MSc I Sem – Life Sciences

Course – Cell Biology

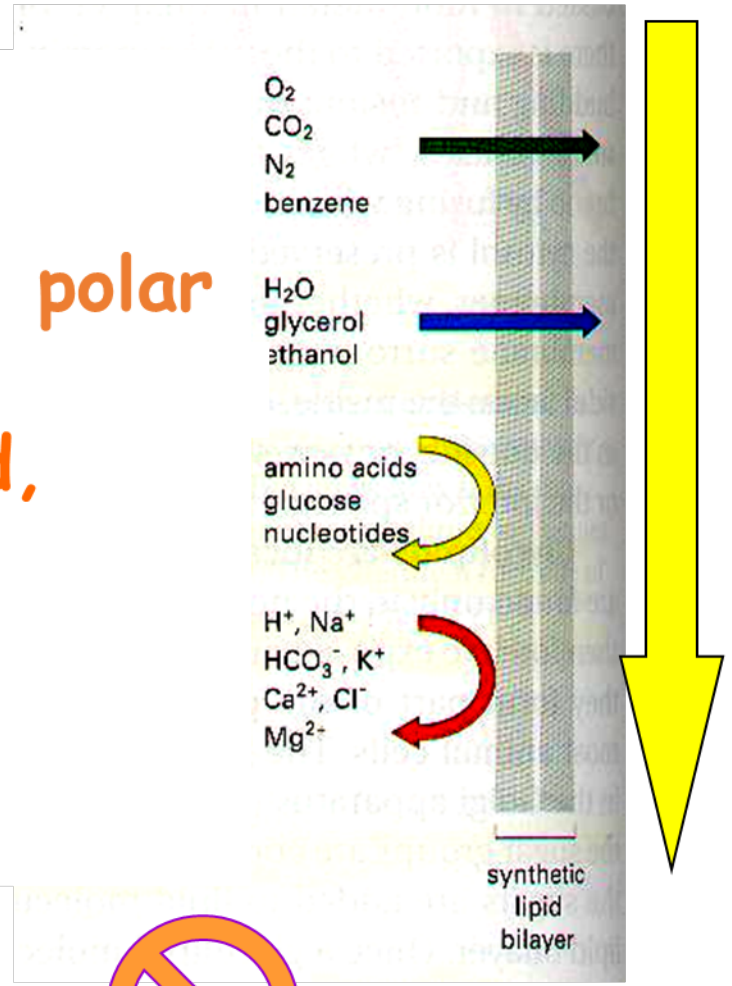
Membrane Transport

1. Permeability
2. Diffusion
3. Role of transport proteins - facilitated
    - Channel proteins
    - Carrier proteins

4. Active vs passive transport

Lipid bilayers are *selectively* permeable

- Small, nonpolar
- Small uncharged, polar
- Larger uncharged, polar molecules
- Ions



Decreasing permeability

Size – polarity – ions

The Permeability of the Lipid Bilayer

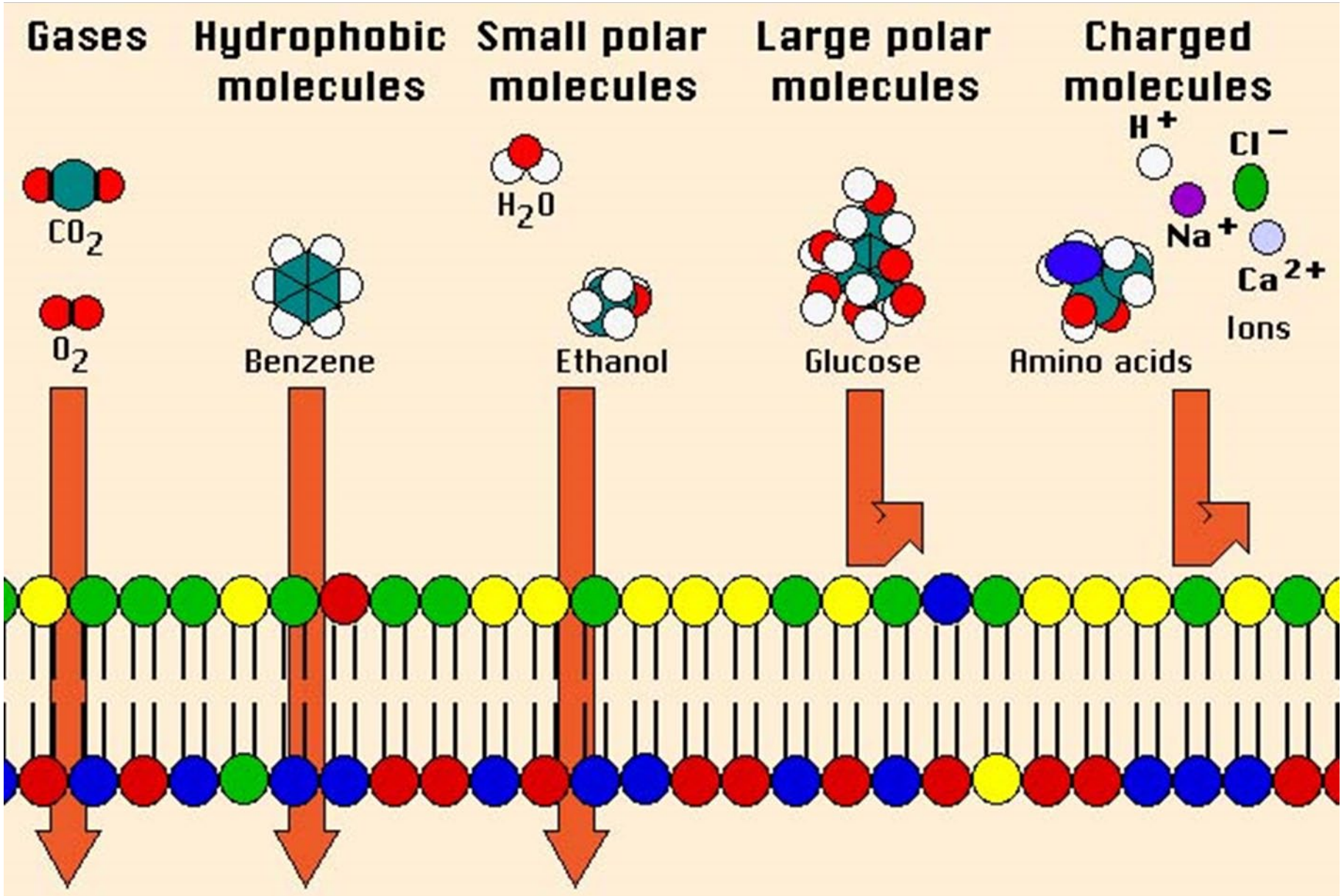
- **Hydrophobic molecules**
  - Are lipid soluble and can pass through the membrane rapidly

- **Polar molecules**
  - Do not cross membrane rapidly

- **Ions**
  - Do not cross the membrane at all

- Plasma membrane is selectively permeable
  - controls which things enter or leave the cell
- Passive transport requires no ATP
  - movement of particles is down their concentration gradient
  - filtration and simple diffusion are examples of passive transport
- Active transport requires ATP
  - transports particles against their concentration gradient
  - carrier mediated (facilitated diffusion and active transport) and vesicular transport are examples of active transport

