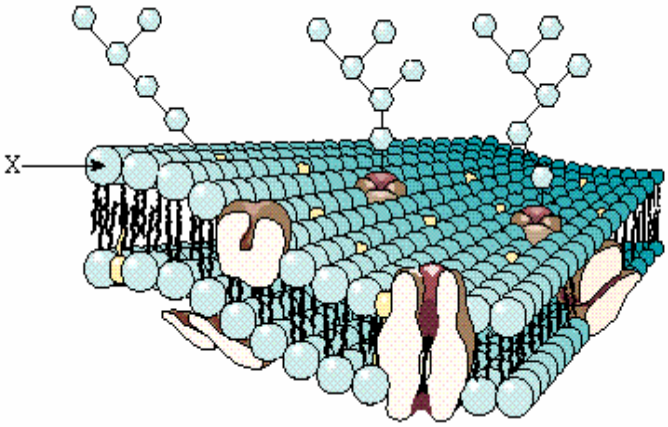
BIOLOGY 12 - Cell Membrane and Cell Wall Function: Chapter Notes

- *The cell membrane is the **gateway into the cell**, and must allow needed things such as **nutrients** into the cell without letting them escape. In the same way, it must allow **wastes** to leave the cell. A **wide variety** of molecules and substances must pass through the cell membrane -- large, small, **hydrophobic**, **hydrophilic**. Molecules of the **same size** must sorted out, and the cell must also be able to get **large amounts** of molecules in and out when necessary. How can the cell membrane accomplish this?*

- The answer lies in its structure. We already know about the **FLUID MOSAIC MODEL** of membrane structure. Why is it given that name?

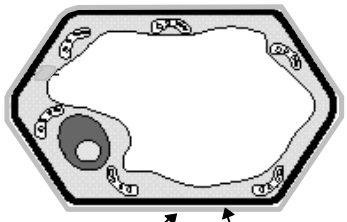
Review of FLUID MOSAIC MODEL:



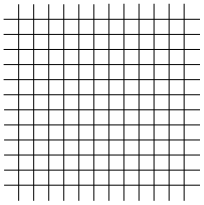
Please Label the Parts of the Cell Membrane

- **double layer** of **phospholipid** molecules ("X" on diagram)
- **consistency of light machine oil** (*~**fluid***)
- **proteins wholly or partly embedded** in phospholipid bilayer ➔ forms ***mosaic*** pattern
- **carbohydrates** strung together in chains are attached to proteins ("**glycoproteins**") or lipids ("**glycolipids**") of membrane. Function as **identification markers** for cell recognition (helps immune system identify which cells belong to body and which are invaders).
- is **SELECTIVELY PERMEABLE**: some molecules enter the cell, while other molecules (which can be the same size) are not allowed to enter. The cell membrane can **discriminate** between different molecules that are the **same size**!
- all living cells, whether plant, animal, fungal, protozoan, or bacterial, are surrounded by cell membranes

Plant Cell Wall



- **plants** have **cell walls** in addition to cell membranes. The cell wall lies **outside** the cell membrane.
- *(bacteria have cell walls too, but bacterial cell walls are NOT the same in composition as plant cell walls).*
- **thickness** of cell wall varies with cell function
- **primary cell wall** is outermost layer, composed of threadlike **cellulose microfibrils**.
- sticky substance called **middle lamella** binds cells together



