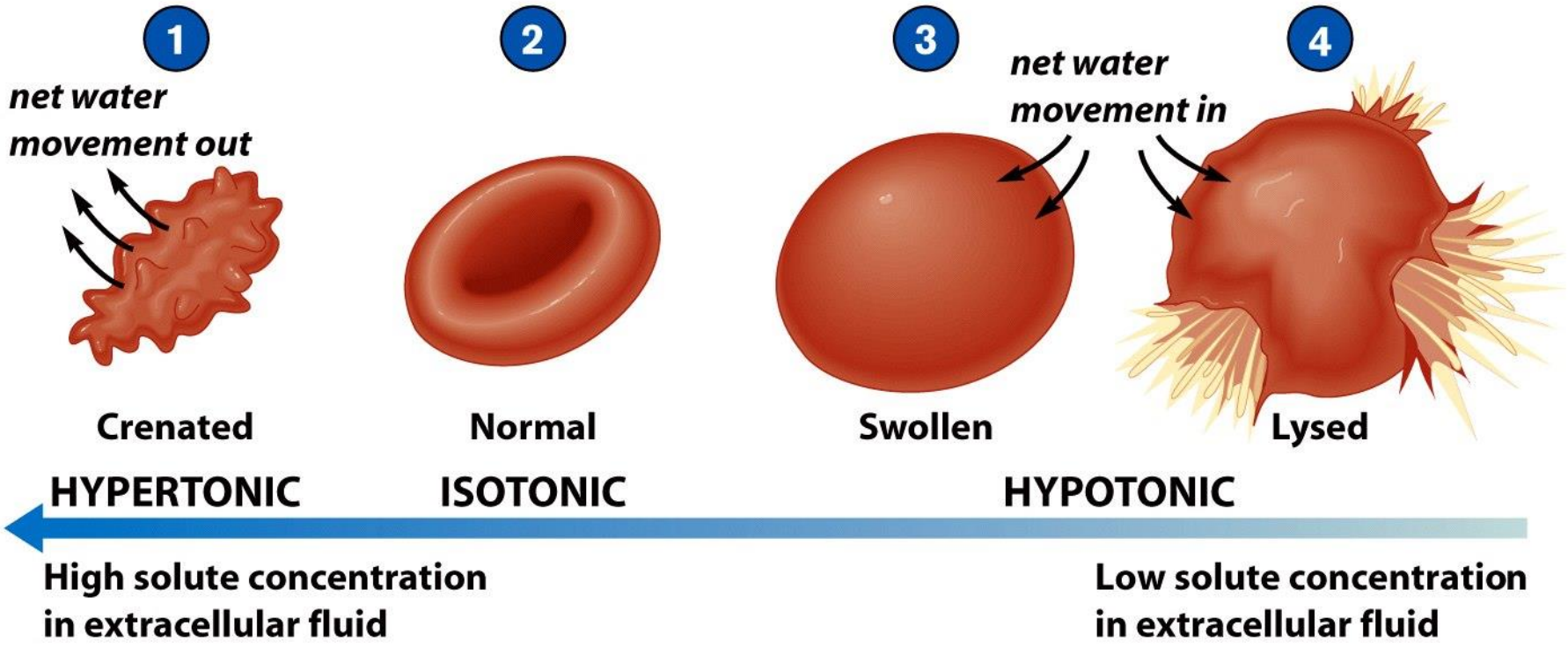


Osmosis

- Special form of diffusion
- Fluid flows from lower solute concentration
- Often involves movement of water
  - Into cell
  - Out of cell

Solution Differences & Cells

- solvent + solute = solution
- Hypotonic
  - Solutes in cell more than outside
  - Outside solvent will flow into cell
- Isotonic
  - Solutes equal inside & out of cell
- Hypertonic
  - Solutes greater outside cell
  - Fluid will flow out of cell


