# MEMBRANE FUNCTION

Methods of Transport

# Basic Membrane Function

- Maintain internal cell environment at a steady state regardless of changes in the external environment
  - Similar to the concept of homeostasis in the human body but this is at the cellular level
- Acts as a selective barrier regulating the movement of substances into and out of the cell

# Terminology

- Solute vs. Solvent
- Concentration vs. Water concentration

# Type of Transport

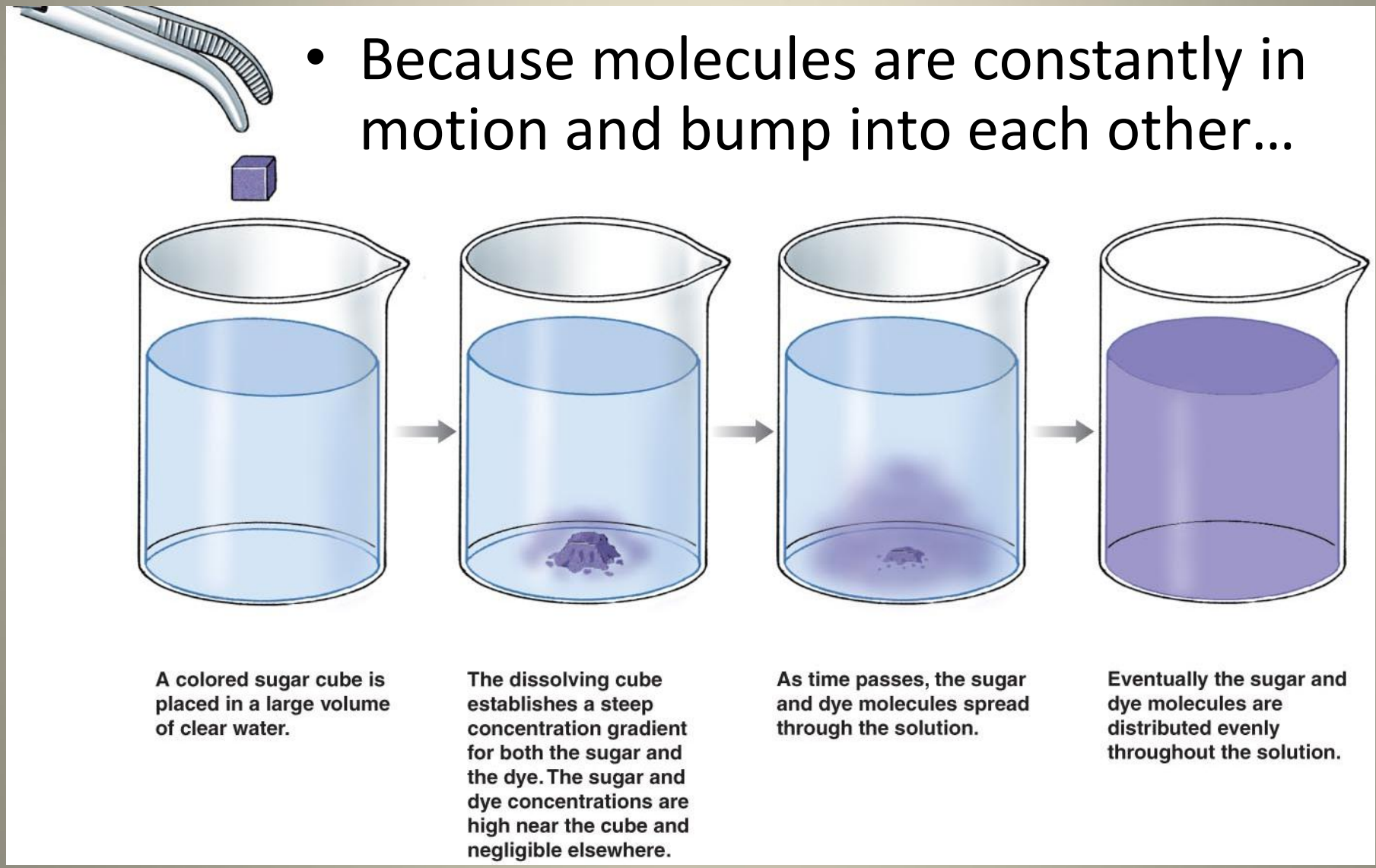
- **Passive transport:**
  1. Simple diffusion
  2. Facilitated diffusion: channel, carrier
  3. Osmosis

- **Active transport:**
  1. Pump

- **Bulk membrane transport:**
  1. Endocytosis: pinocytosis, phagocytosis, receptor-mediated
  2. Exocytosis

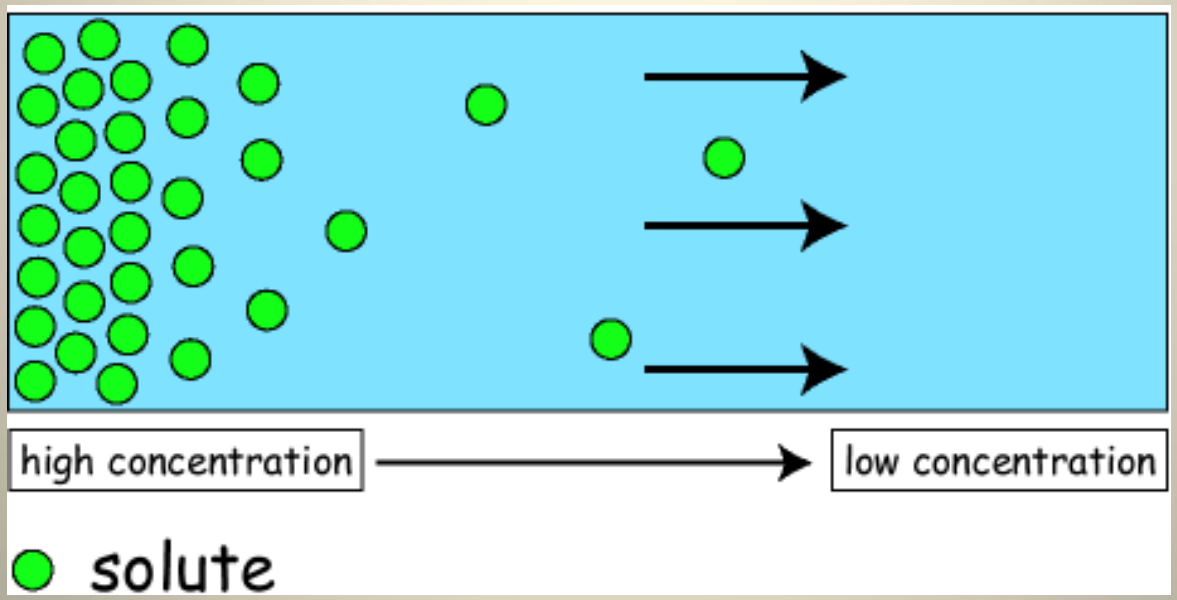
# Diffusion

- Because molecules are constantly in motion and bump into each other…

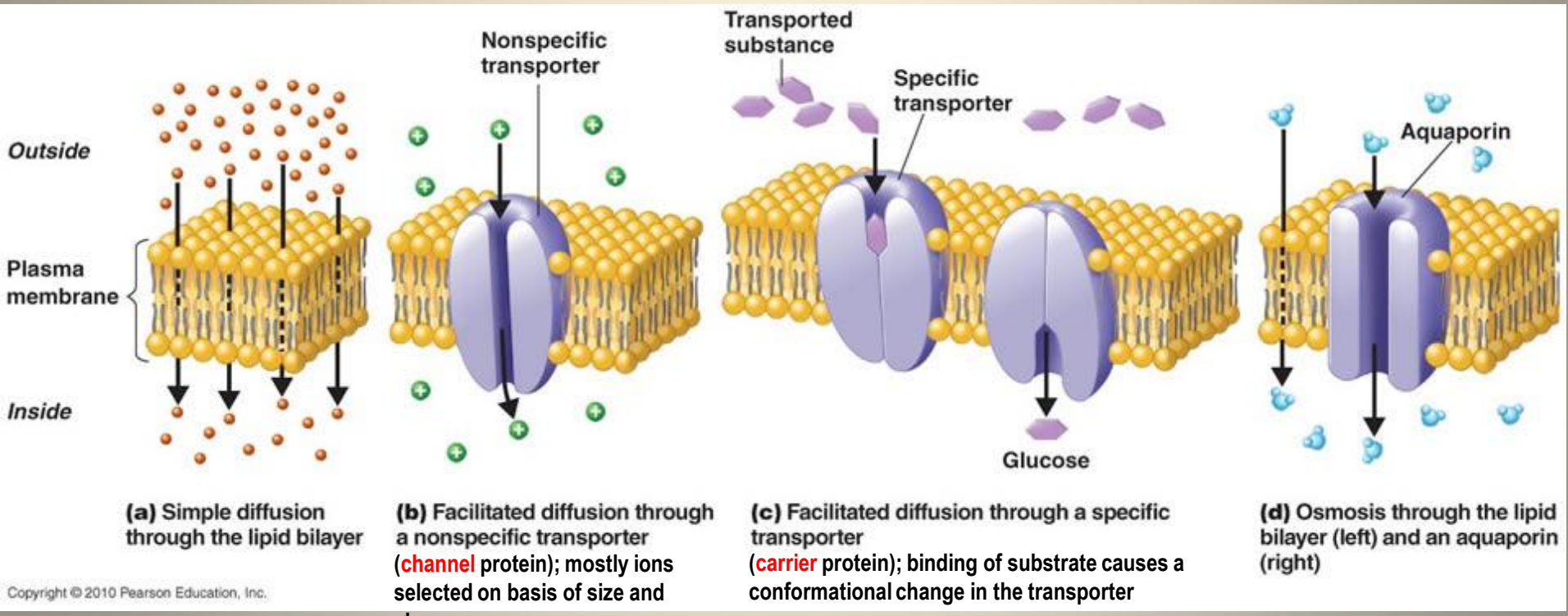


# Passive Transport

- Does not require energy
- Movement of molecules from area of high to low concentration



# Passive Transport

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# 1. Simple Diffusion

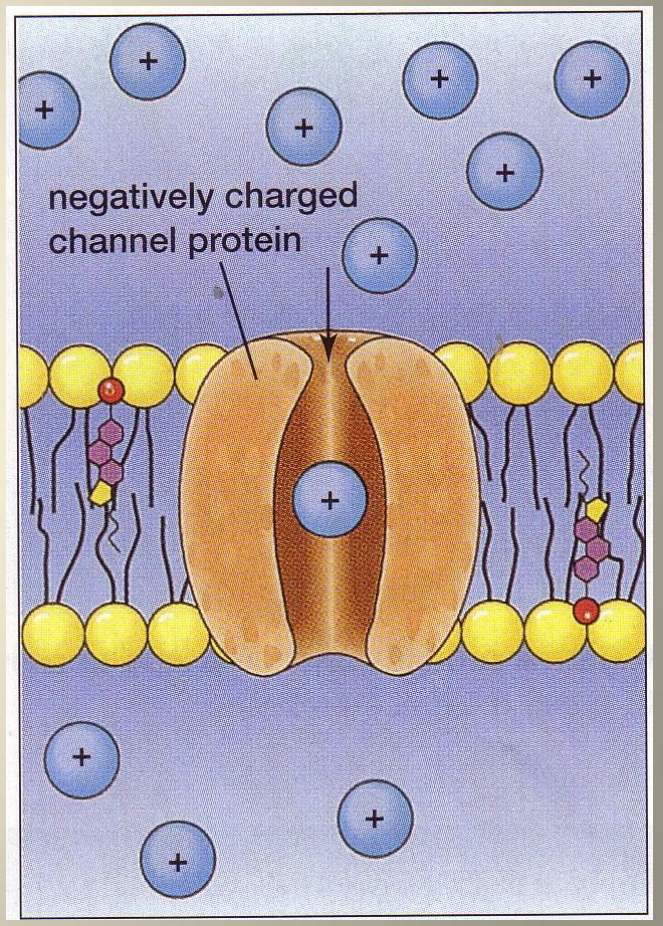
- Movement of molecules
  - Across a semi-permeable membrane
  - Down a concentration gradient
  - From an area of high to low concentration
  - No energy required
- Continues until equilibrium is achieved
- Also known as **simple transport**
  - Transport across a membrane without the assistance of membrane proteins
  - Occurs with small neutral molecules (e.g. $O_2$, $CO_2$)

# 2. Facilitated Transport

- Similar to simple diffusion in that:
  - Across a semi-permeable membrane
  - Passive transport
  - Continues until equilibrium is achieved
- Difference is that a transport protein is involved in the movement of molecules:
  - Channel
    - Un-gated (leak channels)
    - Gated
  - Carrier proteins

# Channel Proteins

- Acts like a tunnel, some have a swing gate
- Can be:
  - Un-gated (leak channels): always opened
  - Gated: can open or close
- Moves:
  - by diffusion (passive transport down concentration gradient)
  - small dissolved charged molecules (e.g. ions)
    - charged particles need help crossing the hydrophobic core

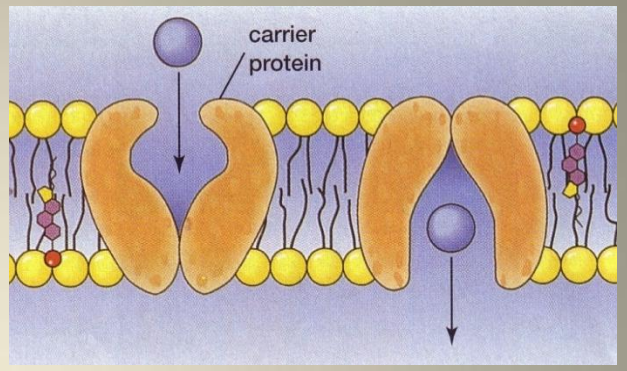


# Channel Protein

- **Aquaporins**: a specific type of channel protein that facilitate the movement of **water** molecules across a membrane

- Question: Why can't water molecules cross a cell membrane by simple diffusion (unaided by a protein)?

