Cell Membranes

Structure and Function

- As a review, fill in the blanks:
  - Molecules are made up of ___.
  - Sugars link together to make ___.
  - Amino acids link together to make ___.
  - Fatty acids are components of ____.

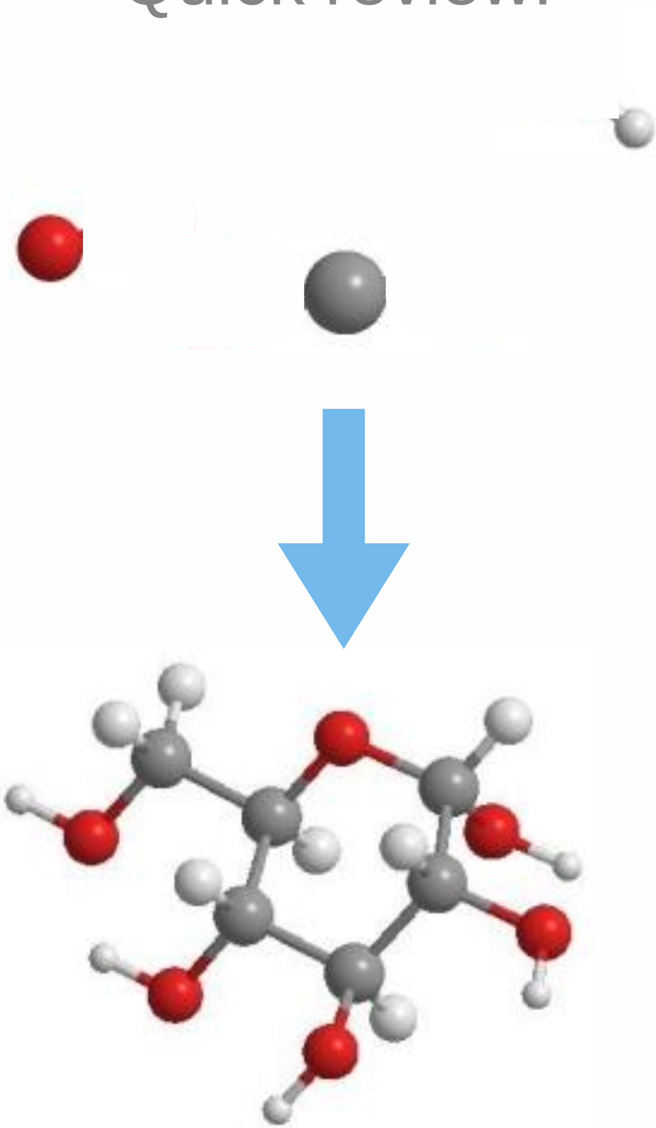
W O R K T O G E T H E R

Quick review:

Atoms

bind together
to make

molecules.



Complex carbohydrates are composed of simple sugars.

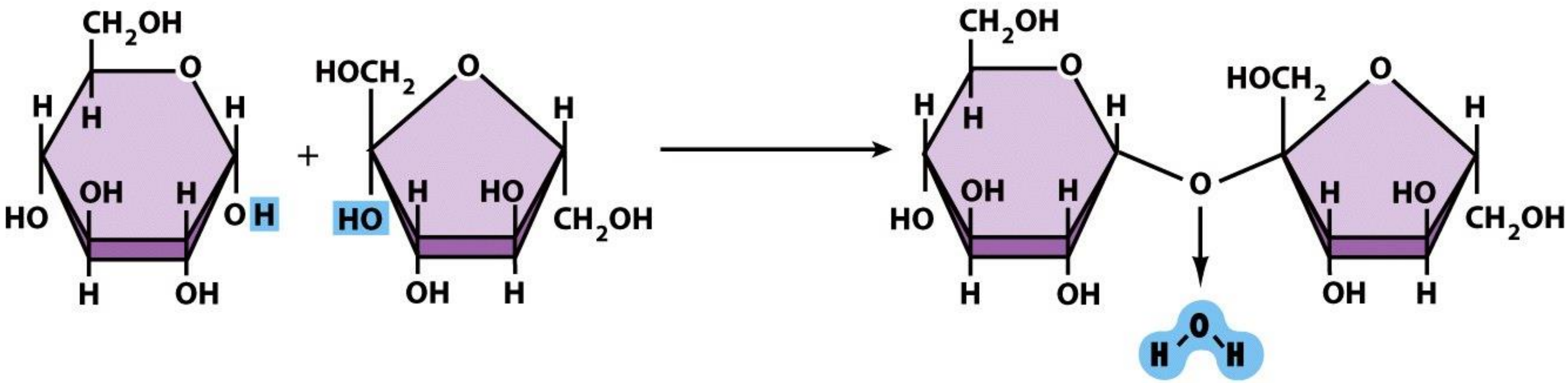


Figure 3-7 Biology: Life on Earth, 8/e

Lipids are composed of fatty acids plus a polar head.

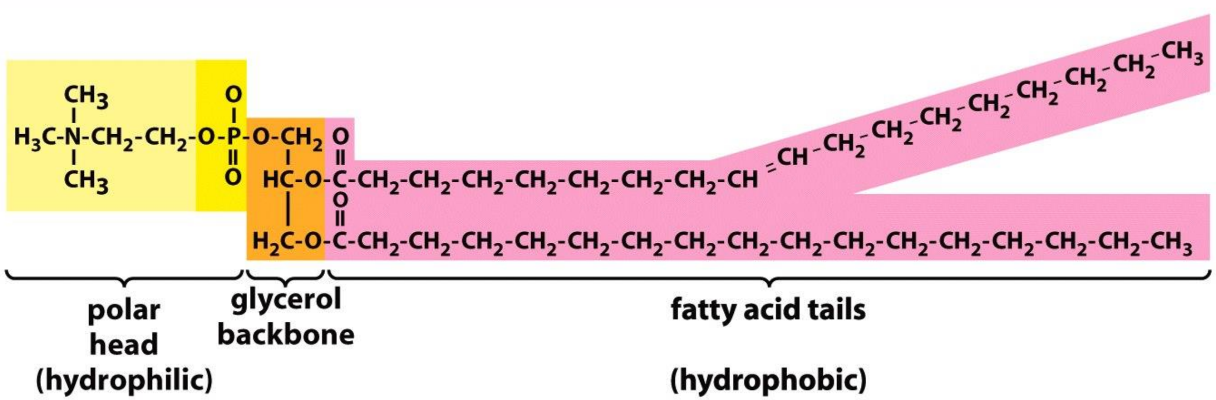


Figure 3-15 Biology: Life on Earth, 8/e

Proteins are long chains of amino acids bound together.

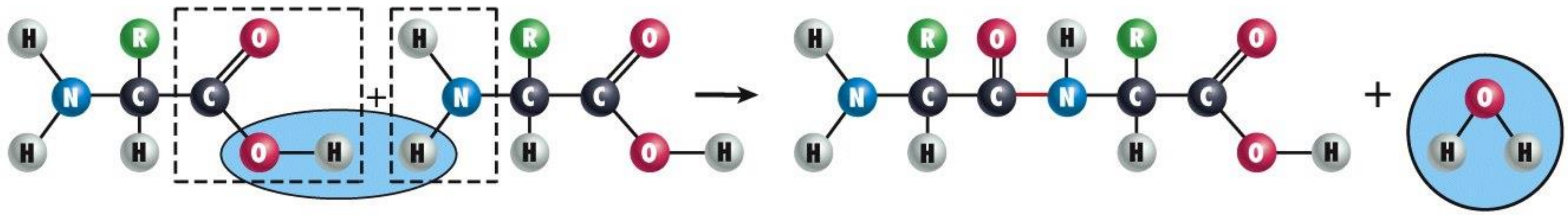
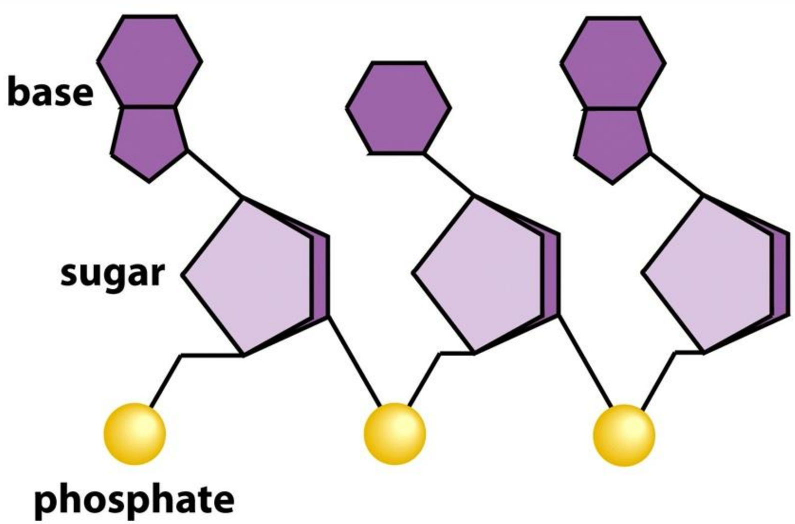


Figure 3-20 Biology: Life on Earth, 8/e

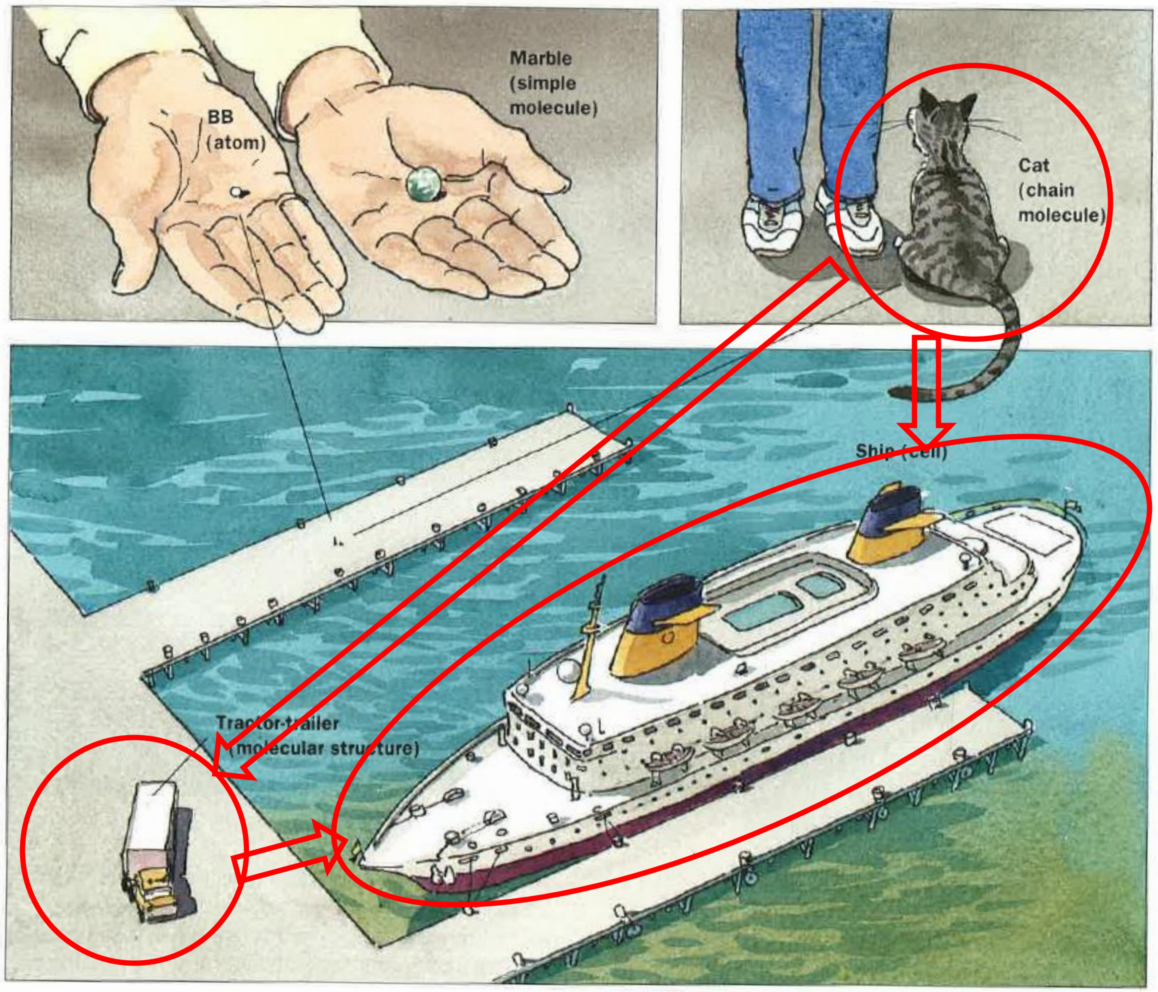
Nucleic acids are composed of chains of nucleotides.