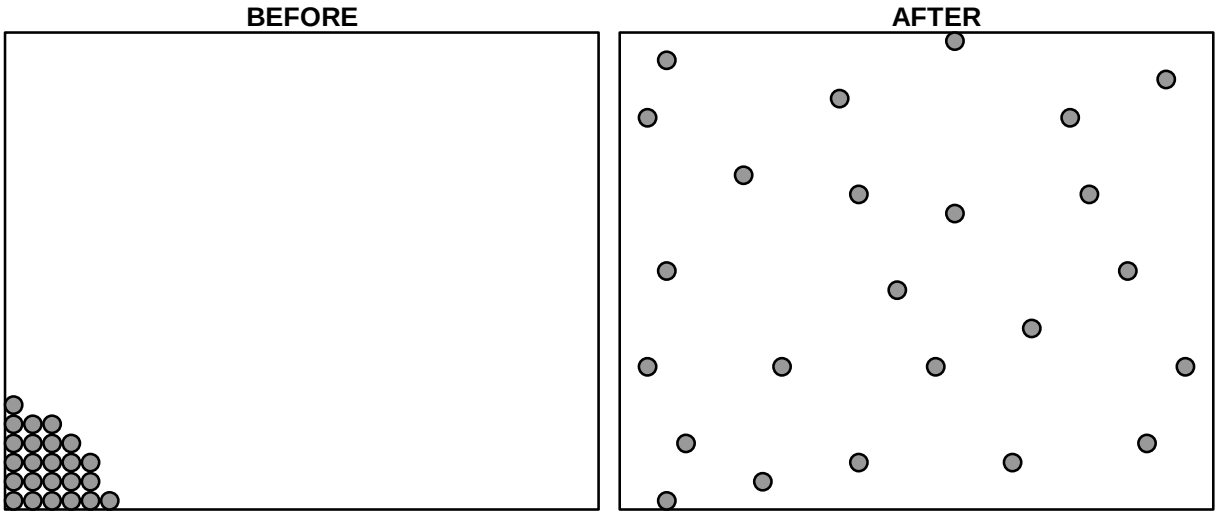
Cellulose Microfibrils

- woody plants also have a **secondary cell wall** which forms inside the primary wall. Composed of alternating layers of cellulose microfibrils reinforced with **lignin** (which adds strength). Function is **support** of large plants. **Wood** is made largely of secondary cell wall material.
- Cellulose of plant cell walls used by humans: **cotton, rayon, flax, hemp, paper, wood, paper** (paper has lignin removed to prevent yellowing). Lignin used in manufacture of rubber, plastics, pigments, adhesives.
- plant cell wall is **SEMI-PERMEABLE** (anything small enough to fit through openings in cellulose microfibrils will get through).
- plant cell therefore relies instead on its cell membrane to regulate what gets in and out.

THERE ARE **THREE GENERAL MEANS BY WHICH SUBSTANCE CAN ENTER AND EXIT CELLS**:

Name	Examples
1. **DIFFUSION**	lipid-soluble molecules, water, gases
2. **TRANSPORT BY CARRIERS** (i.e. active and facilitated transport)	sugars and amino acids sugars, amino acids., ions
3. **ENDOCYTOSIS AND EXOCYTOSIS** (e.g. **pinocytosis** and **phagocytosis**)	macromolecules (e.g. proteins), cells or subcellular material

Diffusion



- diffusion is a **physical process** that can be observed with **any type of particle**. A **UNIVERSAL PHENOMENON**.
- **Law of Diffusion**: particles **MOVE FROM THE AREA OF GREATER CONCENTRATION TO THE AREA OF LESSER CONCENTRATION UNTIL EQUALLY DISTRIBUTED**.
- for instance: *opening a perfume bottle* in corner of a room. The smell of perfume soon permeates the room because the molecules that make up the perfume have drifted to all parts of the room. e.g. dropping dye into water.
- movement by diffusion **requires no energy** to be added (although adding energy (i.e. heat) will speed it up).
- diffusion is a **slow** process. The rate of diffusion is affected by the **concentration gradient** (the **difference in concentration** of the diffusing molecules between the two regions), the **size & shape** of the molecules, and the **temperature**. Diffusion in liquid is slower than in gas. However, distribution of molecules in cytoplasm is **speeded up** by an ever-constant flow of the cytoplasm that is called **cytoplasmic streaming**.

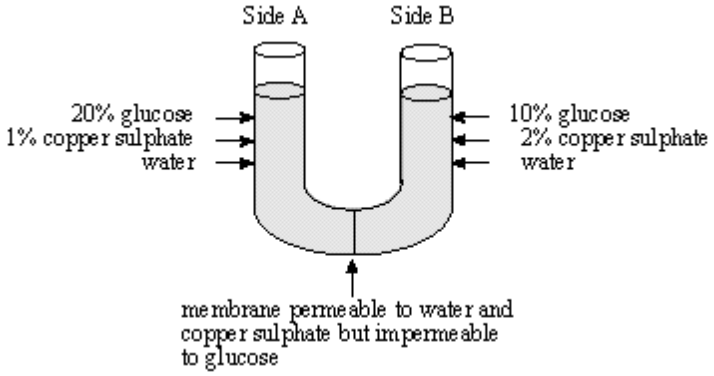
Three Ways of increasing the rate of diffusion:

1. **increase the temperature**
2. **increase the concentration gradient**
3. **decrease the size of the diffusing molecules**

- The properties of the cell membrane allow **few types** of molecules to pass by diffusion: **Lipid-soluble** molecules like **steroids** and **alcohols** can diffuse directly across because the membrane itself is made of lipids.
- **water** diffuses readily across membrane, probably through **charged, protein-lined pores** in the membrane (remember, water is not lipid-soluble) that will not allow anything else but water through.