# Carrier Proteins

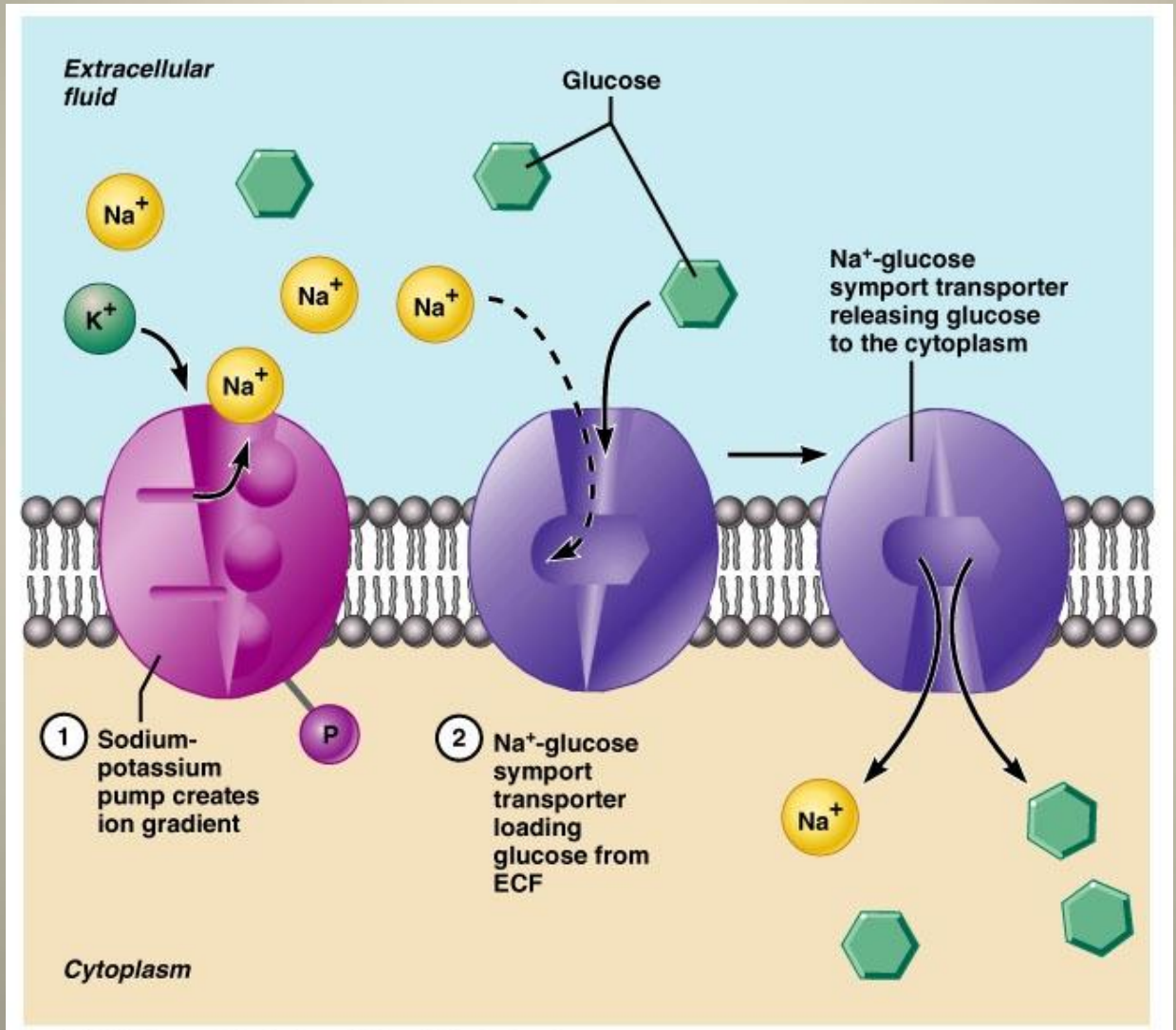



- Acts like a turnstile or revolving door
- Undergo **conformational change** to allow molecules through
- Moves a variety of substances from charged particles to large uncharged molecules (e.g. glucose)
- Note: carrier proteins in active transport are called pumps

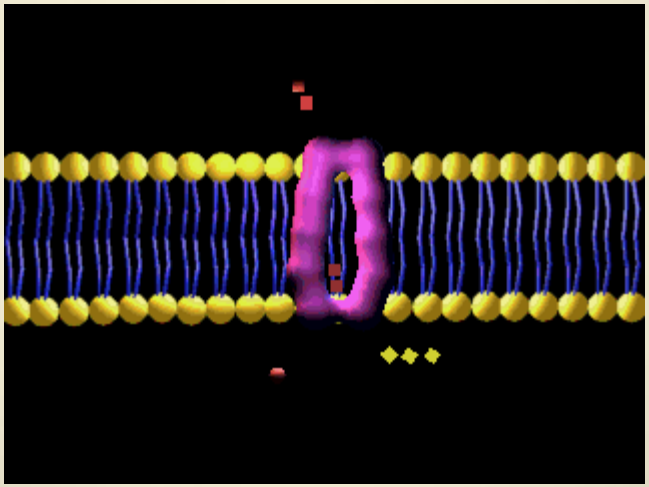
# Direction of Transport (applies to passive and active transporters)

- **Uniport:** movement of a single molecule in one direction
  - E.g. all channel proteins
- **Symport:** movement of 2 molecules in the same direction
  - E.g. Na/glucose symporter
- **Antiport**: movement of 2 molecules in opposite directions
  - E.g. Na/K pump

# Direction of Transport



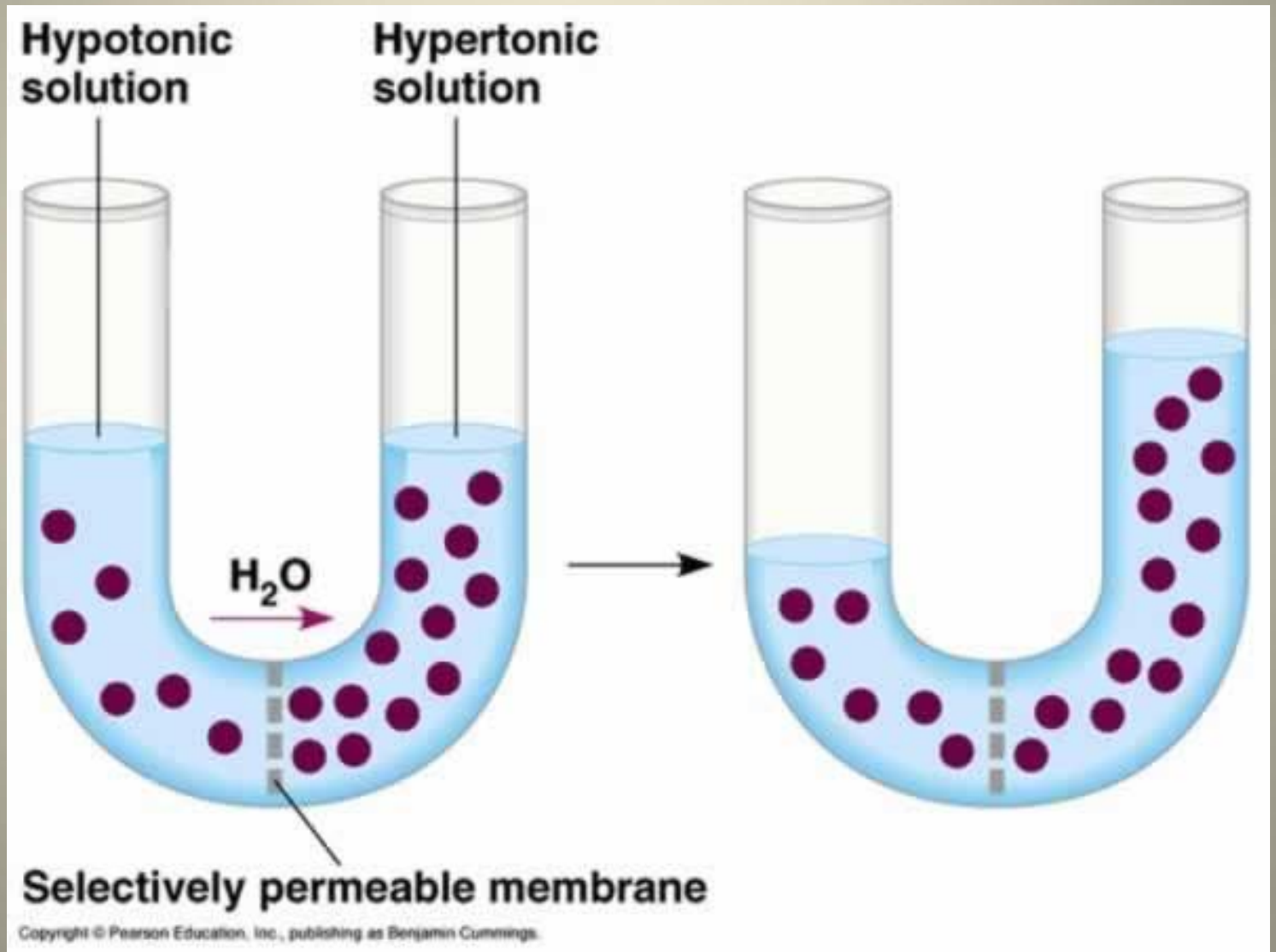
# Antiport Animation



# 3. Osmosis

- Diffusion of **water**
  - In vitro this could occur by simple diffusion
  - In vivo (e.g. a cell), this would be facilitated by aquaporins
- Water moves from an area of high water concentration to an area of low water concentration
- Water will always move in the direction to dilute the solute
- Movement of water is in the opposite direction of the solute

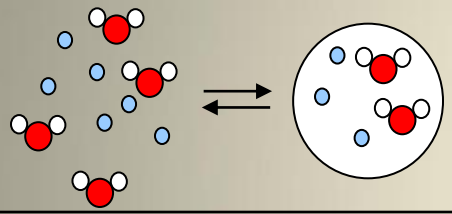
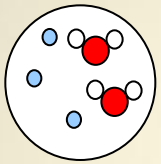
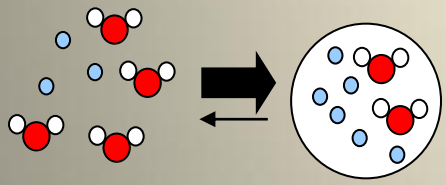
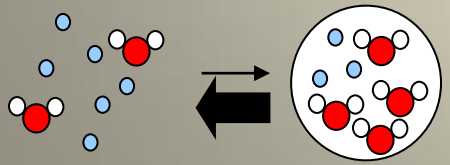
# Osmosis



# Osmotic Environments

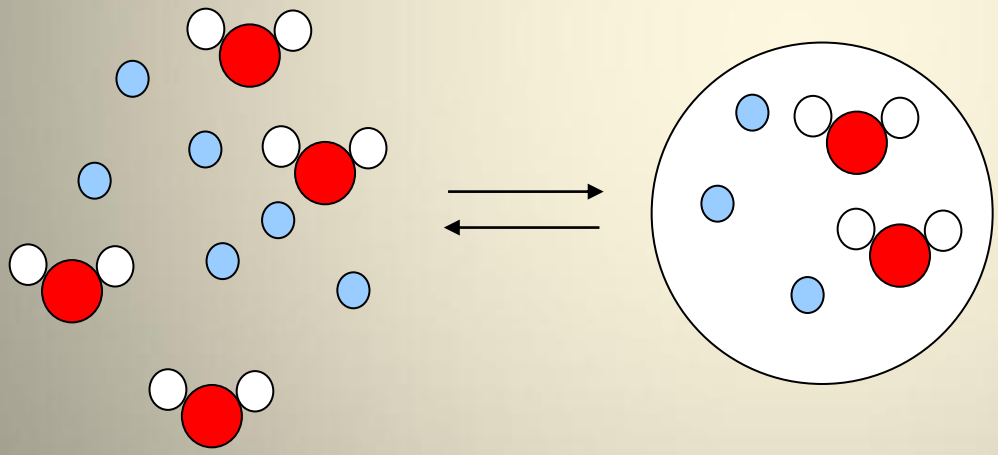
- Tonicity:
  - Osmotic pressure due to the difference in concentration across a semi-permeable membrane
  - Influenced by solutes that cannot cross a membrane
  - refers to the concentration of solutes in the environment surrounding the cell (external)
- Isotonic: Iso = same
- Hypotonic: Hypo = less
- Hypertonic: Hyper = more

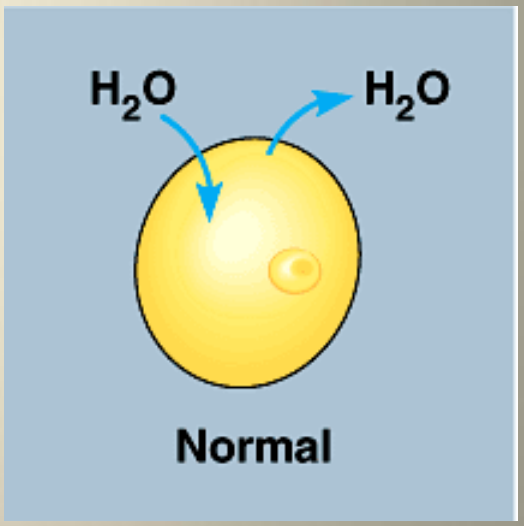
# Refer to chart in worksheet

| Osmotic Environment | | Net movement of water | Effect on animal cell | Effect on RBC | Effect on plant cell |
|---|---|---|---|---|---|
| Before | After | | | | |
|  |  | | | | |
|  | | | | | |
|  | | | | | |

# Isotonic Environment

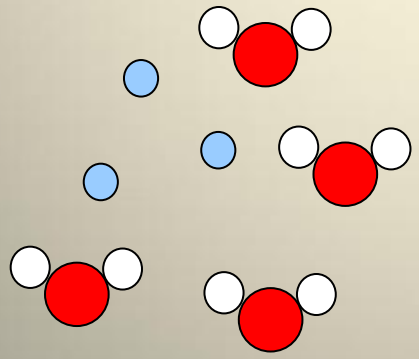
- Equal movement in and out of cell
- Animal cells in equilibrium

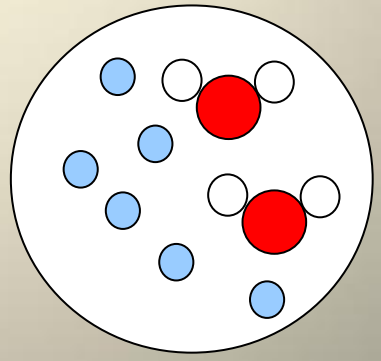




# Hypotonic Environment

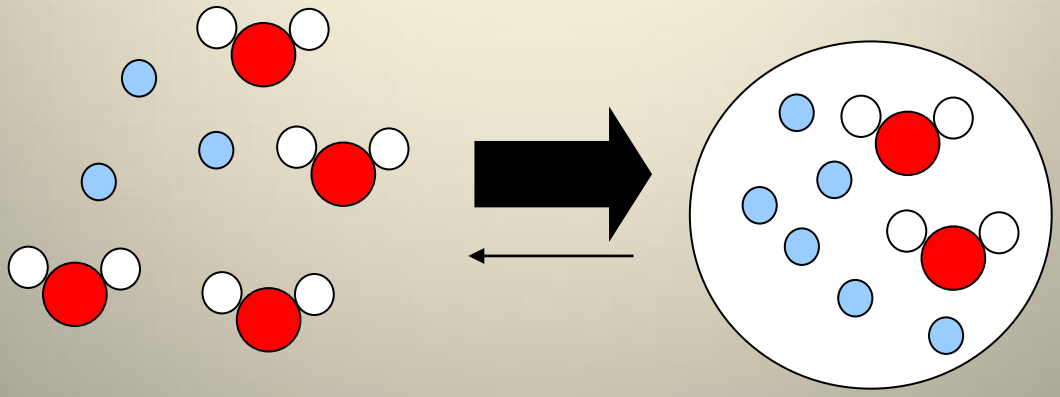
- Hypotonic
  - lower concentration outside of cell
  - Higher concentration inside cell
  - more solutes inside cell
- Which direction will water move?