Building cell parts

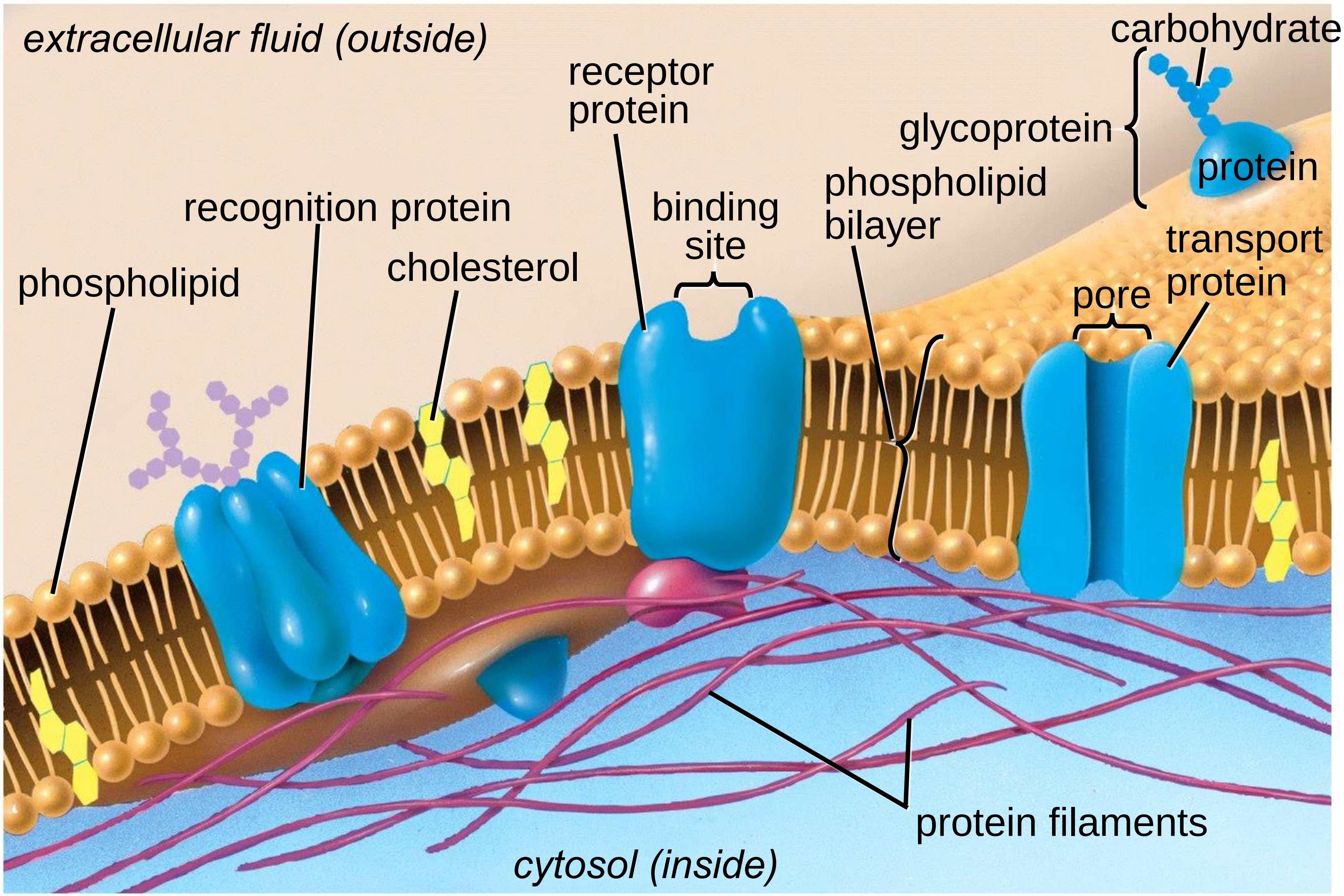
- The biological molecules are the basic building blocks of all cell parts.
- Cell membranes are composed of proteins, lipids, and some complex carbohydrates.

In our model of scale, that the cruise ship represented the cell. We're now going to assemble large chain molecules into the parts of a cell.



The Fluid Mosaic Model of the cell membrane

Which classes of biomolecules are represented here?



Membrane components: Lipid bilayer

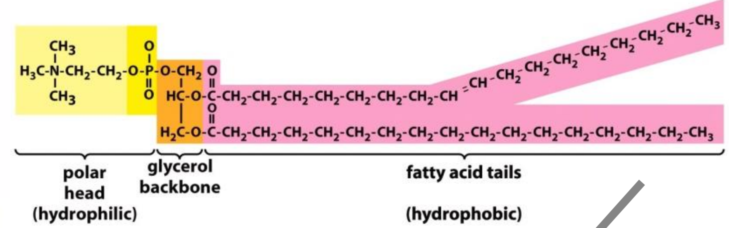
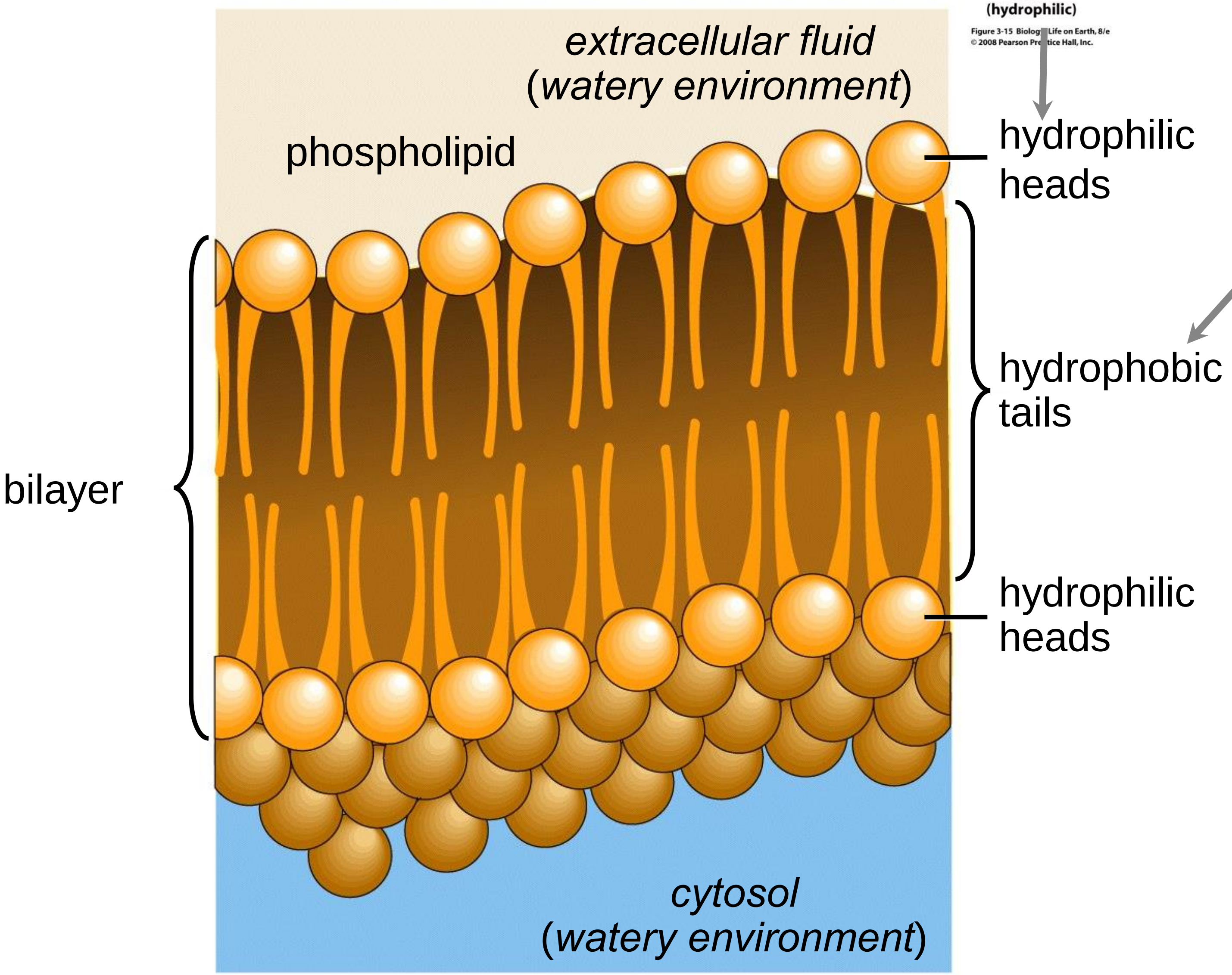
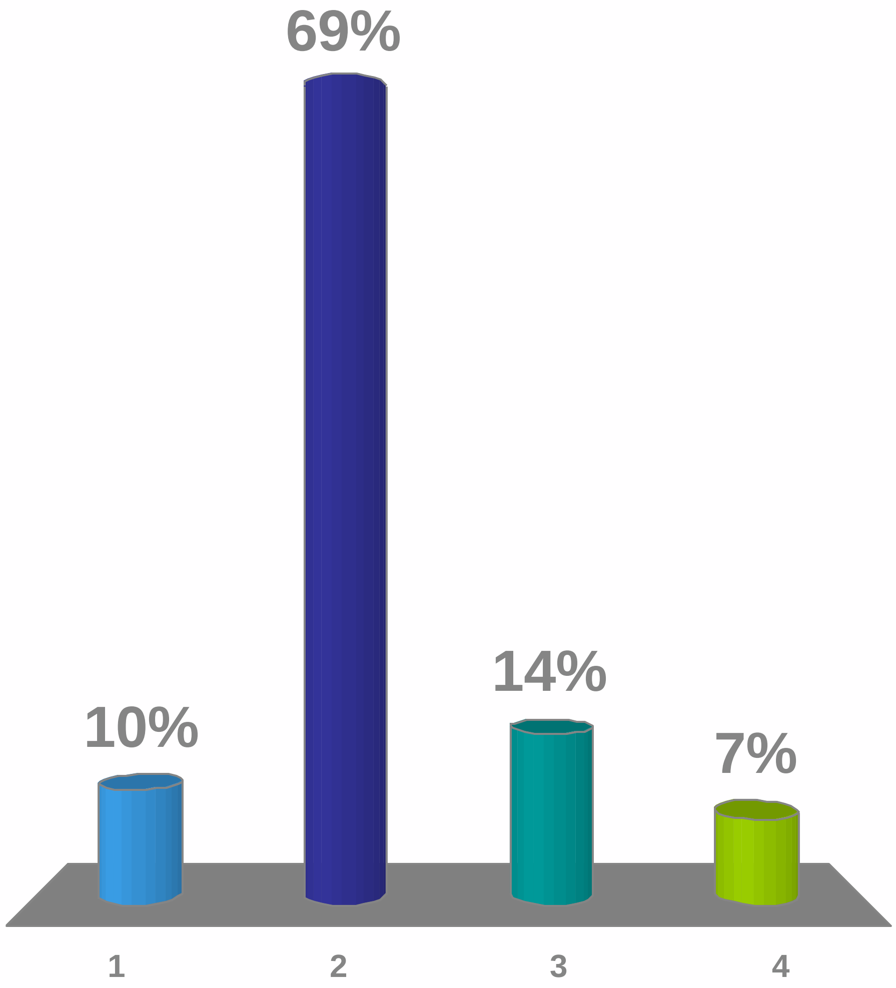


