A microscopic image showing a dense cluster of cells. The cells are primarily green and blue, with many small yellow dots scattered throughout. The background is a dark, textured blue.

How Cells Control Their Environment

Heather Talbott

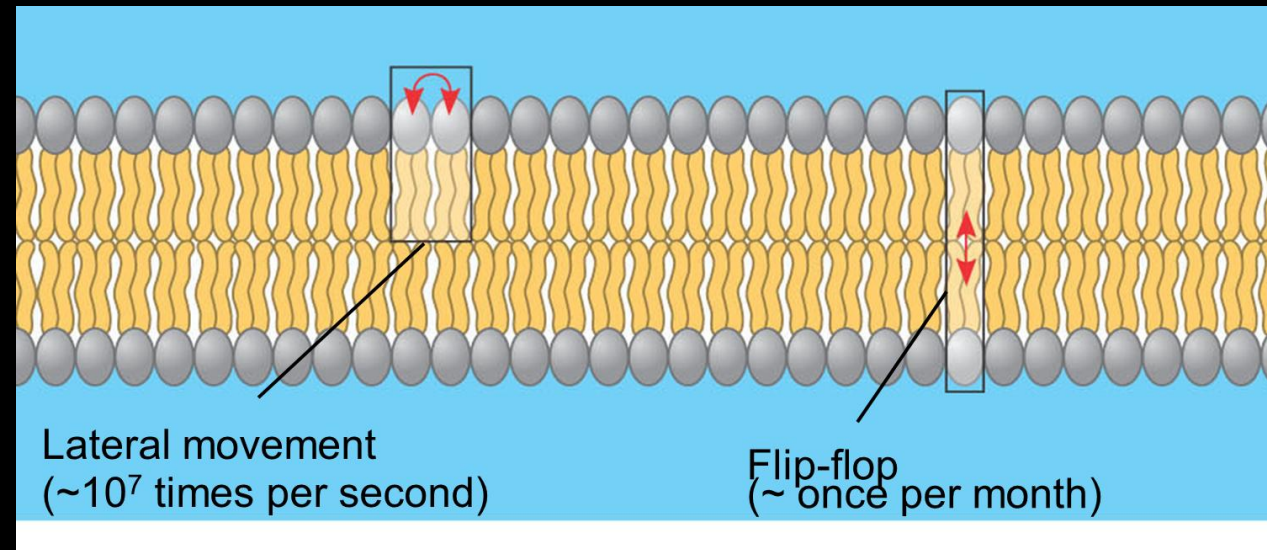
Laramie County Community College

Everything in physiology is about how cells survive, communicate, and work together.

Cell Membranes

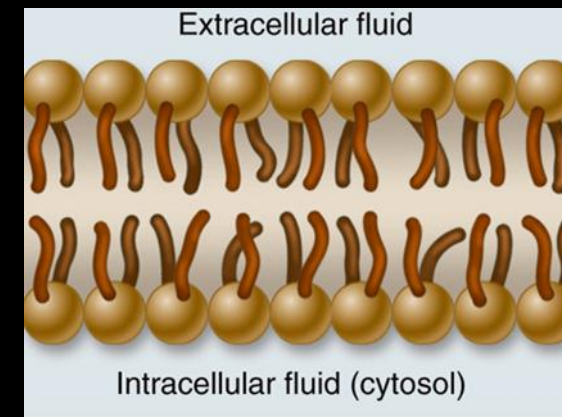
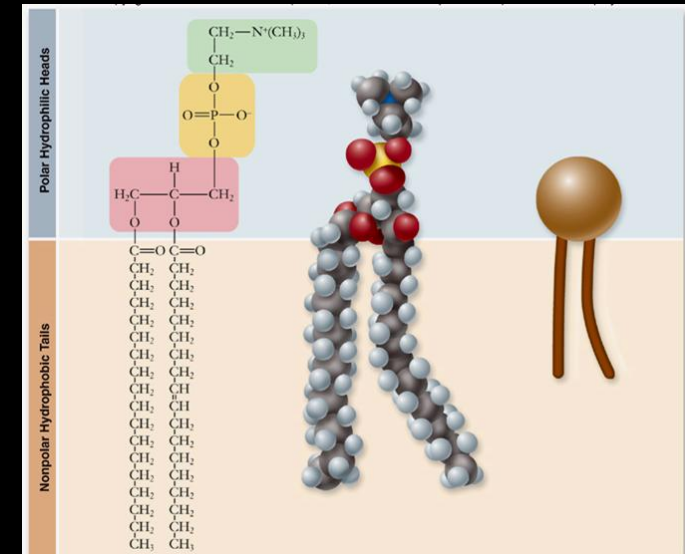
Membranes

- All cells and organelles are surrounded by membranes
- Membranes function to:
 - Separate compartments
 - Control molecular traffic in and out
- Membranes are selectively permeable
 - Some substances can cross easily and others can not get across



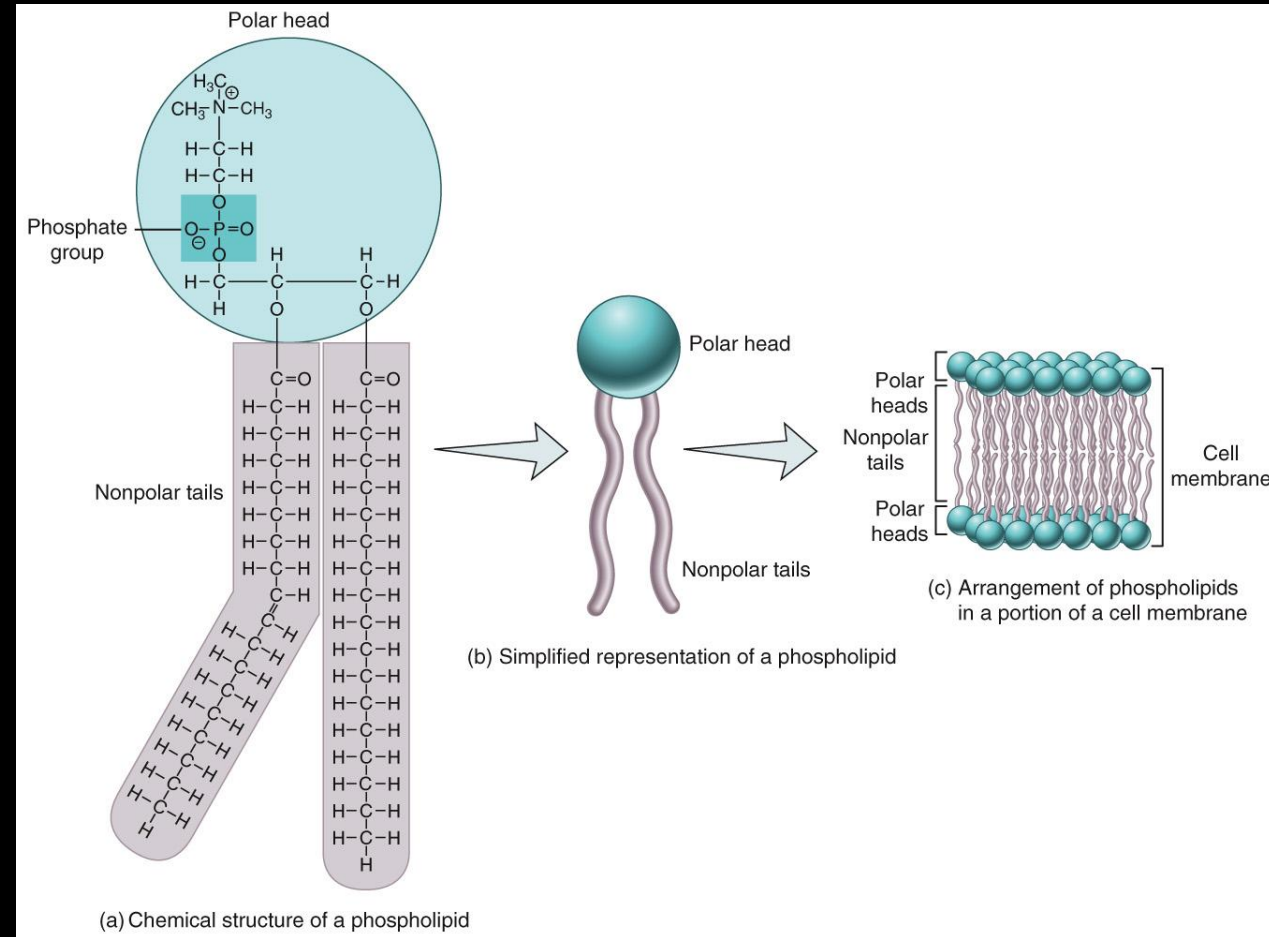
Membrane structure

- Membranes are ~50% phospholipids
- They automatically form into a bilayer with the fatty acid ends attracted to each other