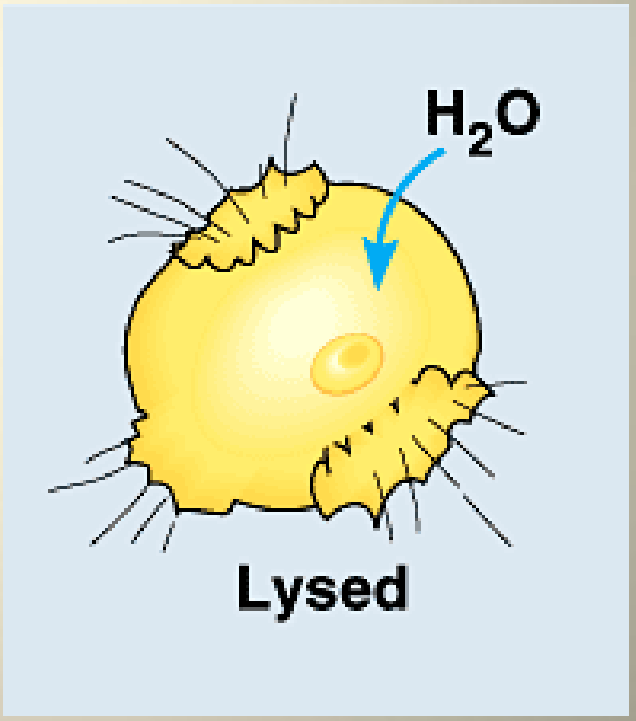
# Hypotonic  Environment

- Water moves into cell
- What will happen to the animal cell?



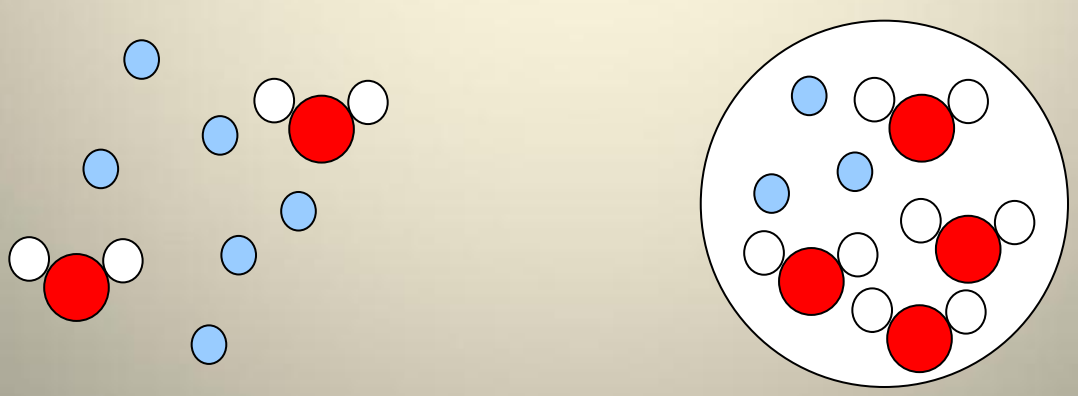
# Hypotonic Environment

- Result: cell expands and may burst
- Osmotic lysis



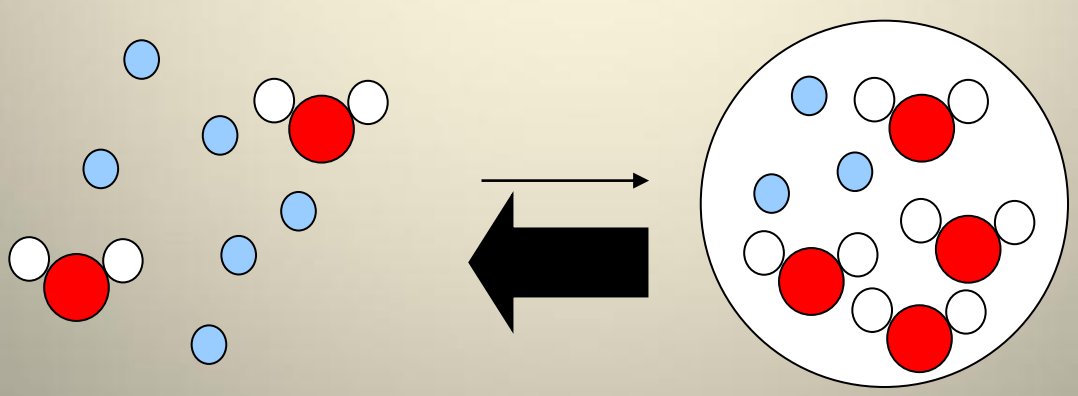
# Hypertonic Environment

- Hypertonic:
  - higher concentration outside of cell
  - more solutes outside of cell
- Which direction will water move?



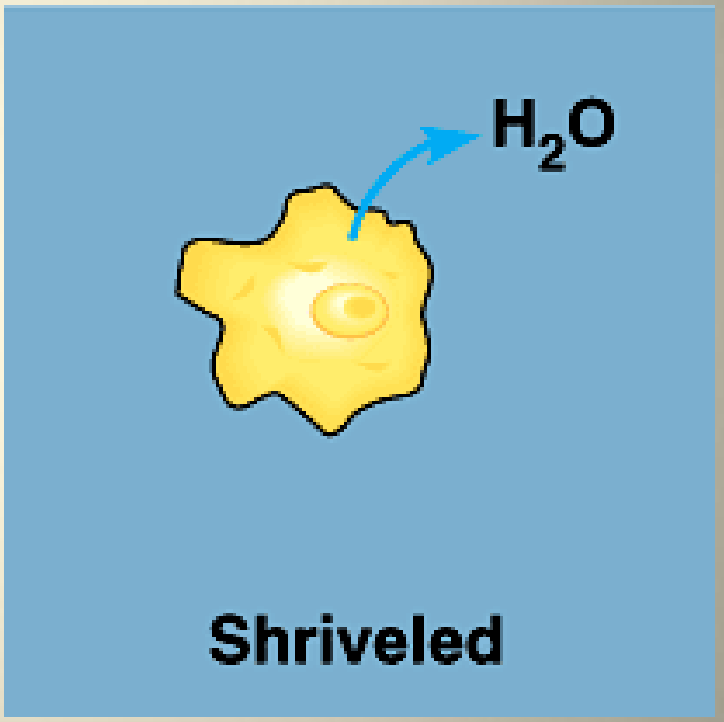
# Hypertonic Environment

- Water moves out of cell
- What happens to the animal cell?



# Hypertonic Environment

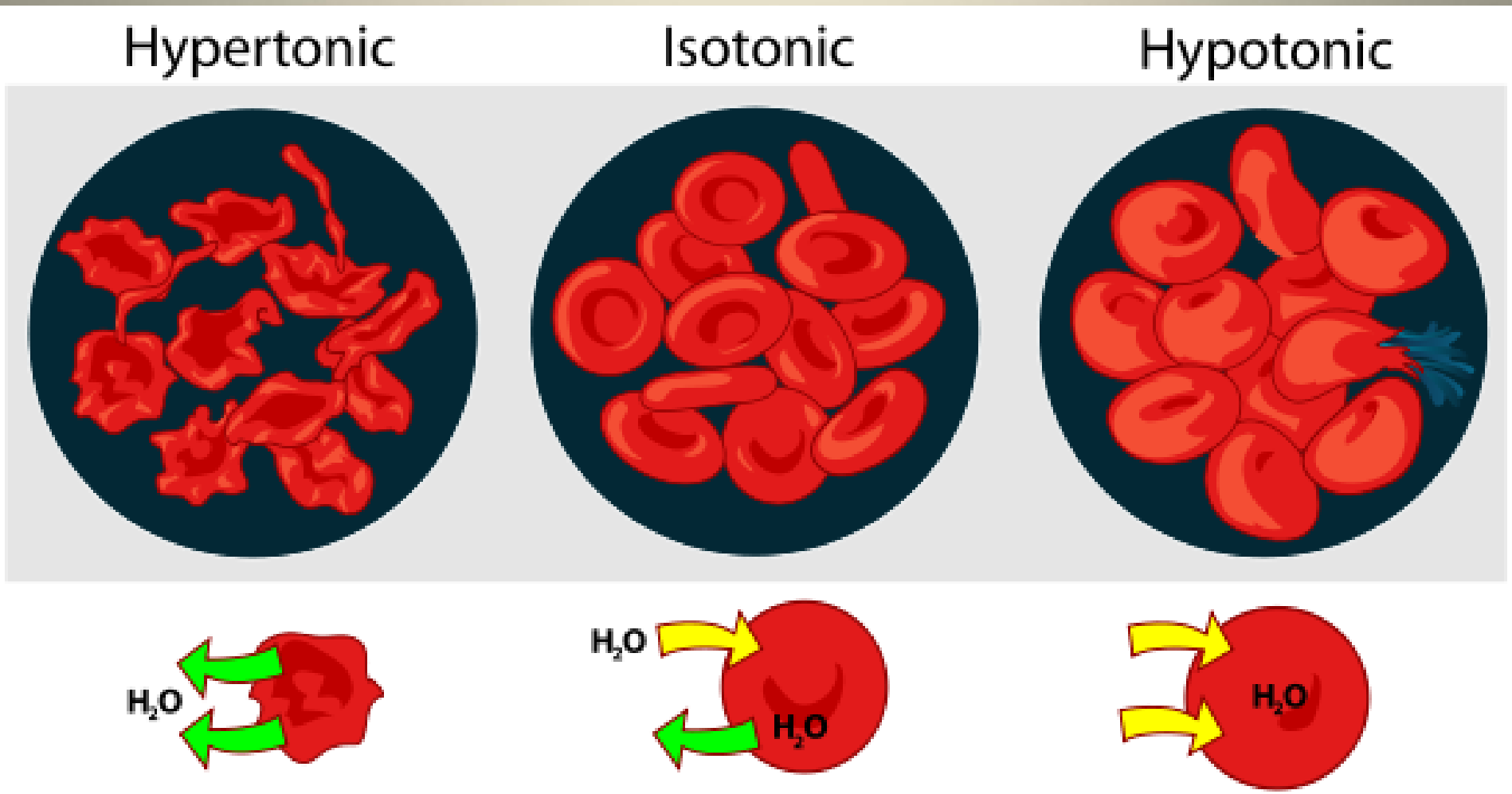
- Result: Cell shrinks



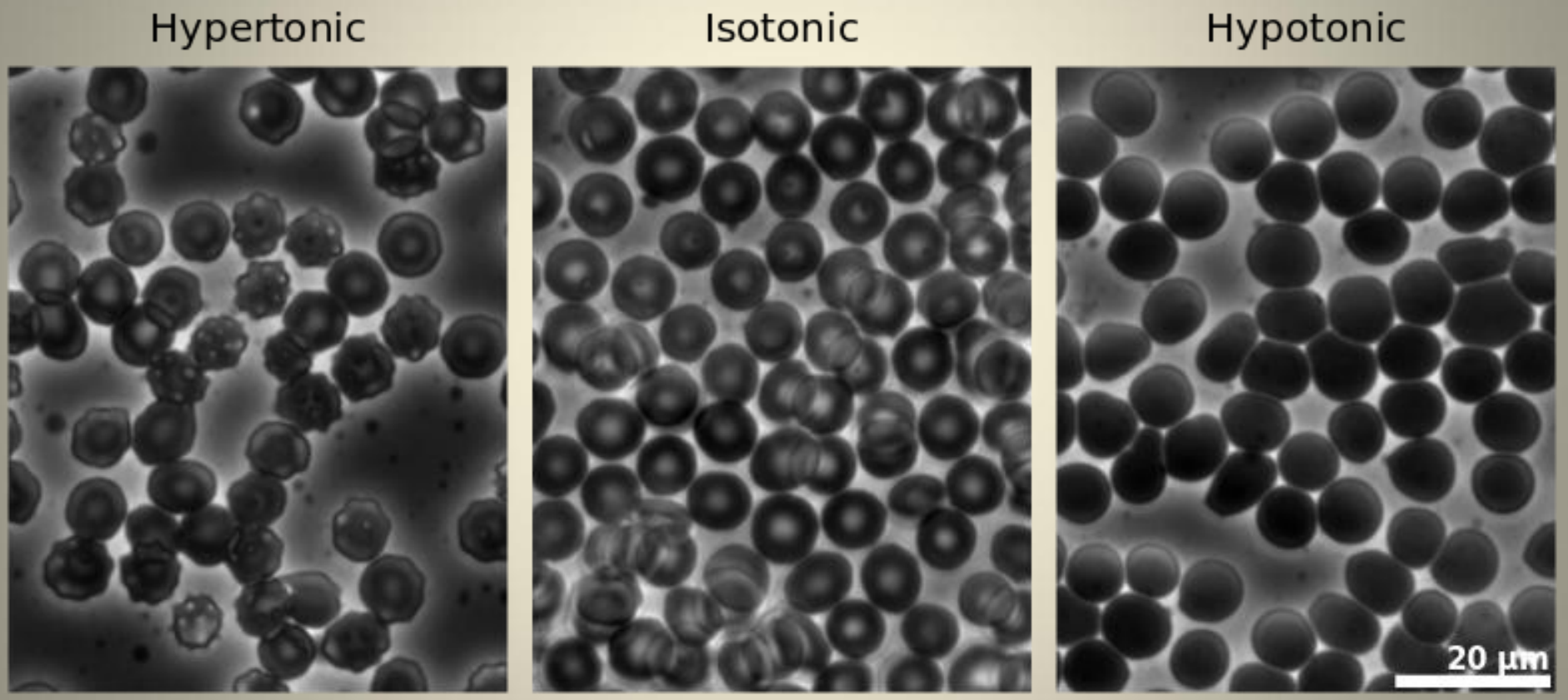
# Red Blood Cells

- Same effect as with animal cells but terminology is different

# Red Blood Cells



# Red Blood Cells



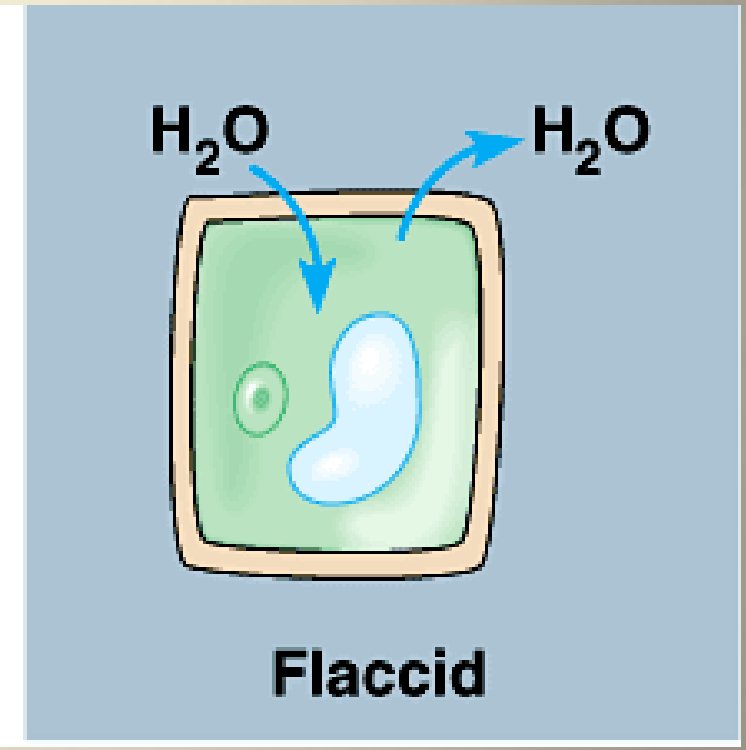

Crenation Equilibrium Hemolysis

# Plant Cells

- Plant cells have cell walls which changes the effect of the osmotic environments

