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# What would happen to a red blood cell in a hypotonic solution

Large quantities of water molecules constantly move across cell membranes by simple diffusion, often facilitated by movement through membrane proteins, including aquaporins. In general, net movement of water into or out of cells is negligible. For example, it has been estimated that an amount of water equivalent to roughly 100 times the volume of the cell diffuses across the red blood cell membrane every second; the cell doesn't lose or gain water because equal amounts go in and out. There are, however, many cases in which net flow of water occurs across cell membranes and sheets of cells. An example of great importance to you is the secretion of and absorption of water in your small intestine. In such situations, water still moves across membranes by simple diffusion, but the process is important enough to warrant a distinct name - osmosis. Osmosis and Net Movement of Water Osmosis is the net movement of water across a selectively permeable membrane driven by a difference in solute concentrations on the two sides of the membrane. A selectively permeable membrane is one that allows unrestricted passage of water, but not solute molecules or ions. Different concentrations of solute molecules leads to different concentrations of free water molecules on either side of the membrane. On the side of the membrane with higher free water concentration (i.e. a lower concentration of solute), more water molecules will strike the pores in the membrane in a give interval of time. More strikes equates to more molecules passing through the pores, which in turn results in net diffusion of water from the compartment with high concentration of free water to that with low concentration of free water. The key to remember about osmosis is that water flows from the lower solute concentration into the solution with higher solute concentration. This means that water flows in response to differences in molarity across a membrane. The size of the solute particles does not influence osmosis. Equilibrium is reached once sufficient water has moved to equalize the solute concentration on both sides of the membrane, and at that point, net flow of water ceases. Here is a simple example to illustrate these principles: Two containers of equal volume are separated by a membrane that allows free passage of water, but totally restricts passage of solute molecules. Solution A has 3 molecules of the protein albumin (molecular weight 66,000) and Solution B contains 15 molecules of glucose (molecular weight 180). Into which compartment will water flow, or will there be no net movement of water? [ answer ] Additional examples are provided on how to determine which direction water will flow in different circumstances. Tonicity When thinking about osmosis, we are always comparing solute concentrations between two solutions, and some standard terminology is commonly used to describe these differences: Isotonic: The solutions being compared have equal concentration of solutes. Hypertonic: The solution with the higher concentration of solutes. Hypotonic: The solution with the lower concentration of solutes. In the examples above, Solutions A and B are isotonic (with each other), Solutions A and B are both hypertonic compared to Solution C, and Solution C is hypotonic relative to Solutions A and B. Diffusion of water across a membrane generates a pressure called osmotic pressure. If the pressure in the compartment into which water is flowing is raised to the equivalent of the osmotic pressure, movement of water will stop. This pressure is often called hydrostatic ("water-stopping") pressure. The term osmolarity is used to describe the number of solute particles in a volume of fluid. Osmoles are used to describe the concentration in terms of number of particles - a 1 osmolar solution contains 1 mole of osmotically-active particles (molecules and ions) per liter. The classic demonstration of osmosis and osmotic pressure is to immerse red blood cells in solutions of varying osmolarity and watch what happens. Blood serum is isotonic with respect to the cytoplasm, and red cells in that solution assume the shape of a biconcave disk. To prepare the images shown below, red cells from your intrepid author were suspended in three types of solutions: Isotonic - the cells were diluted in serum; Note the beautiful biconcave shape of the cells as they circulate in blood. Hypotonic - the cells in serum were diluted in water; At 200 milliosmols (mOs), the cells are visibly swollen and have lost their biconcave shape, and at 100 mOs, most have swollen so much that they have ruptured, leaving what are called red blood cell ghosts. In a hypotonic solution, water rushes into cells. Hypertonic - A concentrated solution of NaCl was mixed with the cells and serum to increase osmolarity; At 400 mOs and especially at 500 mOs, water has flowed out of the cells, causing them to collapse and assume the spiky appearance you see. Predict what would happen if you mixed sufficient water with the 500 mOs sample shown above to reduce its osmolarity to about 300 mOs. Calculating Osmotic and Hydrostatic Pressure The flow of water across a membrane in response to differing concentrations of solutes on either side - osmosis - generates a pressure across the membrane called osmotic pressure. Osmotic pressure is defined as the hydrostatic pressure required to stop the flow of water, and thus, osmotic and hydrostatic pressures are, for all intents and purposes, equivalent. The membrane being referred to here can be an artificial lipid bilayer, a plasma membrane or a layer of cells. The osmotic pressure P of a dilute solution is approximated by the following:  $P = RT (C_1 + C_2 + \dots + C_n)$  where R is the gas constant (0.082 liter-atmosphere/degree-mole), T