Osmosis & Dialysis

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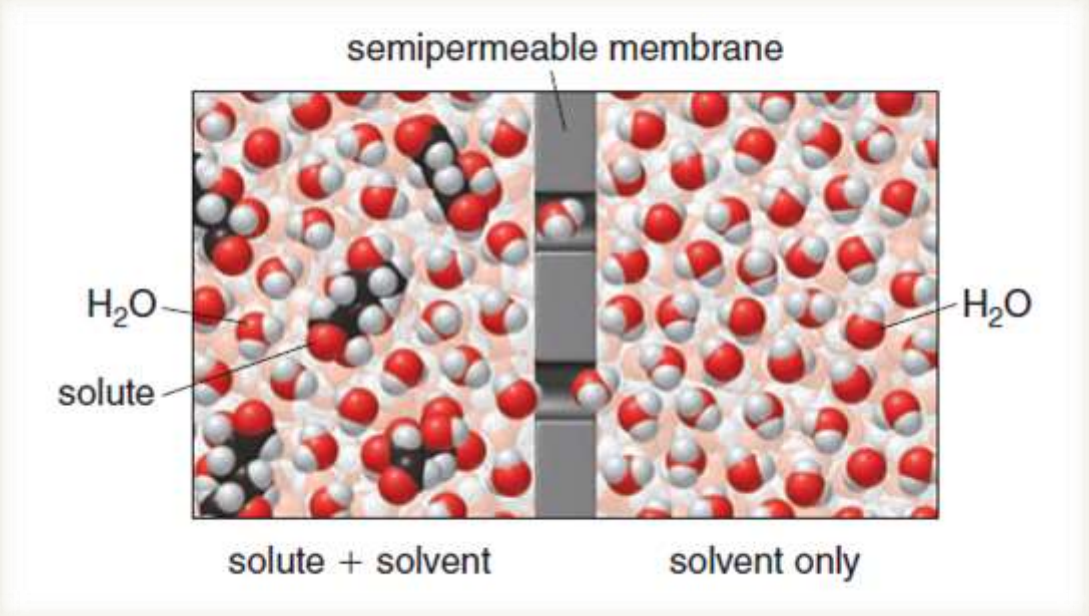
Lecture 4