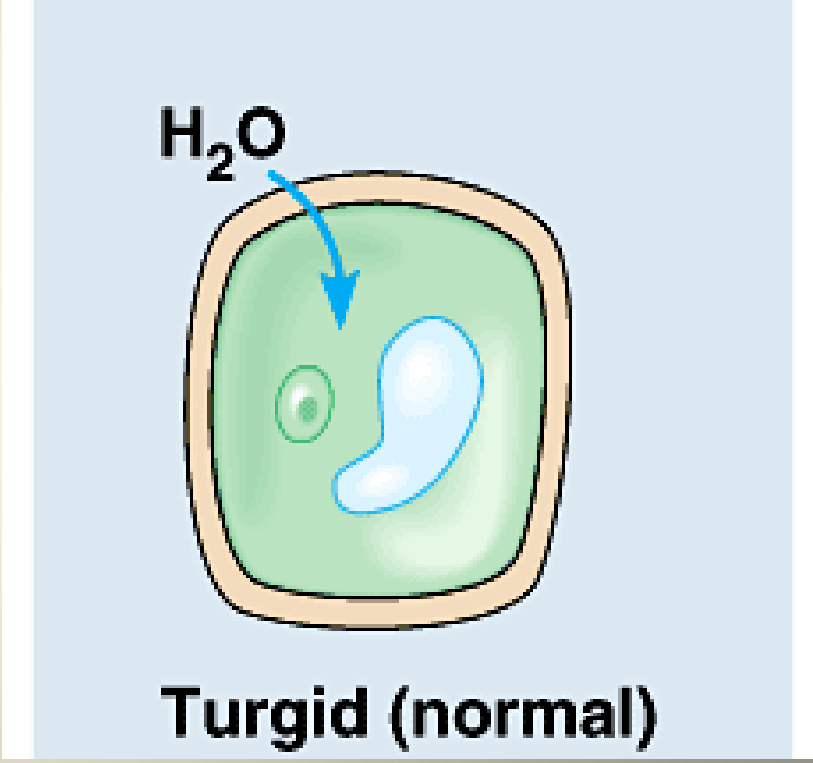
# Plant Cell in Isotonic Environment

- Plant cell is **flaccid**:
  - Lacking firmness (may wither)
- Water movement in equilibrium is unable to provide cell with the internal pressure necessary for structural support



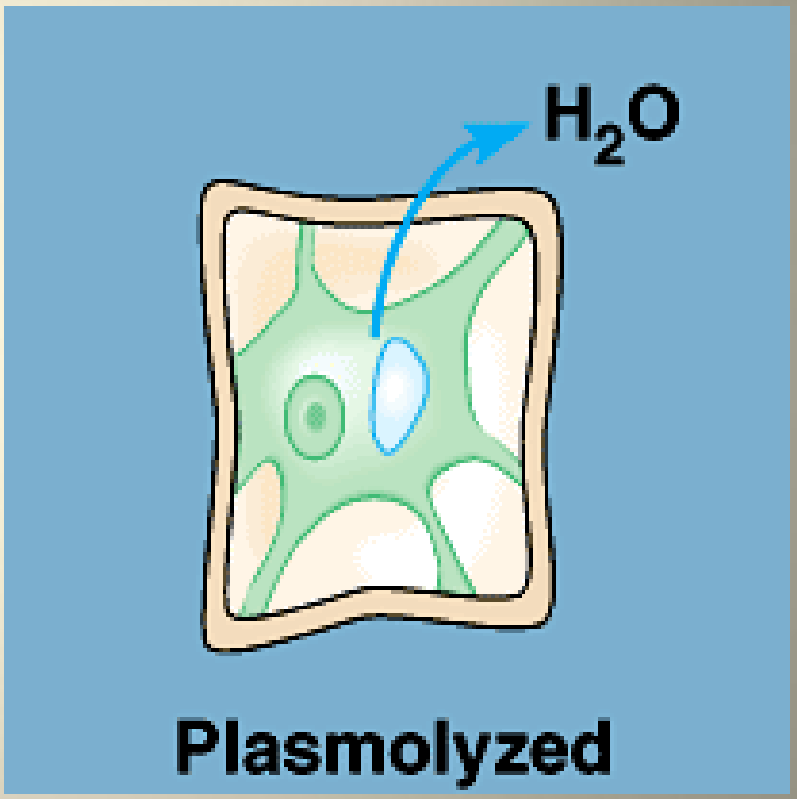
# Plant Cell in Hypotonic Environment

- Rigid cell wall prevents plant cell from rupturing
- **Turgor pressure**
  - Increased internal pressure due to water entry provides structural support for plant
- Turgidity: cell swelling

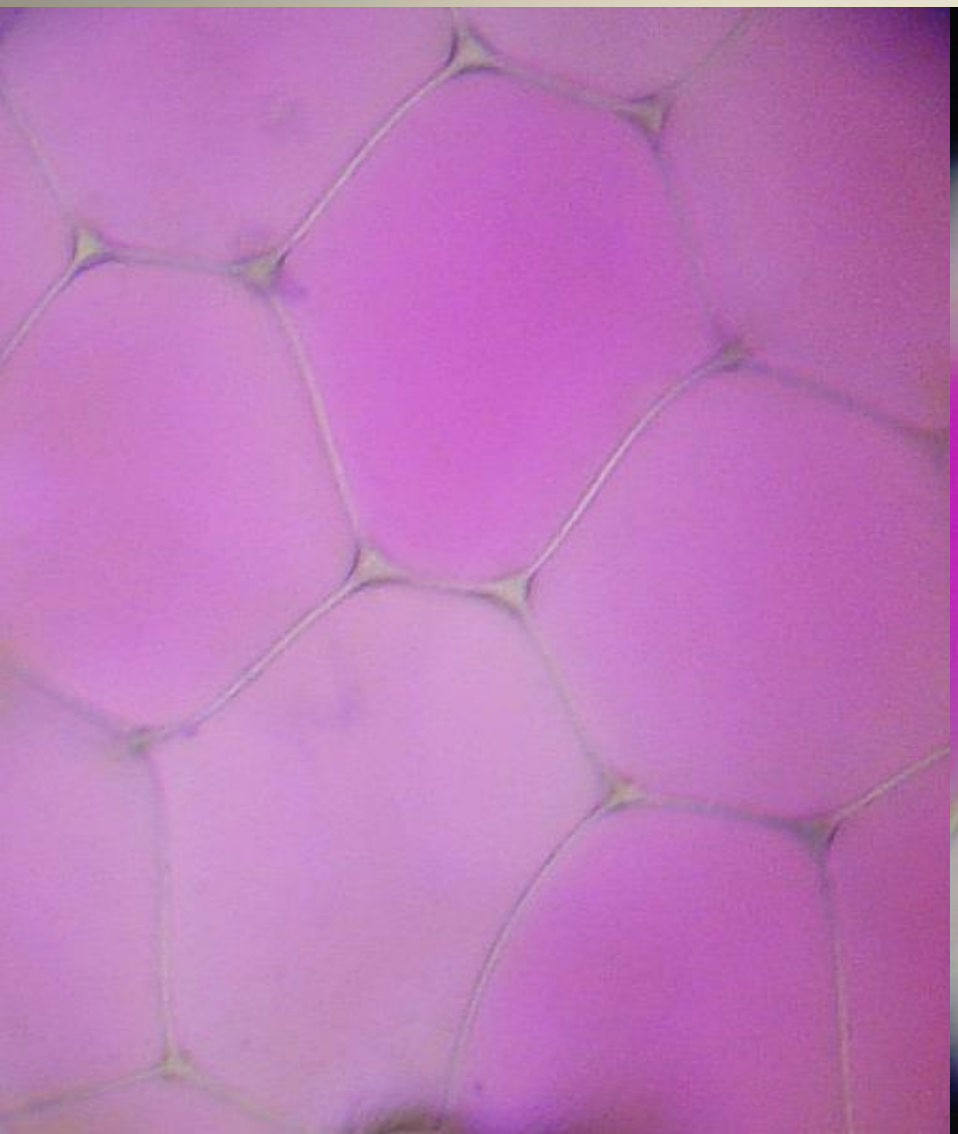


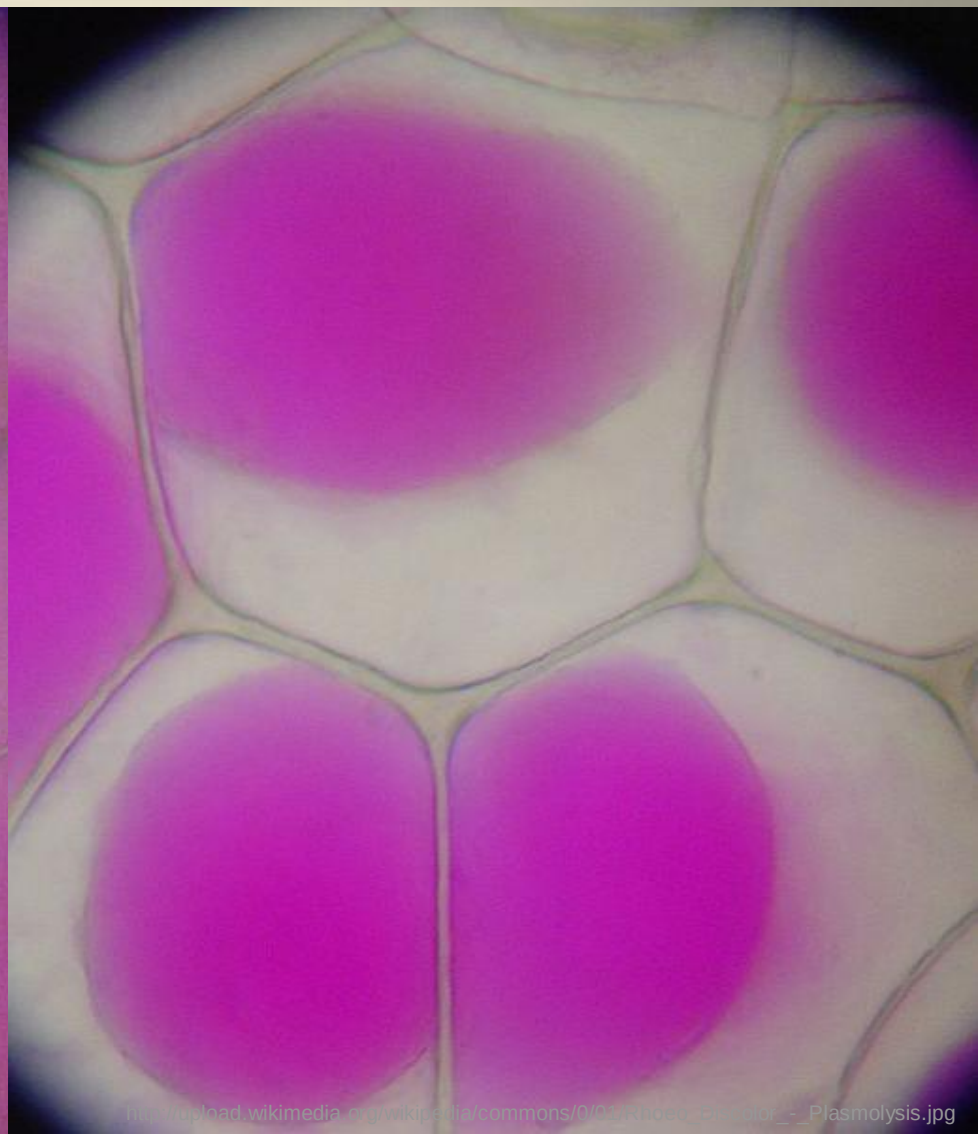
# Plant Cell in Hypertonic Environment

- As water moves out of cell, cell wall maintains its shape
- But cell membrane and cytoplasm shrinks
- **Plasmolysis**: shrinking of plasma membrane and cytoplasm away from cell wall