1
net water
movement out
2
3
net water
movement in
4
Crenated
Normal
Swollen
Lysed
HYPERTONIC
ISOTONIC
HYPOTONIC
High solute concentration
in extracellular fluid
Low solute concentration
in extracellular fluid

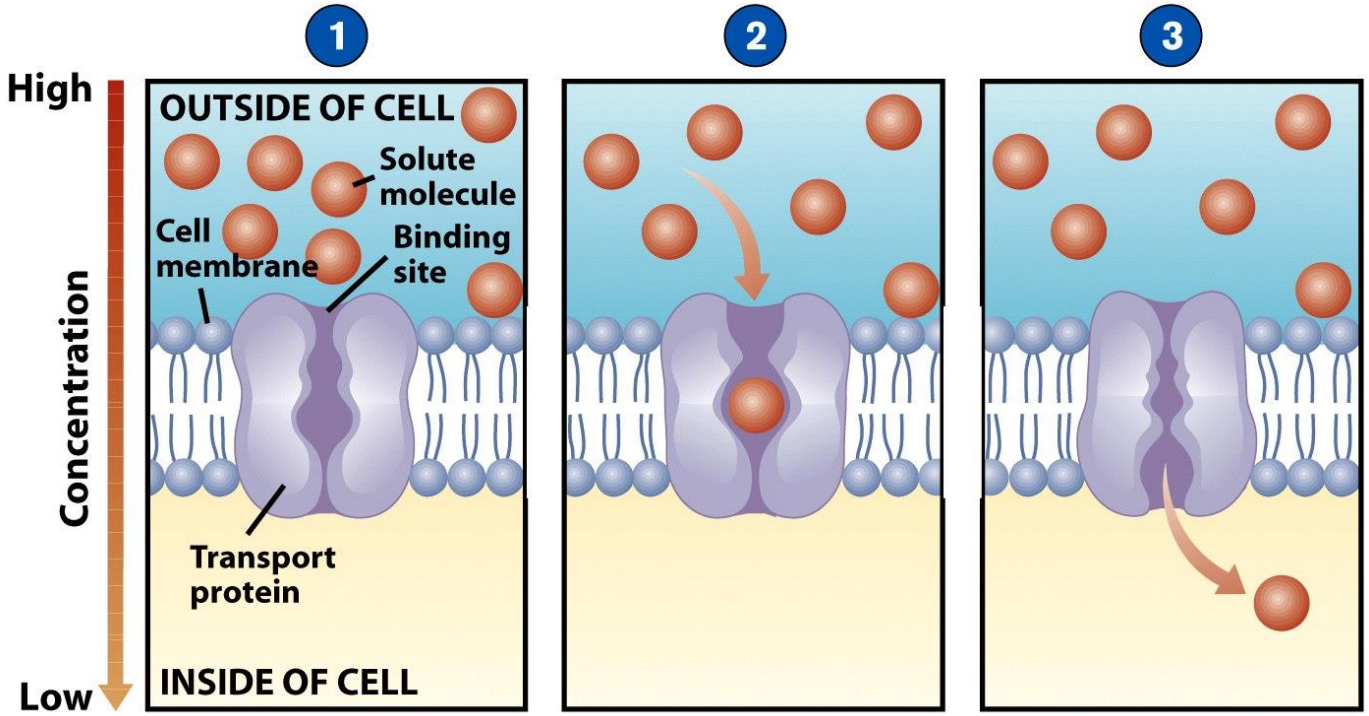
Facilitated Diffusion

- Differentially permeable membrane

- Channels (are specific) help molecule or ions enter or leave the cell
- Channels usually are transport proteins (aquaporins facilitate the movement of water)
- No energy is used