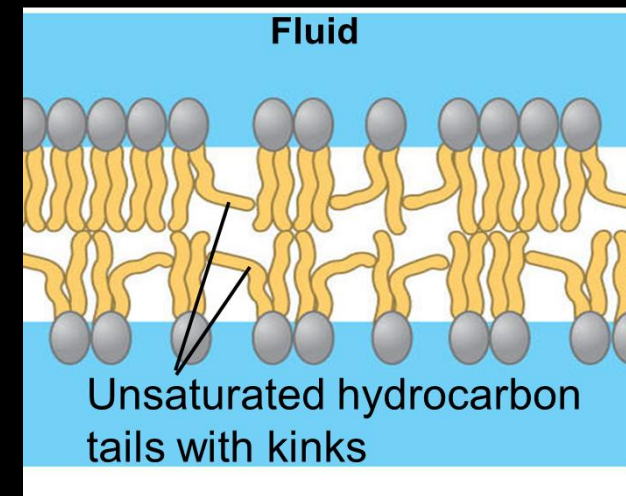
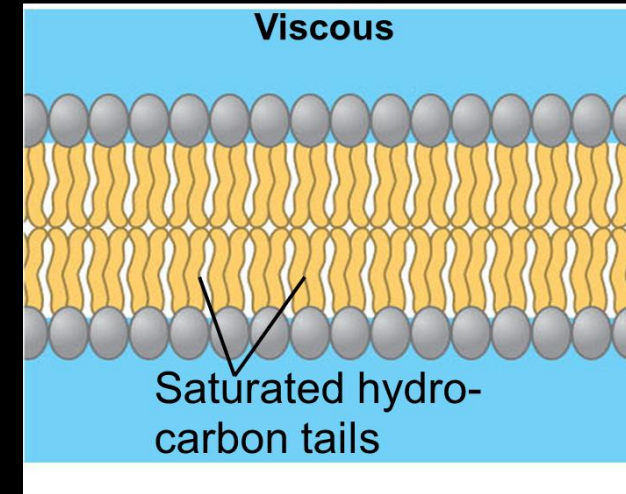
Phospholipids

- **Phospholipids:** a lipid that has two nonpolar tails and a polar head
- When in water phospholipids will automatically create a **bilayer**.
 - The nonpolar lipid tails will face each other to stay away from the water
 - The polar heads will face away from the tails and toward the water



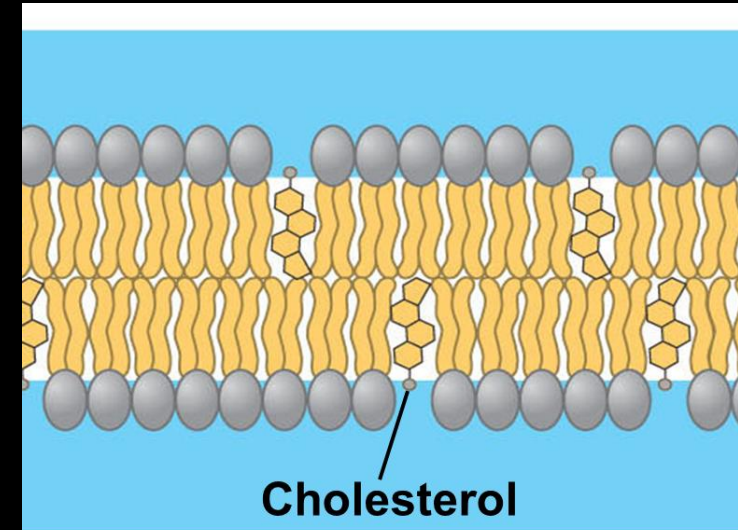
Membrane fluidity

- The fluidity of the membrane is impacted by:
 - Temperature
 - cold temperatures make the membrane less fluid than warm temperatures
 - Level of saturation of the fatty acid tails
 - saturated fatty acids make the membrane less fluid than unsaturated fatty acids



Cholesterol

- The steroid cholesterol is hydrophobic and can help keep membranes fluid in certain organisms (e.g. mammals) by “breaking up” the lipids, particularly at low temperature



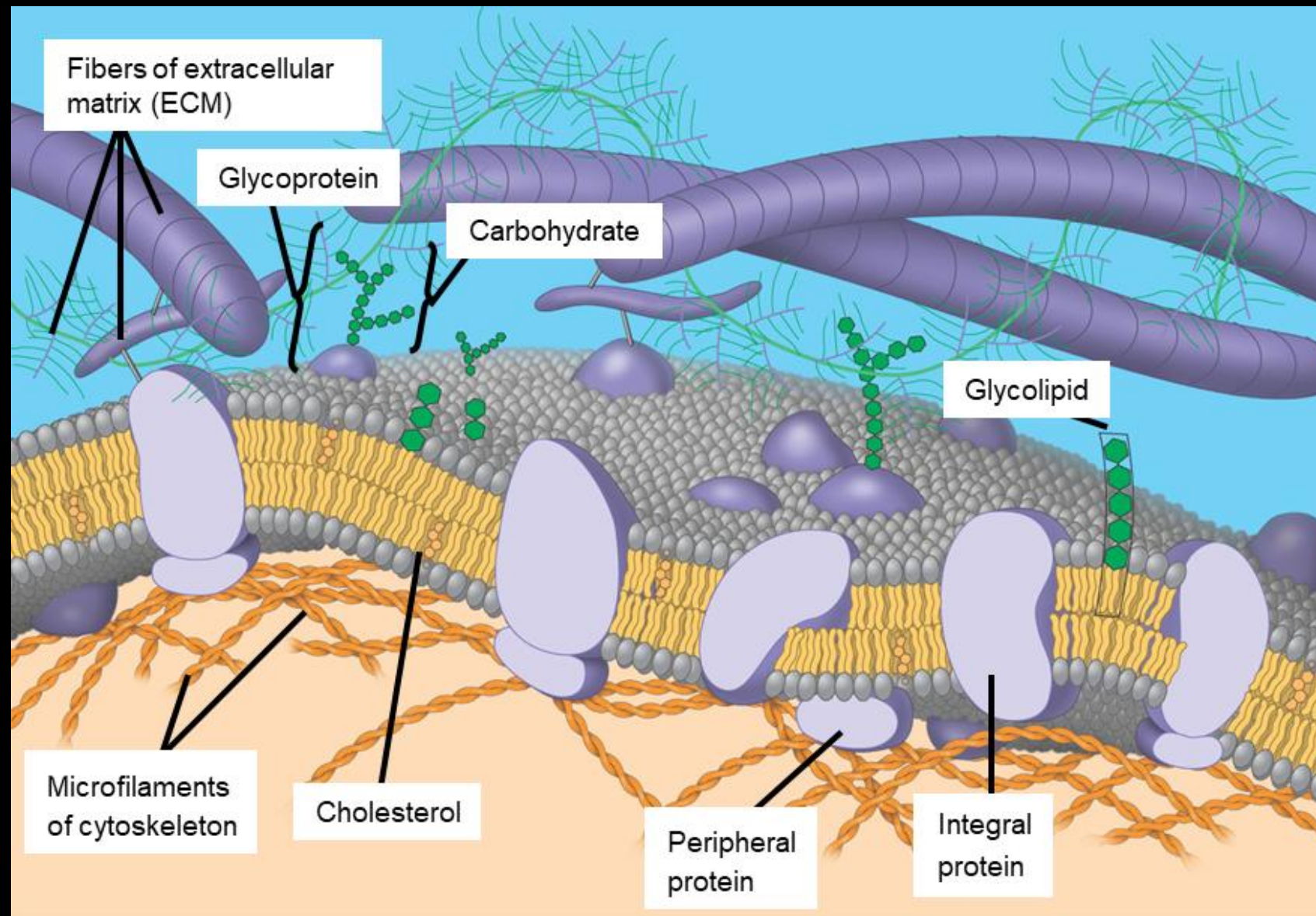
Membrane proteins

Membranes are also ~50% proteins with various functions

The proteins in the membrane can be:

Peripheral: on cytoplasmic or extracellular side

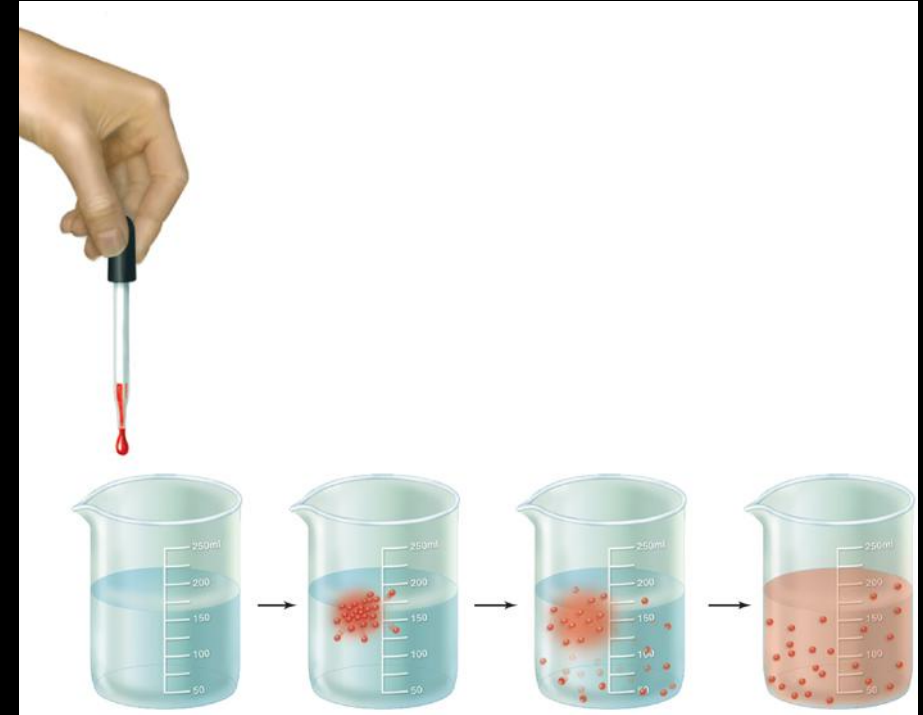
Integral: span the membrane



Moving Across Membranes

Diffusion

- Diffusion is the movement of molecules from high to low concentration
- Amount of substance in a defined space/volume
- Diffusion moves down the concentration gradient

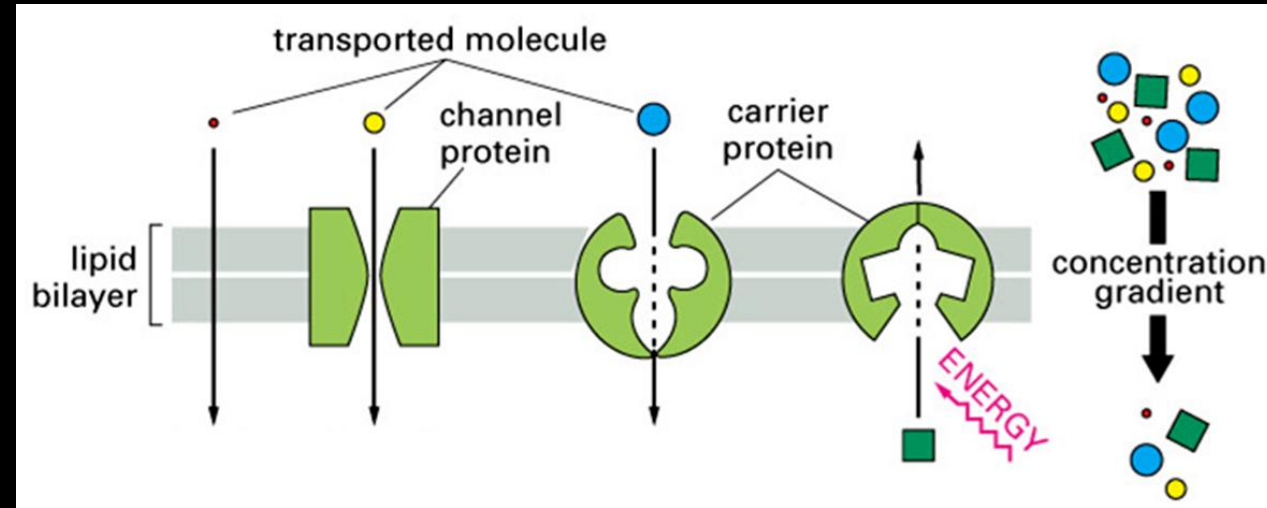


Movement across Membranes

- Molecules that can diffuse directly across the lipid bilayer are small and nonpolar molecules
 - O₂, CO₂
- Larger polar molecules and ions must use transport proteins to get across the membrane

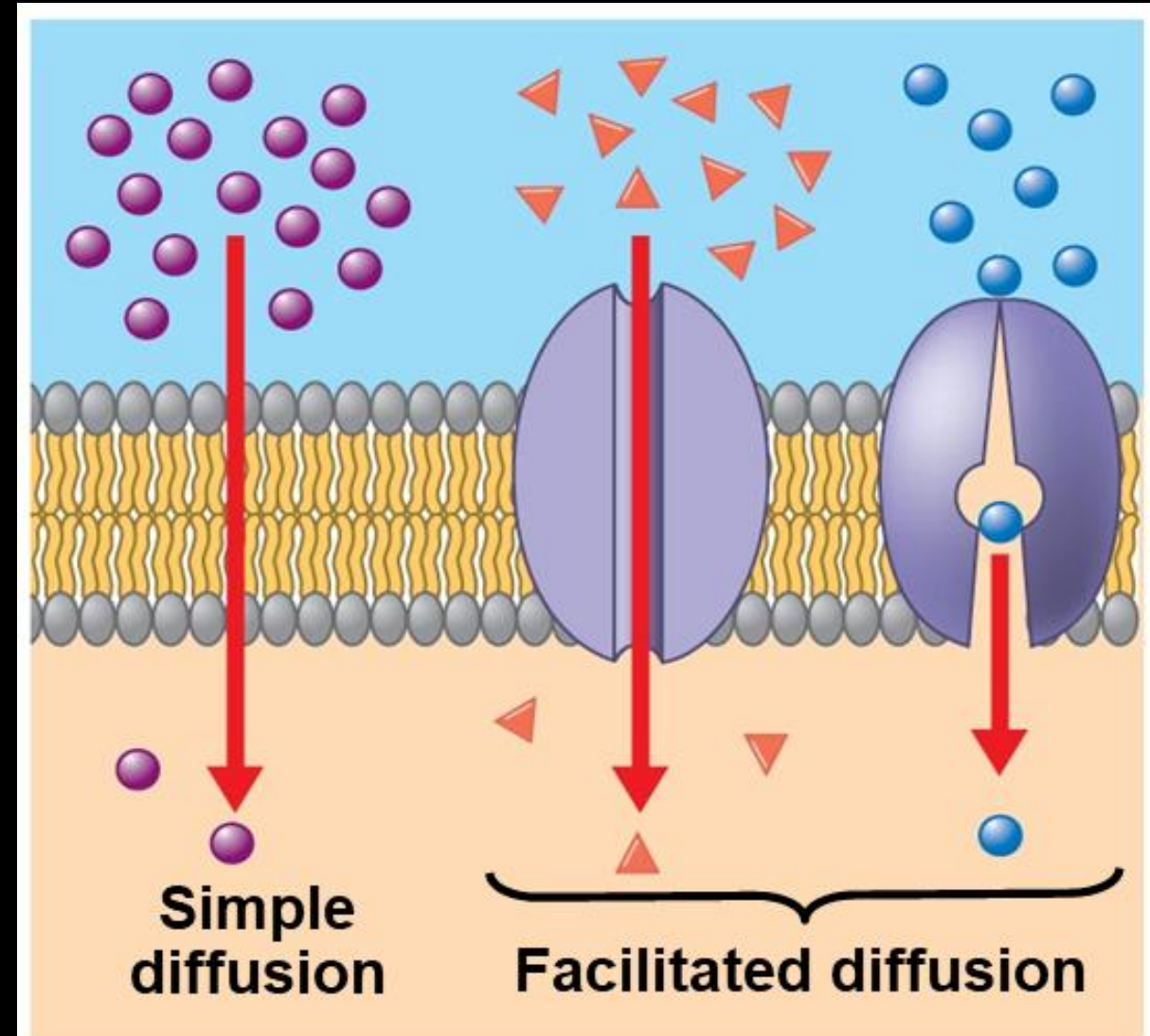
Membrane transport

- For a molecule to cross the membrane, it has to either:
- Directly cross through the lipids
- Cross through a protein