Figure 3-15 Biology: Life on Earth, 8/e

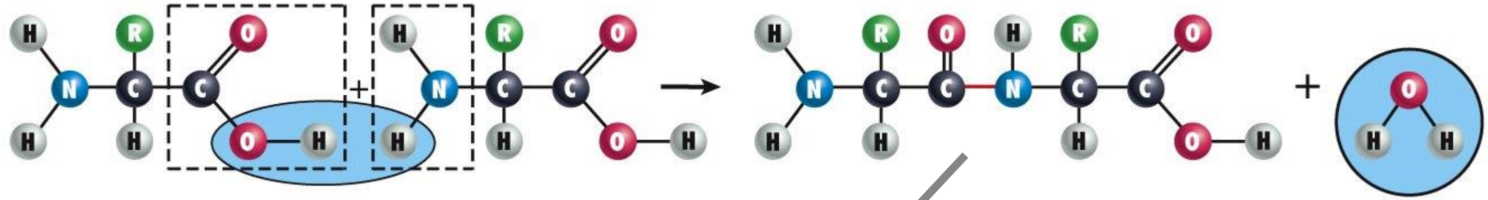


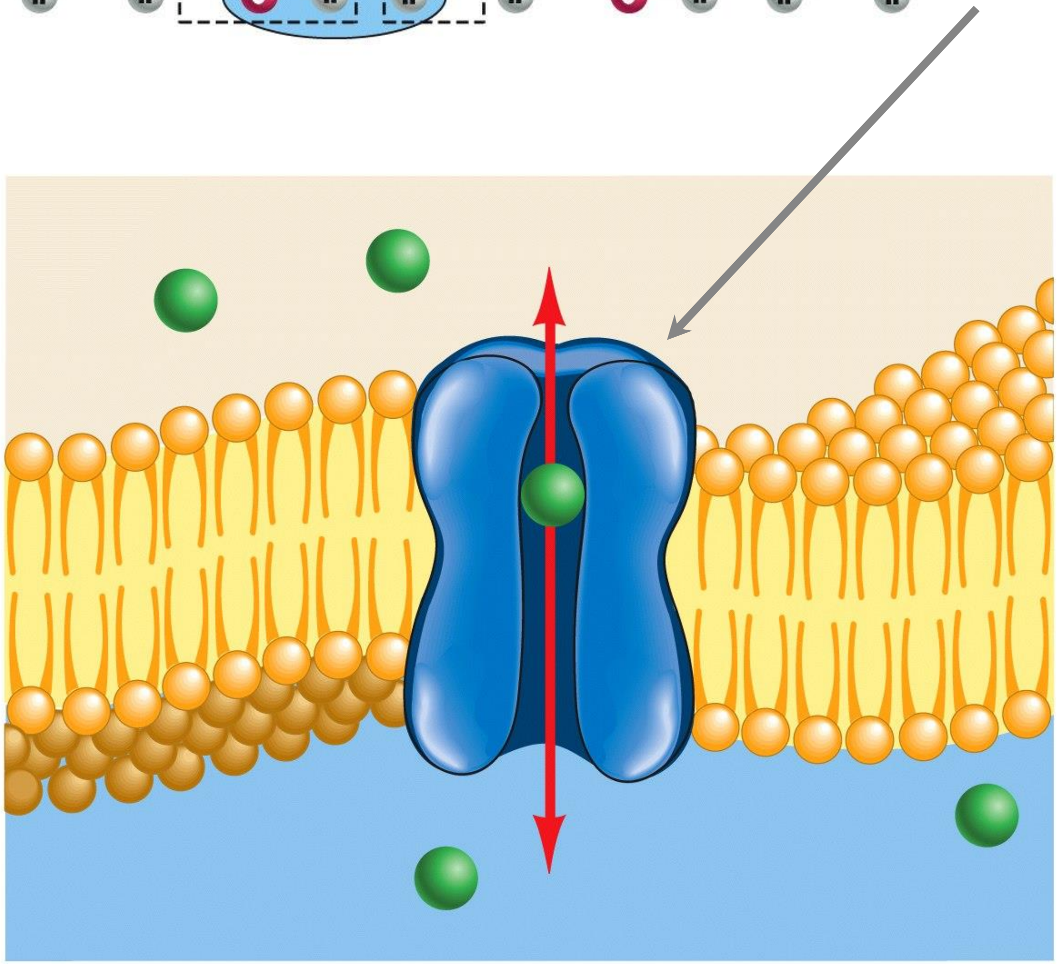
Why do the fatty acid tails of phospholipids point toward each other in the membrane?

1. They are non-polar, so they are hydrophilic.
2. They are non-polar, so they are hydrophobic.
3. They are polar, so they are hydrophilic.
4. They are polar, so they are hydrophobic.



Membrane components: proteins





The final shape of the protein determines its function.

What conditions can denature proteins?

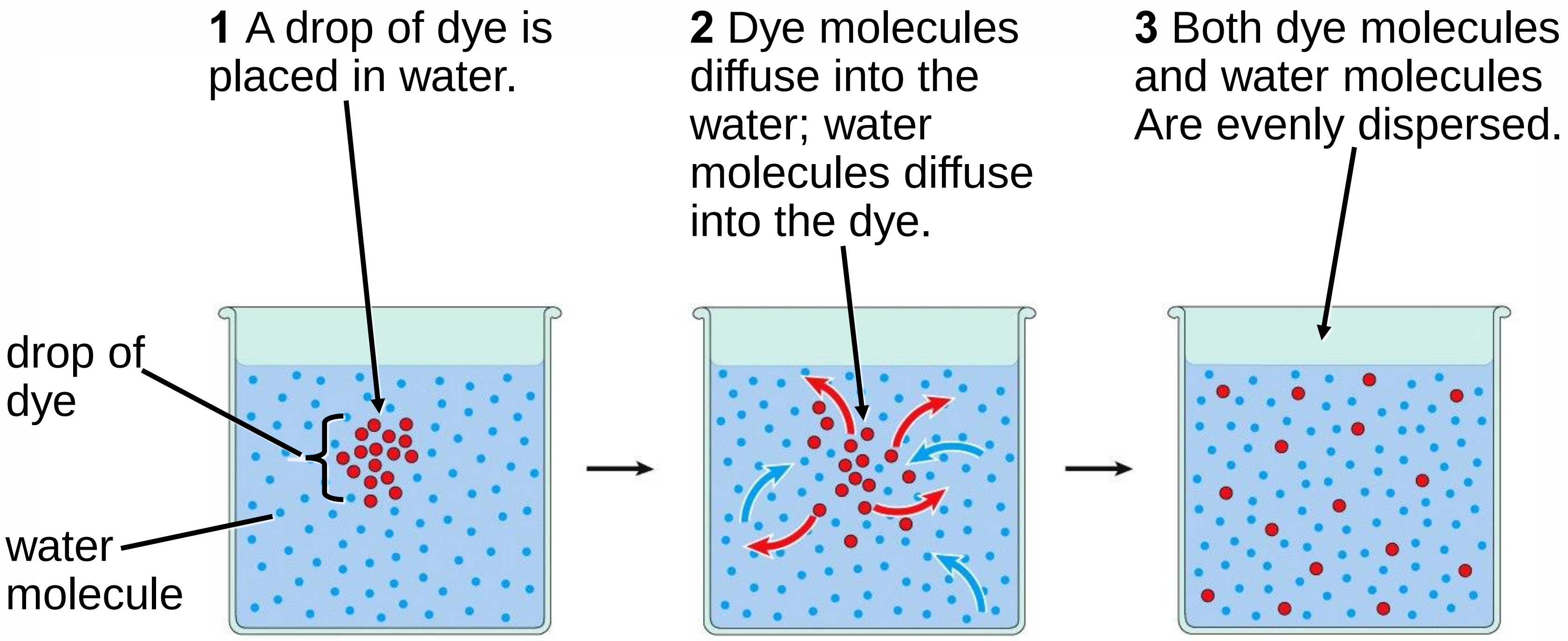
- Make some predictions:
  - What are some characteristics of molecules that can diffuse directly through the lipid layer of the cell membrane?
  - What are some characteristics of molecules that will need the assistance of carrier proteins to move through the membrane?

WORK TOGETHER

Transport of Materials

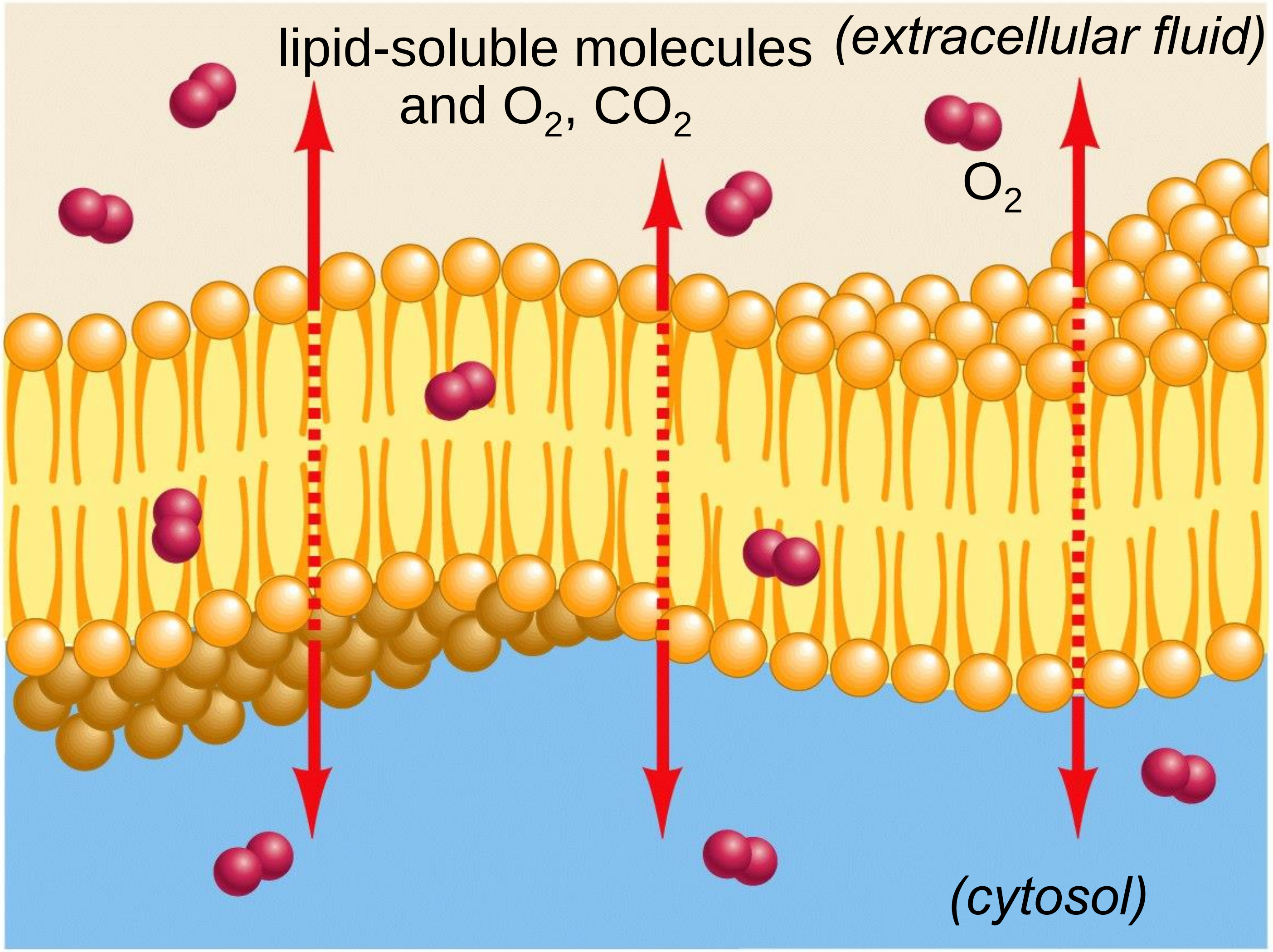
- **Passive transport:**
  - Simple diffusion
  - Facilitated diffusion
  - Osmosis
- **Energy-consuming transport:**
  - Active transport
  - Exo/Endocytosis