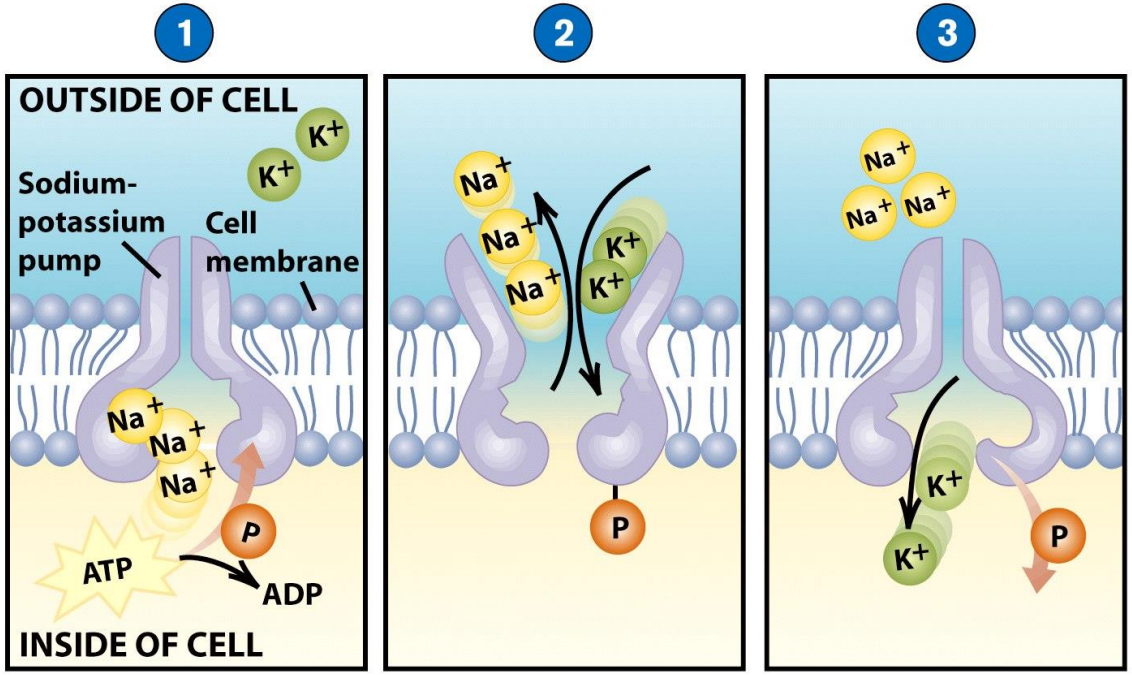
Process of Facilitated Transport

- Protein binds with molecule
- Shape of protein changes
- Molecule moves across membrane



Active Transport

- Molecular movement
- Requires energy (against gradient)
- Example is sodium-potassium pump