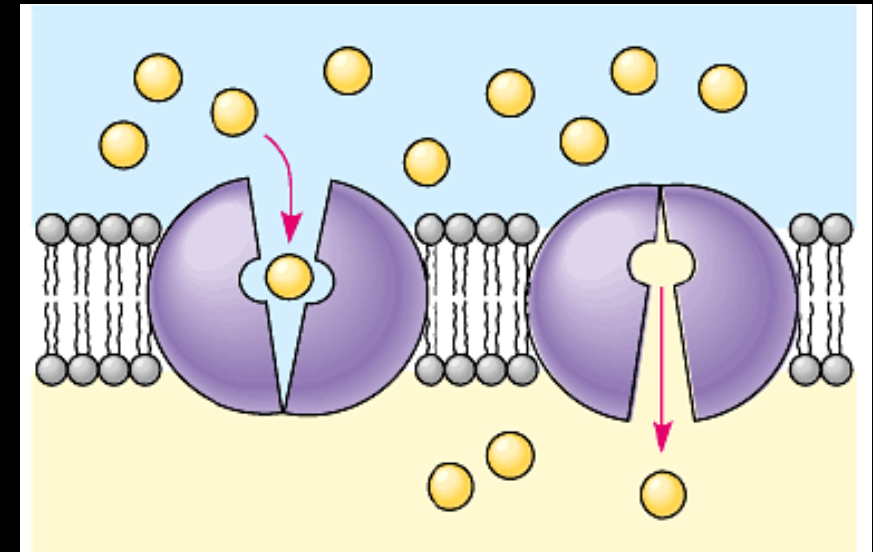
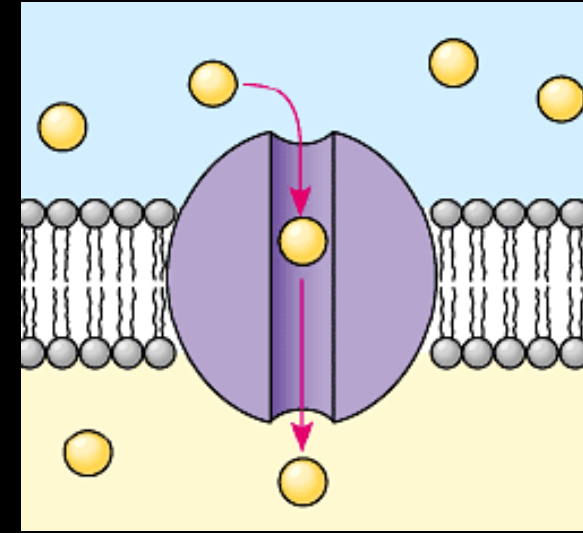
Passive transport

- Passive transport can be either simple diffusion or facilitated diffusion
- **Simple diffusion:** uncontrolled movement across the membrane
- **Facilitated diffusion:** makes use of a channel or carrier protein
 - This type of transport protein allows a specific molecule or ion to cross the membrane based on its size and shape



Facilitated diffusion proteins

- **Channel proteins** allow fast transport
- **Carrier proteins** are very specific for their transport molecule
- Reminder...no energy required for either of these when used in passive transport



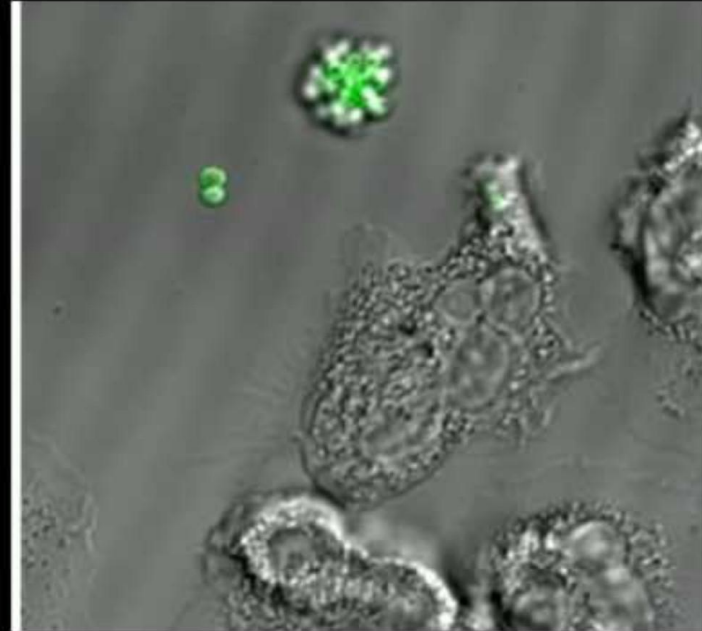
Active transport proteins

- Specialized proteins used in active transport include:
- uniporters – move one molecule at a time
- symporters – move two molecules in the same direction
- antiporters – move two molecules in opposite directions
- Greek:
- Uni- = singular
- Sym- = together
- Anti- = against or opposed
- *porta* = gate or door

Bulk Transport

- Bulk transport of substances is accomplished by
- endocytosis – movement of substances into the cell (e.g. phagocytosis)
- exocytosis – movement of materials out of the cell
- Requires ATP

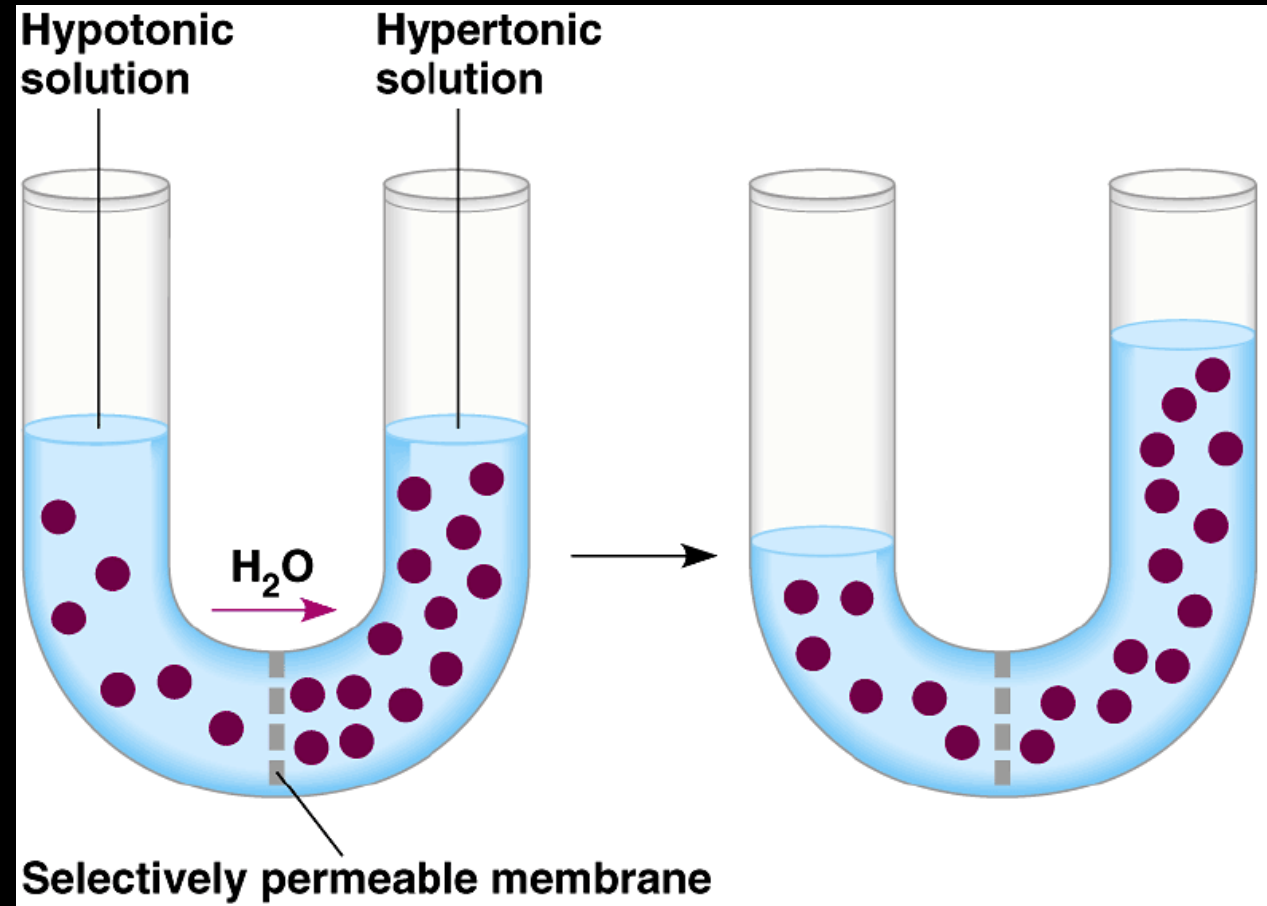
- Greek:
- endo- = within
- exo- = out
- -cyto = hollow place, cell
- -osis = condition of (Latin)