is the absolute temperature, and  $C_1 \dots C_n$  are the molar concentrations of all solutes (ions and molecules). Similarly, the osmotic pressure across of membrane separating two solutions is:  $P = RT (\Delta C)$  where  $\Delta C$  is the difference in solute concentration between the two solutions. Thus, if the membrane is permeable to water and not solutes, osmotic pressure is proportional to the difference in solute concentration across the membrane (the proportionality factor is RT). Advanced and Supplemental Topics Send comments to Richard.Bowen@colostate.edu A hypertonic solution contains a higher concentration of solutes compared to another solution. The opposite solution with a lower concentration is known as the hypotonic solution. Scientists must describe cell contents compared to the environment. If a cell is placed in a hypertonic solution, the cell is considered hypotonic. If the cytosol of the cell is a hypertonic solution, it means the environment is hypotonic, or more weakly concentrated. This is of great importance because solutes and water tend to flow or diffuse along their gradients. Two solutions mixed together will eventually become a single solution. If the solutions are separated by a permeable membrane that only allows water through, the solutions will become isotonic as the water moves between the two solutions. Isotonic solutions have equal concentrations, although they may have different volumes. This movement of ions and water is extremely important to cells. Cells use ion gradients for a number of purposes. For example, plant cells use a hypertonic solution within their central vacuole to help draw water into the vacuole. This expands the chamber and allows plants to create turgor pressure in their cells. Animal cells, especially nerve cells, rely on a hypertonic solution and the ions in it to create an action potential or nerve signal. The electrical activity of these cells relies on the positive and negative charges of the ions in the hypertonic solution. To regulate the amount of water in the body, the human brain has special proteins called osmoreceptors, which can measure the osmolarity of the environment surrounding the cell. If the environment becomes a highly hypertonic solution, it is because there is not enough water in the blood to dilute the solutes. The hypothalamus releases hormones while increasing the permeability of membranes in the kidney. The kidney resorbs the water that would have been excreted and adds it back to the bloodstream. The blood becomes more isotonic compared to the cells, and normal processes can continue. Compared to fresh water, salt water is a hypertonic solution. This means that for cells to function, they must contain a cytosol that is a more hypertonic solution than salt water. Sea turtles, for example, live in a much more hypertonic solution compared to freshwater turtles. If you put a freshwater turtle in seawater, the hypertonic seawater will dehydrate the turtle. Instead of being hydrated by the water, the solute-dense ocean water will pull water from the body to balance the difference in osmolarity. To overcome this obstacle, sea turtles and other sea animals have developed unique pathways to remove excess salts. The salts move from the digestive tract into the bloodstream. When they reach the salt gland, they are removed. This creates an internal environment that is higher in solutes, but one that doesn't lose excess amounts of water to the environment. Generally, plants prefer to live in hypotonic environments. In a hypotonic environment, water easily floods plant cells and they can remain turgid, or rigid, due to pressures exerted on their cell walls by the influx of water. The plants use this water potential to give their bodies structure and move water from the roots to the top of the plant. However, many plants have adapted to live in hypertonic environments. Marshes by the sea, mangrove swamps, and other brackish waters contain a much higher salt content than fresh water. The soil becomes saturated with these salts, creating a much higher solute concentration in the soil. Most plants would shrivel up if they were transplanted to this habitat, but a special group of plants known as Halophytes has evolved to overcome this obstacle. By increasing the osmolarity of their roots, the plants are able to change from a hypotonic environment inside the cell compared to the environment, to a hypertonic solution in the cytosol. This lowers the water potential of the root cells and allows water to enter the cells. The cells either store the excess salts in the roots or transport the salts to the leaves, where they can be excreted out of glands. The plasma membrane that surrounds cells is a special permeable membrane that separates the contents of the cell from the environment. The plasma membrane is embedded with special membrane transport proteins that help transport solutes across. It also has special protein channels called aquaporins that allow water to flow freely across the membrane. The cell must use energy to actively move solutes into and out of the cell. Too many solutes and the cytosol will become a hypertonic solution compared to the environment. Cells without cell walls can burst in this condition. Effects of hypertonic, hypotonic and isotonic solutions to red blood cells Too few solutes in the environment will become the hypotonic solution. In this case, the opposite will happen, as water moves out of the cell. Water moves against the concentration gradient of solutes, moving from areas of low solute concentration to areas of high solute concentration. In another sense, water moves with the water concentration gradient, from areas of high water concentration to areas of low water concentration. Organisms that regulate the osmolarity of their cells are known as osmoregulators. Typically, cells try to