

Section 9.4: Water Balance

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- 1. (a)** Both diffusion and osmosis use concentration gradients to move molecules across a semi-permeable membrane. Diffusion is the movement of solute particles from areas of high concentration to areas of low concentration. Osmosis is the movement of water from areas of high concentration to areas of low concentration.

(b) Osmosis is particularly important for biological functions because membranes separate internal and external environments, and many solutes cannot readily diffuse across these membranes. To maintain osmotic and ionic balance, water must pass through these membranes instead.
- 2.** Cells need to use osmoregulation because it helps maintain a balance of water and ion concentrations between the intra- and extra-cellular fluid, and the body and the external environment.
- 3.** Excretion removes nitrogenous waste products from the body. These wastes are dissolved in the aqueous environment of the body. Osmoregulation helps to remove these wastes from the extra-cellular fluid in order to maintain optimal ionic and water concentrations.
- 4.** Advantages: Urea is much less toxic than ammonia, and can be expelled from the body with a much smaller amount of water (i.e. it can exist in higher concentrations than ammonia), which allows terrestrial animals to retain their limited supply of water. Disadvantage: producing urea requires a much greater amount of the energy than producing ammonia.
- 5.** An advantage for birds to creating uric acid as their nitrogenous waste compound is that uric acid is the least toxic of the three nitrogenous wastes, and so requires much less water to safely dissolve and expel. This is important because the birds' bodies are relatively small and they must use as little water in the excretion of waste as possible. Retaining large amounts of water to dissolve urea or ammonia in a non-toxic concentration would increase the mass of a bird and might impair its ability to fly.
- 6.** Carnivores on a high-protein diet would produce more urea because the deamination of amino acids from proteins produces ammonia, which is converted into urea. The breakdown of carbohydrates does not produce ammonia.
- 7.** If a cell found in the ocean were suddenly placed in a beaker of fresh water, the cell would rapidly take on water by osmosis and would continue to do so until it was isosmotic to its new surroundings. However, the intake of so much water would cause the cell to swell and probably burst.
- 8.** Osmoregulation is the process of balancing the cell's water concentrations and dissolved substances. During osmoregulation, water moves from inside the cell through the cell membrane to the extracellular fluid. Excretion plays an important role because it helps to eliminate this water, together with wastes such as urea, from the body.
- 9.** Membranes are classified based on their permeability: impermeable—no substance can pass through; permeable—lets solutes and solvents pass through; semi-permeable/selectively permeable—allows solvents and some solutes through.
- 10.** A walleye living in Lake Ontario could not live in the Bay of Fundy because the internal environment of a freshwater fish like the walleye is hyperosmotic to freshwater. It tends to gain water and has to excrete large volumes of urine to get rid of the excess water. However, the walleye would be hyposmotic to the salt water and it would tend to lose water to the environment. It would not be able to prevent the loss of water and remain isosmotic.

11. A solution that has a higher concentration of solutes is said to be hypertonic to a solution with a lower concentration of solutes. Hypertonic describes the concentrations of the solutes. If there is a permeable membrane between the two solutions, solutes will move out of the hypertonic solution. A hyperosmotic solution has a lower concentration of water than a hypoosmotic solution. If there is a semipermeable membrane between the two solutions, water will move into the hyperosmotic solution. The hypertonic solution is also hyperosmotic, but hypertonic describes the relative concentrations of solutes and hyperosmotic describes the relative concentrations of water.

12. Active transport is made possible by specific membrane proteins. These proteins act as pumps, pushing ions and molecules through the membrane using energy from ATP molecules.

13. Mineral salts and other particles such as glucose, urea and proteins (all particles inside and outside the cell) generate a small or large osmotic gradient between the intracellular and extracellular spaces. Osmotic pressure depends on the number of particles dissolved in a solution and not on the types of particles.

14. Salt and sugar are used in the drying of fruit and meat because they maintain a highly hypertonic environment. Therefore they draw water out of the tissue by osmosis and ultimately dehydrate the fruit and meat.