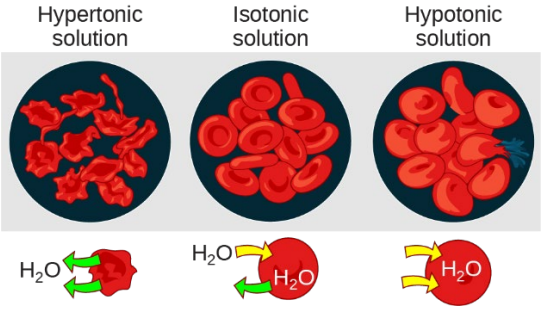
Biology 2e
Unit 2: The Cell
Chapter 5: Structure and Function of Plasma Membranes

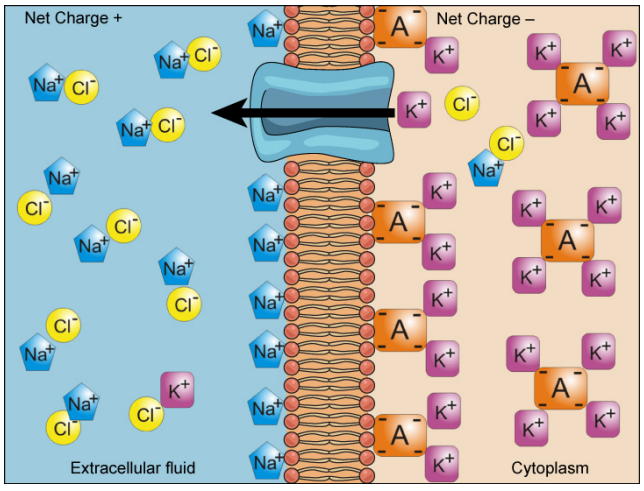
Visual Connection Questions

1. A doctor injects a patient with what the doctor thinks is an isotonic saline solution. The patient dies, and an autopsy reveals that many red blood cells have been destroyed. Do you think the solution the doctor injected was really isotonic?



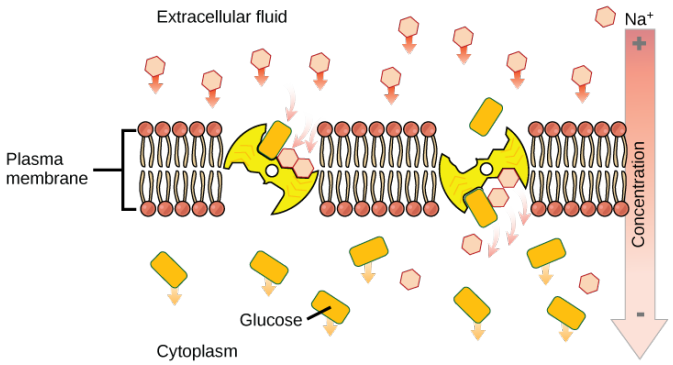
No, it must have been hypotonic as a hypotonic solution would cause water to enter the cells, thereby making them burst.

2. Injecting a potassium solution into a person's blood is lethal. This is how capital punishment and euthanasia subjects die. Why do you think a potassium solution injection is lethal?



Cells typically have a high concentration of potassium in the cytoplasm and are bathed in a high concentration of sodium. Injection of potassium dissipates this electrochemical gradient. In heart muscle, the sodium/potassium potential is responsible for transmitting the signal that causes the muscle to contract. When this potential is dissipated, the signal can't be transmitted, and the heart stops beating. Potassium injections are also used to stop the heart from beating during surgery.

3. If the pH outside the cell decreases, would you expect the amount of amino acids transported into the cell to increase or decrease?



A decrease in pH means an increase in positively charged H^+ ions, and an increase in the electrical gradient across the membrane. The transport of amino acids into the cell will increase.

Review Questions

4. Which plasma membrane component can be either found on its surface or embedded in the membrane structure?

a. protein

5. Which characteristic of a phospholipid contributes to the fluidity of the membrane?

d. double bonds in the fatty acid tail

6. What is the primary function of carbohydrates attached to the exterior of cell membranes?

a. identification of the cell

7. A scientist compares the plasma membrane composition of an animal from the Mediterranean coast with one from the Mojave Desert. Which hypothesis is most likely to be correct?

b. The cells from the Mojave Desert animal will have a higher cholesterol concentration in the plasma membranes.

8. Water moves via osmosis _____.

c. from an area with a high concentration of water to one of lower concentration

9. The principal force driving movement in diffusion is the _____.

c. concentration gradient

10. What problem is faced by organisms that live in fresh water?

a. Their bodies tend to take in too much water.

11. In which situation would passive transport **not** use a transport protein for entry into a cell?
d. Oxygen moving into a cell after oxygen deprivation

12. Active transport must function continuously because _____.
d. diffusion is constantly moving solutes in opposite directions

13. How does the sodium-potassium pump make the interior of the cell negatively charged?
c. by expelling more cations than are taken in

14. What is the combination of an electrical gradient and a concentration gradient called?
d. electrochemical gradient

15. What happens to the membrane of a vesicle after exocytosis?
c. It fuses with and becomes part of the plasma membrane.

16. Which transport mechanism can bring whole cells into a cell?
b. phagocytosis

17. In what important way does receptor mediated endocytosis differ from phagocytosis?
c. It brings in only a specifically targeted substance

18. Many viruses enter host cells through receptor-mediated endocytosis. What is an advantage of this entry strategy?
c. The virus only enters its target host cell type.