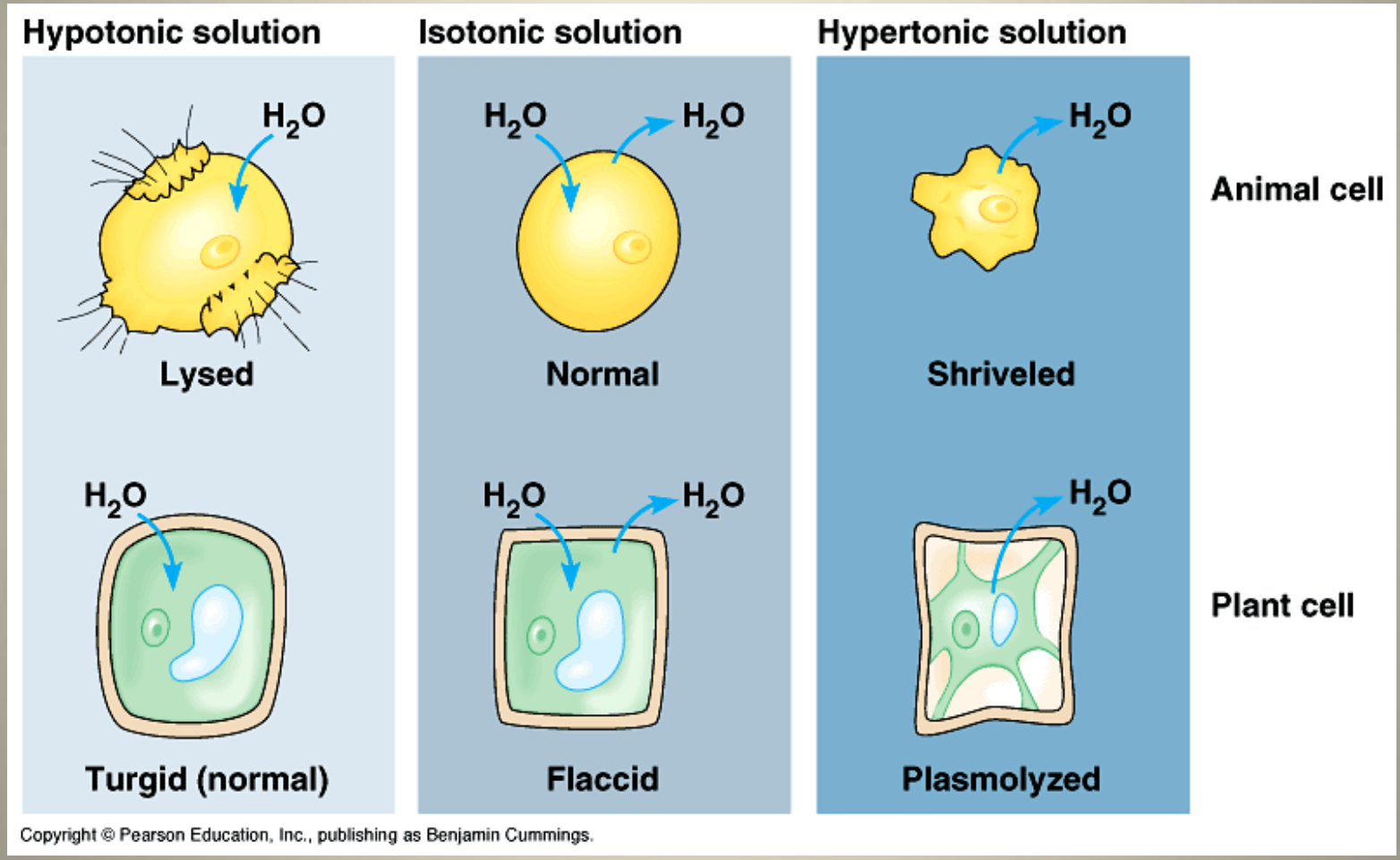


# Plant Cell in Hypertonic Environment



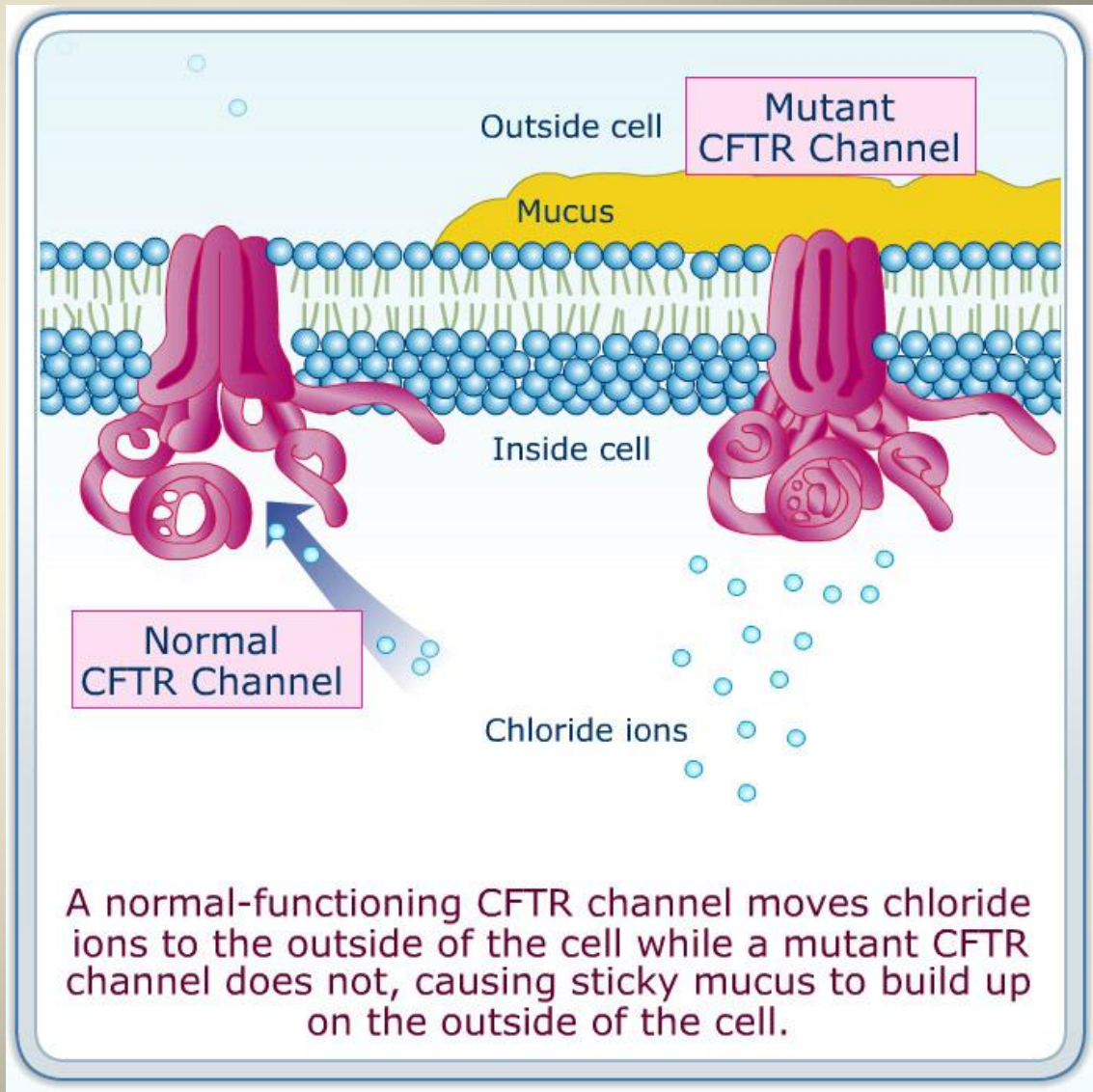


# Comparing Animal and Plant Cell

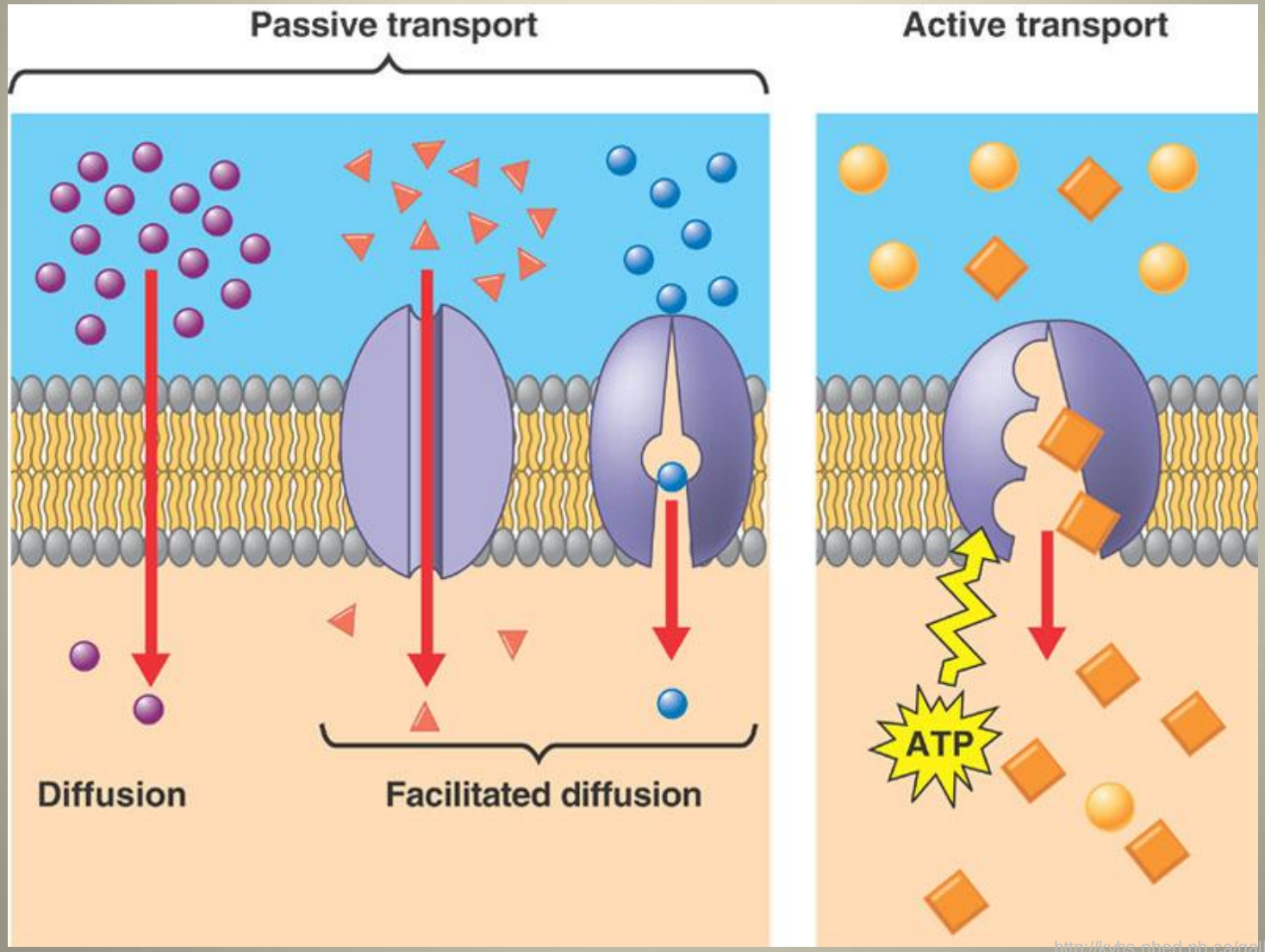


# CFTR and Osmosis

- How does this relate to osmosis?
- Hint: why does sticky mucus build up outside of the cell?



# Types of Transport



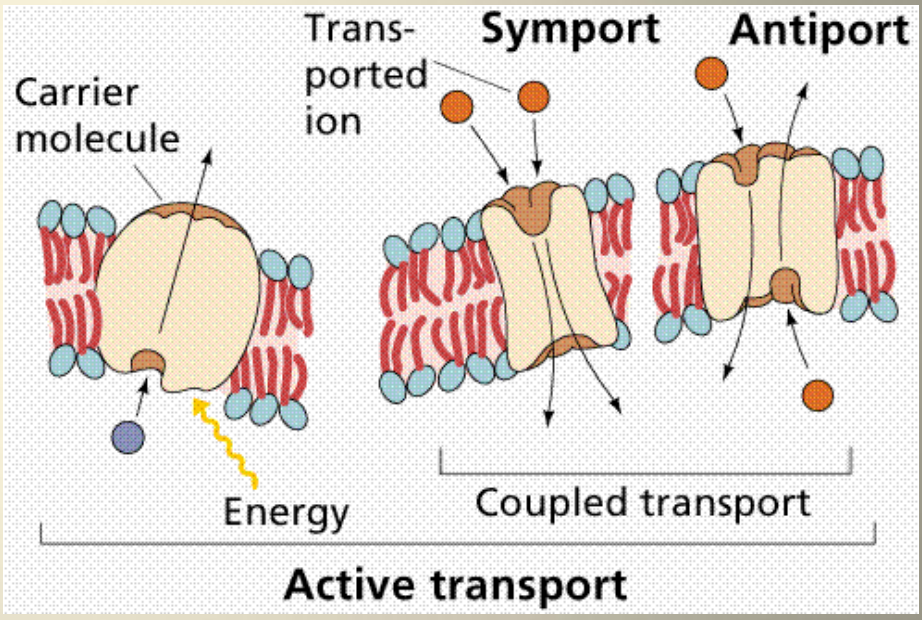

http://kvhs.nbed.nb.ca/gallant/biology/Transport.jpg

# Active Transport

- Movement of molecules against concentration gradient
- From low to high concentration
- Requires energy in the form of **ATP**
- Requires a transport protein: **pump**
- ATP induces a conformational change in the protein pump to allow specific molecules to enter/exit cell against its concentration gradient

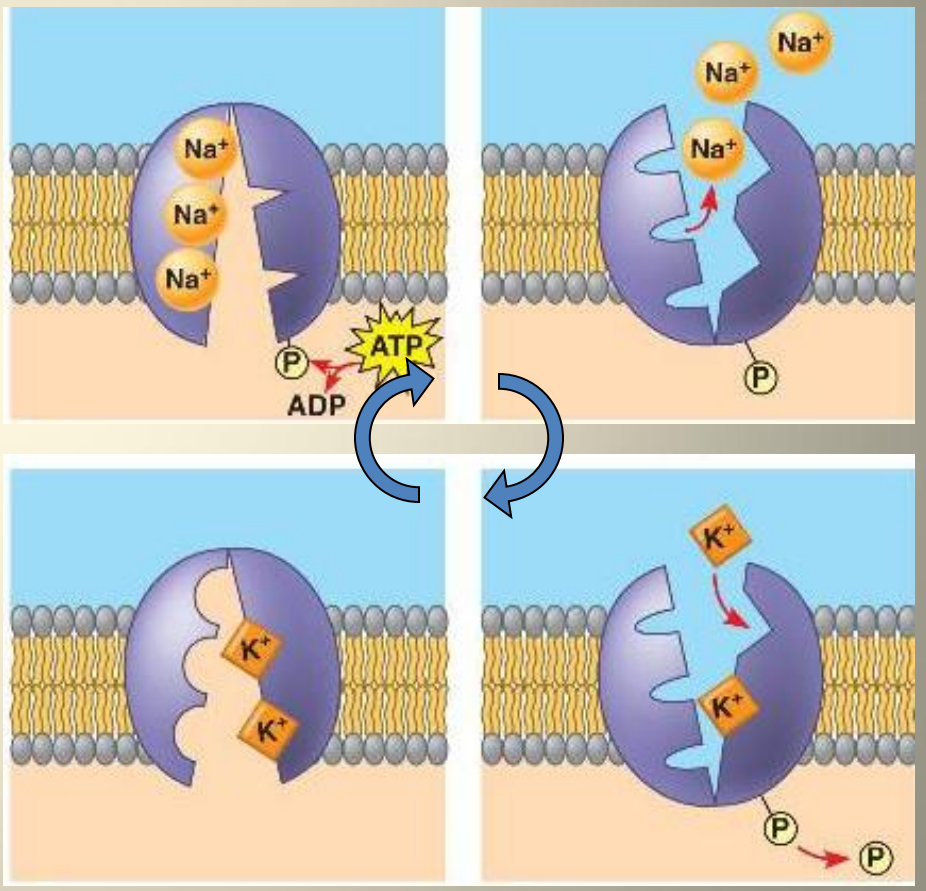
# Types of Pumps

- Pumps often function the same as carrier proteins except that they move molecules against the gradient and thus require energy
- Pumps can also be coupled so that 2 molecules are moved against the concentration gradient



# Example: Na-K Pump

- Active transport
- Antiport
- Pump oscillates between 2 conformational states:
  - 3 Na+ out of the cell
  - 2 K+ into the cell