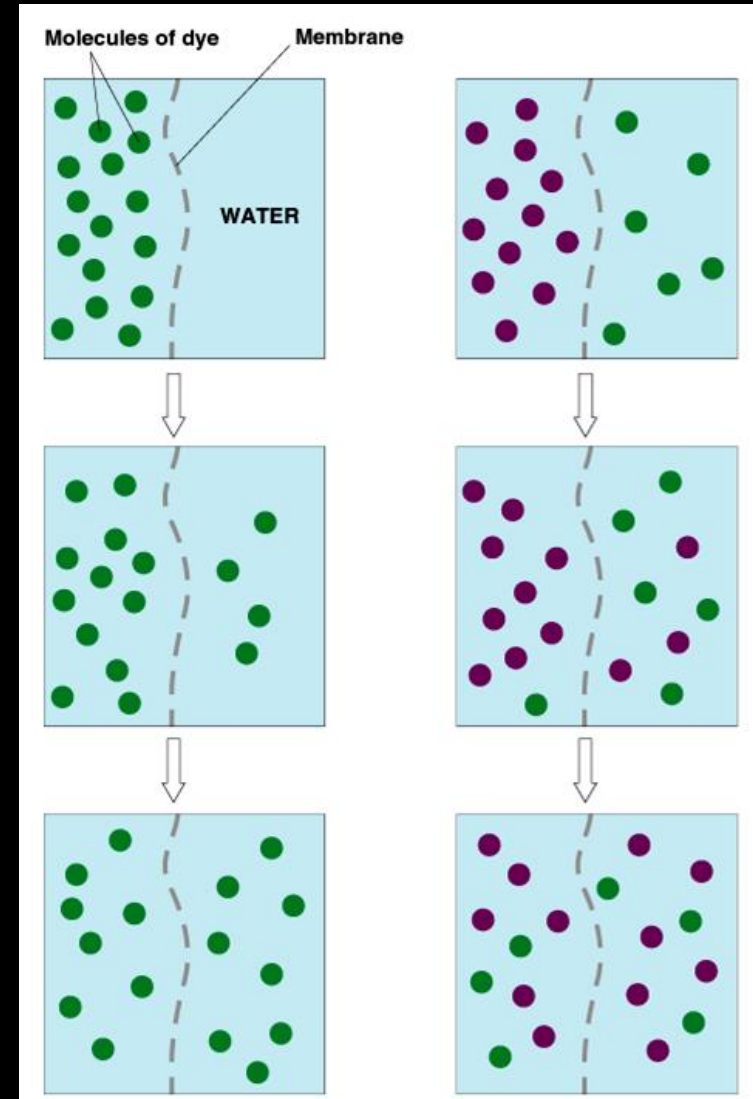
Water balance

Osmosis

- **Osmosis:** the transport of water across a membrane is called
- The water will always travel to where there are more solutes (sugar, salt, etc.) and less water
- If the solutes cannot pass the membrane, the water will move to make the concentrations equal via osmosis



- The direction of osmosis is determined only by a difference in total solute concentration
- The kinds of solutes in the solutions do not matter
- When two solutions have equal solutes, there is still movement, but no net osmosis

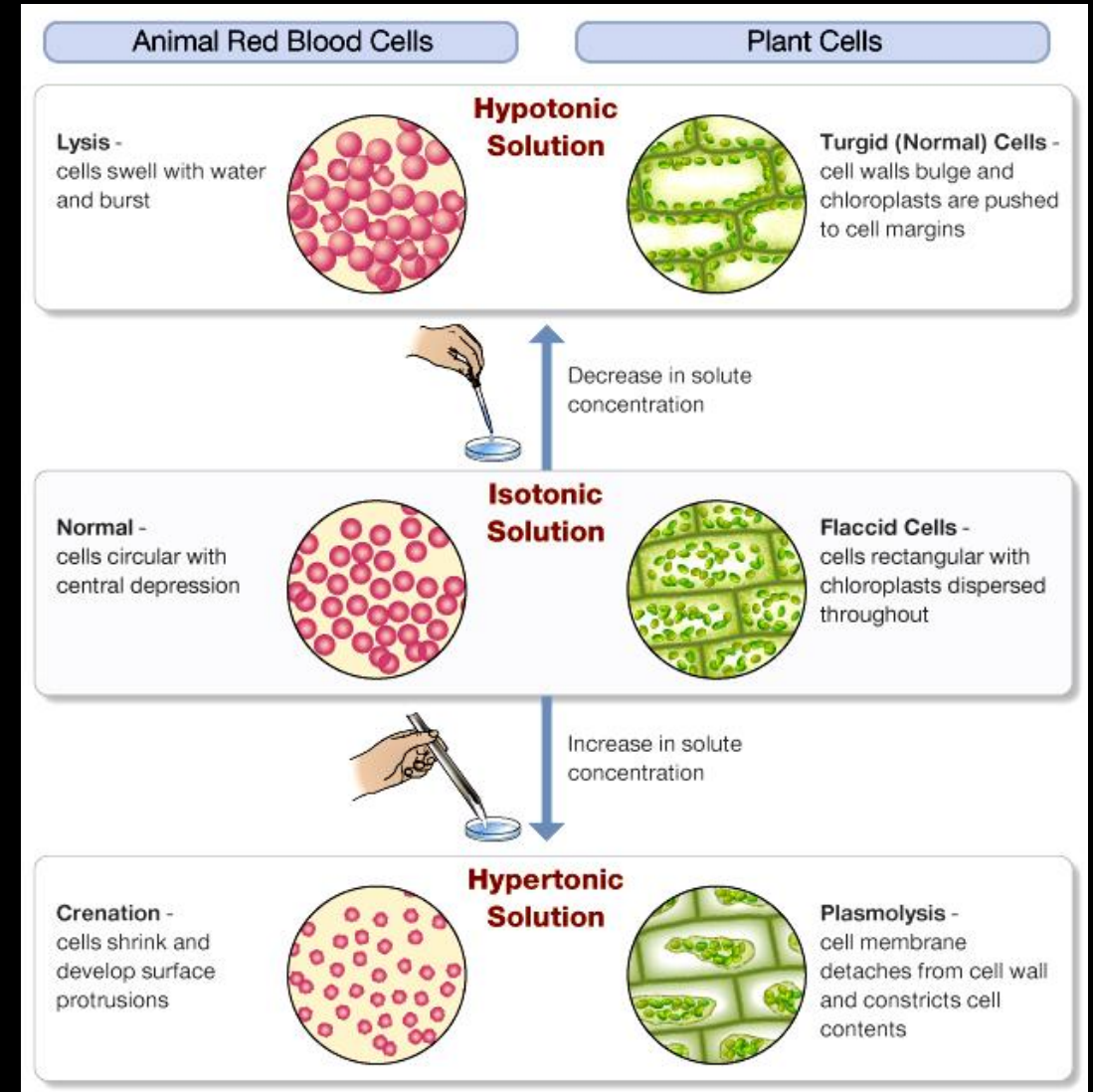


Tonicity

- Two solutions on either side of a membrane can have three possible names regarding osmosis:
- **Hypertonic:** this solution has more solutes
- **Hypotonic:** this solution has less solutes
- **Isotonic:** this solution has the same number of solutes as the solution on the other side of the membrane