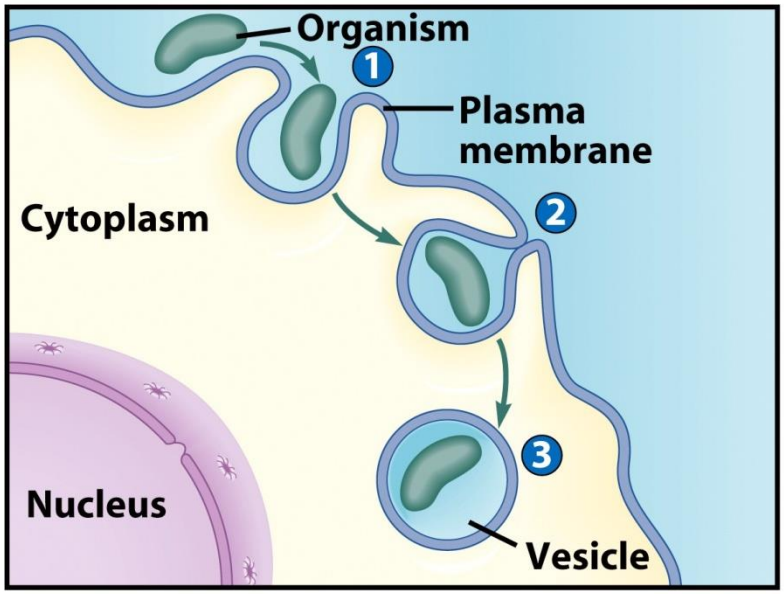


Endocytosis

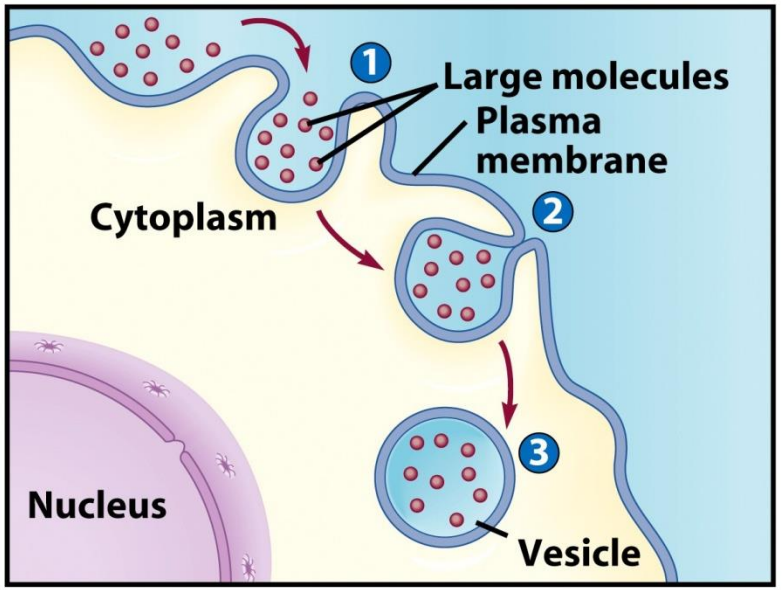
- Movement of large material
  - Particles
  - Organisms
  - Large molecules
- Movement is into cells
- Types of endocytosis
  - bulk-phase (nonspecific)
  - receptor-mediated (specific)

Process of Endocytosis

- Plasma membrane surrounds material
- Edges of membrane meet
- Membranes fuse to form vesicle