maintain their cytoplasm as a hypertonic solution compared to the environment. While this does pose certain structural problems, it allows water to flow freely through the cell, and participate in many of the necessary reactions. If cells were hypotonic, they would eventually lose most of their water to the environment. Other organisms, osmoconformers, have the same osmolarity as the environment, although the exact solutes may be different. This ensures that they neither lose nor gain lots of water. We thoroughly check each answer to a question to provide you with the most correct answers. Found a mistake? Let us know about it through the REPORT button at the bottom of the page. Cell Transport Quiz Question Your answer: Correct answer: You got  $\{ \{ \text{SCORE\_CORRECT} \} \}$  out of  $\{ \{ \text{SCORE\_TOTAL} \} \}$  Quiz Answers 1. Osmosis is the movement of \_\_\_\_ across a membrane. 2. Which is true about active transport? It requires energy it does not require energy It moves substances down the concentration gradient it moves material from high to low concentration 3. This picture represents what type of cell transport? endocytosis exocytosis osmosis passive transport 4. Movement across the cell membrane that does not require energy is called active transport passive transport 5. Due to the higher concentration of oxygen in the air than your blood, oxygen goes from the lungs into the red blood cells by... Facilitated Diffusion Simple Diffusion Active Transport Osmosis 6. This cell structure helps organisms maintain homeostasis by controlling what substances may enter or leave cells. vacuole nucleus cell membrane cell wall 7. Passive transport requires no concentration gradients osmosis motion energy 8. What type of transport is illustrated? facilitated diffusion active transport diffusion osmosis 9. This picture represents which type of cellular transport? passive transport endocytosis exocytosis osmosis 10. Which of the following is not an example of active transport? sodium-potassium pump endocytosis exocytosis facilitated diffusion 11. When particles move out of a cell through facilitated diffusion, the cell \_\_\_\_\_. gains energy uses energy releases energy does not use energy 12. Which of these is NOT a type of passive transport? Endocytosis Osmosis Diffusion Facilitated diffusion 13. Which way would the purple molecules move through the semi permeable membrane? From the A side to the B-side From the B side to the A side None of the purple molecules would move 14. Large molecules and ions can easily pass through the cell membrane without any help true- they pass right through false- they need a protein channel 15. The picture is an example of... active transport passive transport diffusion osmosis 16. Particles too large to enter the membrane...need help from channel proteins...no energy is required. active transport passive transport facilitated diffusion 17. The movement of molecules against a concentration gradient simple diffusion facilitated diffusion active transport osmosis 18. If a molecule passes through a protein, but goes down a gradient, it is called active transport endocytosis facilitated diffusion exocytosis 19. The difference in the concentration of a substance across a space is called a concentration 20. If there is a concentration gradient, substances will move from an area of high concentration to an area of \_\_\_\_\_ concentration 21. The cell membrane is impermeable selectively (semi) permeable 22. A solution that causes a cell to swell is called a hypertonic hypotonic isotonic 23. This cell was placed into which type of solution? Hypertonic Hypotonic Isotonic Cannot determine 24. The salt in the glass of saltwater is considered the solvent solution pepper solute 25. Isotonic Solution Hypertonic Solution Hypotonic Solution Facilitated Diffusion 26. Isotonic Solution Hypertonic Solution Hypotonic Solution Facilitated Diffusion 27. In the given scenario what will happen to the organism: salt is poured onto eggplant. Water will move out of the eggplant cells and the cells will shrink. Water will move out of the eggplant cells and the cells will swell. Water will move into the eggplant cells and the cells will swell. Terms To Learn Requires the input of energy to move molecules from a low concentration to a high concentration The movement of relatively large quantities of material into or out of a cell at one time (does not use energy) The use of proteins in a cell membrane to move molecule from a low concentration on one side to a high concentration on the other. The movement of relatively large quantities of material into a cell at one time. The movement of relatively large quantities of material out of a cell at one time. The movement of molecules from a high concentration to a low concentration, without the input of energy The movement of water from a high concentration to a low concentration, across a semi-permeable membrane without the input of energy. Scenario: Salt is poured onto a leech causing it to release its bite from the victim. Scenario: Cell in the human body take cholesterol particles in by endocytosis. Scenario: Carrier Transport Scenario: Cells in the human body have proteins that work to maintain negatively charged particles inside of the cell while keeping positively charged particles outside of the cell. This goes against concentration gradient. Scenario: Ink that was released into the water by a squid moments later became unnoticeable. ability of particle to pass through a membrane The concentration of solutes in the solution is lower than inside the cell. The concentration of solutes in the solution is higher than inside the cell. The concentration of solutes inside the cell is the same as outside the cell. Let us know if this was helpful. That's the only way we can improve.

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