Permeability of the Cell Membrane

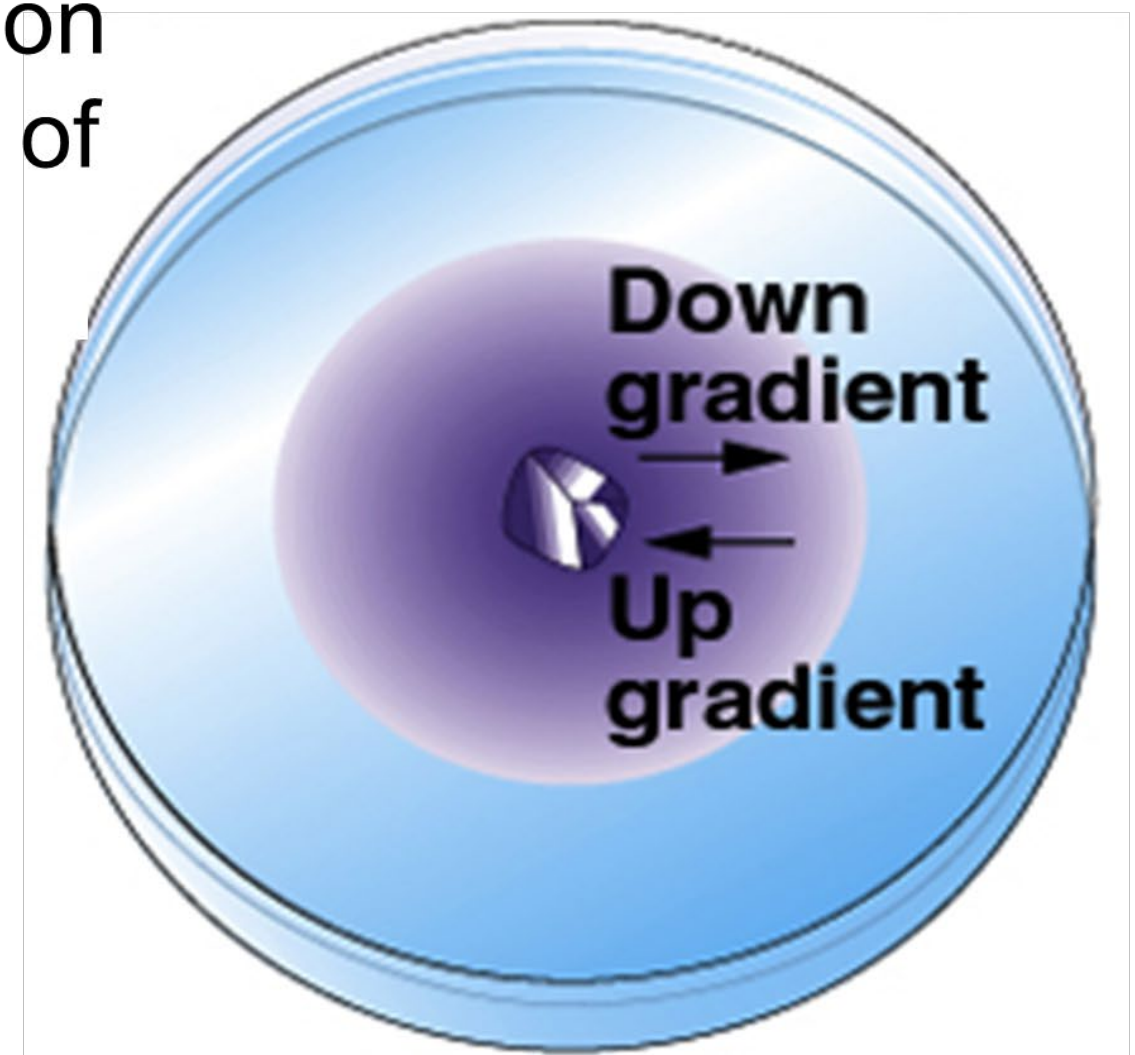


Filtration

- Movement of particles through a selectively permeable membrane by hydrostatic pressure
- Hydrostatic pressure - the force exerted on the membrane by water
- In capillaries, blood pressure forces water, salts, nutrients and solutes into tissue fluid, while larger particles like blood cells and protein are held back
  - filtration of wastes from the blood occurs in the kidneys

Simple Diffusion

- Simple diffusion is the movement of particles as a result of their constant, random motion
- Net diffusion is the movement of particles from an area of high concentration to an area of low concentration (down or with the concentration gradient)



Diffusion Rates

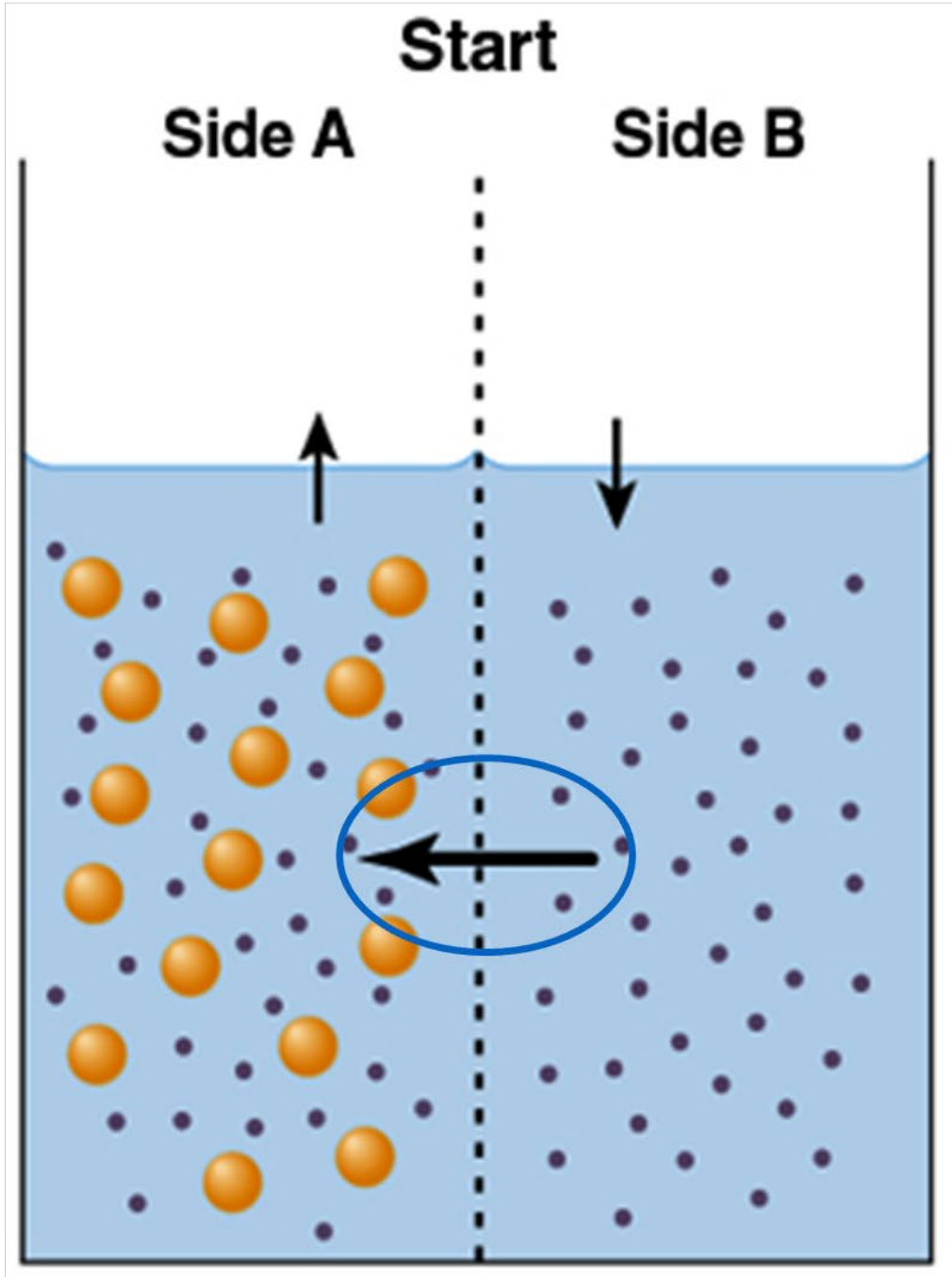
- Factors that affect rate of diffusion through a membrane
  - temperature - ↑ temp., ↑ motion of particles
  - molecular weight - larger molecules move slower
  - steepness of conc. gradient - ↑difference, ↑ rate
  - membrane surface area - ↑ area, ↑ rate
  - membrane permeability - ↑ permeability, ↑ rate
- Correct diffusion rates are very important to cell survival

Osmosis

- Diffusion of **water** through a selectively permeable membrane

from an area of **more water** (side B = less dissolved solute)