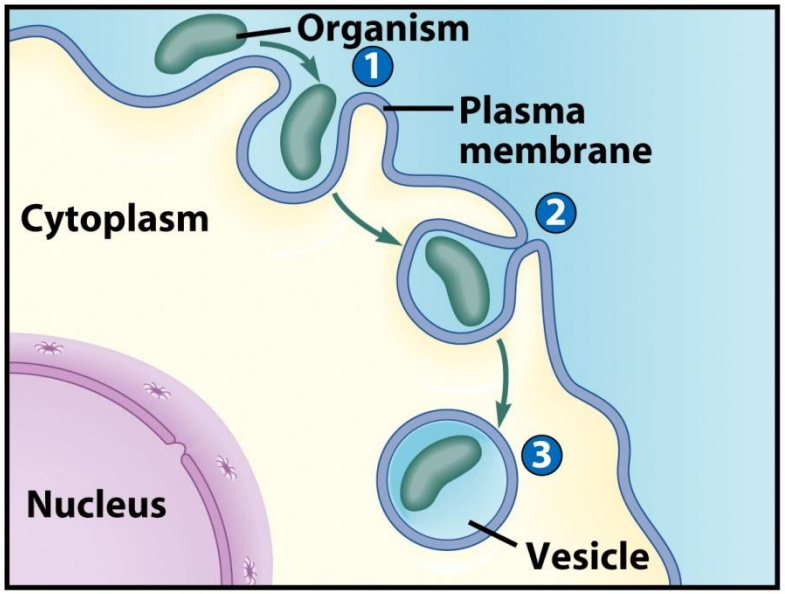
PHAGOCYTOSIS



PINOCYTOSIS

Forms of Endocytosis

- Phagocytosis – cell eating
- Pinocytosis – cell drinking



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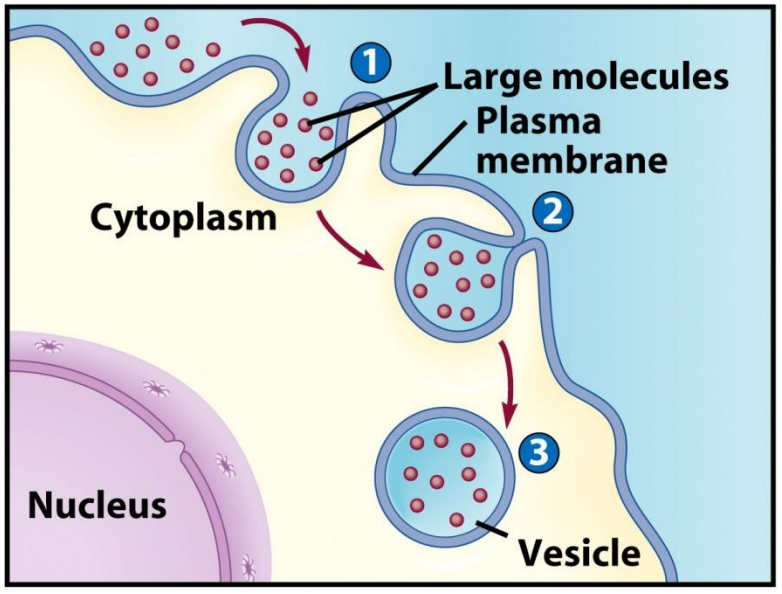
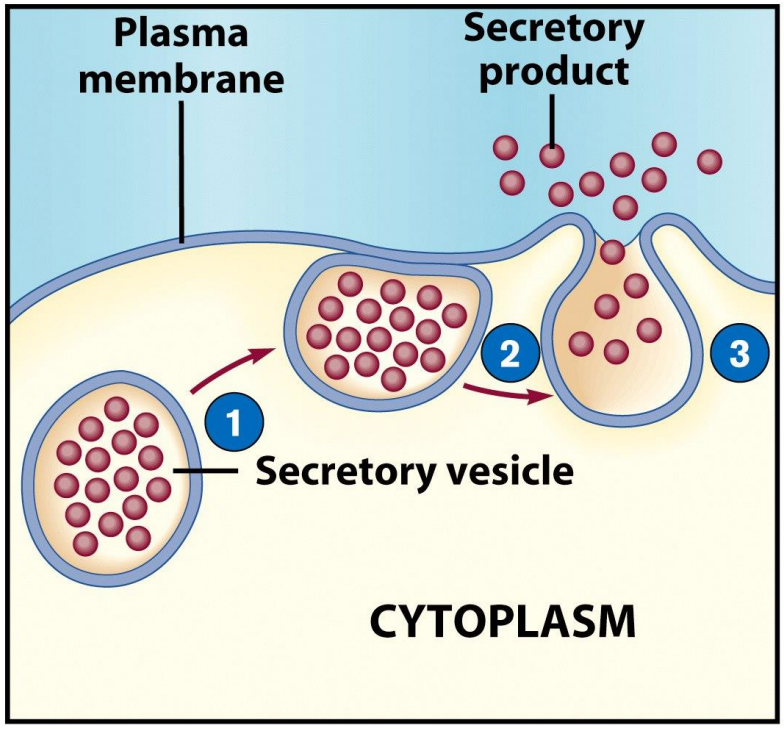
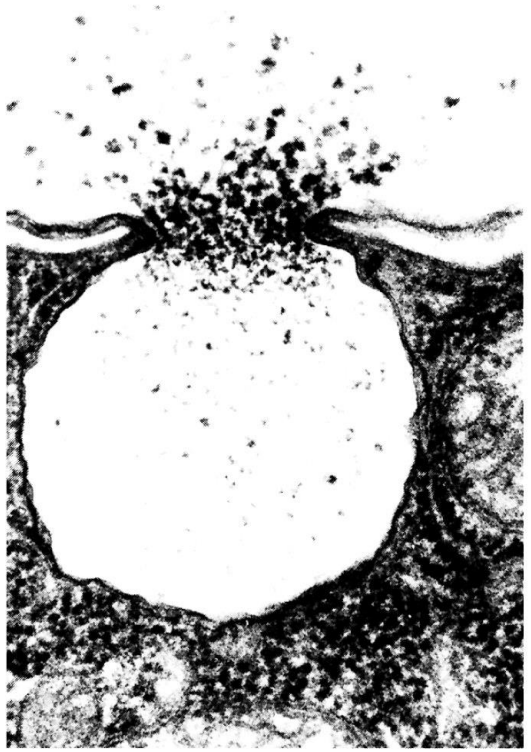