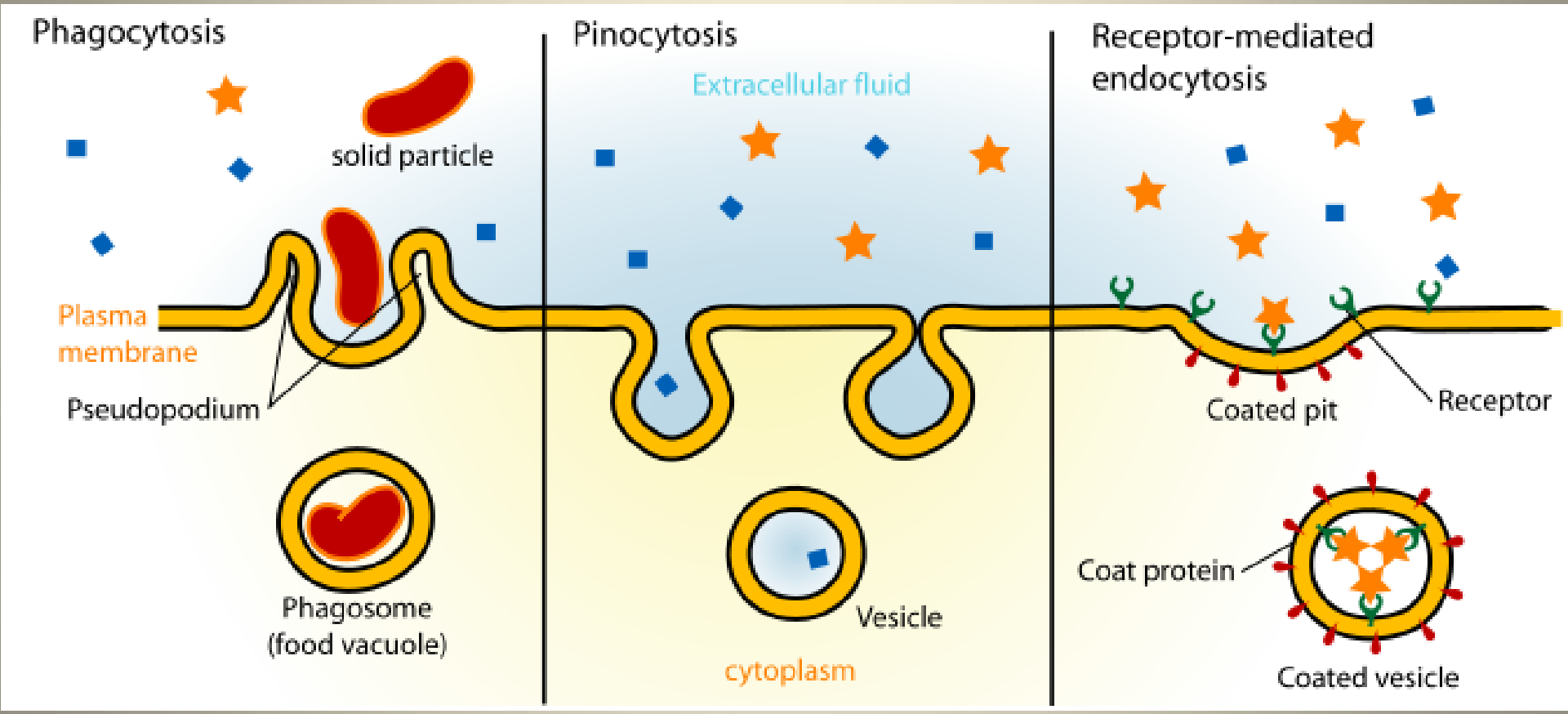
# Bulk Membrane Transport

- Transport of molecules:
  - in large quantity
  - too large or too polar to pass through the membrane
- Involves the folding of the cell membrane to form a vesicle

# Types of Bulk Membrane Transport

1. Endocytosis – entry into the cell
   - Phagocytosis
   - Pinocytosis
   - Receptor-mediated endocytosis
2. Exocytosis – exiting the cell

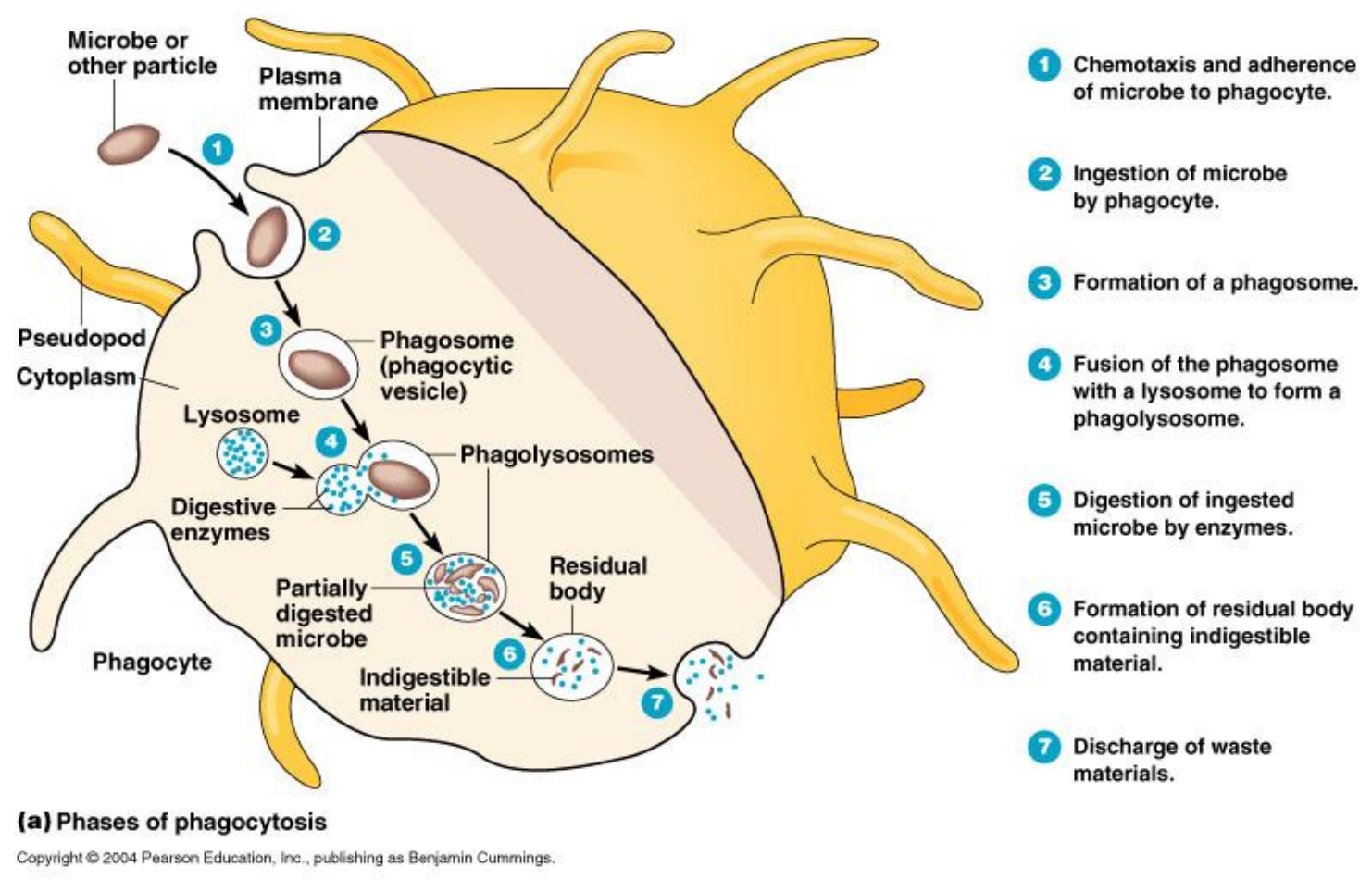
# 1. Endocytosis



# Phagocytosis

- “Cellular eating”
- A process by which living cells ingest other cells or large particles
- Found in simpler forms of life for feeding (e.g. amoebas)
- Used in higher order organisms as a defense mechanism against invasion by foreign particles
  - **Phagocyte**: a white blood cell specialized for protecting the body by ingesting foreign substances

# Phagocytosis

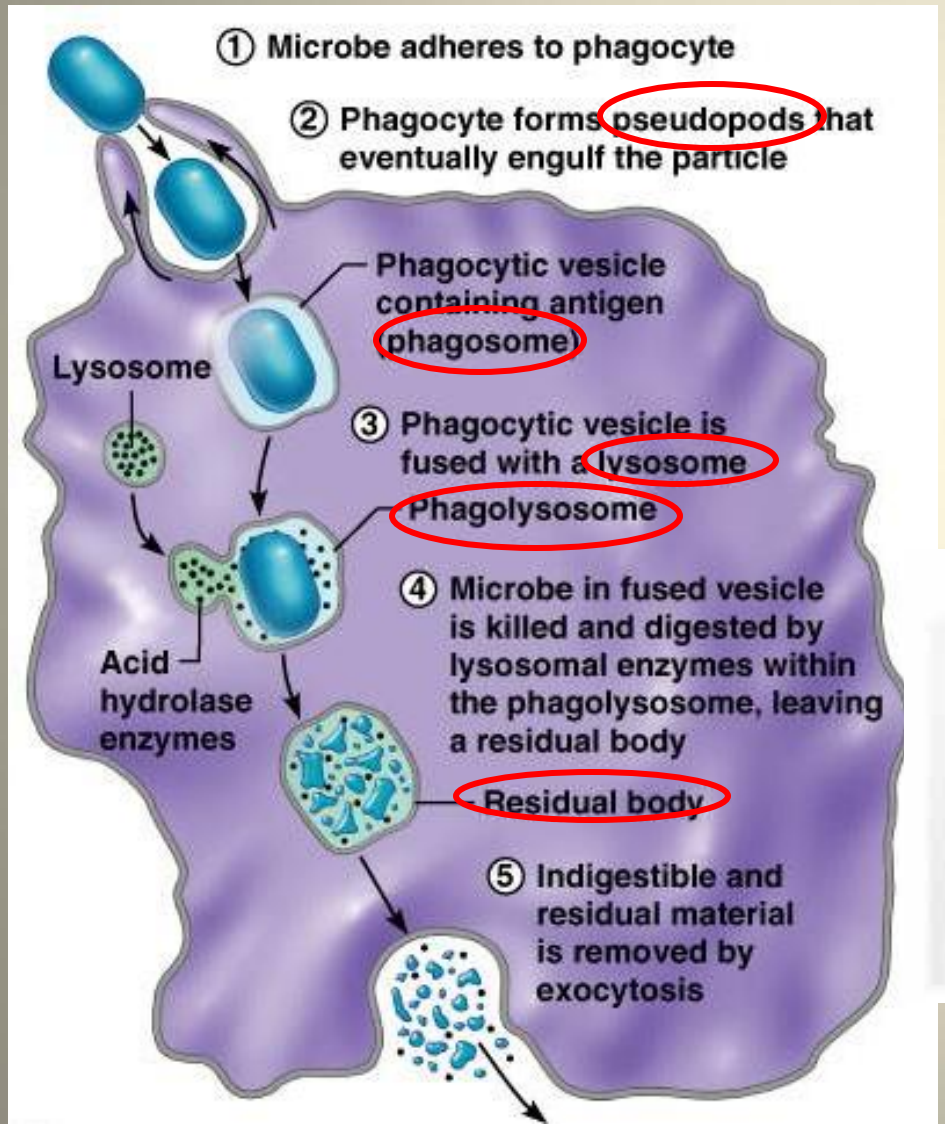


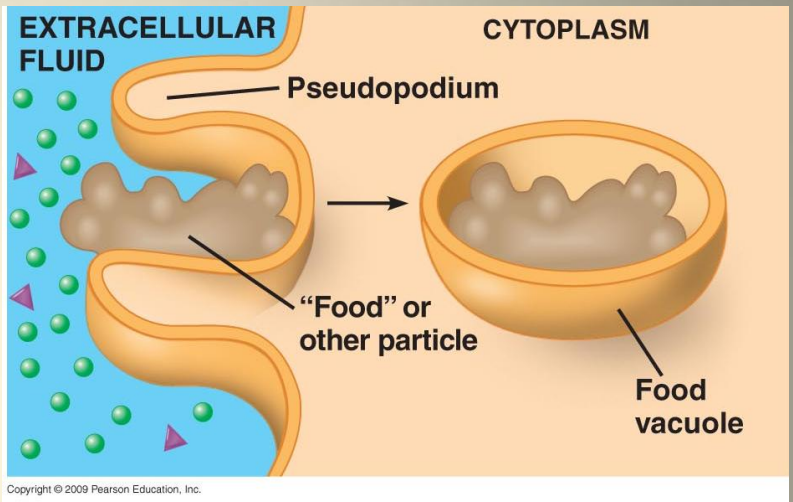

**(a)** Phases of phagocytosis

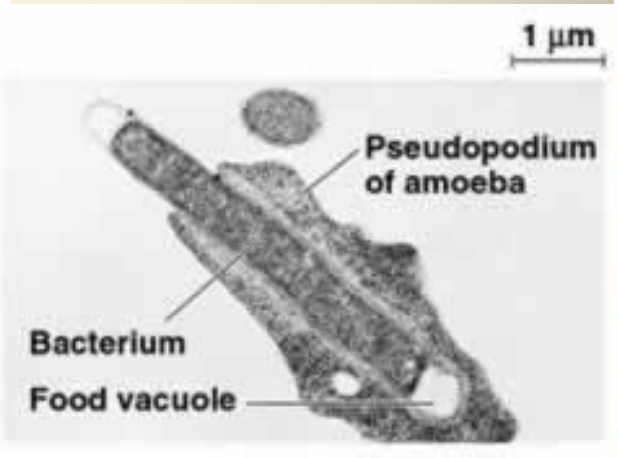
# Mechanisms of Phagocytosis

- Cell engulfs a particle by wrapping a **pseudopodia** (extension) around it
- Enclosed in a large enough sac to be classified as a **vacuole** called a **phagosome**
- Phagosome fuses with a **lysosome** forming a **phagolysosome**
- Hydrolytic enzymes in the lysosome digest the particle
- **Residual body** contains indigestible material which is eventually discharged by exocytosis