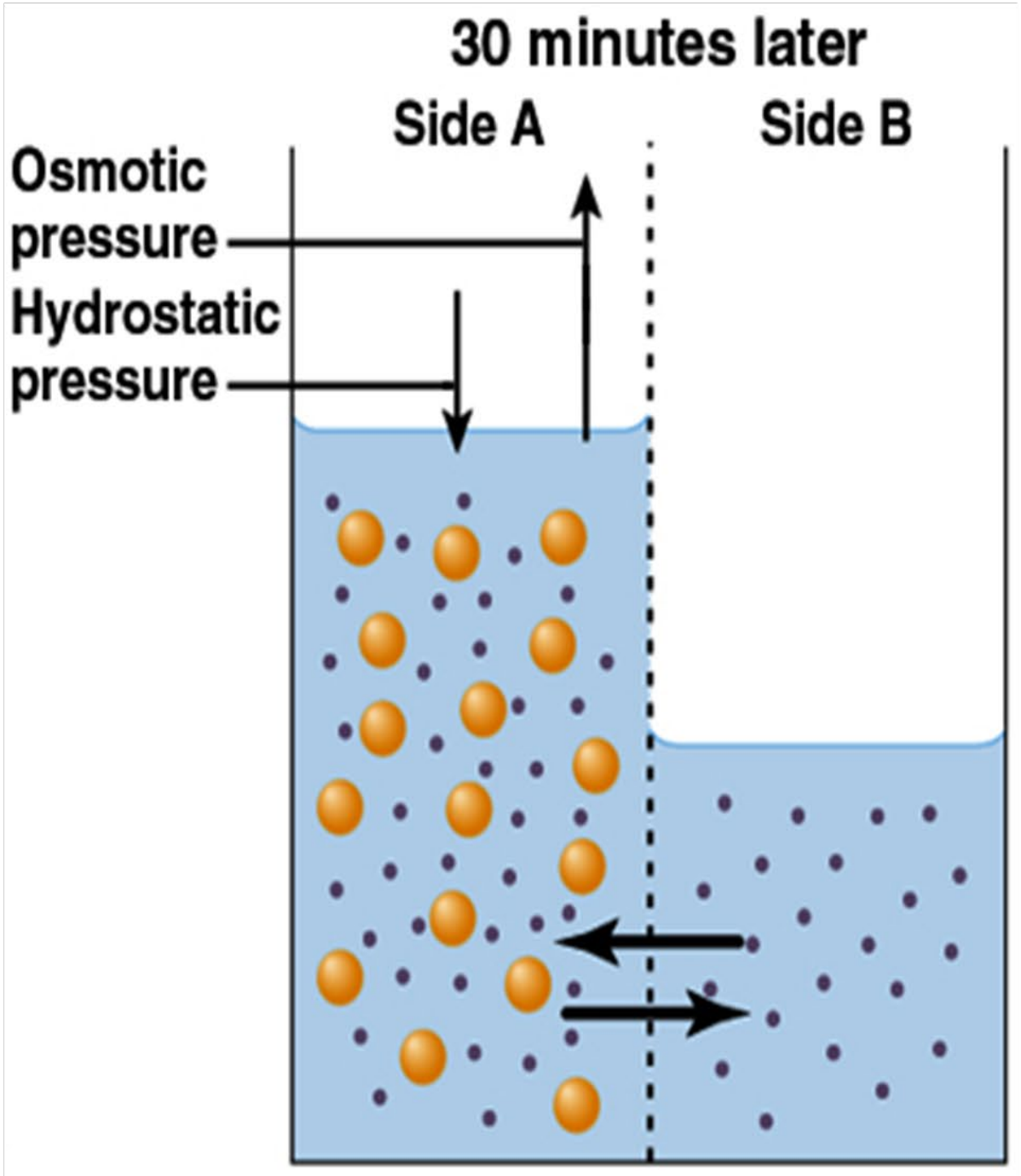
to an area of **less water** (side A = more dissolved solute)



Osmotic Pressure

- Amount of hydrostatic pressure required to stop osmosis = osmotic pressure

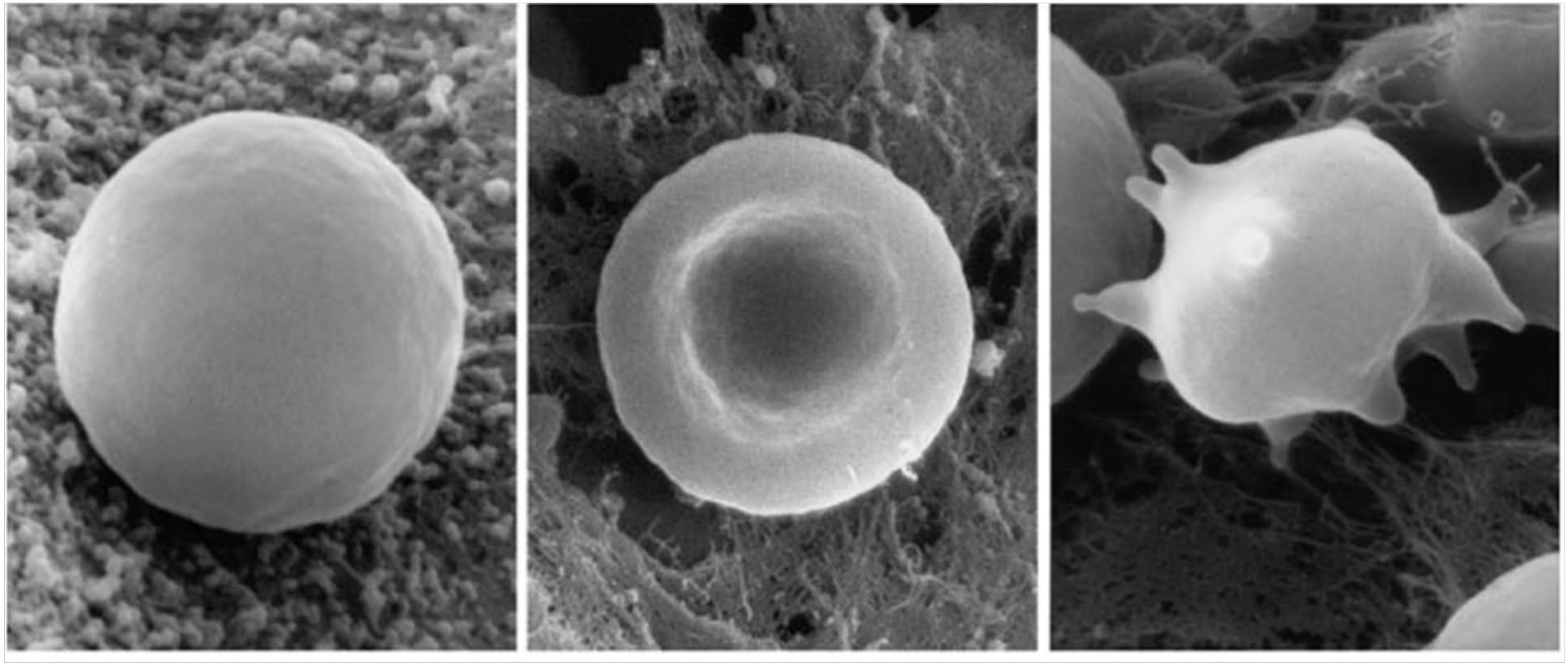
- Osmosis slows to a stop due to filtration of water back across membrane due to ↑ hydrostatic pressure



Tonicity

- Tonicity - ability of a solution to affect fluid volume and pressure within a cell
  - depends on concentration and permeability of solute
- Hypotonic solution
  - has low concentration of nonpermeating solutes (high water concentration)
  - cells in this solution would absorb water, swell and may burst (lyse)
- Hypertonic solution
  - has high concentration of nonpermeating solutes (low water concentration)
  - cells in this solution would lose water +shrivel (crenate)
- Isotonic solution = normal saline

Effects of Tonicity on RBCs



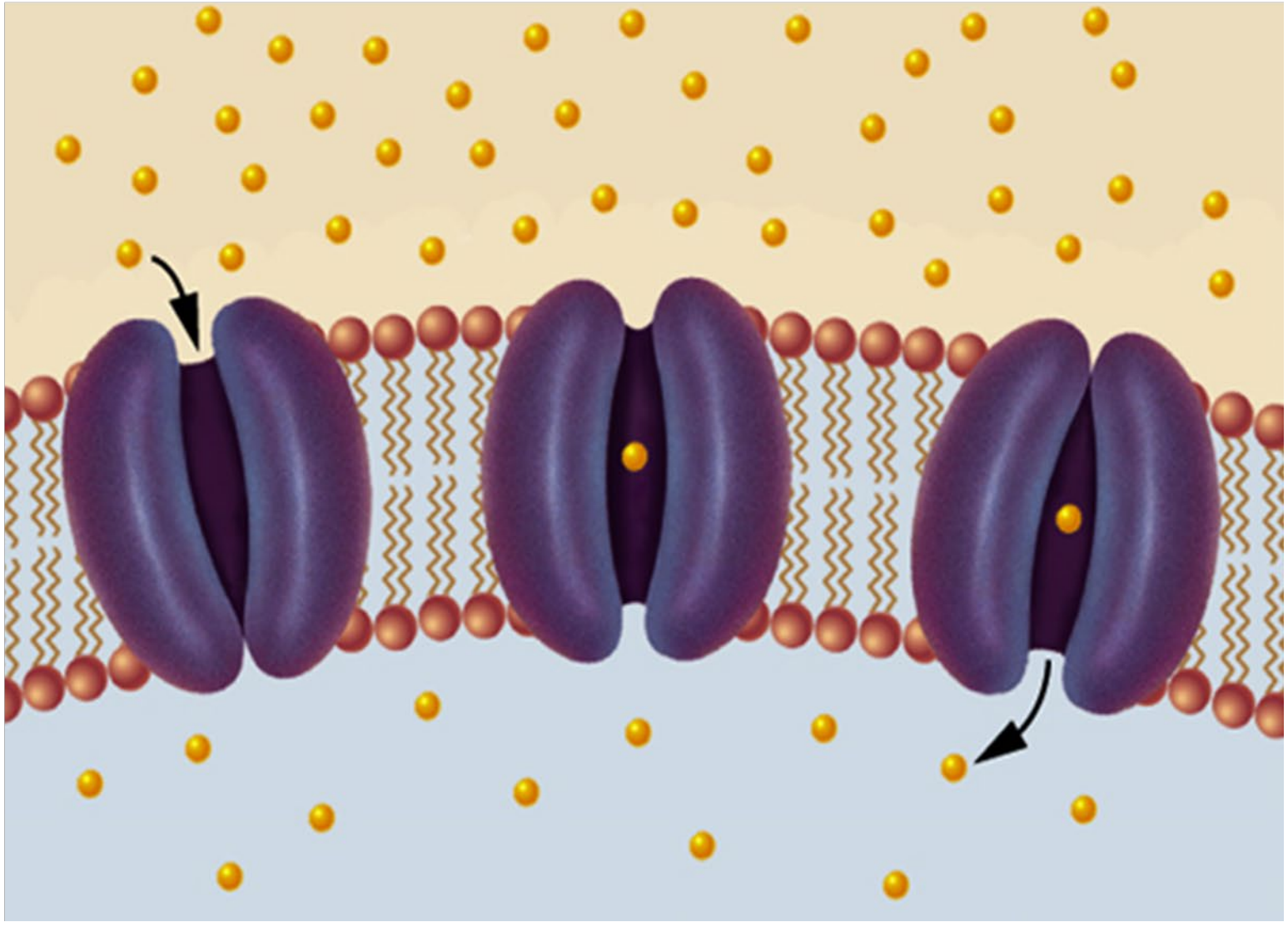
Hypotonic, isotonic and hypertonic solutions affect the fluid volume of a red blood cell. Notice the crenated and swollen cells.