PINOCYTOSIS

Exocytosis

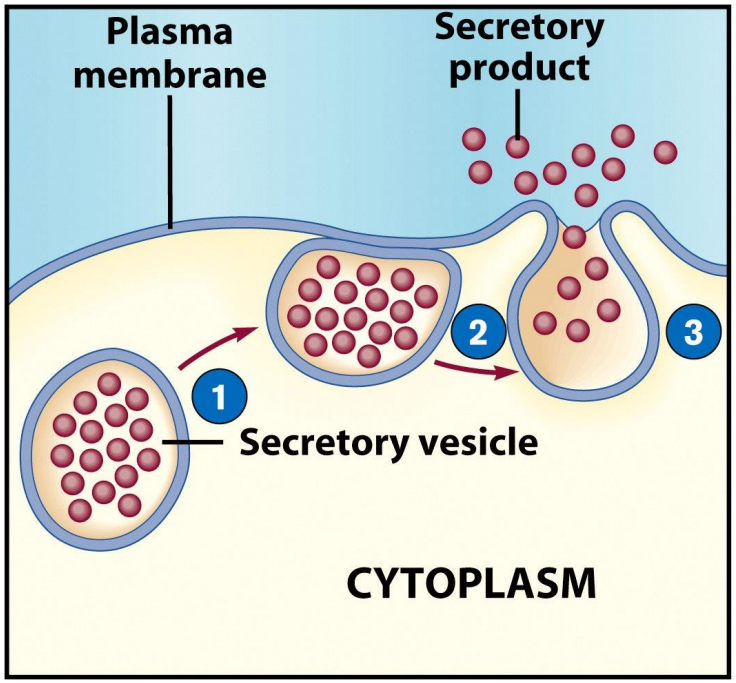
- Reverse of endocytosis
- Cell discharges material