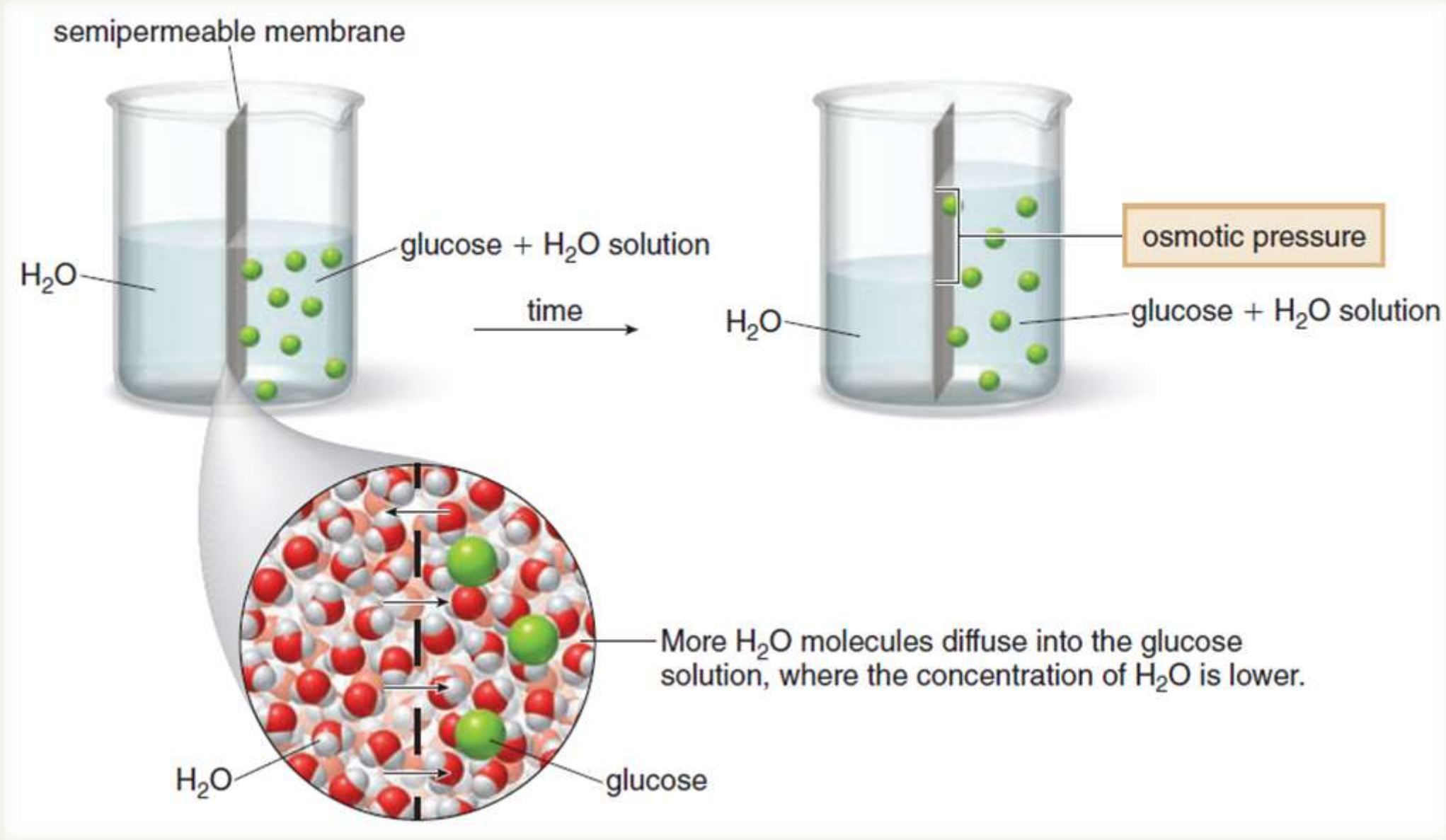
6. Osmosis and Dialysis

- The membrane that surrounds living cells is an example of a ***semipermeable membrane.***
- A membrane that allows water and small molecules to pass across, but ions and large molecules cannot.



6.1 Osmosis

- ***Osmosis:*** is the spontaneous net movement of solvent molecules through a semi-permeable membrane into a region of higher solute concentration (from a more dilute solution to a more concentrated solution.), in the direction that tends to equalize the solute concentrations on the two sides.
- ***Osmotic pressure*** is the pressure that prevents the flow of additional solvent into a solution on one side of a semipermeable membrane.
- Osmotic pressure depends only on the number of particles in a solution. ***The greater the number of dissolved particles, the greater the osmotic pressure.*** A 0.1 M NaCl solution has twice the osmotic pressure as a 0.1 M glucose solution, since each NaCl is composed of two particles, Na^+ cations and Cl^- anions.


semipermeable membrane
H_2O
glucose + H_2O solution
time
osmotic pressure
H_2O
glucose + H_2O solution
More H_2O molecules diffuse into the glucose solution, where the concentration of H_2O is lower.
H_2O
glucose

PROBLEM

A 0.1 M glucose solution is separated from a 0.2 M glucose solution by a semipermeable membrane. (a) Which solution exerts the greater osmotic pressure? (b) In which direction will water flow between the two solutions? (c) Describe the level of the two solutions when equilibrium is reached.

Analysis

The solvent (water) flows from the less concentrated solution to the more concentrated solution.

Solution

A. The greater the number of dissolved particles, the higher the osmotic pressure, so the 0.2 M glucose solution exerts the greater pressure.
B. Water will flow from the less concentrated solution (0.1 M) to the more concentrated solution (0.2 M).
C. Since water flows into the 0.2 M solution, its height will increase, and the height of the 0.1 M glucose solution will decrease.