Carrier Mediated Transport

- Proteins carry solutes across cell membrane
- Specificity
  - solute binds to a receptor site on carrier protein that is specific for that solute
  - differs from membrane enzymes because solutes are unchanged
- Types of carrier mediated transport
  - **facilitated diffusion and active transport**

Facilitated Diffusion

- Carrier-mediated, passive transport of solute across membrane **down** its concentration gradient
- Solute binds to carrier, carrier changes shape and releases solute on other side of membrane.
- No energy needed.

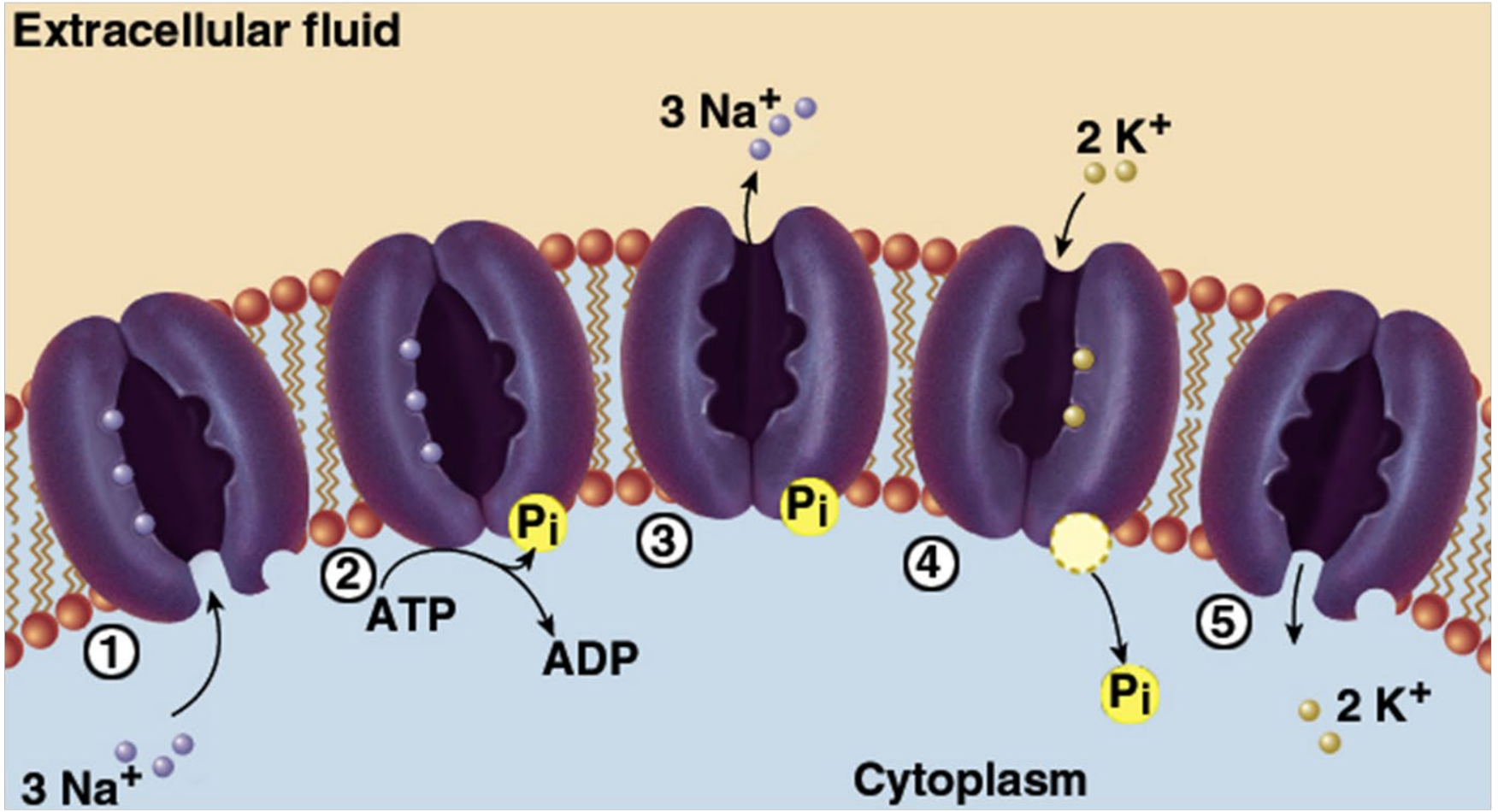


Active Transport

- Carrier-mediated, active transport of solute across membrane **against** its concentration gradient. Energy required.
- Solute binds to carrier, ATP phosphorylates carrier and carrier changes conformation. Carrier releases solute on other side of membrane
- Prominent example is the sodium-potassium pump, movement of calcium out of cell or movement of amino acids into cell.

Sodium-Potassium Pump

Cytoplasmic Na^+ bind to carrier, carrier hydrolyzes ATP and changes conformation, releases 3 Na^+ in ECF, binds 2 K^+, resumes conformation and releases K^+ inside the cell.



Na+ and K+ constantly leak through the membrane requiring action of Na+-K+ pump.