Diffusion



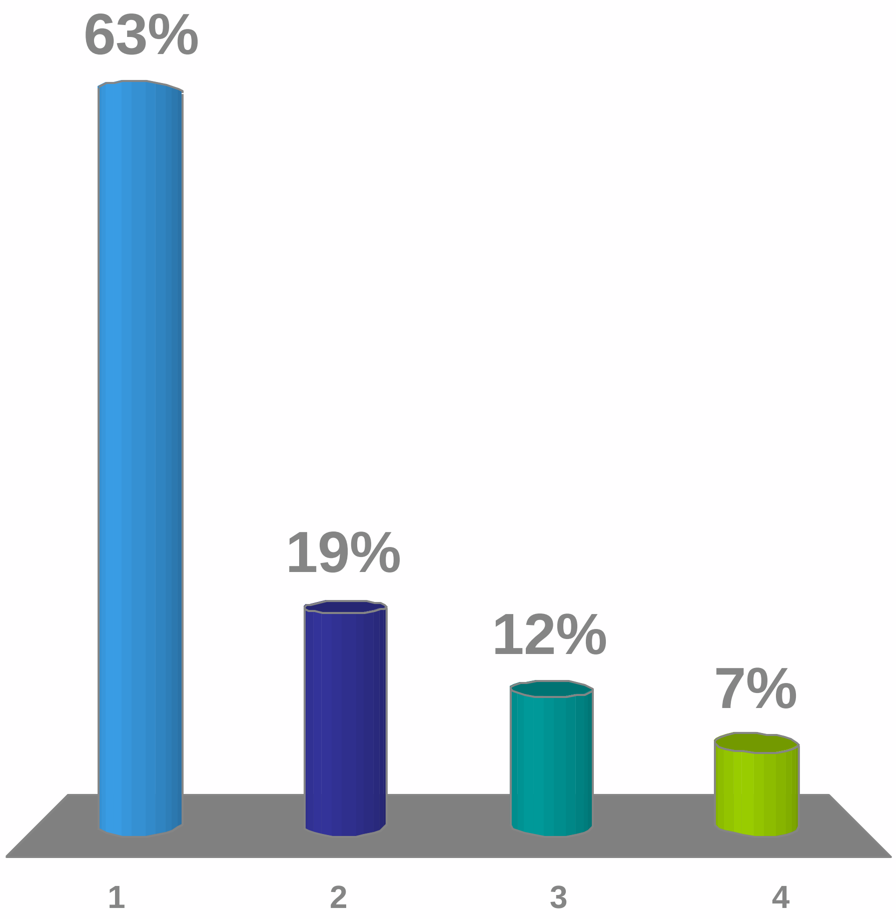
The movement of molecules in solution from a high concentration of that molecule in the direction of a low concentration of that molecule until equilibrium is reached.

Diffusion across a membrane

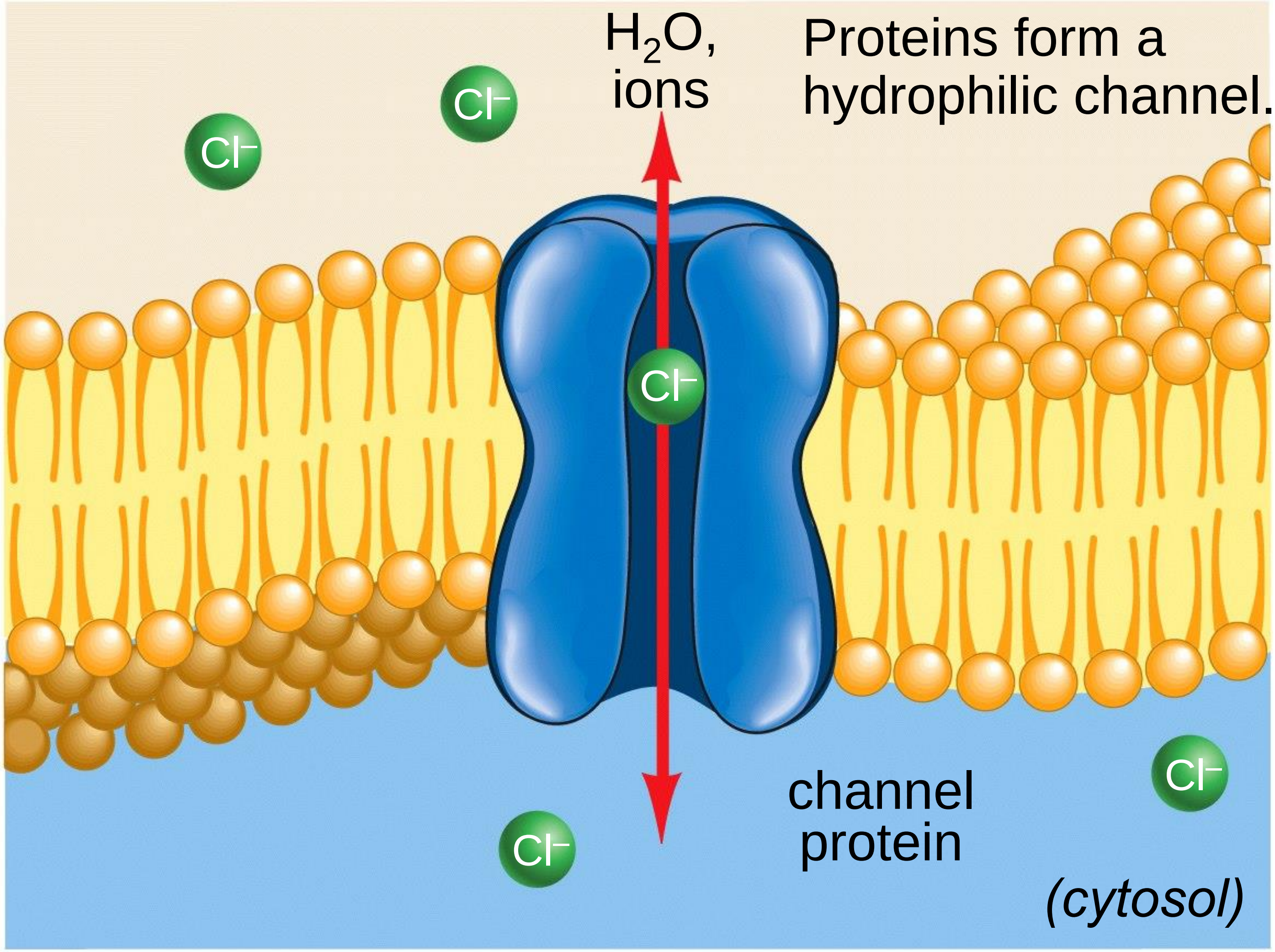


Why does passive diffusion through the lipid layer only occur with gases and small, lipid-soluble molecules?

1. These substances are non-polar, and so is the lipid layer.
2. These substances are polar, and so is the lipid layer.
3. These substances are non-polar, the lipid layer is polar.
4. These substances are polar, the lipid layer is non-polar.