PROBLEM

Which solution in each pair exerts the greater osmotic pressure?

a. 1.0% sugar solution or 5.0% sugar solution

b. 3.0 M NaCl solution or a 4.0 M NaCl solution

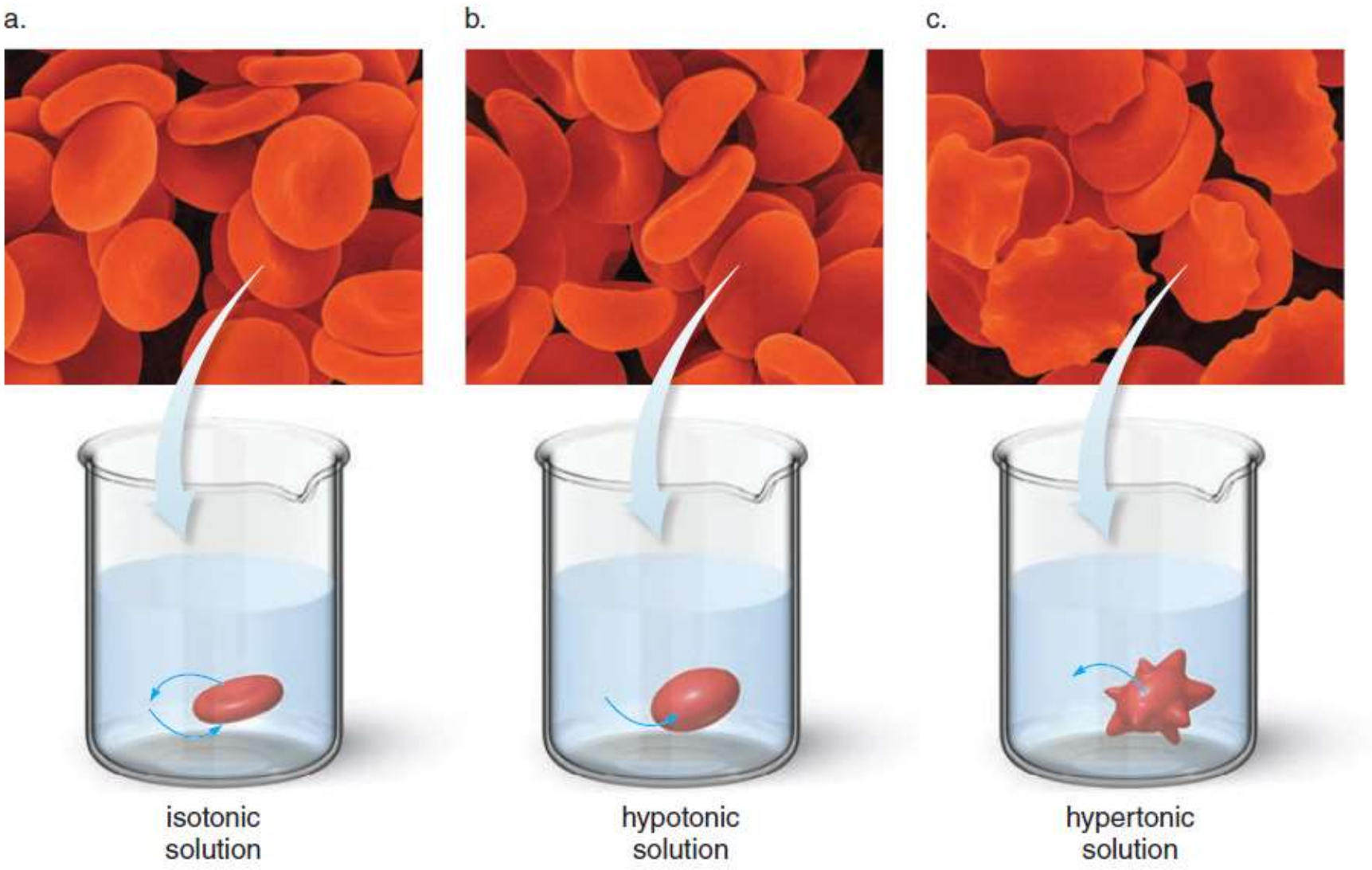
c. 1.0 M glucose solution or a 0.75 M NaCl solution

Home Work 3

Describe the process that occurs when a 1.0 M NaCl solution is separated from a 1.5 M NaCl solution by a semipermeable membrane in terms of each of the following: (a) the identity of the substances that flow across the membrane; (b) the direction of flow before and after equilibrium is achieved; (c) the height of the solutions after equilibrium is achieved.