Osmosis

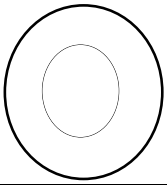
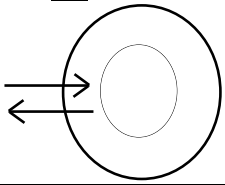
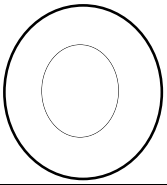
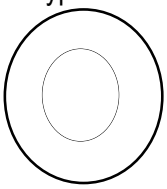
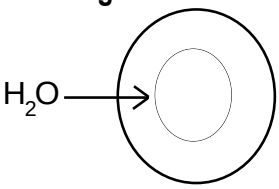
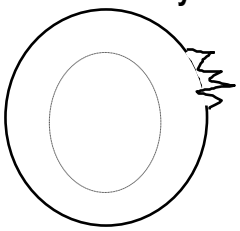
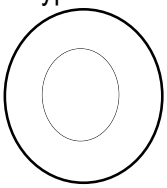
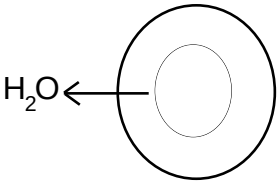
- the movement of water across a selectively permeable membrane is **a special case of diffusion** called **OSMOSIS**.
- **Definitions**:
  Osmosis: ***the net movement of water molecules from the area of greater concentration to the area of lesser concentration across a selectively-permeable membrane***.
  Solute: particles which are dissolved in water
  Solvent: liquid which dissolves the solute. This is water when we are talking about osmosis.
  Solution: combination of solute and solvent.
  Osmotic Pressure: the pressure due to the flow of water from the area of greater concentration to the area of lesser concentration. The **greater the concentration difference** across the membrane, the **greater the osmotic pressure**.



Explain what would happen to the concentrations of water, glucose, and copper sulphate on side A of this experiment.

- In cellular systems, **water can move easily across membranes**, but other molecules can't. Therefore, it is often **only water** that can move and follow the law of diffusion. According to the law of diffusion, water will move from where it is more concentrated (i.e. solution that has **less** solute in it) to where it is less concentrated (i.e. solution that has **more** solute in it). This has important consequences on living systems.
- **Cells may be placed in solutions** that contain the same number of solute molecules per volume as the cell (**= isotonic solution**), a greater number of solute molecules per volume (**= hypertonic solution**), or a lesser number of solute molecules per volume than the cell (**= hypotonic solution**).

Summary of what happens to <u>ANIMAL</u> <u>CELLS</u> placed in different tonicities of solution:

Tonicity of Solution Cell is Put Into	Net Movement of Water	Effect on Cell
Isotonic 	No <u>net</u> movement 	Remains the same 
Hypotonic 	Cell **gains** water 	Cell **Swells & May Burst**  "**lysis**"
Hypertonic 	Cell **loses** water 	Cell Shrinks  "**crenation**"

Isotonic ("same" "strength") solution:

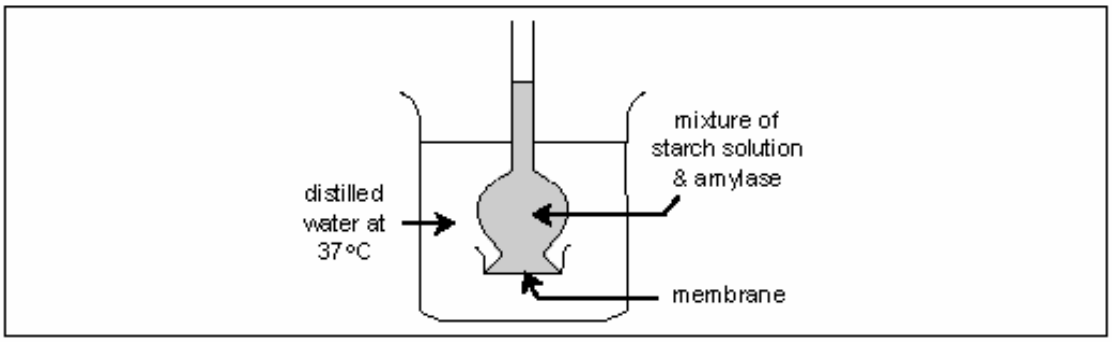
- **no net movement** of water across membrane.
- **Same number** of solute molecules per unit volume
- Cells placed in such a solution **neither** gain or lose water
- a **0.9 percent solution of NaCl is isotonic to red blood cells** (RBC). *How can you tell this is so*?