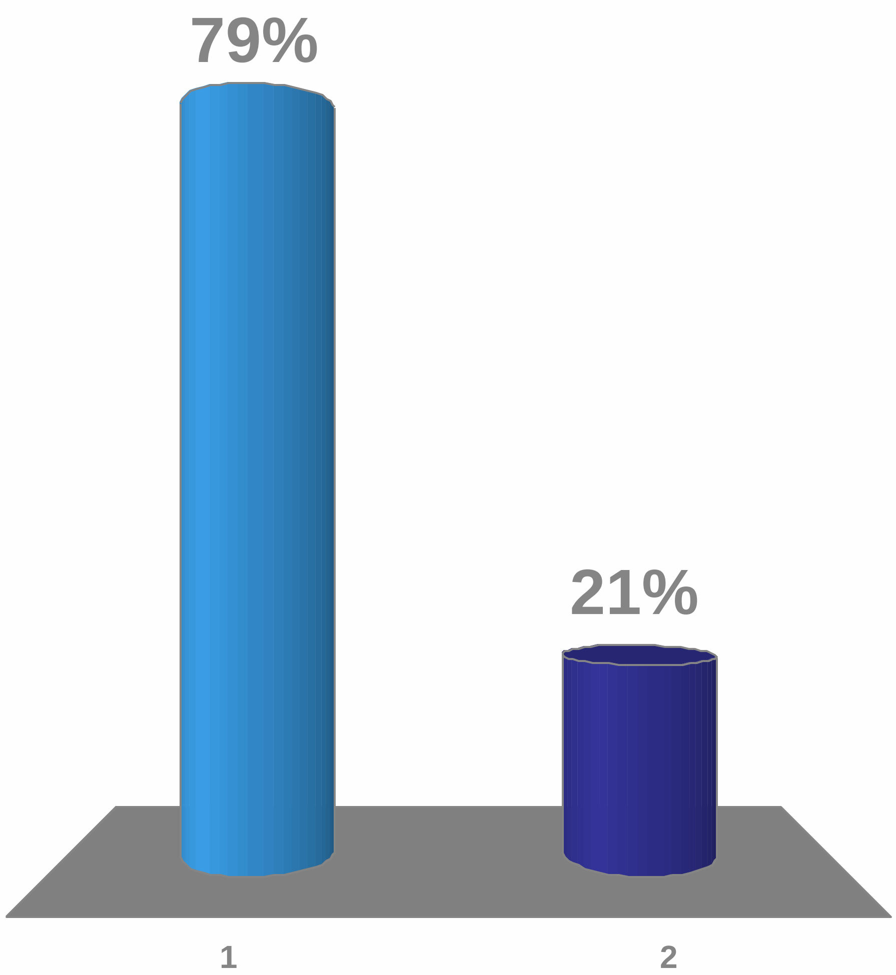
Facilitated diffusion



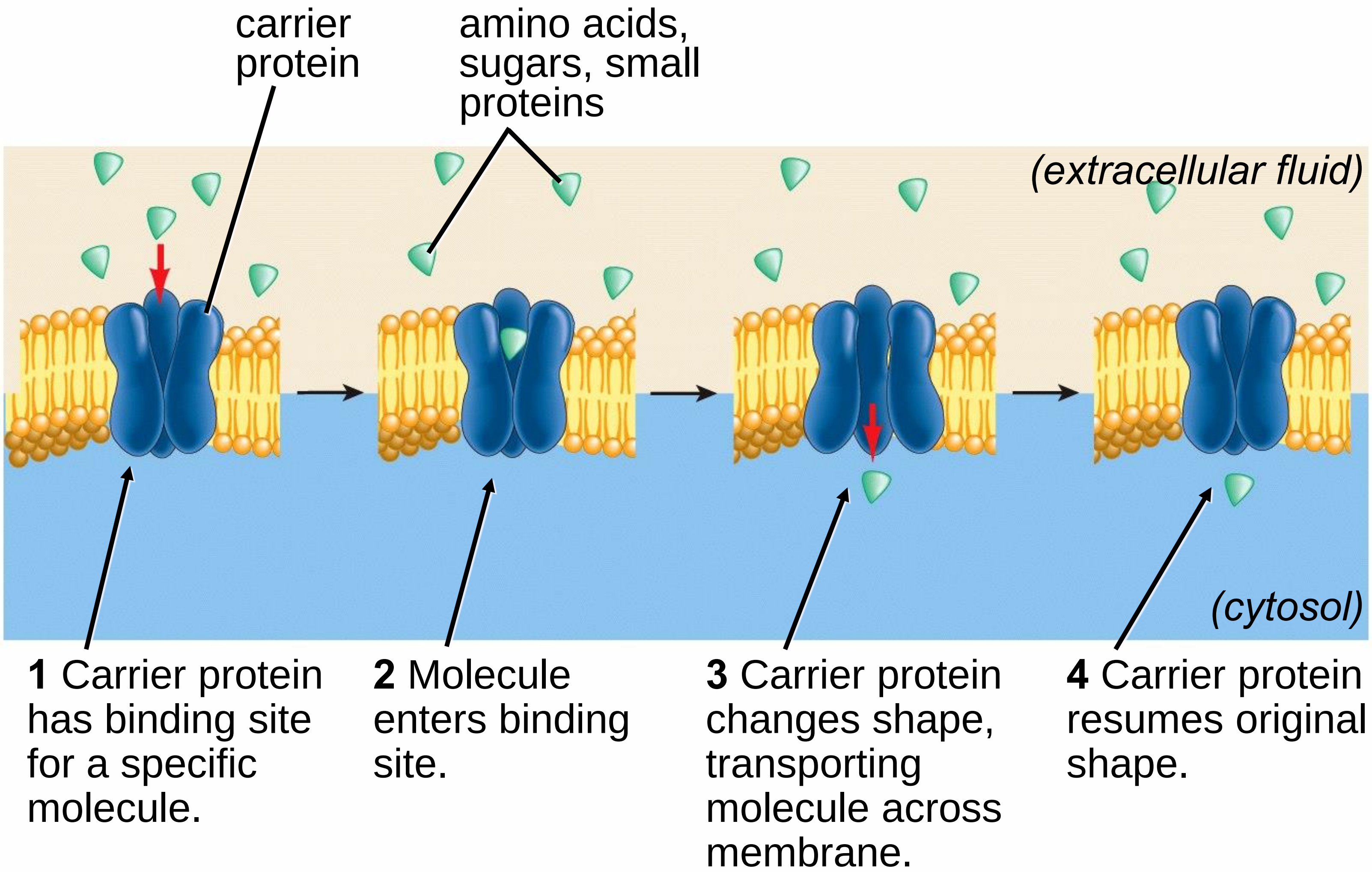
Why are channel proteins necessary to move hydrophilic ions through the membrane?

Why are channel proteins necessary to move hydrophilic ions through the cell membrane?

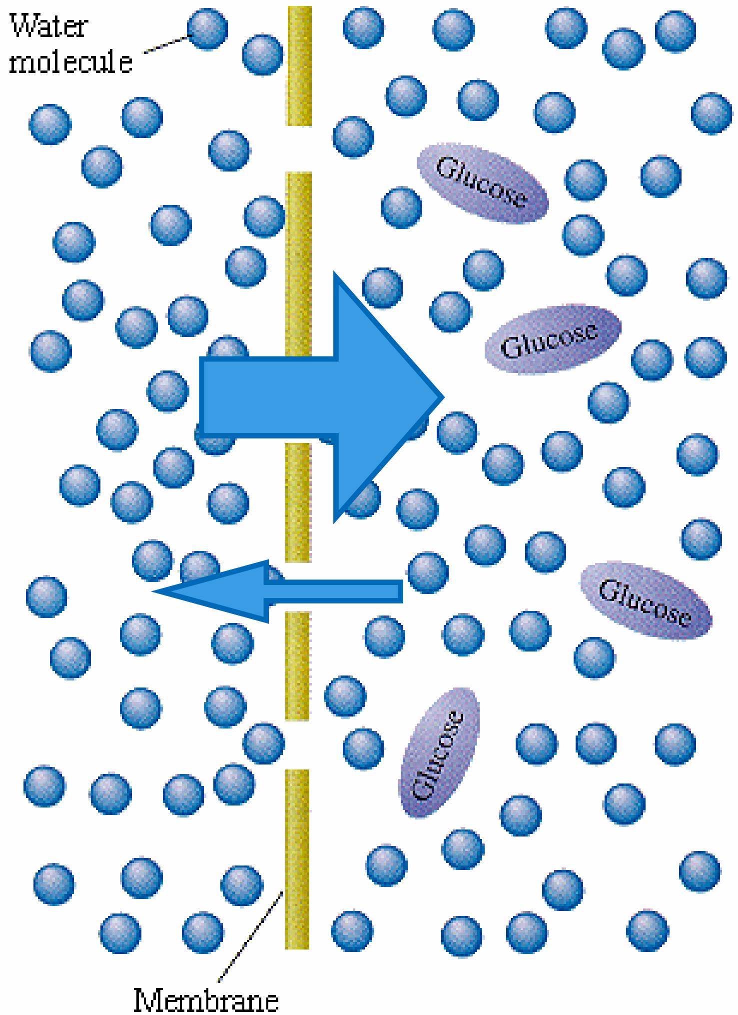
1. Ions are charged; they cannot go through a non-polar lipid layer.
2. Ions are not charged; they cannot move through a non-polar lipid layer.



Passive transport by facilitated diffusion



Osmosis



Which direction will water move here?

The **diffusion**

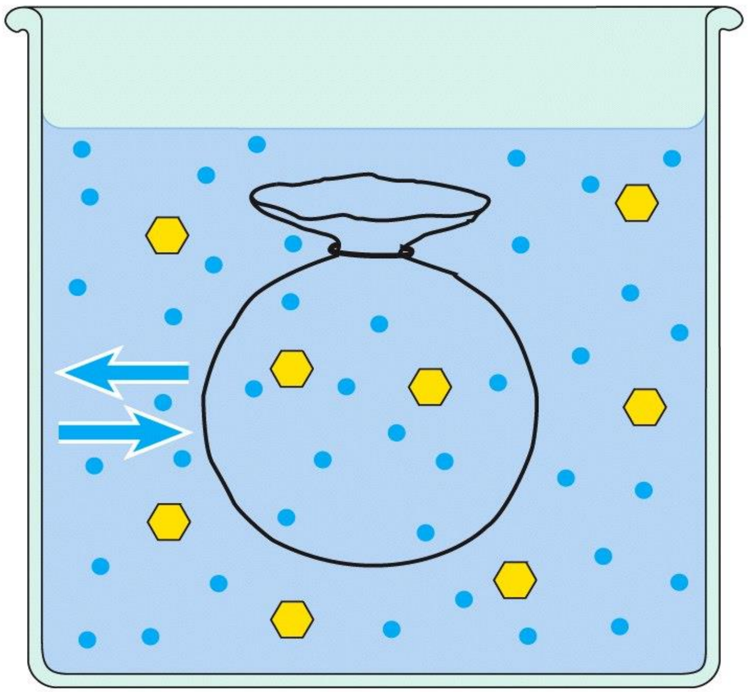
of **water**

through a semi-permeable **membrane.**

Water moves from *its own* high concentration to *its own* low concentration.

Tonicity

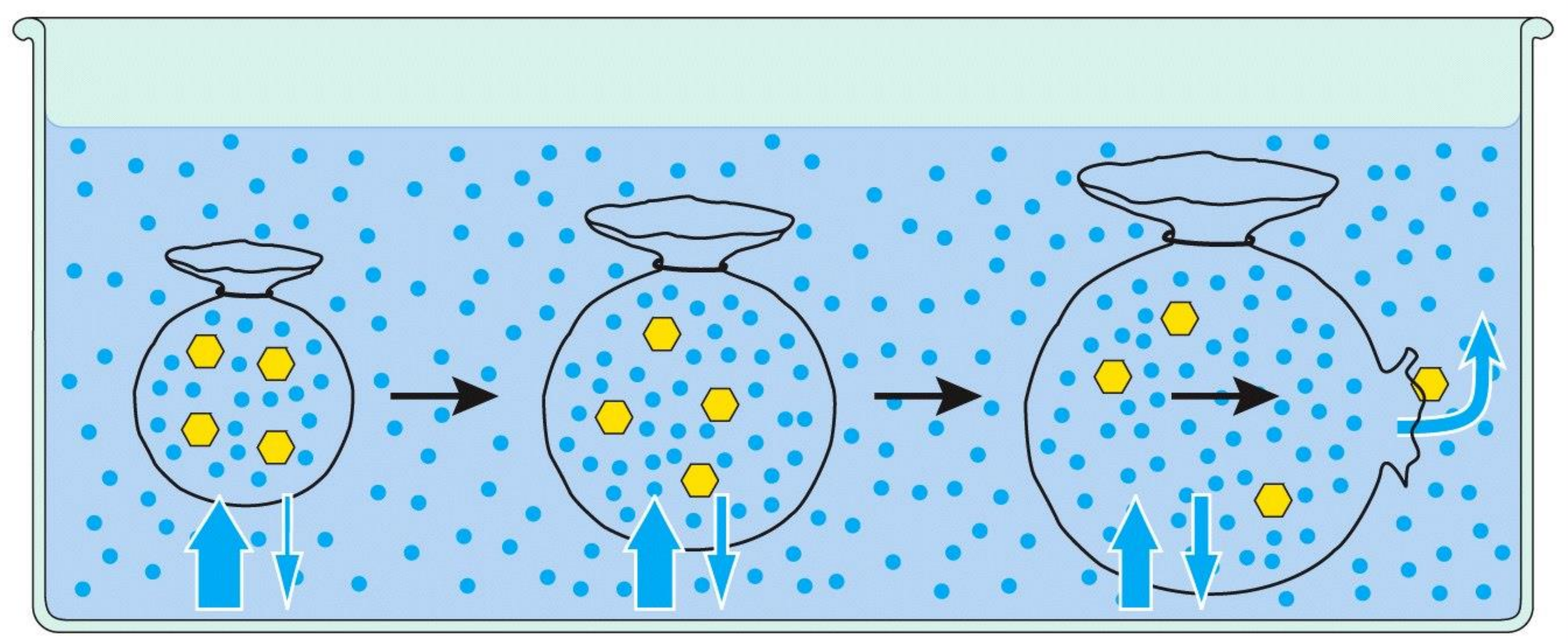
If the contents of a cell and the fluid around the cell have the same concentration of dissolved solutes...



...the fluid is **isotonic** compared with the cell. Water moves in and out in equal amounts.

Tonicity

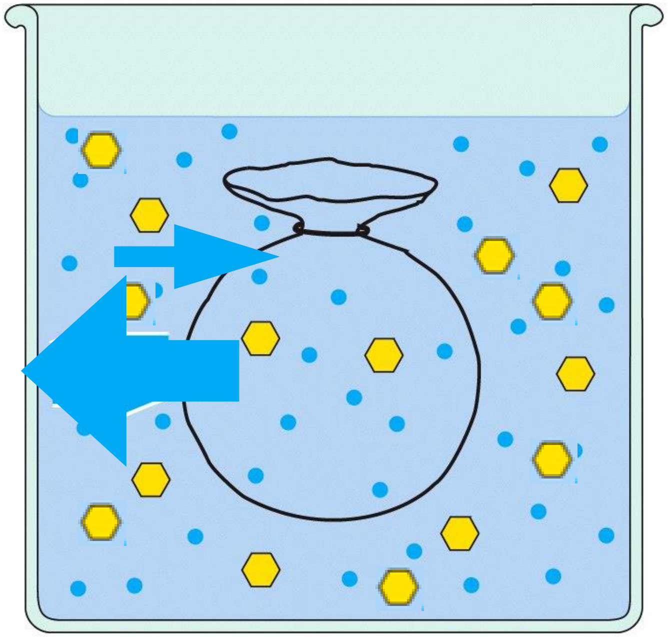
If the the fluid around the cell contains **less** dissolved solute than the fluid in the cell...