Swelling and Shrinking of Cells

- Cell size depends on the surrounding solution
- **Lysis**: animal cells swell so much they burst, occurs in hypotonic environments
- **Crenation**: animal cells shrink in hypertonic environments



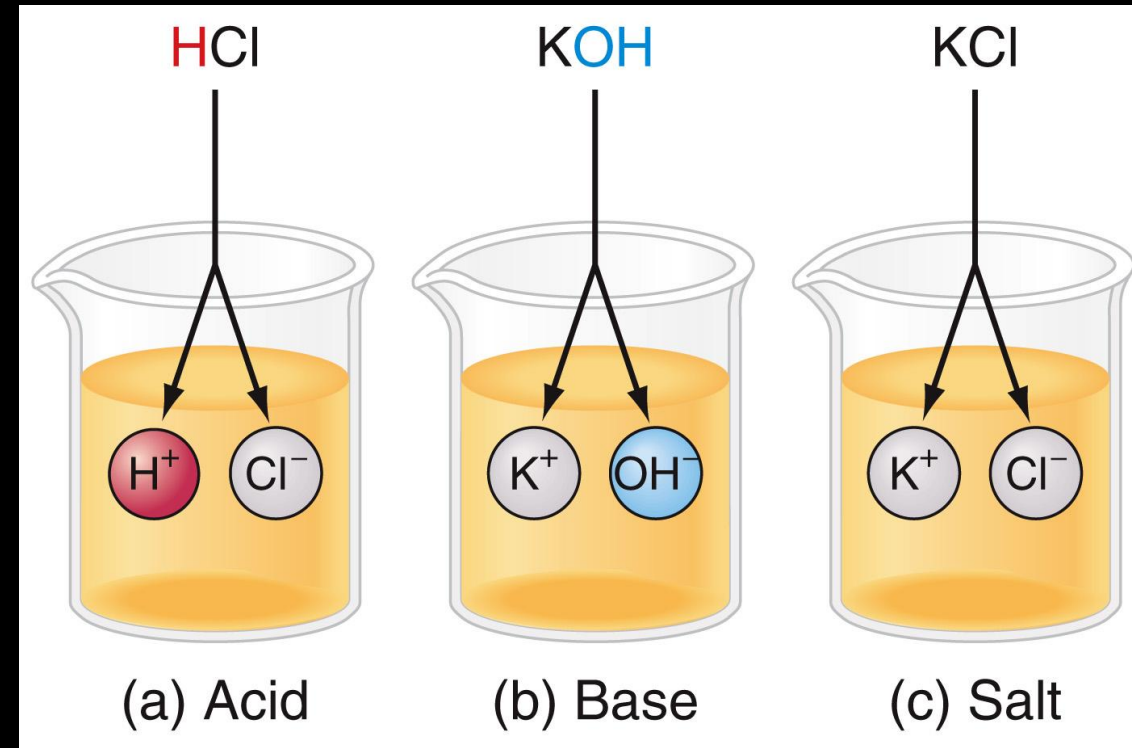
IV Fluids

- IV fluids affect water movement in and out of cells
- The salt concentration of an IV matters
 - Isotonic IV (Normal Saline, 0.9% NaCl) for stability
 - Hypotonic IV used when patient is dehydrated
 - Hypertonic IV used to reduce swelling

pH & Buffers

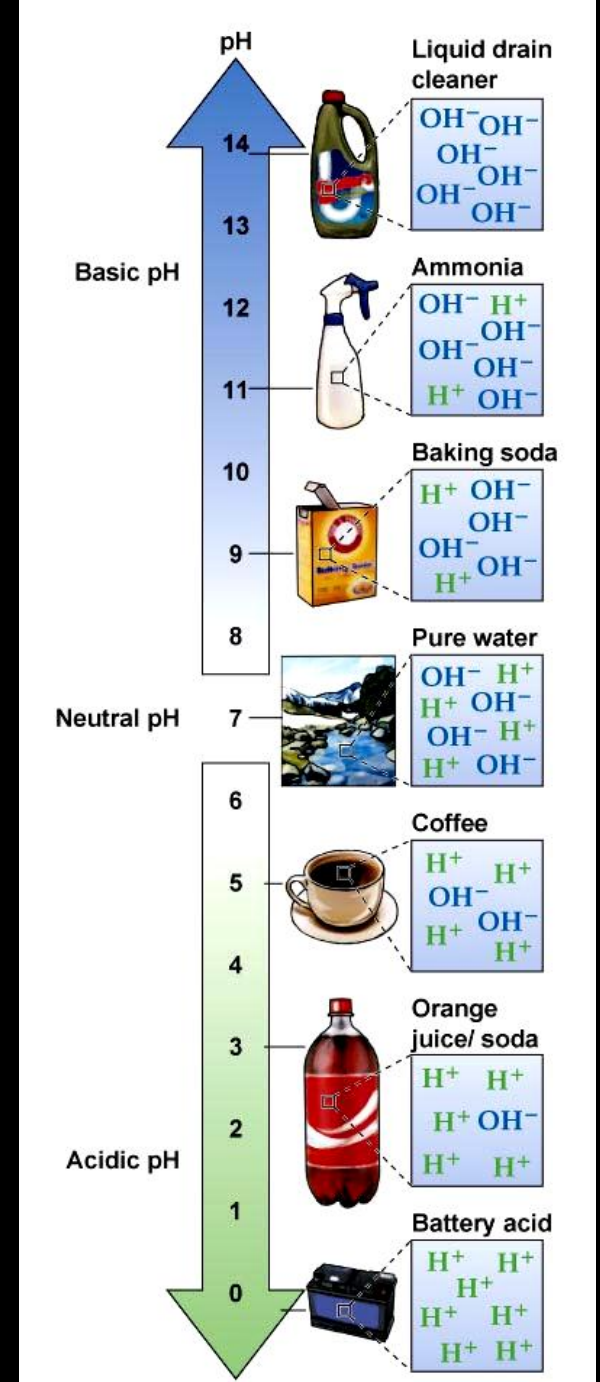
Acids, Bases, and Salts

- When molecules dissolve in water some dissociate and separate into ions in solution
- Acid: substance that dissociates and adds one or more hydrogens ions (H^+) into solution; proton donor
- Base: substance that dissociates and adds one or more hydroxide ions (OH^-) into solution (or removes a proton; proton acceptor)
- Salt: dissociates into cations and anions, neither of which is H^+ or OH^-