19. Which of the following organelles relies on exocytosis to complete its function?
a. Golgi apparatus

20. Imagine a cell can perform exocytosis, but only minimal endocytosis. What would happen to the cell?
b. The plasma membrane would increase in size over time.

Critical Thinking Questions

21. Why is it advantageous for the cell membrane to be fluid in nature?
The fluid characteristic of the cell membrane allows greater flexibility to the cell than it would if the membrane were rigid. It also allows the motion of membrane components, required for some types of membrane transport.

22. Why do phospholipids tend to spontaneously orient themselves into something resembling a membrane?
The hydrophobic, nonpolar regions must align with each other in order for the structure to have minimal potential energy and, consequently, higher stability. The fatty acid tails of the

phospholipids cannot mix with water, but the phosphate “head” of the molecule can. Thus, the head orients to water, and the tail to other lipids.

23. How can a cell use an extracellular peripheral protein as the receptor to transmit a signal into the cell?

Peripheral proteins can bind to other molecules in the extracellular space. However, they cannot directly transmit a signal to the inside of the cell since they do not have a transmembrane domain (region that goes through the plasma membrane to the inside of the cell). They must associate with integral membrane proteins in order to pass the signal to the inside of the cell.

24. Discuss why the following affect the rate of diffusion: molecular size, temperature, solution density, and the distance that must be traveled.

Heavy molecules move more slowly than lighter ones. It takes more energy in the medium to move them along. Increasing or decreasing temperature increases or decreases the energy in the medium, affecting molecular movement. The denser a solution is, the harder it is for molecules to move through it, causing diffusion to slow down due to friction. Living cells require a steady supply of nutrients and a steady rate of waste removal. If the distance these substances need to travel is too great, diffusion cannot move nutrients and waste materials efficiently to sustain life.

25. Why does water move through a membrane?

Water moves through a membrane in osmosis because there is a concentration gradient across the membrane of solute and solvent. The solute cannot effectively move to balance the concentration on both sides of the membrane, so water moves to achieve this balance.

26. Both of the regular intravenous solutions administered in medicine, normal saline and lactated Ringer’s solution, are isotonic. Why is this important?

Injection of isotonic solutions ensures that there will be no perturbation of the osmotic balance, and no water taken from tissues or added to them from the blood.

27. Describe two ways that decreasing temperature would affect the rate of diffusion of molecules across a cell’s plasma membrane.

Decreasing temperature will decrease the kinetic energy in the system. A lower temperature means less energy in the molecules, so they will move at a slower speed. Lowering temperature also decreases the kinetic energy of the molecules in the plasma membrane, compressing them together. This increases the density of the plasma membrane, which slows diffusion into the cell.

28. A cell develops a mutation in its potassium channels that prevents the ions from leaving the cell. If the cell’s aquaporins are still active, what will happen to the cell? Be sure to describe the tonicity and osmolarity of the cell.

Without functional potassium channels, the potassium ions that are pumped into the cell will accumulate. This increases the osmolarity inside the cell, creating a hypotonic solution. Since

the plasma membrane is still selectively permeable to water by the aquaporins, water will flow into the cell. If the potassium concentration is high enough, enough water will eventually flow into the cell to lyse it.

29. Where does the cell get energy for active transport processes?

The cell harvests energy from ATP produced by its own metabolism to power active transport processes, such as the activity of pumps.

30. How does the sodium-potassium pump contribute to the net negative charge of the interior of the cell?

The sodium-potassium pump forces out three (positive) Na^+ ions for every two (positive) K^+ ions it pumps in, thus the cell loses a positive charge at every cycle of the pump.

31. Glucose from digested food enters intestinal epithelial cells by active transport. Why would intestinal cells use active transport when most body cells use facilitated diffusion?

Intestinal epithelial cells use active transport to fulfill their specific role as the cells that transfer glucose from the digested food to the bloodstream. Intestinal cells are exposed to an environment with fluctuating glucose levels. Immediately after eating, glucose in the gut lumen will be high, and could accumulate in intestinal cells by diffusion. However, when the gut lumen is empty, glucose levels are higher in the intestinal cells. If glucose moved by facilitated diffusion, this would cause glucose to flow back out of the intestinal cells and into the gut. Active transport proteins ensure that glucose moves into the intestinal cells, and cannot move back into the gut. It also ensures that glucose transport continues to occur even if high levels of glucose are already present in the intestinal cells. This maximizes the amount of energy the body can harvest from food.

32. The sodium/calcium exchanger (NCX) transports sodium into and calcium out of cardiac muscle cells. Describe why this transporter is classified as secondary active transport.

The NCX moves sodium down its electrochemical gradient into the cell. Since sodium's electrochemical gradient is created by the Na^+/K^+ pump, a transport pump that requires ATP hydrolysis to establish the gradient, the NCX is a secondary active transport process.

33. Why is it important that there are different types of proteins in plasma membranes for the transport of materials into and out of a cell?

The proteins allow a cell to select what compound will be transported, meeting the needs of the cell and not bringing in anything else.

34. Why do ions have a difficult time getting through plasma membranes despite their small size?

Ions are charged, and consequently, they are hydrophilic and cannot associate with the lipid portion of the membrane. Ions must be transported by carrier proteins or ion channels.