Hypotonic Solutions ("hypo" means "less than")

- these solutions have **lower concentration** of **solute** than the cell contents.
- if cell placed in hypotonic solution, **water will enter cell**, it will **<u>swell</u> <u>and</u> <u>possibly</u> <u>burst</u>**.
- e.g. a salt solution with a concentration lower than 0.9% is hypotonic to RBC.

Hypertonic Solutions ("greater" "strength")

- **<u>greater</u> <u>concentration</u>** (symbol for concentration ="[ ]") of solute than the cell (and therefore a lesser [ ] of water
- if a cell is placed in hypertonic solution, water will leave the cell and the cell will **shrivel** up. This is called **<u>CRENATION</u>** in animal cells. e.g. a 10% solution of NaCl is hypertonic to RBC -- they'll shrink

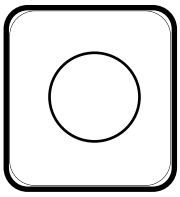
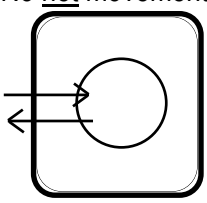
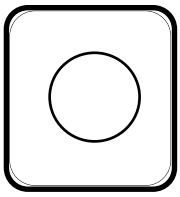
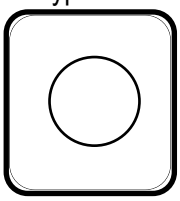
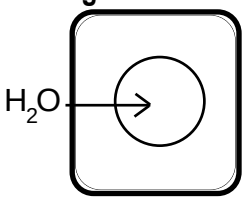
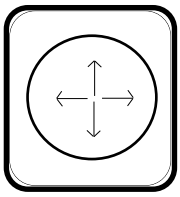
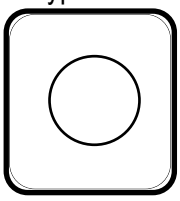
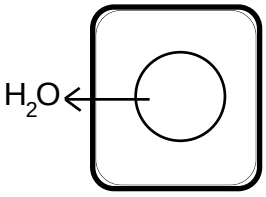
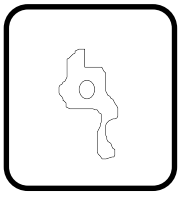


1. A student set up the experiment illustrated above and kept it at 37°C. After five minutes, the distilled water in the beaker was tested and found to contain a sugar but no starch.

   a) What had occurred inside the tube? **(1 mark)**

Significance of Tonicity to <u>PLANT</u> <u>CELLS</u>

Summary of what happens to <u>PLANT</u> <u>CELLS</u> placed in different tonicities of solution:

Tonicity of Solution Cell is Put Into	Net Movement of Water	Effect on Cell
Isotonic 	No <u>net</u> movement 	Remains the same 
Hypotonic 	Cell **gains** water 	Greater water pressure inside cell  "**turgor pressure**"
Hypertonic 	Cell **loses** water 	Cell Contents Shrink, but cell wall retains its shape  "**plasmolysis**"