Functions of Sodium-Potassium Pump

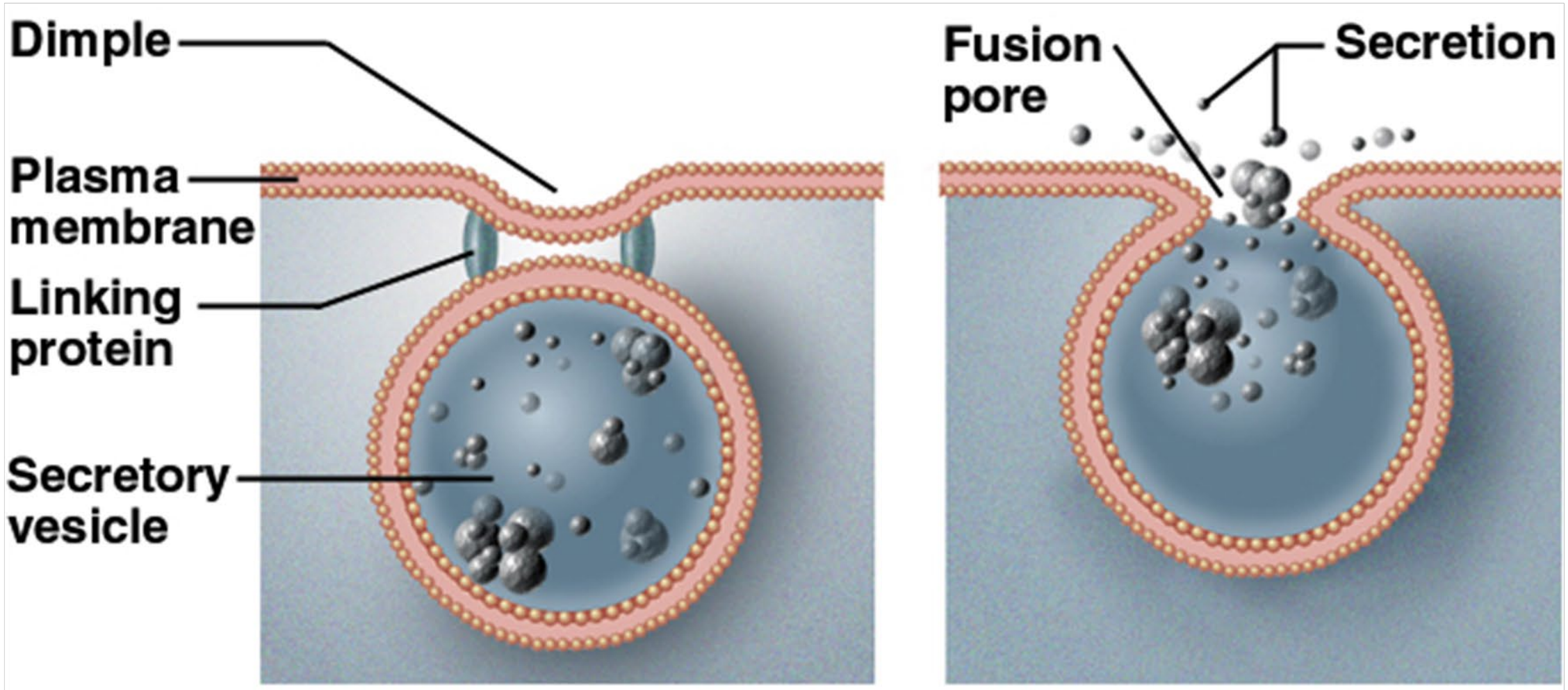
- Regulation of cell volume
  - cell anions attract cations causing osmosis
  - Cell swelling stimulates the Na^+- K^+ pump to ↓ ion concentration, ↓ osmolarity and cell swelling
- Heat production (thyroid hormone increase number of pumps that produce heat as a by-product)
- Maintenance of a membrane potential in all cells
  - Na^+- K^+ pump keeps inside of membrane negative, outside of membrane positive
- Secondary active transport
  - made possible by steep concentration gradient of Na+ and K+ across the cell membrane
  - symporters move Na+ with 2nd solute easily into cell

Vesicular Transport

- Transport of large particles or fluid droplets through membrane in bubblelike vesicles of plasma membrane, uses ATP
- **Exocytosis** – vesicular transport **out** of cell
- **Endocytosis** – vesicular transport **into** cell
  - phagocytosis – engulfing large particles by pseudopods
  - pinocytosis – taking in fluid droplets
  - receptor mediated endocytosis – taking in specific molecules

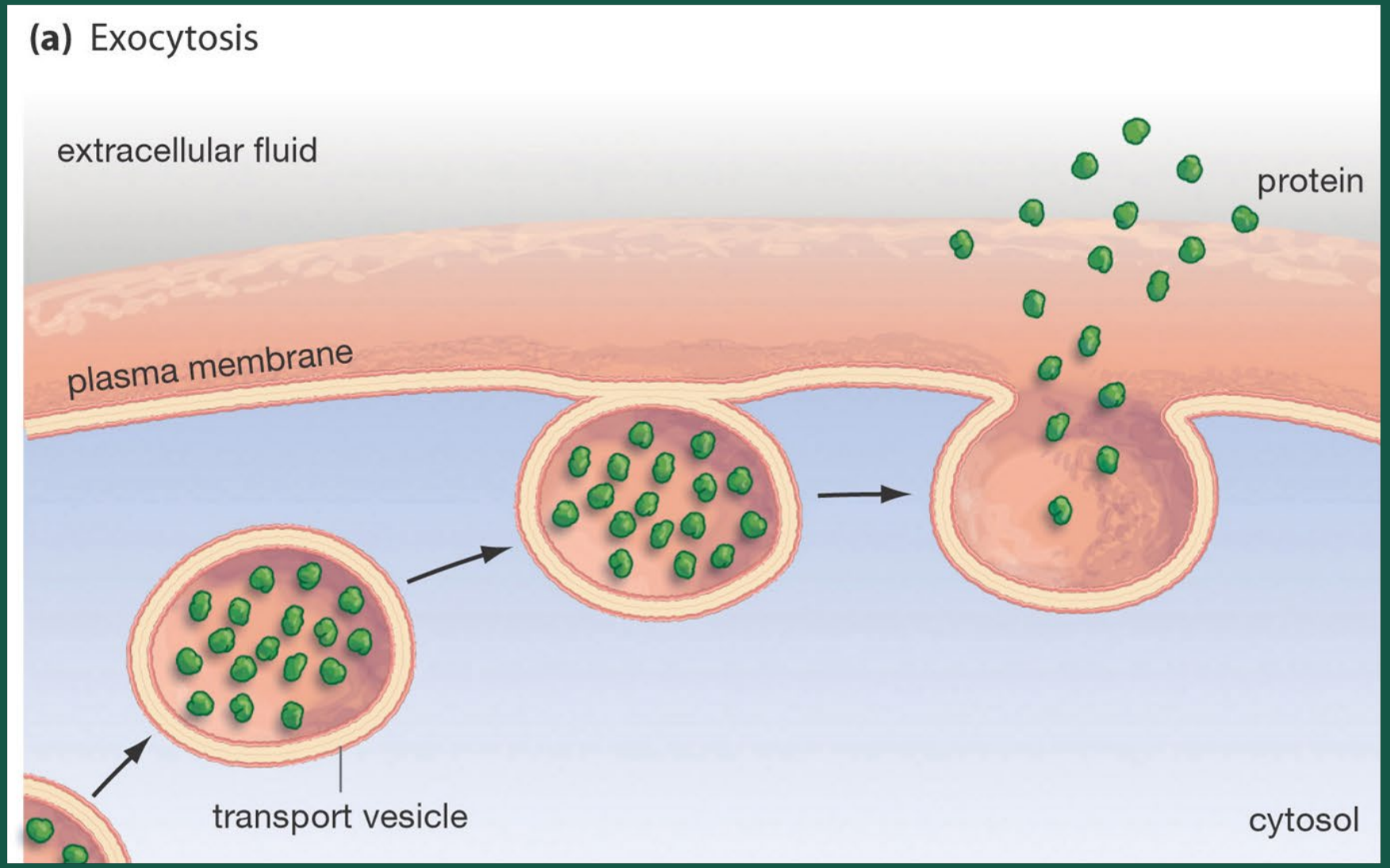
Exocytosis

- Eliminating or secreting material from cell or replacement of plasma membrane



Moving the "Big Stuff"

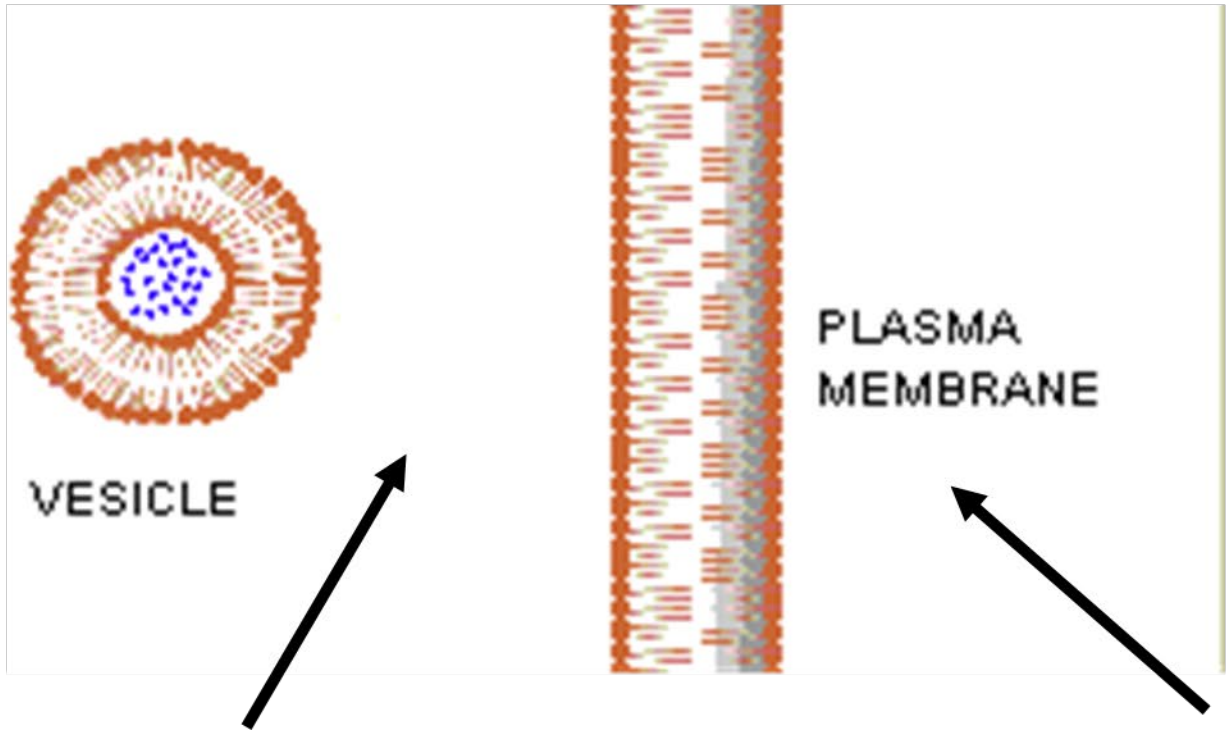
Exocytosis- moving things out.