...the fluid is **hypotonic** compared with the cell. More water enters the cell than leaves. The cell may swell to the point of bursting.

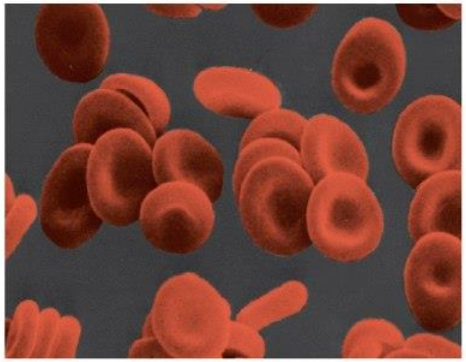
Tonicity

If the fluid around the cell contains **more** dissolved solute than the fluid inside the cell...

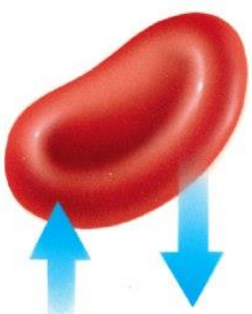


...the fluid is **hypertonic** compared with the cell. More water leaves the cell than enters. The cell shrinks.

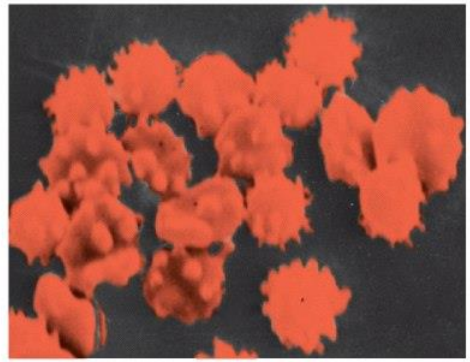
What is the tonicity of the solutions that these red blood cells have been dropped into?



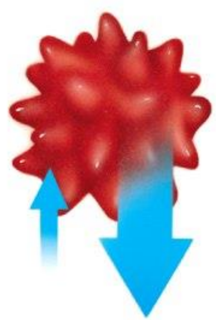
(a) Isotonic solution



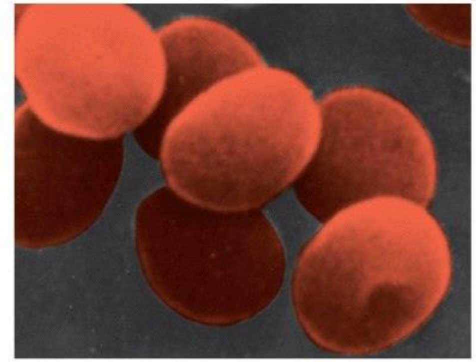
Equal movement of water into and out of cells.



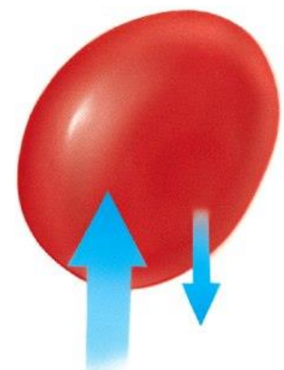
(b) Hypertonic solution



Net water movement out of cells.



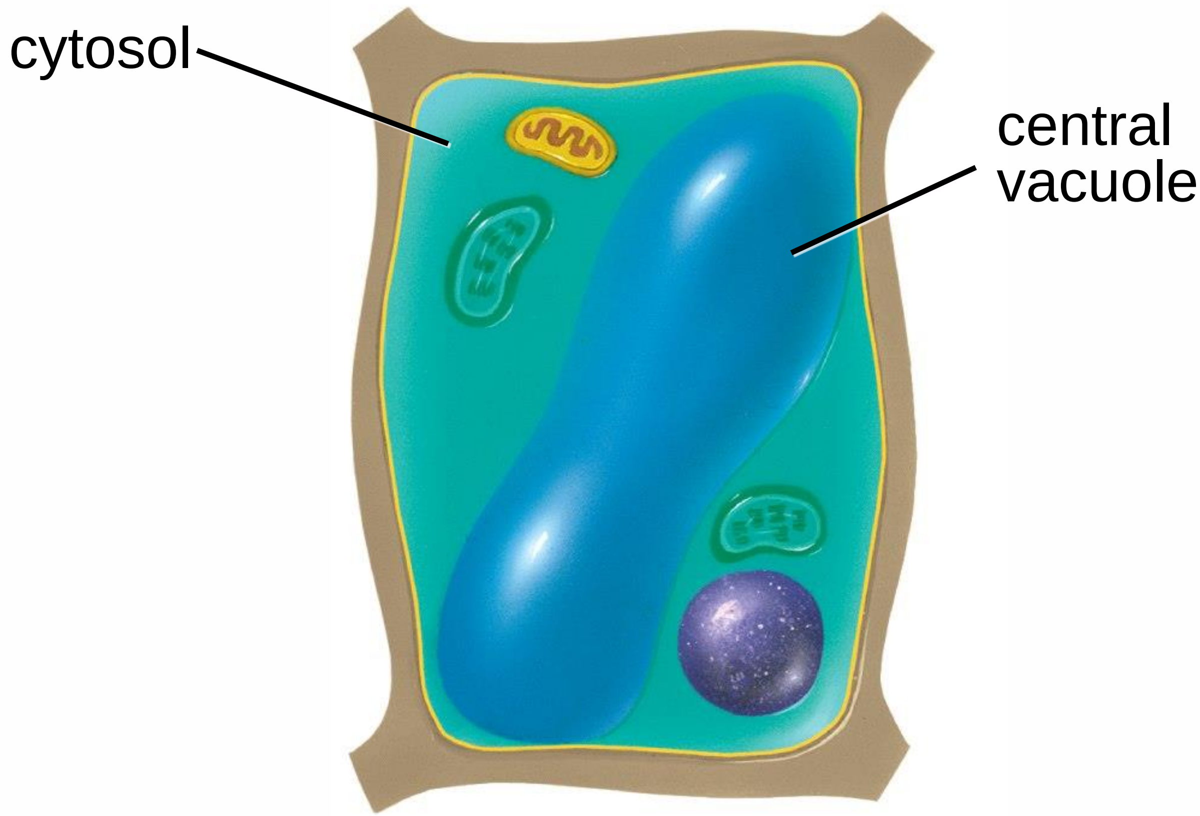
(c) Hypotonic solution



Net water movement into cells.

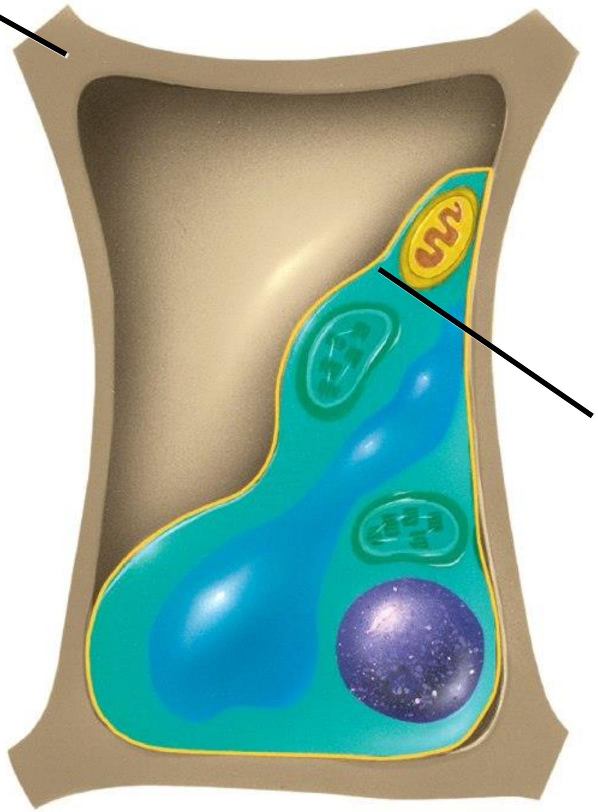
WORK TOGETHER

Tonicity and plant cells



When water is plentiful, it fills the central vacuole, pushes the cytosol against the cell wall, and helps maintain the cell's shape.

Tonicity and plant cells



When water is scarce, the central vacuole shrinks and the cell wall is unsupported.

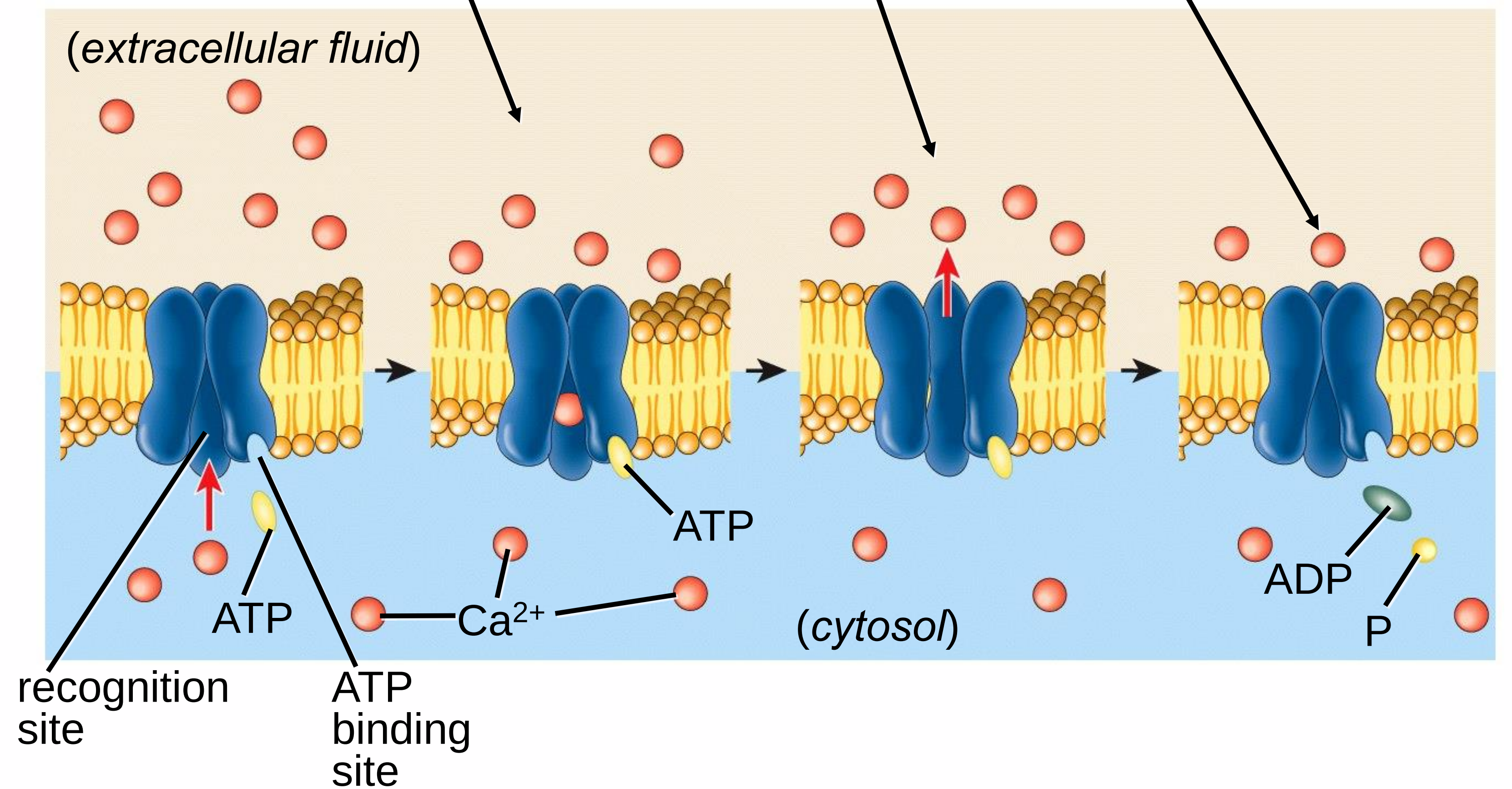
Plants wilt when water is scarce. They also wilt if salt is added to the soil. Why?