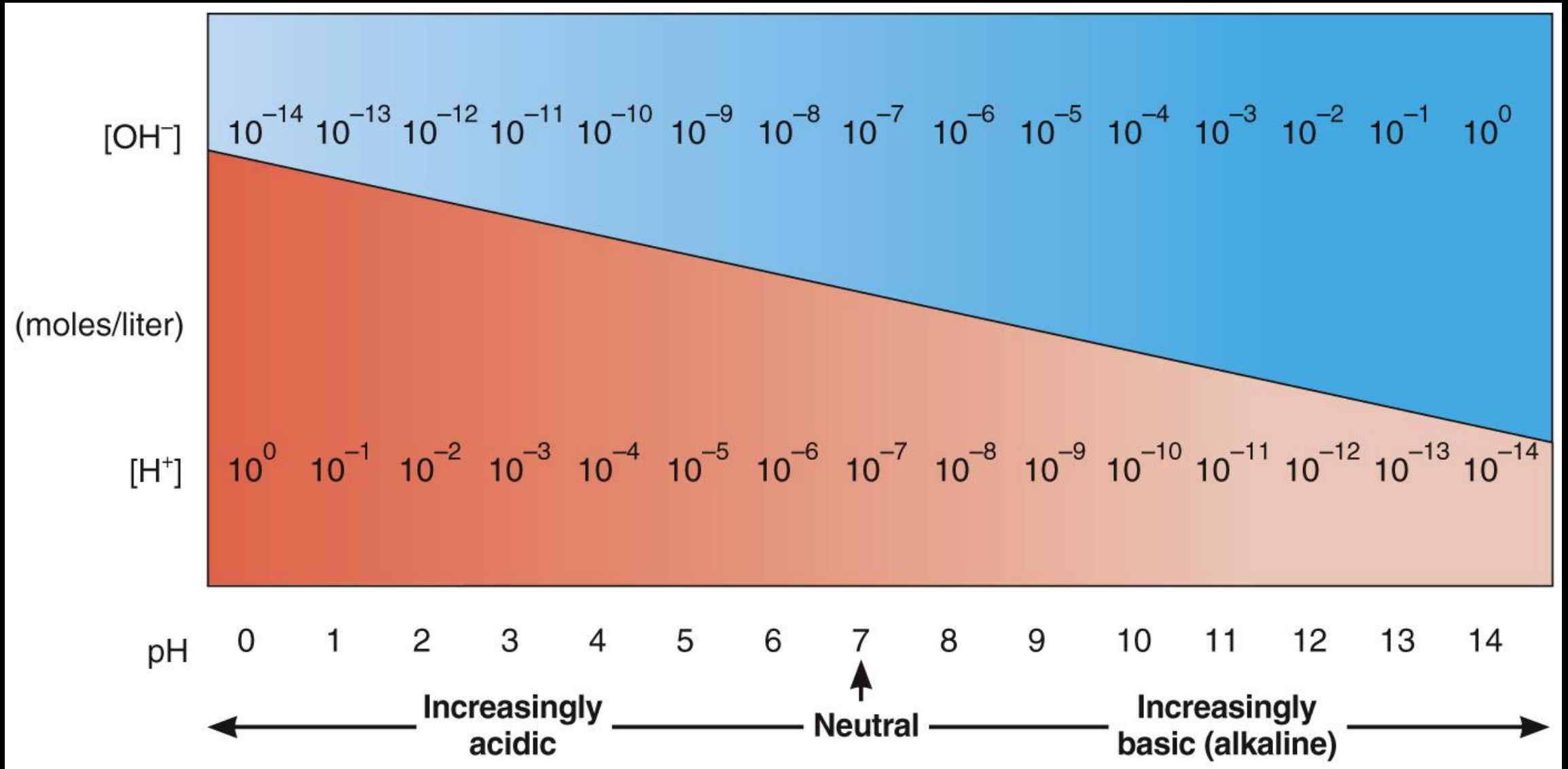


pH

- **pH scale**: the amount of H^+ in solution and represents a solution's acidity or alkalinity
 - Logarithmic scale from 0-14
 - Calculation $pH = -\log[H^+]$
 - 0-6 is acidic
 - 7 is neutral
 - 8-14 is basic
- Blood pH normal range = 7.35-7.45