# Phagocytosis




# Lysosome

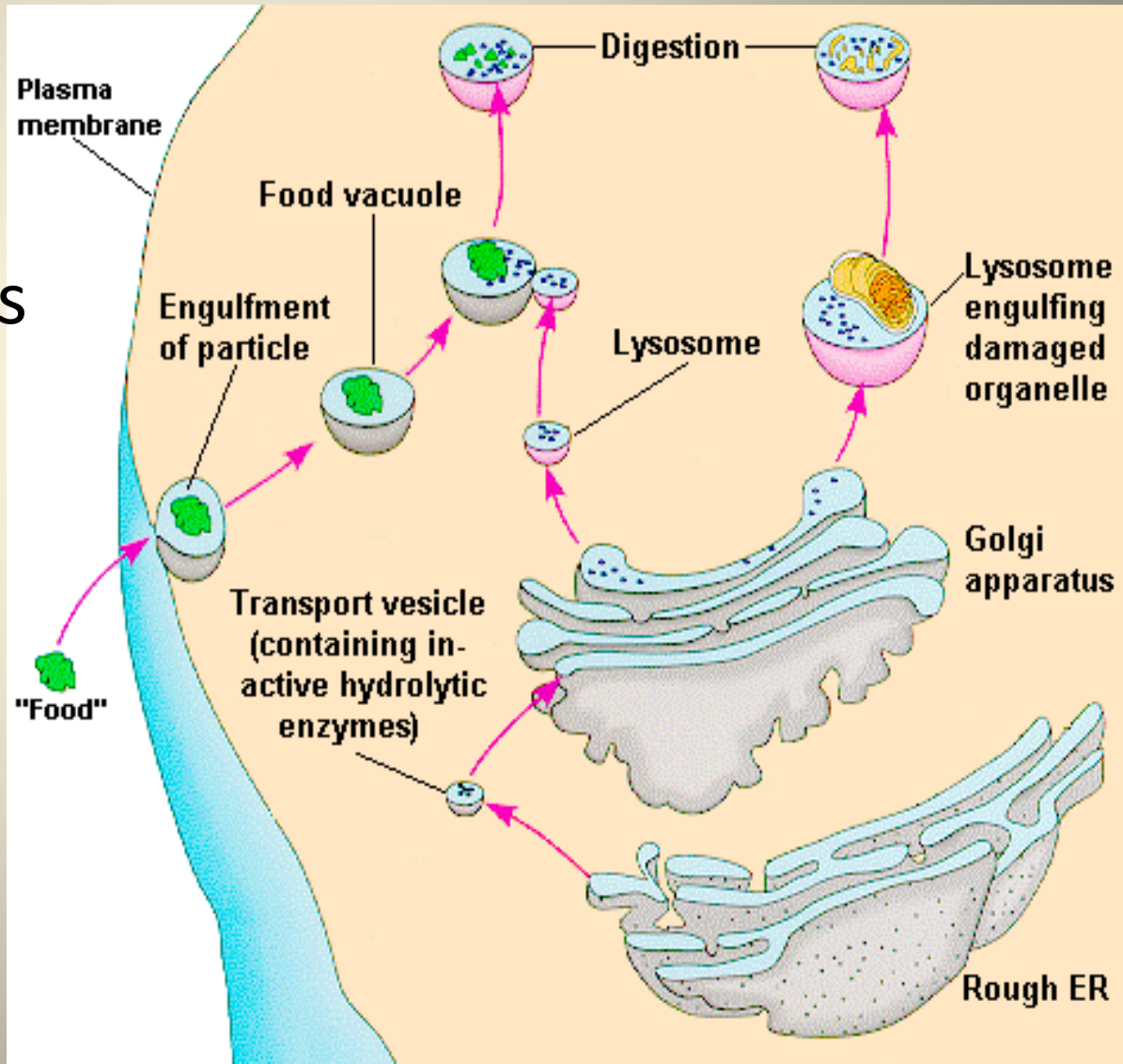
- Membrane bound sac of hydrolytic enzymes
- Enzymes work best at pH 5
- Maintains acidic pH by pumping H+ into the lumen

- Question: Why would a cell want lysosomal enzymes to function at a pH that is different from the cytosol (neutral pH)?

http://www.daviddarling.info/images/lysosome.gif

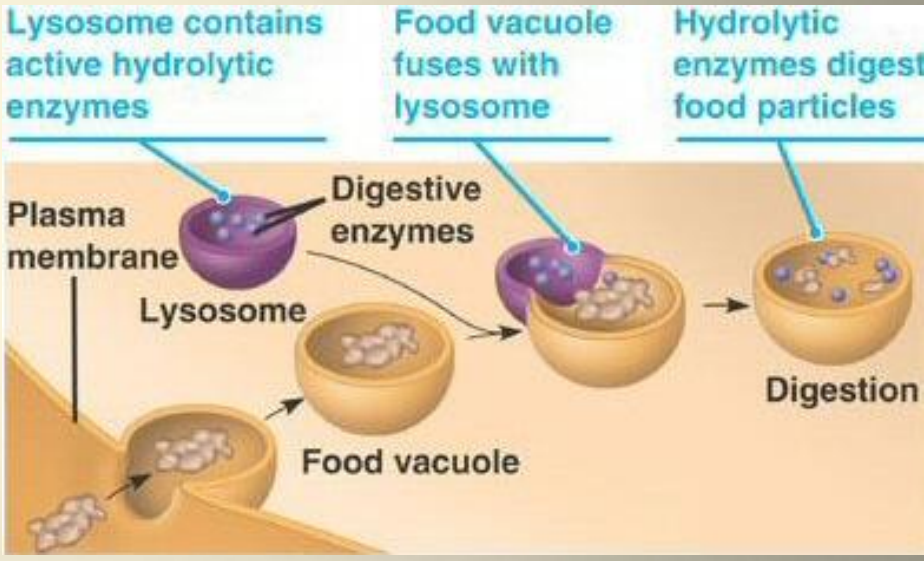
# Lysosome Functions

- In phagocytosis
- Autophagy



# Lysosome Function in Phagocytosis

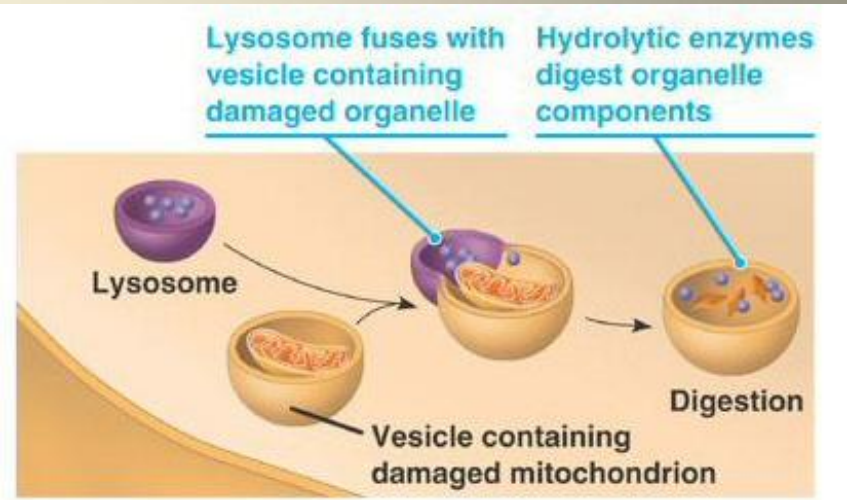
- fuse with food vacuole to digest food
  - acts similarly to stomach in animals
- fuses with phagosome to breakdown microorganisms
  - e.g. WBC digesting bacteria




http://kvhs.nbed.nb.ca/gallant/biology/lysosome.jpg

# Lysosome Function in Autophagy

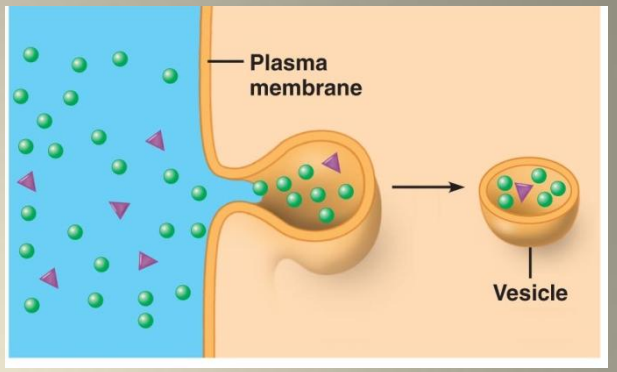
- Autophagy: lysosome recycles cell's own organic material
- Important in development of multicellular organisms
  - Tadpole to frog: destroy cells of tail
  - Human embryos: destroy webbing between fingers



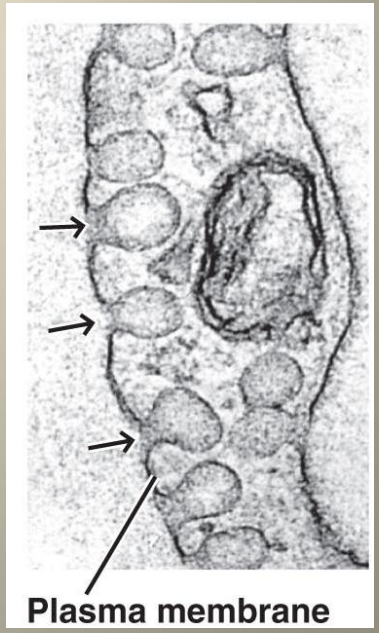
(b) Autophagy: lysosome breaking down damaged organelle

http://kvhs.nbed.nb.ca/gallant/biology/lysosome.jpg

# Pinocytosis




- “Cellular drinking”
- Ingestion of dissolved materials
- Occurs in most cell types
- Cell folds inwards (invaginates) to take in fluid containing the desired substance
- Process is unspecific in terms of what is being ingested

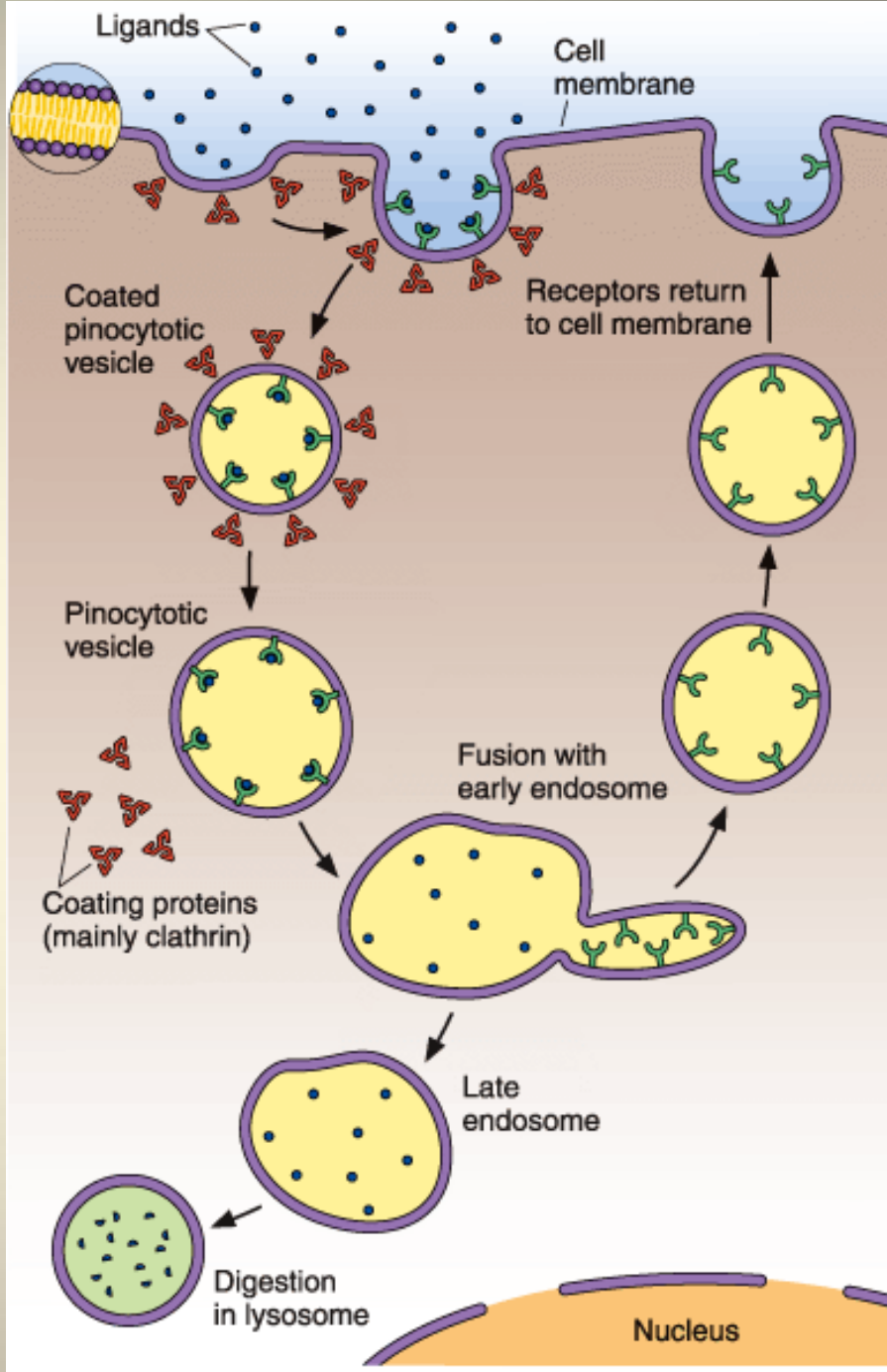


# Receptor-Mediated Endocytosis

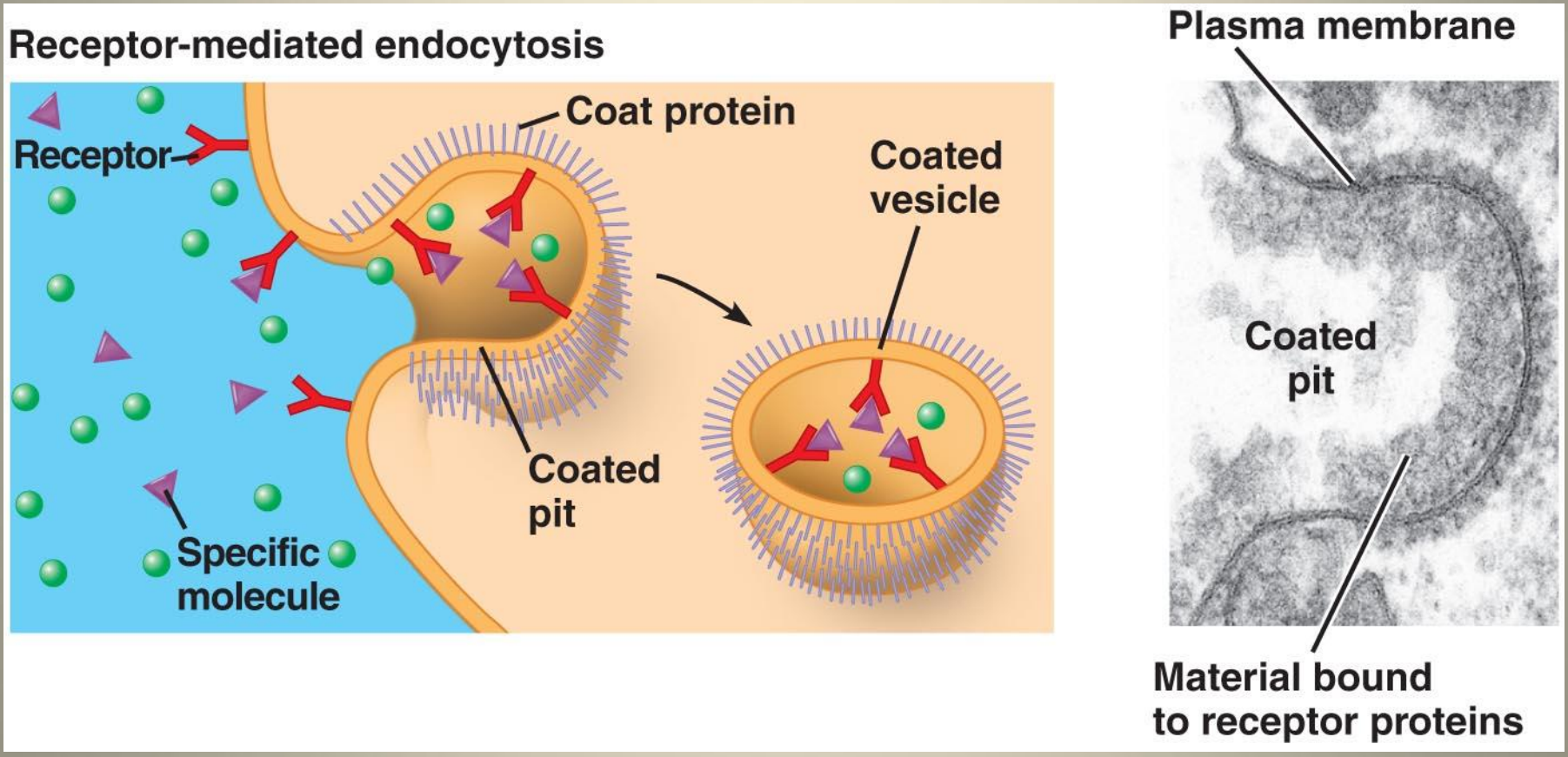
- Intake of molecules that bind specifically to a receptor on the surface of the cell
- **Ligand**: a molecule that binds to a receptor
- Receptor proteins are usually clustered in regions of the membrane called **coated pits** which contain **coat proteins** that help form vesicles for endocytosis