Active Transport

1 The transport protein binds both ATP and Ca^{2+}.

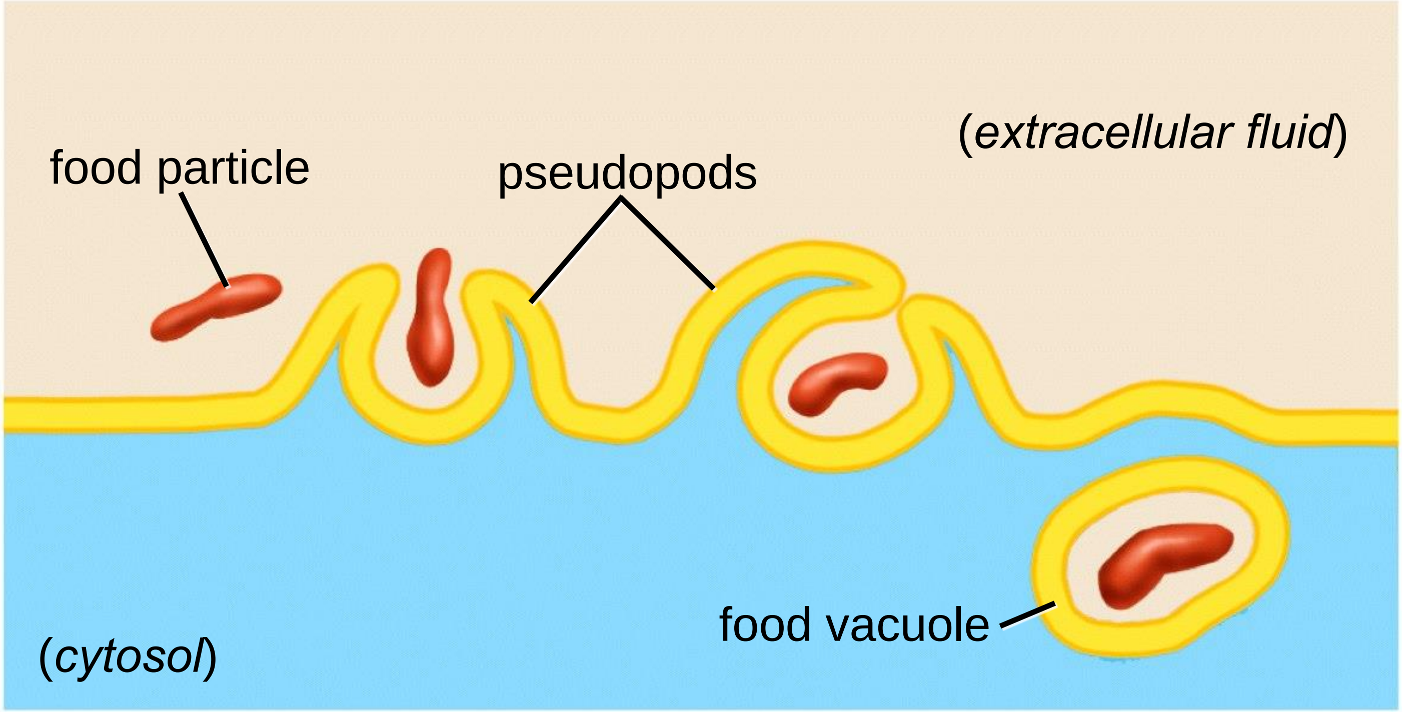
2 Energy from ATP Changes the shape of the transport protein and moves the ion across the membrane.

3 The protein releases the ion and the remnants of ATP (ADP and P) and closes.

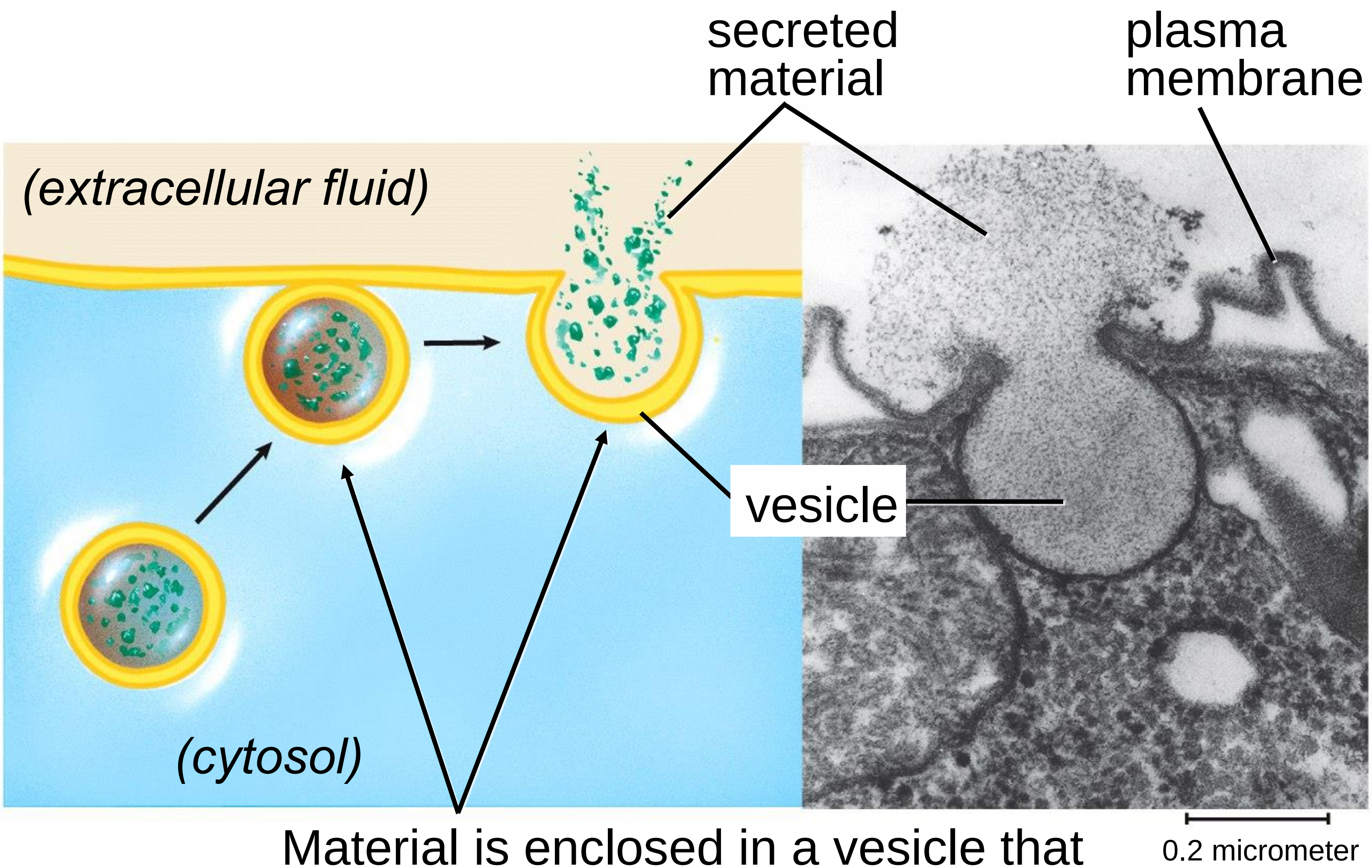


Endocytosis

Phagocytosis is one example of endocytosis.



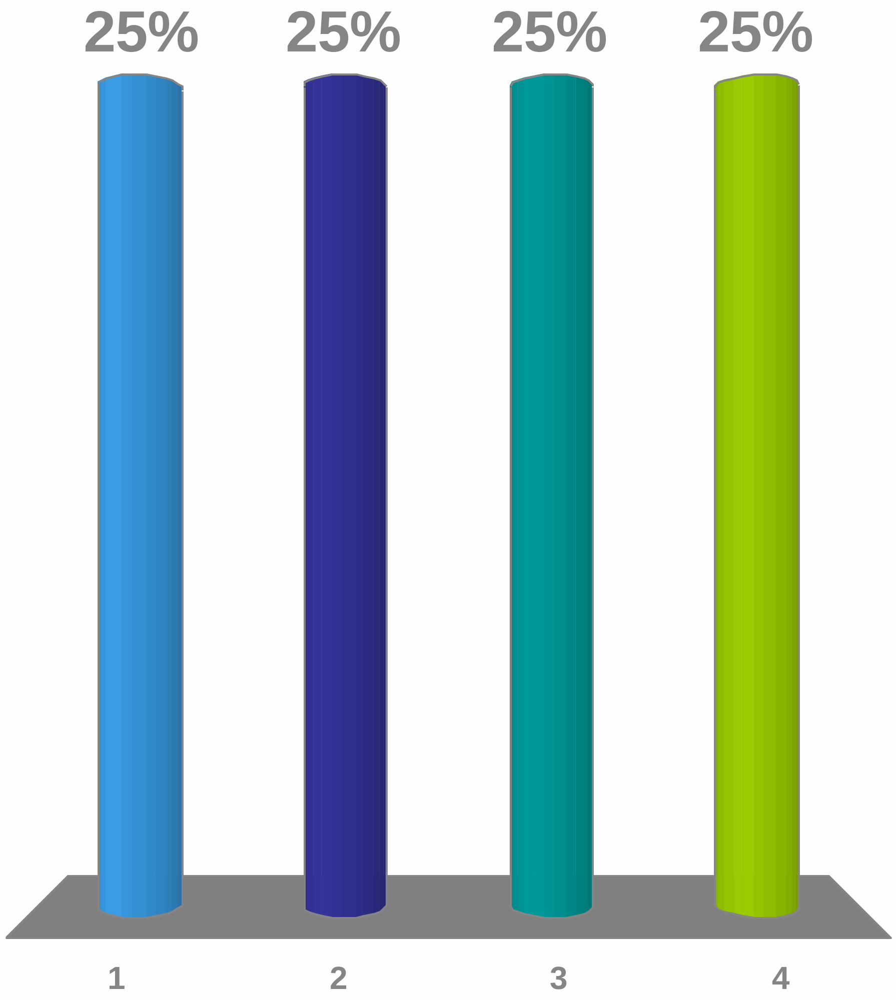
Exocytosis



Material is enclosed in a vesicle that fuses with the plasma membrane, allowing its contents to diffuse out.

If a plant cell needs to concentrate sugar in a cell, what kind of transport will it use?

1. Simple diffusion.
2. Facilitated diffusion.
3. Active transport.
4. Osmosis.



- Osmosis is a kind of diffusion. Summarize what makes osmosis a special type of diffusion.

WORK TOGETHER

- How does pore size affect the diffusion of different molecules?

- Biological membranes are selectively permeable; some molecules can cross while others cannot. One way to affect this is through pore size.