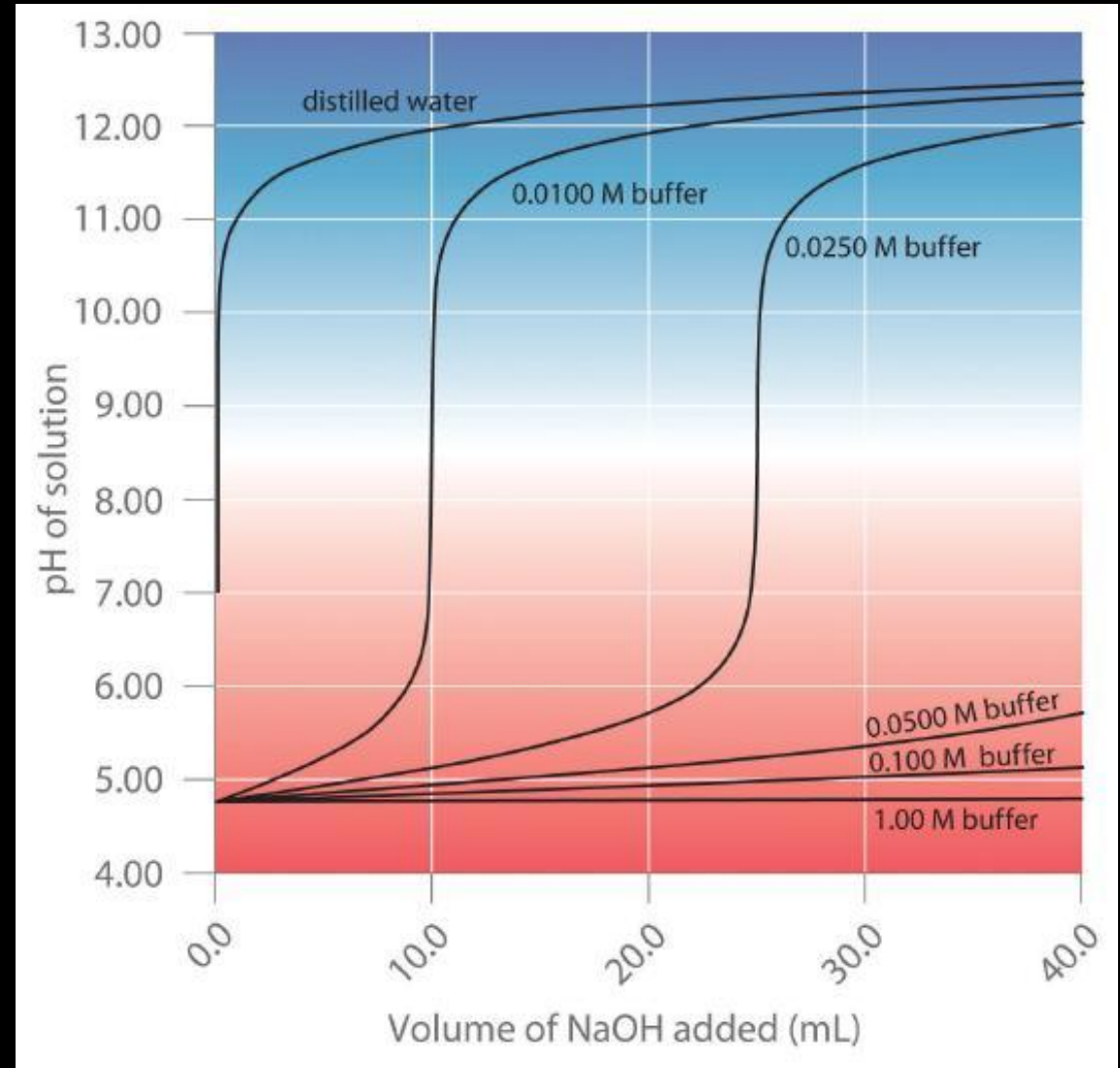


pH Scale



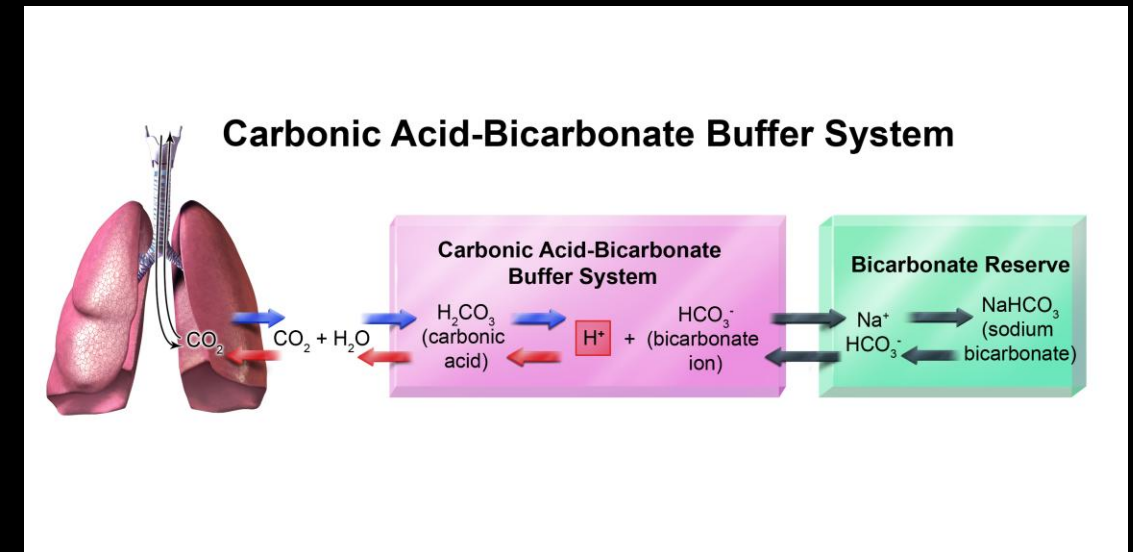
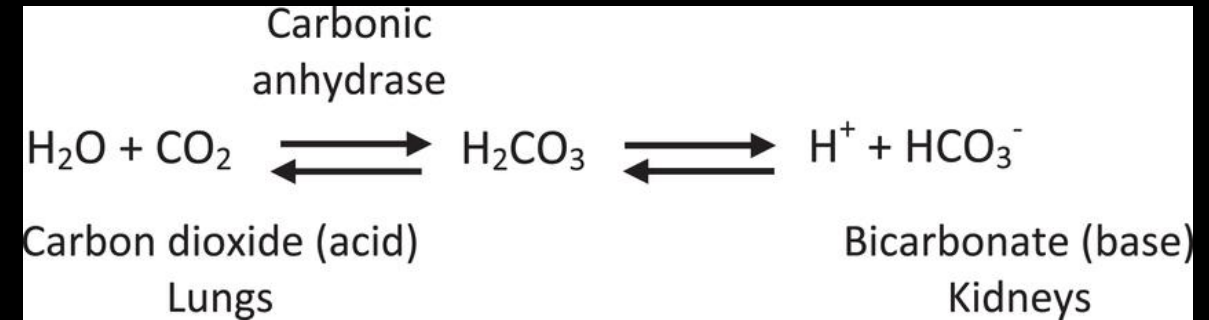
Buffers

- even though strong acids and bases are continually taken into and formed by the body, the pH of fluids inside and outside of cells remains almost constant
- Buffer system: an aqueous solution that resists significant changes in pH



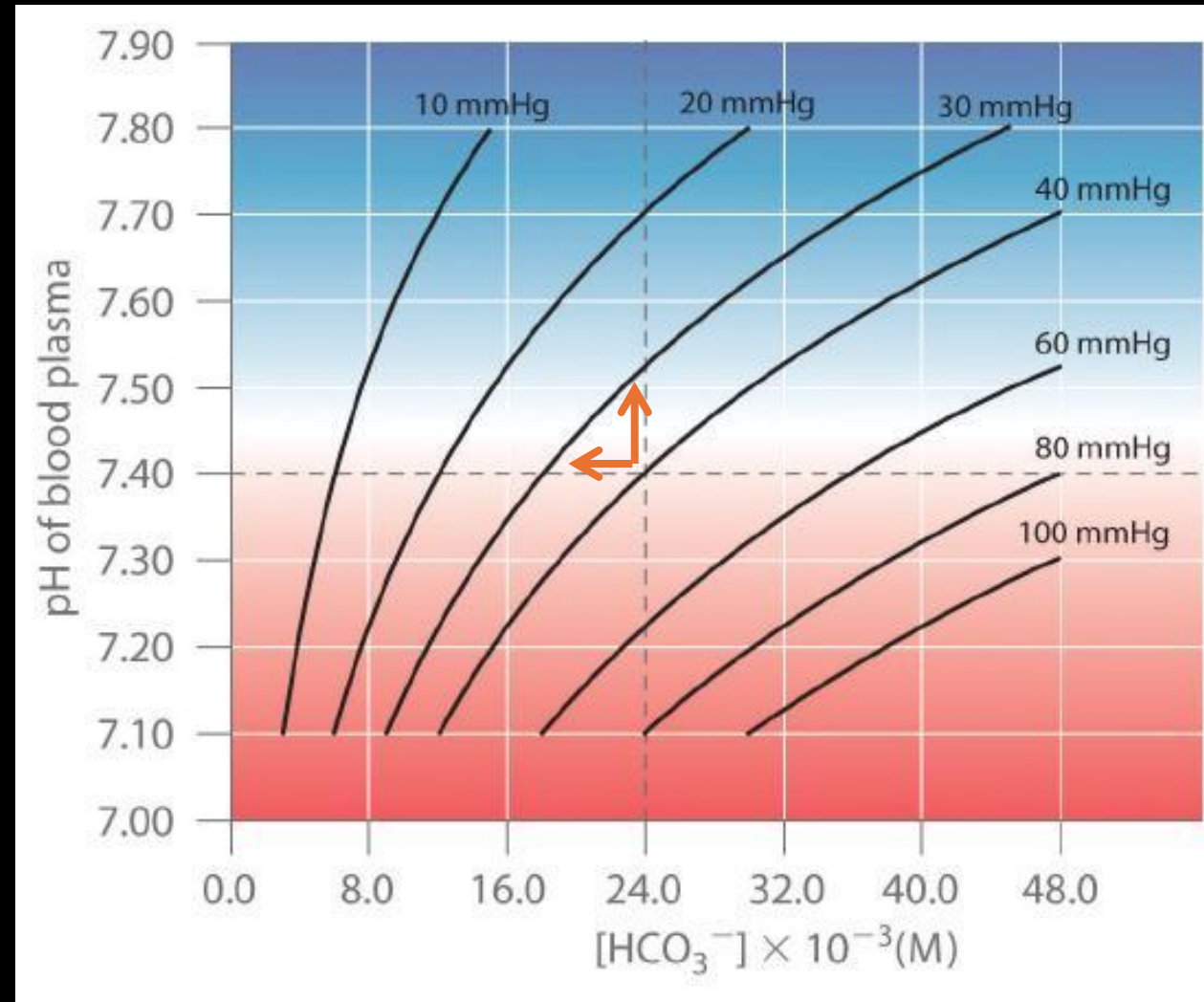
Blood Buffers

- Carbonic acid – bicarbonate buffer system: main buffering system of blood
- carbonic acid (H_2CO_3) is a weak acid
- bicarbonate (HCO_3^-) is a weak base



Altitude Sickness

- **Buffering in Blood:**
- pH versus carbonic acid concentration $[\text{HCO}_3^-]$
- Curves shown for different atmospheric pressures
- Denver, Colorado pressure ~30 versus ~40 mmHg at sea level causes a decrease in carbonic acid and an increase in blood pH
- Responsible for the general malaise that many people experience at high altitudes



Body Fluids

Extracellular Fluid (ECF)

- Extracellular Fluid (ECF): all body fluid that is found outside of cells.
- Cells constantly exchange materials with ECF
- Surrounds and supports cells
- Provides nutrients and oxygen and removes wastes
- Helps maintain pH and ion balance

Interstitial Fluid

- Interstitial Fluid: a type of ECF that fills the spaces between tissue cells.
- Formed from plasma leaving capillaries
- Bathes and surrounds cells
- Allows exchange of: Oxygen, Nutrients, Wastes

Plasma

- **Plasma:** the liquid portion of blood that carries cells, nutrients, hormones, and wastes.
- Makes up about 55% of blood volume
- Contains: Water, Proteins, Glucose, Electrolytes, Hormones, Wastes,
- Functions: Transports substances, maintains blood pressure, and helps regulate pH

Specialized Body Fluids

- Cerebrospinal Fluid (CSF):
Surrounds the brain and spinal cord to cushion and protect nervous tissue
- Synovial Fluid: Found in joints, reduces friction and absorbs shock
- Aqueous & Vitreous Humors: Found in eyes, maintain eye shape, and support vision
- Lymph: Found in lymphatic vessels, returns fluid to bloodstream and supports immune system

How Body Fluids Work Together

- Fluid Compartments Work as a System
- Constant exchange occurs between plasma, ECFs, interstitial fluids and cells
- Balance is tightly regulated
- Problems with balance can cause: swelling (edema), dehydration, low blood pressure, organ stress

Resources

- Dingess, Paige (2025)
- Grammarly. (2026). Grammarly (Version 14.1268.0) [Software].
<https://www.grammarly.com/>
- OpenAI. (2026). ChatGPT (GPT-5) [Large language model].
<https://chat.openai.com/>

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