Molecules are **moved out** of the cell by **vesicles** that **fuse** with the plasma membrane. This is how many **hormones** are secreted and how **nerve cells** communicate with one another.

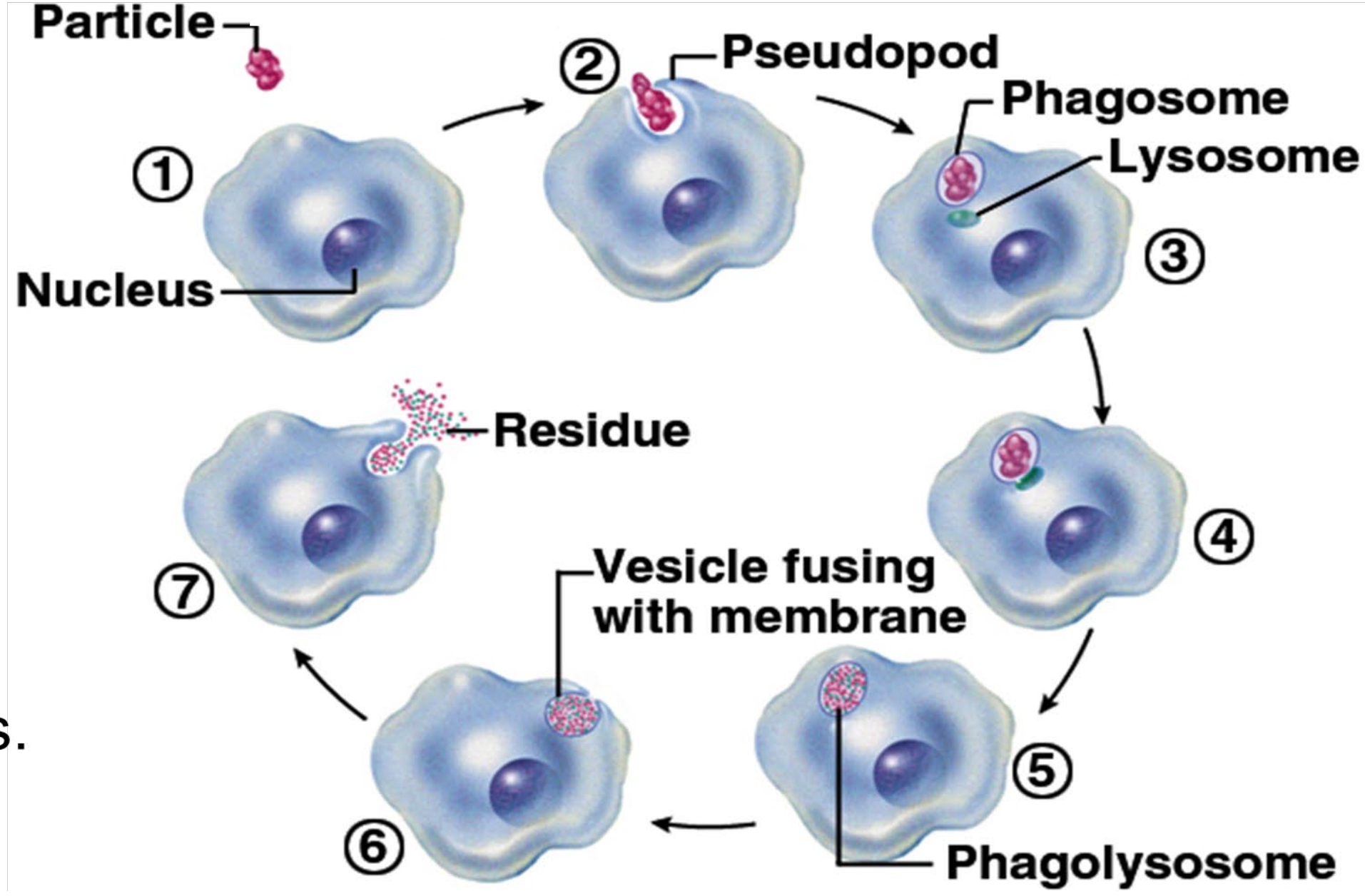
Exocytosis

The opposite of endocytosis is exocytosis. Large molecules that are manufactured in the cell are released through the cell membrane.



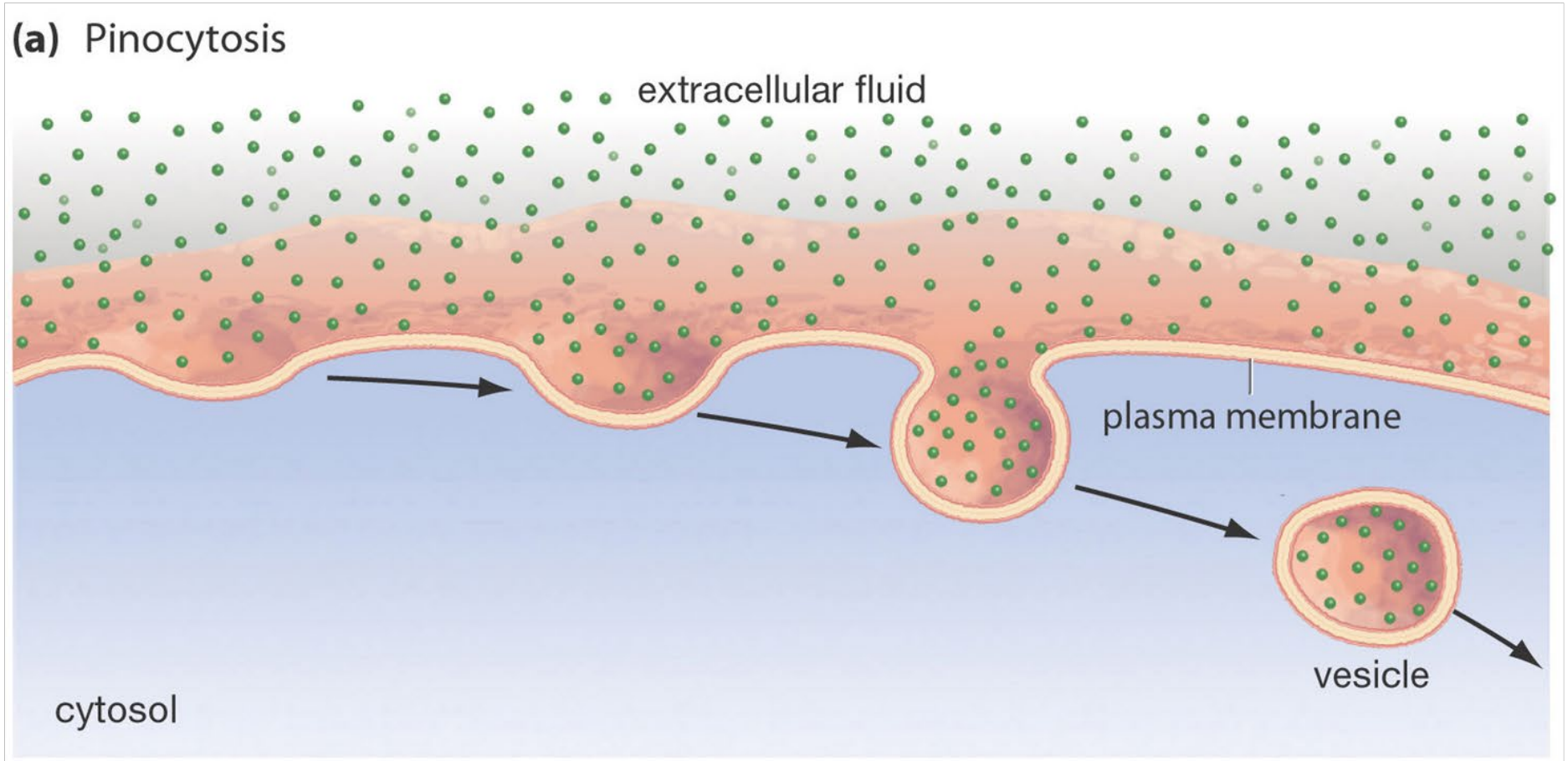
Phagocytosis

Keeps tissues free of debris and infectious microorganisms.