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Recap

- Cell parts, such as cell membranes, are made up of biological molecules.
- The form and properties of the molecules determine their functions.
- Cell membranes actively and passively control what materials enter and leave the cell.

Membrane Fluidity

- Explain the function of membrane fluidity in the structure of cells

Key Points

- The membrane is fluid but also fairly rigid and can burst if penetrated or if a cell takes in too much water.
- The mosaic nature of the plasma membrane allows a very fine needle to easily penetrate it without causing it to burst and allows it to self-seal when the needle is extracted.

- If saturated fatty acids are compressed by decreasing temperatures, they press in on each other, making a dense and fairly rigid membrane.
- If unsaturated fatty acids are compressed, the “kinks” in their tails push adjacent phospholipid molecules away, which helps maintain fluidity in the membrane.

- The ratio of saturated and unsaturated fatty acids determines the fluidity in the membrane at cold temperatures.
- Cholesterol functions as a buffer, preventing lower temperatures from inhibiting fluidity and preventing higher temperatures from increasing fluidity.

In a nut shell

- The mosaic nature of the membrane, its phospholipid chemistry, and the presence of cholesterol contribute to membrane fluidity.

Key Terms

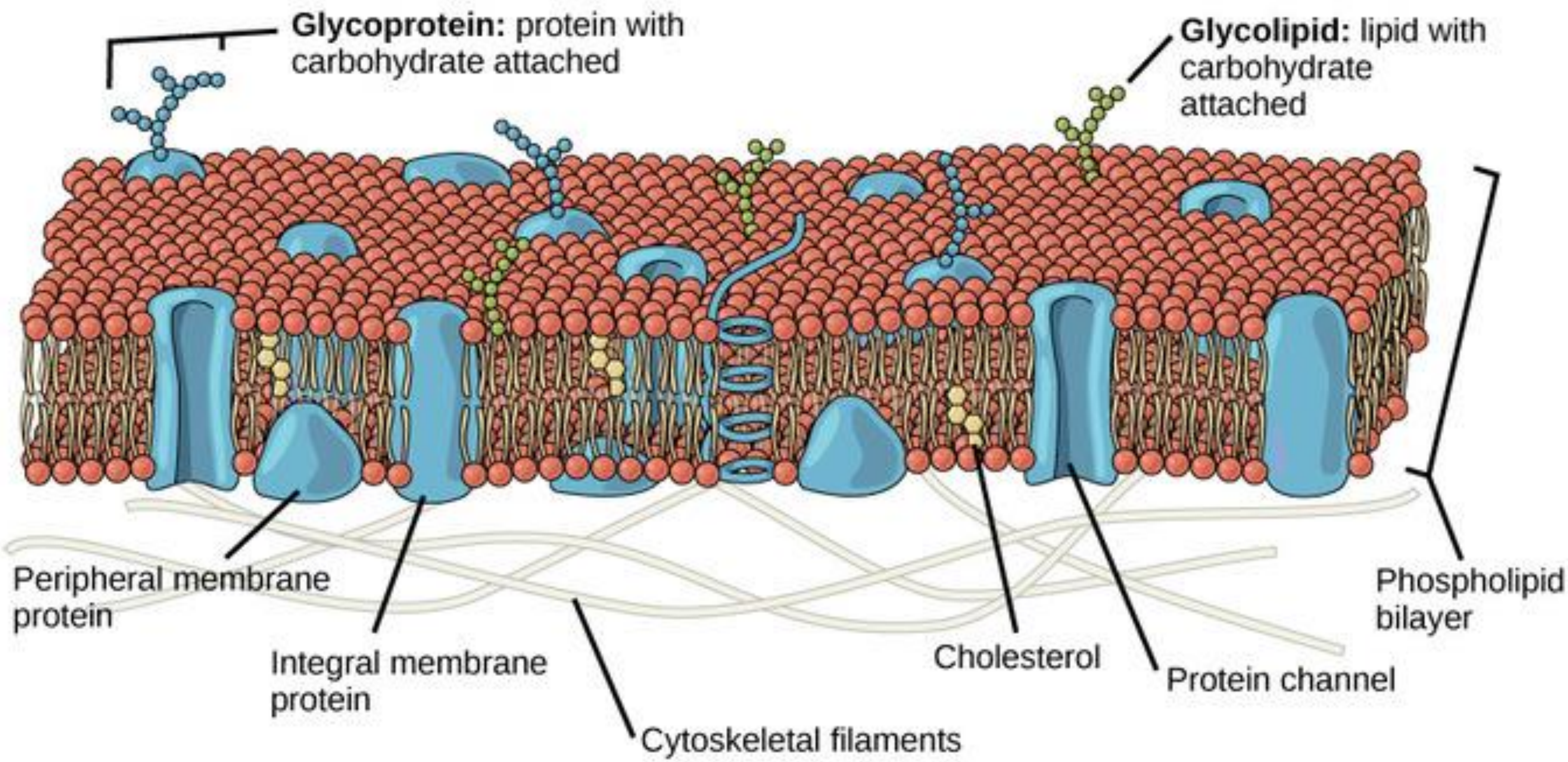
- **phospholipid**: Any lipid consisting of a diglyceride combined with a phosphate group and a simple organic molecule such as choline or ethanolamine; they are important constituents of biological membranes
- **fluidity**: A measure of the extent to which something is fluid. The reciprocal of its viscosity.

- There are multiple factors that lead to membrane fluidity.
- First, the mosaic characteristic of the membrane helps the plasma membrane remain fluid.
- The second factor that leads to fluidity is the nature of the phospholipids themselves.

First

- The integral proteins and lipids exist in the membrane as separate but loosely-attached molecules.
- The membrane is not like a balloon that can expand and contract; rather, it is fairly rigid and can burst if penetrated or if a cell takes in too much water.

- However, because of its mosaic nature, a very fine needle can easily penetrate a plasma membrane without causing it to burst; the membrane will flow and self-seal when the needle is extracted.



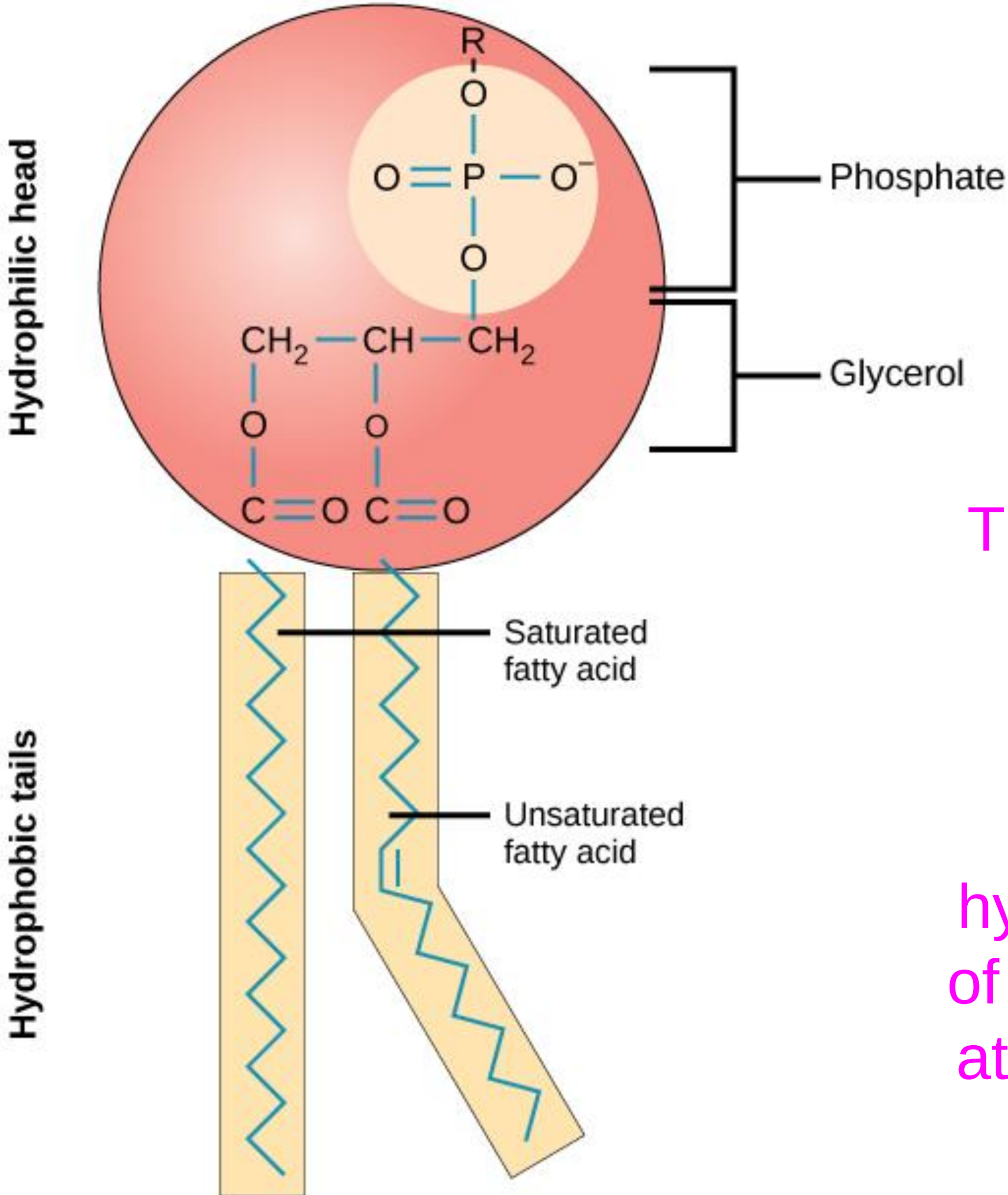
Membrane Fluidity: The plasma membrane is a fluid combination of phospholipids, cholesterol, and proteins. Carbohydrates attached to lipids (glycolipids) and to proteins (glycoproteins) extend from the outward-facing surface of the membrane.

Second

- The second factor that leads to fluidity is the nature of the phospholipids themselves.
- In their saturated form, the fatty acids in phospholipid tails are saturated with bound hydrogen atoms; there are no double bonds between adjacent carbon atoms.

- This results in tails that are relatively straight. In contrast, unsaturated fatty acids do not contain a maximal number of hydrogen atoms, although they do contain some double bonds between adjacent carbon atoms; a double bond results in a bend of approximately 30 degrees in the string of carbons.

- Thus, if saturated fatty acids, with their straight tails, are compressed by decreasing temperatures, they press in on each other, making a dense and fairly rigid membrane. If unsaturated fatty acids are compressed, the “kinks” in their tails elbow adjacent phospholipid molecules away, maintaining some space between the phospholipid molecules.



The structure of a phospholipid molecule: This phospholipid molecule is composed of a hydrophilic head and two hydrophobic tails. The hydrophilic head group consists of a phosphate-containing group attached to a glycerol molecule. The hydrophobic tails, each containing either a saturated or an unsaturated fatty acid, are long hydrocarbon chains.

- This “elbow room” helps to maintain fluidity in the membrane at temperatures at which membranes with saturated fatty acid tails in their phospholipids would “freeze” or solidify.
- The relative fluidity of the membrane is particularly important in a cold environment.

- cold environment tends to compress membranes composed largely of saturated fatty acids, making them less fluid and more susceptible to rupturing.
- Many organisms (fish are one example) are capable of adapting to cold environments by changing the proportion of unsaturated fatty acids in their membranes in response to the lowering of the temperature.

Third factor

- In animals, the third factor that keeps the membrane fluid is cholesterol.
- It lies alongside the phospholipids in the membrane and tends to dampen the effects of temperature on the membrane.
- Thus, cholesterol functions as a buffer, preventing lower temperatures from inhibiting fluidity and preventing higher temperatures from increasing fluidity too much.