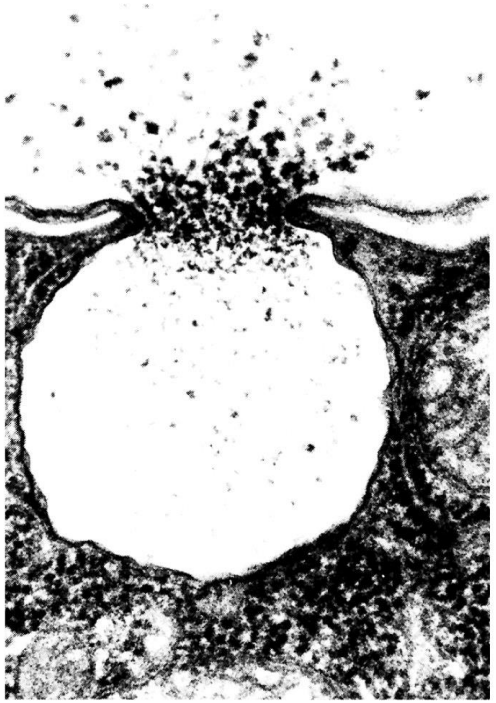


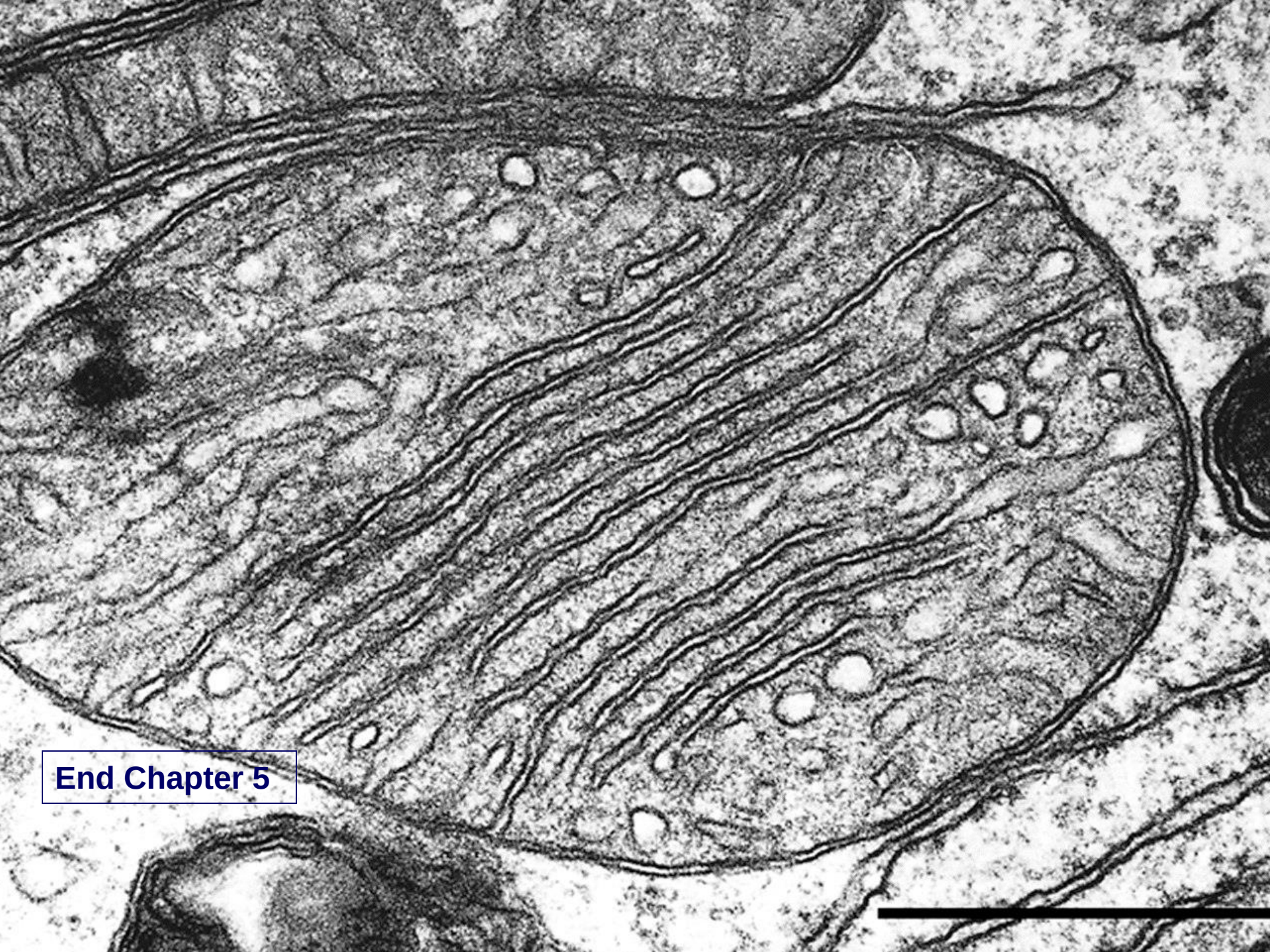


Exocytosis

- Vesicle moves to cell surface
- Membrane of vesicle fuses
- Materials expelled






End Chapter 5