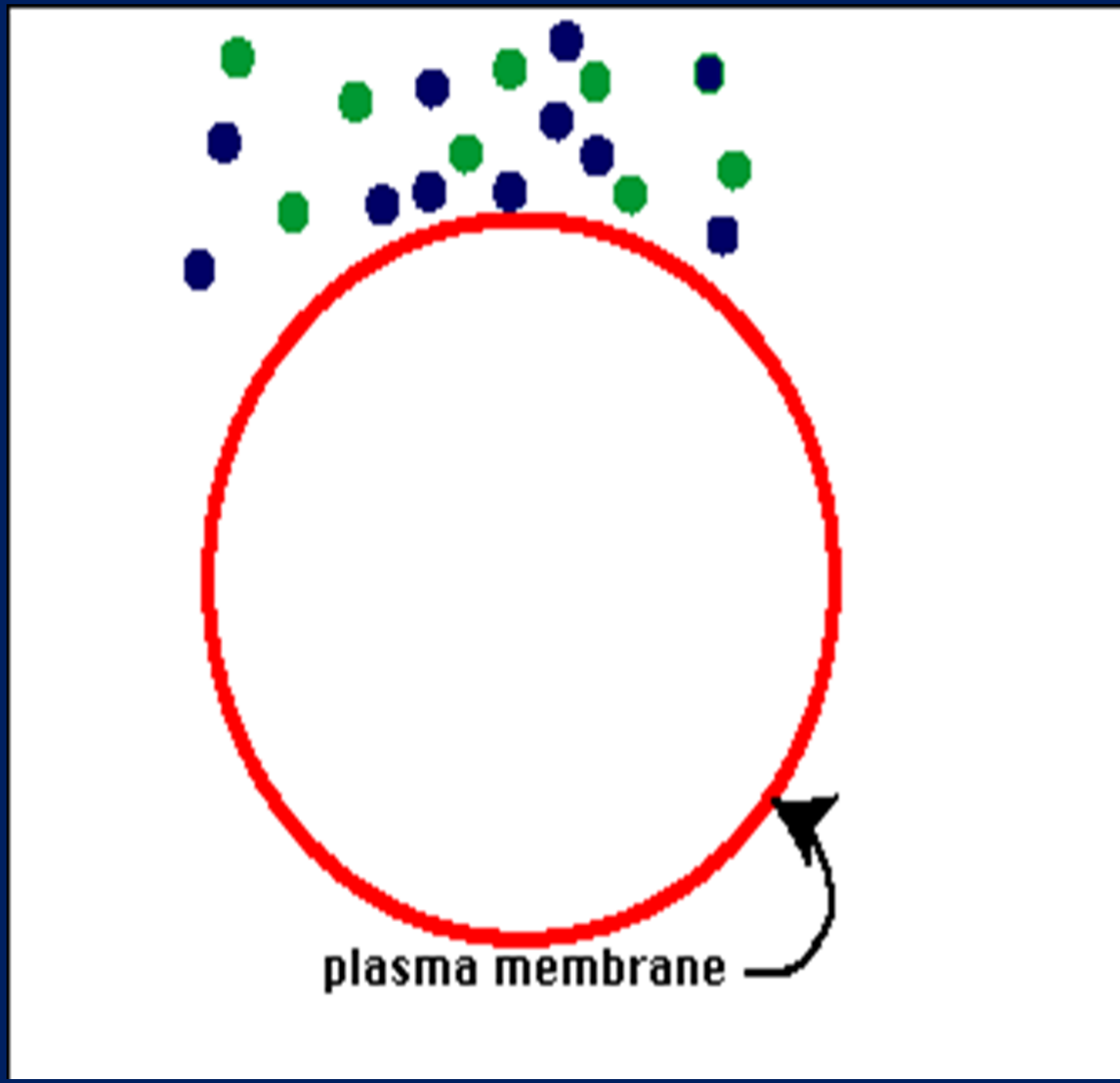
Pinocytosis or Cell-Drinking

- Cell takes in droplets of ECF
  - occurs in all human cells
- Plasma membrane dimples, then pinches off as pinocytotic vesicle in the cytoplasm