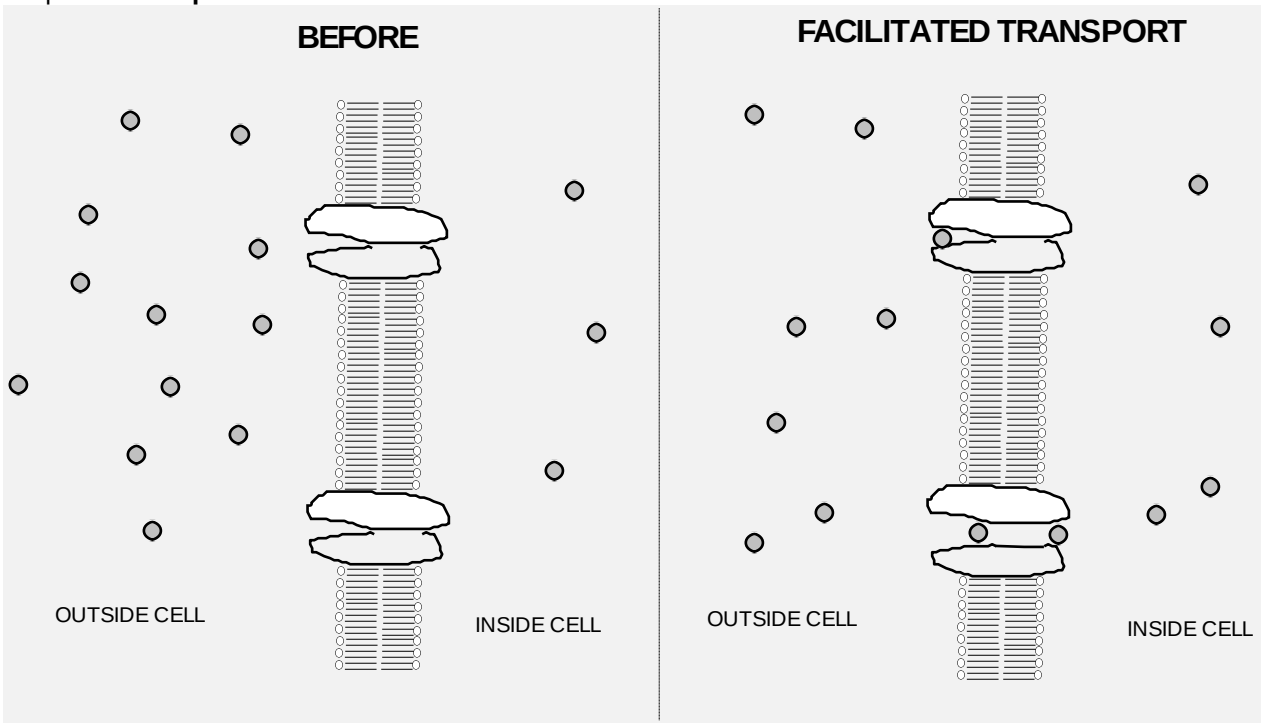
- **Hypertonic solutions** cause **<u>PLASMOLYSIS</u>** (shrinking of cell due to osmosis).
- **central vacuole loses water**, cell membrane shrinks and pulls away from cell wall.
- **Hypotonic solutions** causes **<u>TURGOR</u> <u>PRESSURE</u>,** against rigid cell wall (turgor pressure occurs when plant cells, placed in hypotonic solution, admit water. As water enters, **pressure builds up inside the cell** (*<u>hydrostatic</u> <u>pressure</u>*). When hydrostatic pressure = osmotic pressure, the plant is said to have developed turgor pressure).

- cell wall keeps cell from bursting
- **osmosis continues until turgor pressure = osmotic pressure**
- turgor pressure important for plant cells to **retain erect positions.** Now you should be able to explain why plants wilt when you don't water them!