# Mechanism of receptor-mediated endocytosis

- Ligands bind to receptor
- Membrane pinches to form vesicle
- Ligand detaches from receptors
- Vesicle pinch into 2 parts:
  - free ligand
  - empty receptor
- Ligands fuse with lysosome
- Receptors returned to cell surface



# Receptor-Mediated Endocytosis



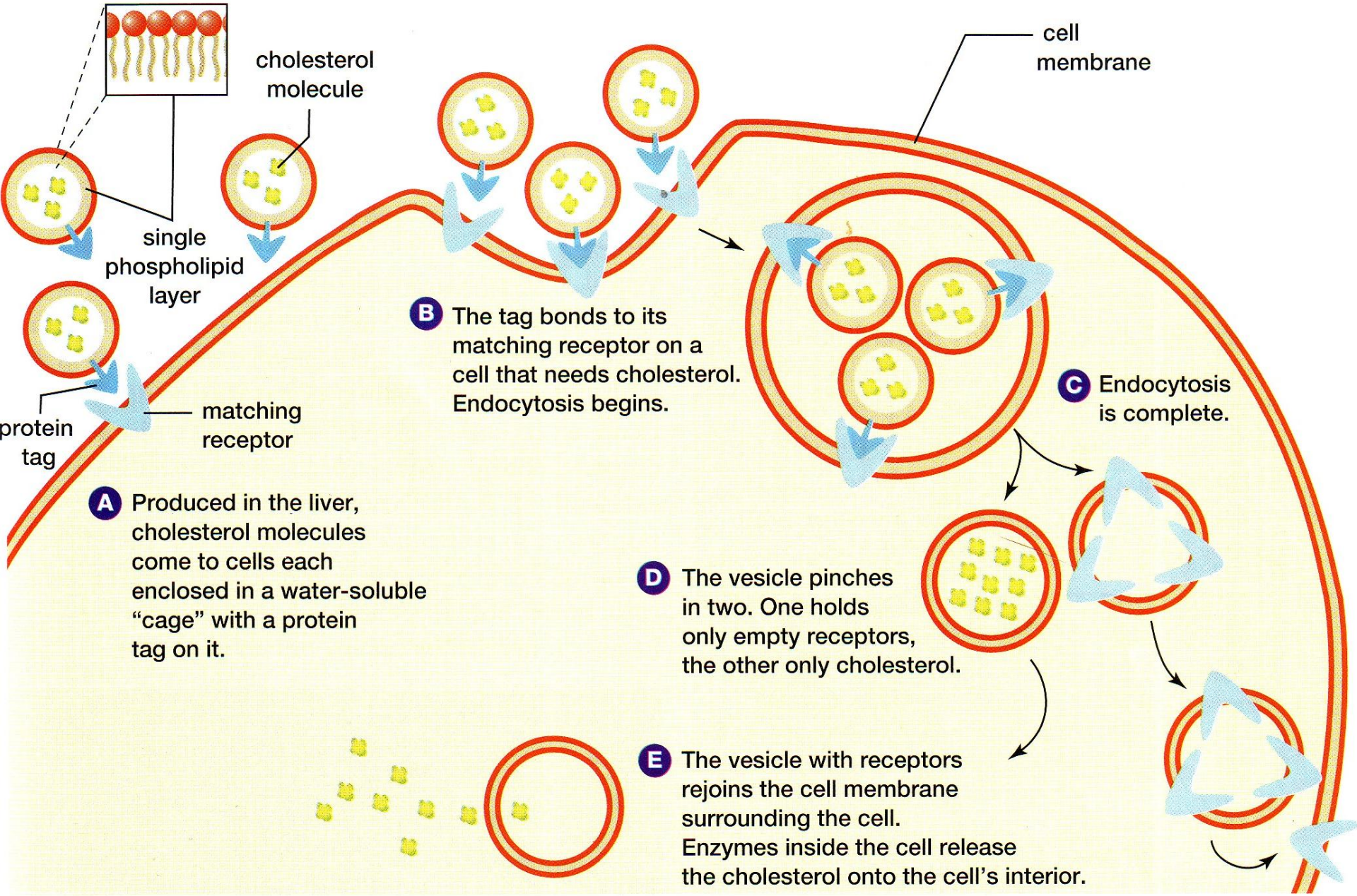
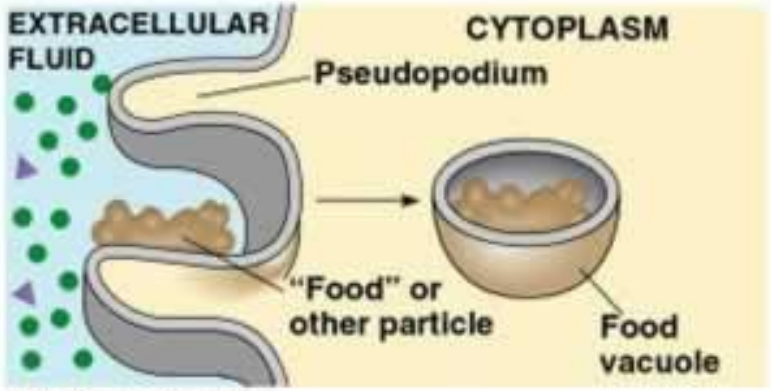
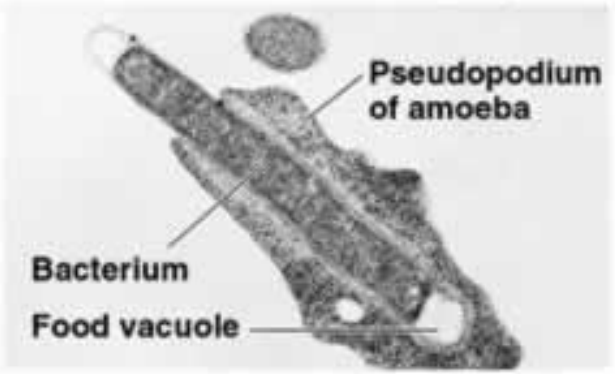
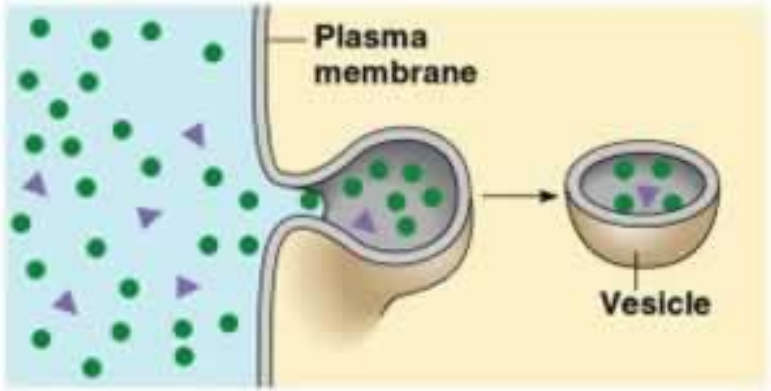



**Figure 1.41** The transport of cholesterol molecules from the extracellular fluid into the cell interior is an example of receptor-mediated endocytosis.

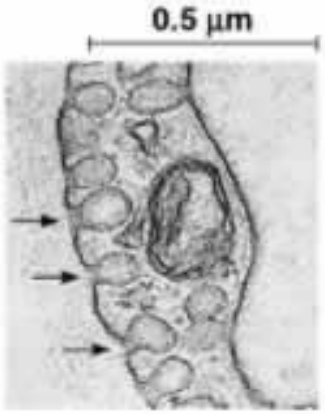


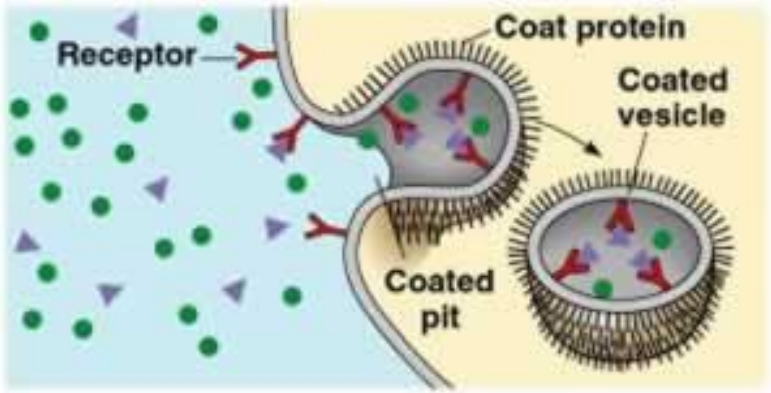

(a) Phagocytosis



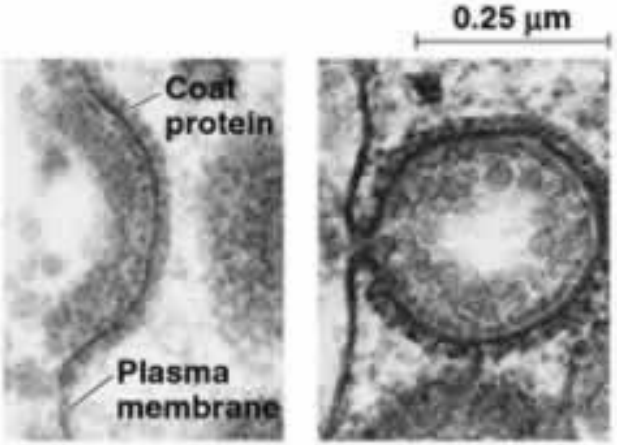




(b) Pinocytosis




(c) Receptor-mediated endocytosis



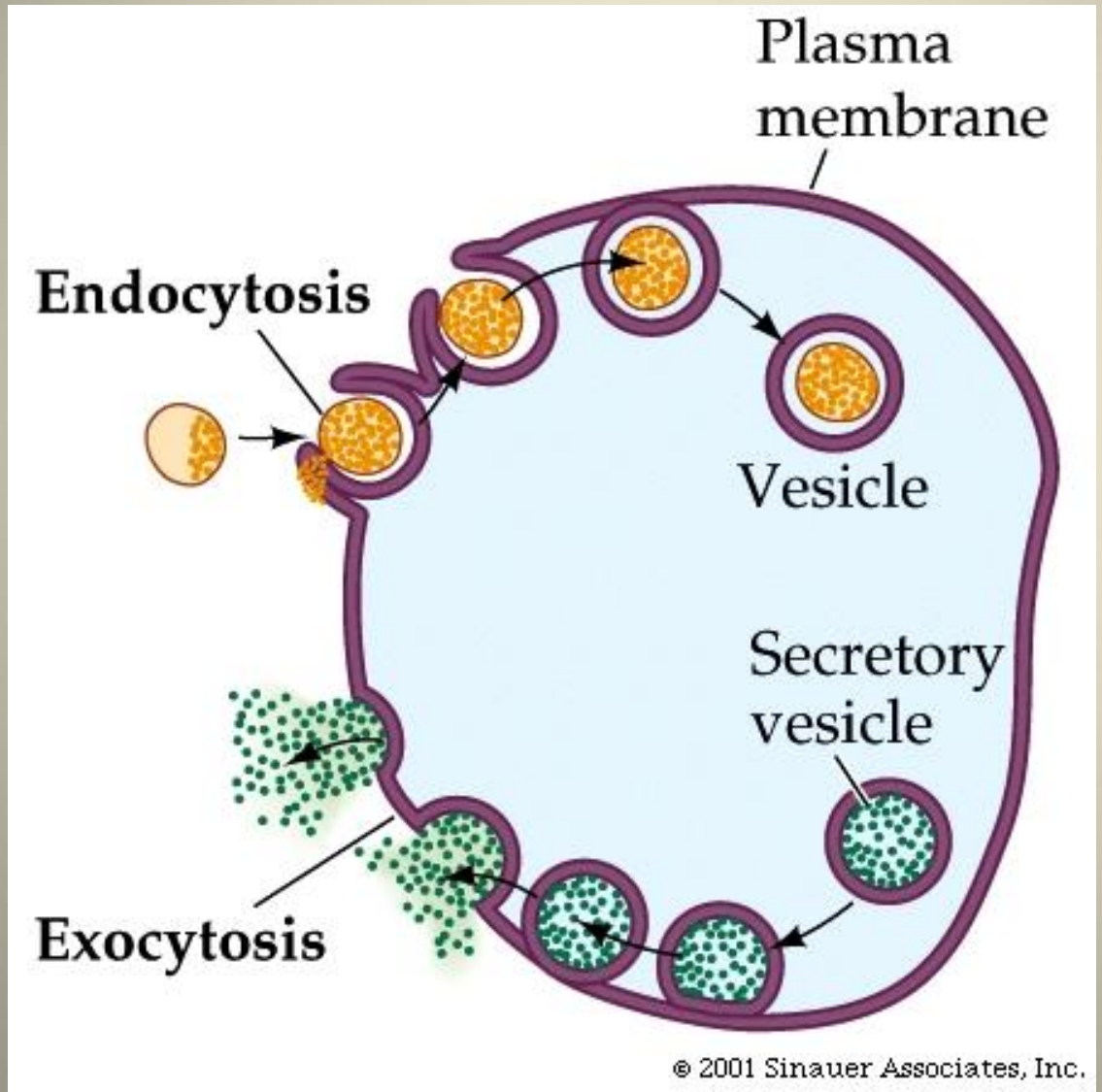
# 2. Exocytosis

- Movement of materials from the cell to the cell surface within membrane bound vesicles
- Vesicles formed off Golgi body or from endocytosis
- Reverse of endocytosis

# Exocytosis function

- Secretion: release of waste, toxins, signaling molecules
- Recycling of membrane proteins (e.g. receptors)
- Restoring the cell membrane:
  - To keep the total surface area of the membrane constant, exocytosis must balance out endocytosis

# Endocytosis & Exocytosis



# Bulk Membrane Transport: Big Idea

- How does bulk membrane transport differ from all the other methods of transport studied so far?
- In other words, why is it in its own category?

# HW Question

1. An integral protein changes conformation to transport substances from one side of the membrane to the other. It is also able to move 2 different molecules in the same direction. Classify this type of transport and the protein involved. [3 marks]
2. Provide a real life everyday example of when you have encountered a hypotonic or hypertonic environment. Describe what affect it had and the reason for the observed phenomena. [2 marks]
3. How does the function of phagocytosis differ in the human body compared to single cellular organisms? Provide an example for each. [4 marks]