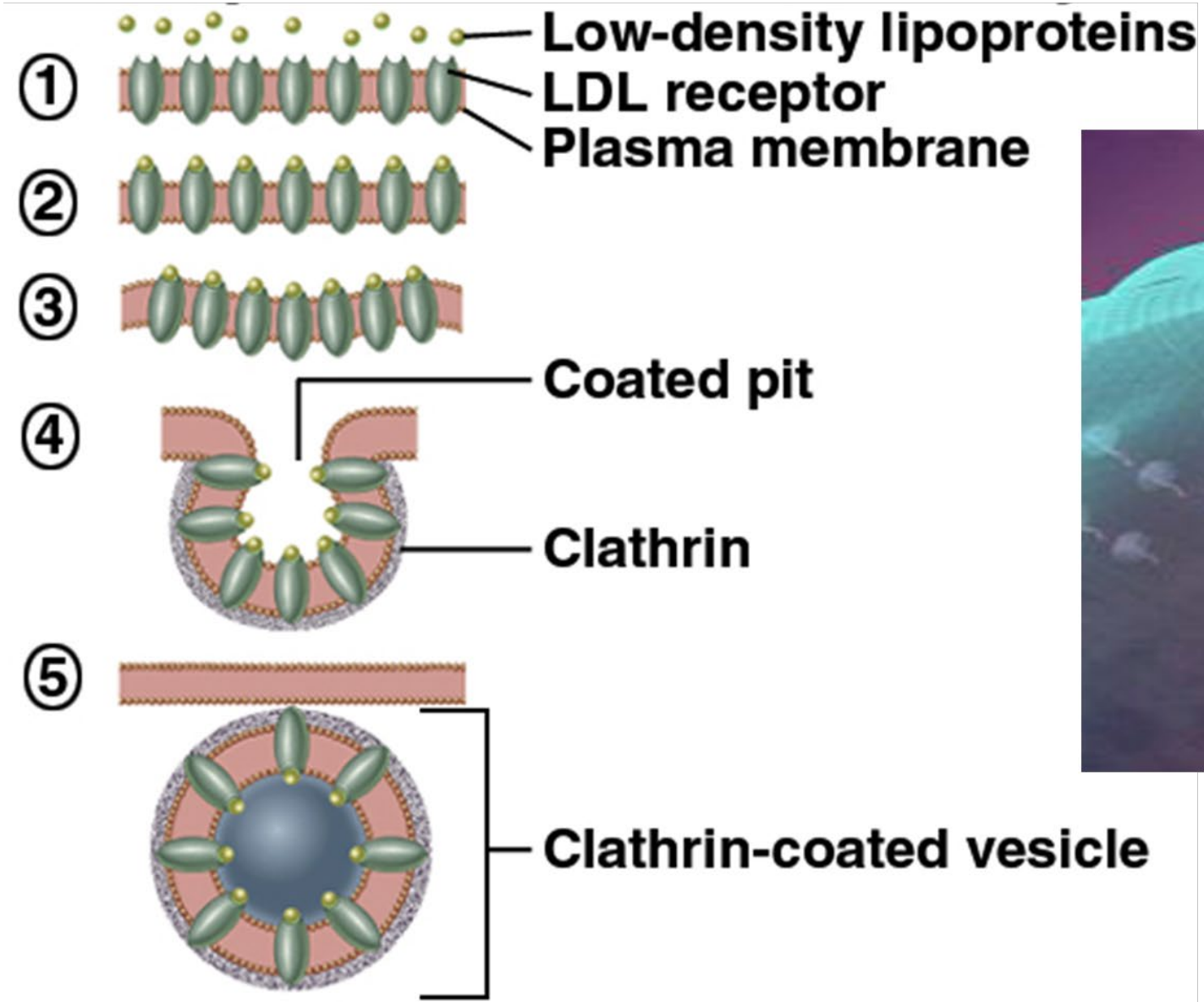


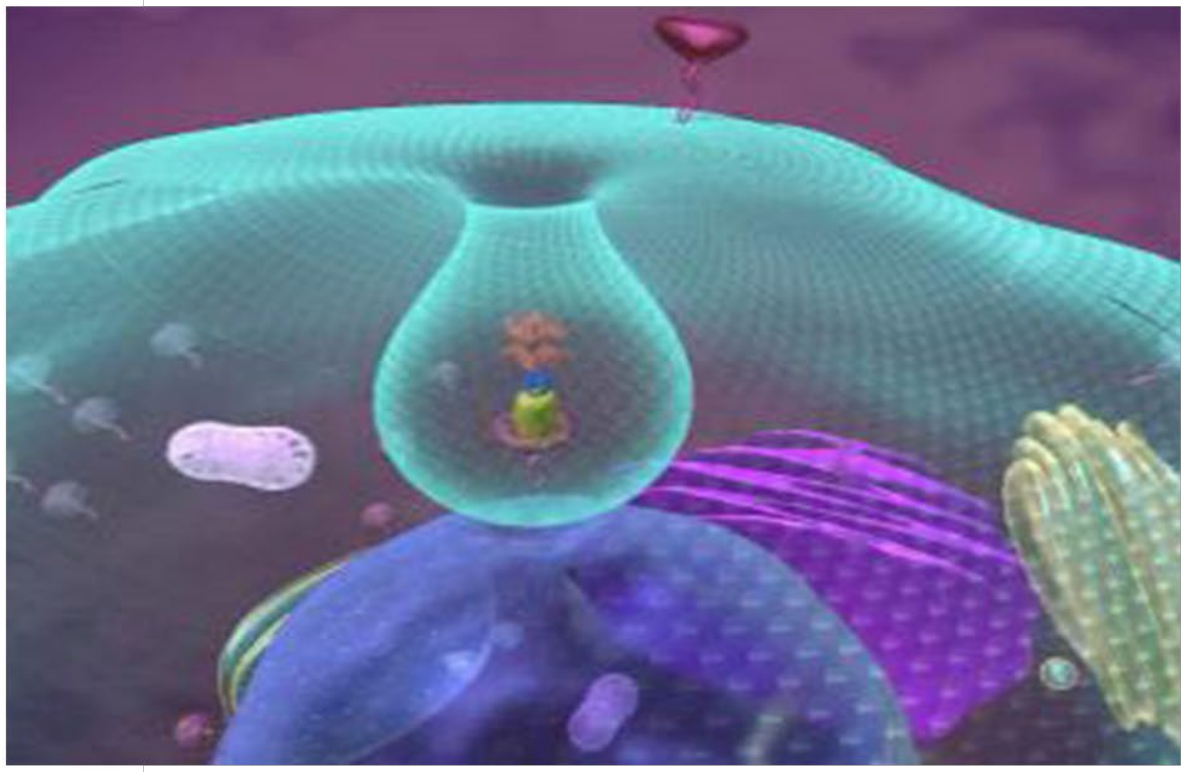
Pinocytosis

- Cell forms an **invagination**
- Materials **dissolve in water** to be brought into cell
- Called **“Cell Drinking”**

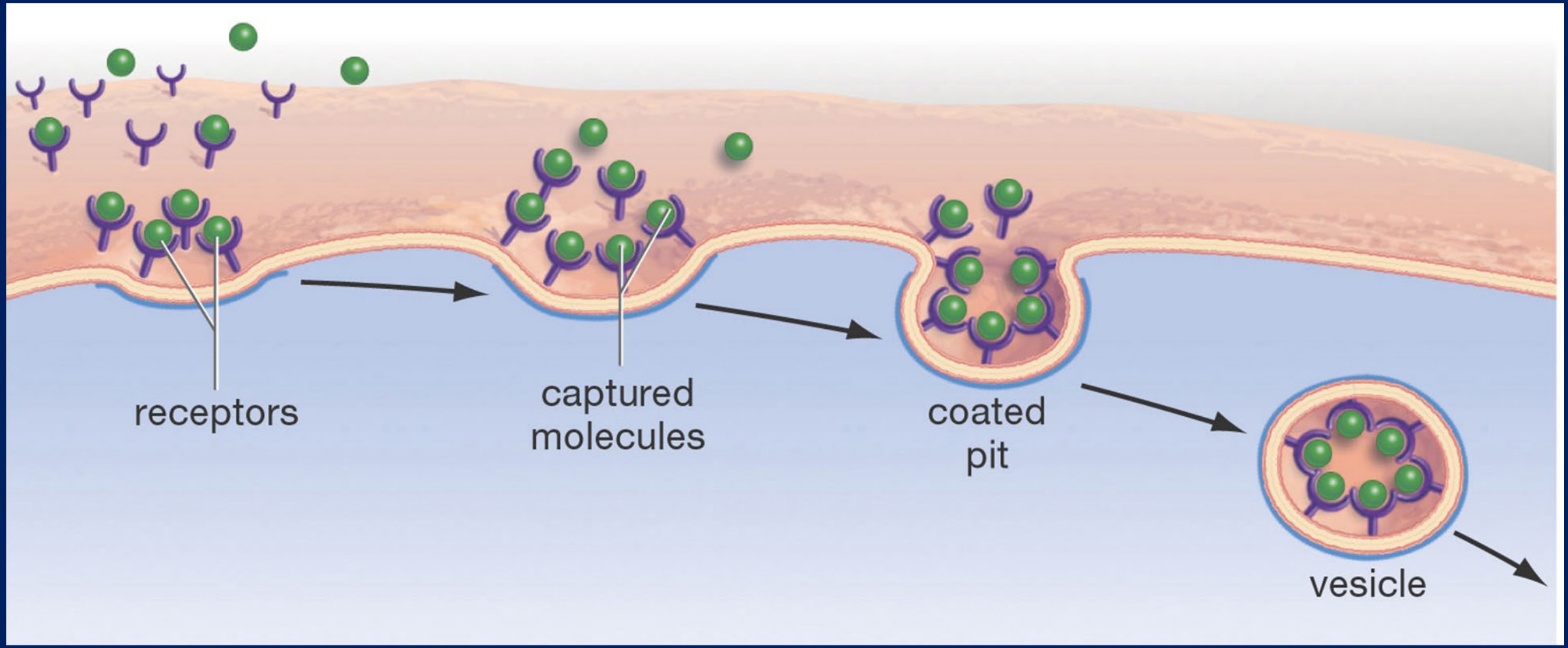


Receptor Mediated Endocytosis



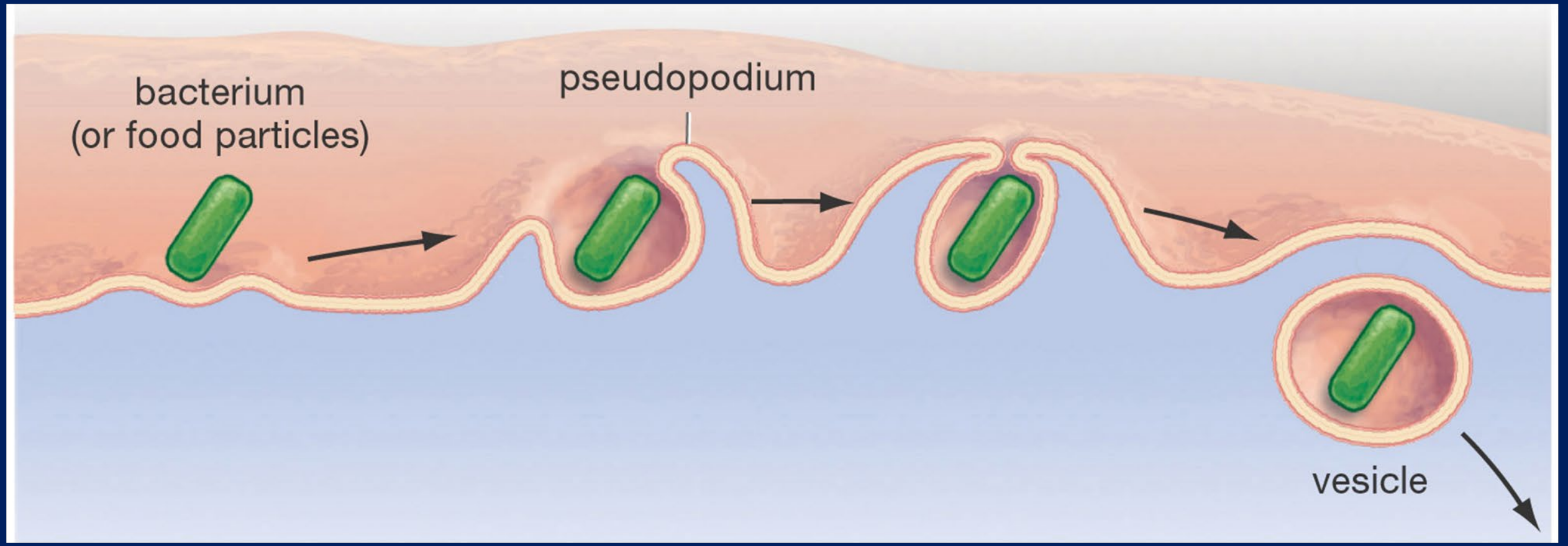


Receptor-Mediated Endocytosis



Some integral proteins have receptors on their surface to recognize & take in hormones, cholesterol, etc.

Endocytosis – Phagocytosis



Used to engulf large particles such as food, bacteria, etc. into vesicles Called "Cell Eating"

Contents from Open Access Online Resources