TRANSPORT BY CARRIERS

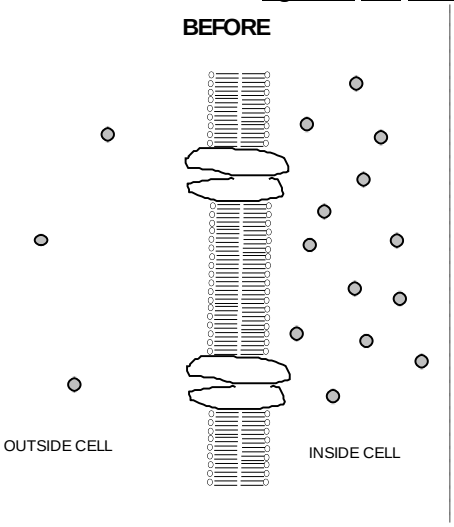
FACILITATED TRANSPORT

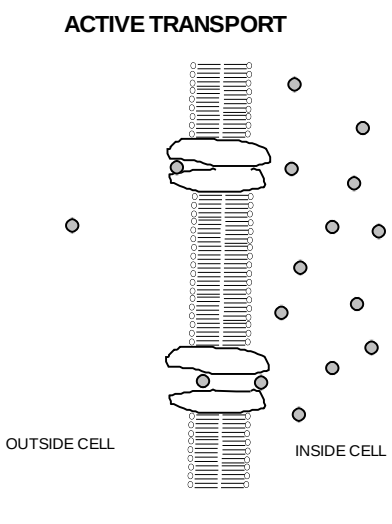
- utilizes **PROTEIN CARRIERS** in cell membrane to control passage of molecules in and out of cell.
- are **highly specific** - each carrier passes only one type molecule
- molecules only pass along concentration gradient.
- **REQUIRES NO ENERGY** - is like diffusion in this sense
- explains how **lipid-insoluble molecules** like **GLUCOSE** and **AMINO ACIDS** cross the cell membrane.



ACTIVE TRANSPORT

- also performed by **protein carriers**
- **REQUIRES ENERGY** (ATP)
- moves molecules **against the concentration gradient** (i.e. in the opposite direction of diffusion).





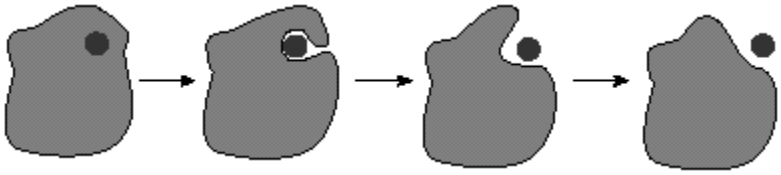
- molecules **move from area of lower concentration to area of higher concentration**.
- Active Transport **vitally important** to organisms:
  e.g. **Iodine & Thyroid Gland**. $[I^-]$ is low in blood, high in Thyroid Gland. Active Transport moves I^- from blood to thyroid.
  e.g. Na^+ actively transported out of urine by kidney tubule cells
  e.g. **sodium/potassium pump** in nerve/muscle cells (see text). Moves Na^+ from inside to outside of cell, and K^+ from outside to inside.
  e.g. Na^+ Cl^- and **cystic fibrosis** - a **genetic disease**, usually **fatal**, caused by **blockage of Cl^- transport**.

ENDOCYTOSIS AND EXOCYTOSIS

- another way to get molecules, **especially large particles**, in and out of cell.
- **ENDOCYTOSIS**: cell membrane forms a **vesicle** around the substance to be taken in.
  - **Phagocytosis**: what you call endocytosis if particles taken in really large (like other cells - e.g. human macrophages). Can be see with **light** microscope.

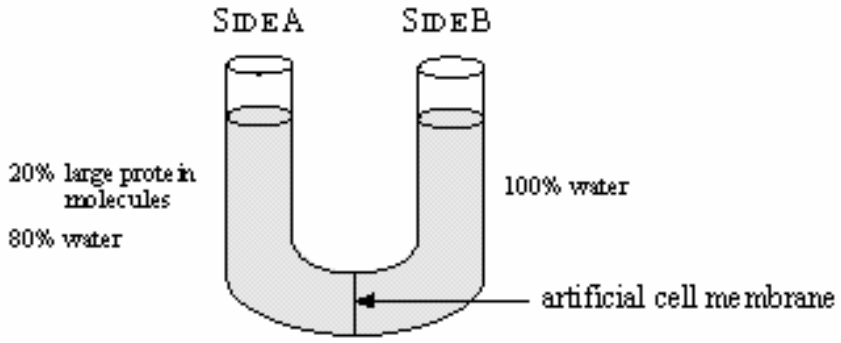
  - **Pinocytosis**: (= cell drinking) - same idea as phagocytosis, except smaller particles taken in (requires electron microscope to see).

- **EXOCYTOSIS**: **Reverse of endocytosis**. Vacuole within cell fuses with cell membrane and the vacuole contents are deposited on the outside. Important in secretion and excretion in cells.



Multiple Choice Question:

What will happen to the protein solution in Side **A** of the apparatus in the diagram below?



A. It will become less concentrated since water passes from **B** to **A**.
B. It will become more concentrated since water passes from **B** to **A**.
C. It will become more concentrated since water passes from **A** to **B**.
D. It will become less concentrated since protein will move from **A** to **B**.