6.2 Osmosis and Biological Membranes

- Since cell membranes are semipermeable and biological fluids contain dissolved ions and molecules, osmosis is an ongoing phenomenon in living cells. Fluids on both sides of a cell membrane must have the same osmotic pressure to avoid pressure buildup inside or outside the cell. Any intravenous solution given to a patient, therefore, must have the same osmotic pressure as the fluids in the body.
- Two solutions with the same osmotic pressure are said to be ***isotonic.***
- ***A hypotonic*** solution has a lower osmotic pressure than body fluids.
- ***A hypertonic*** solution has a higher osmotic pressure than body fluids.



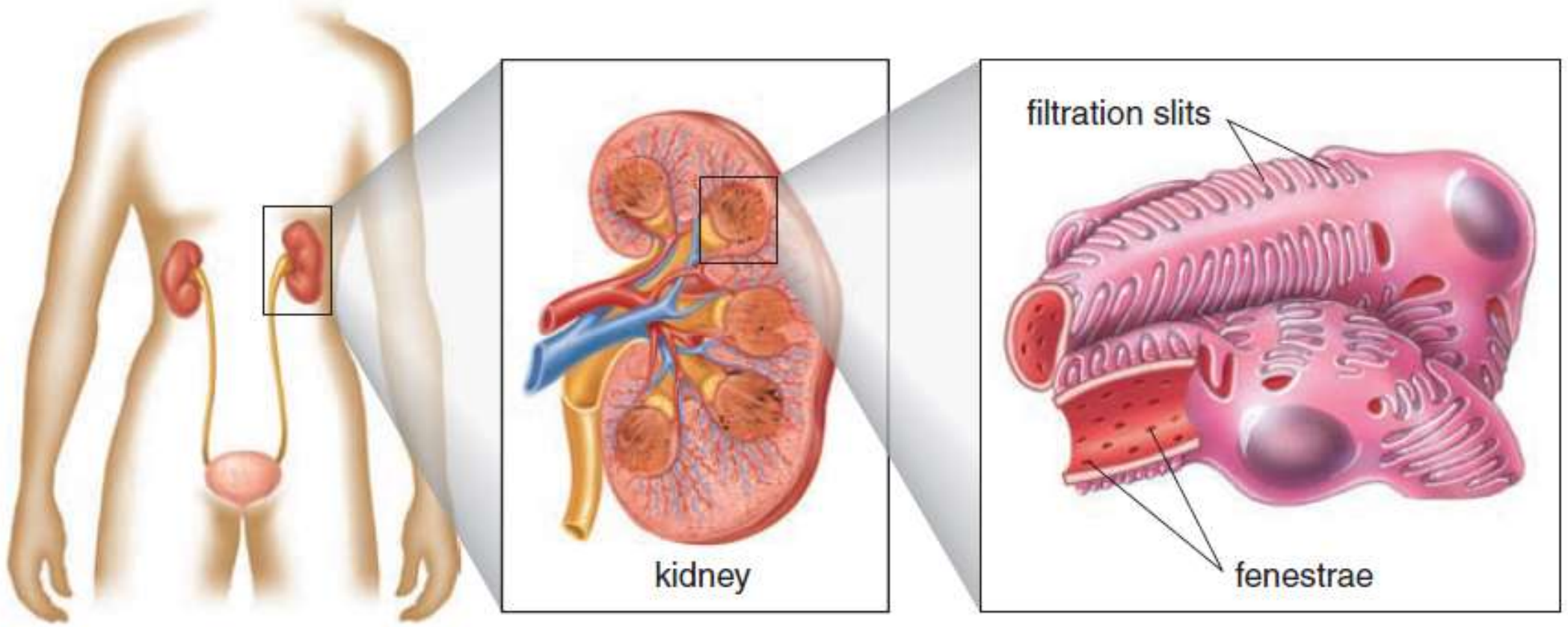
(a) In an isotonic solution, the movement of water into and out of the red blood cell occurs to an equal extent and the red blood cell keeps its normal volume. (b) In a hypotonic solution, more water moves into the cell than diffuses out, so the cell swells and eventually it can rupture (hemolysis). (c) In a hypertonic solution, more water moves out of the cell than diffuses in, so the cell shrivels (crenation).

6.2 Osmosis and Biological Membranes

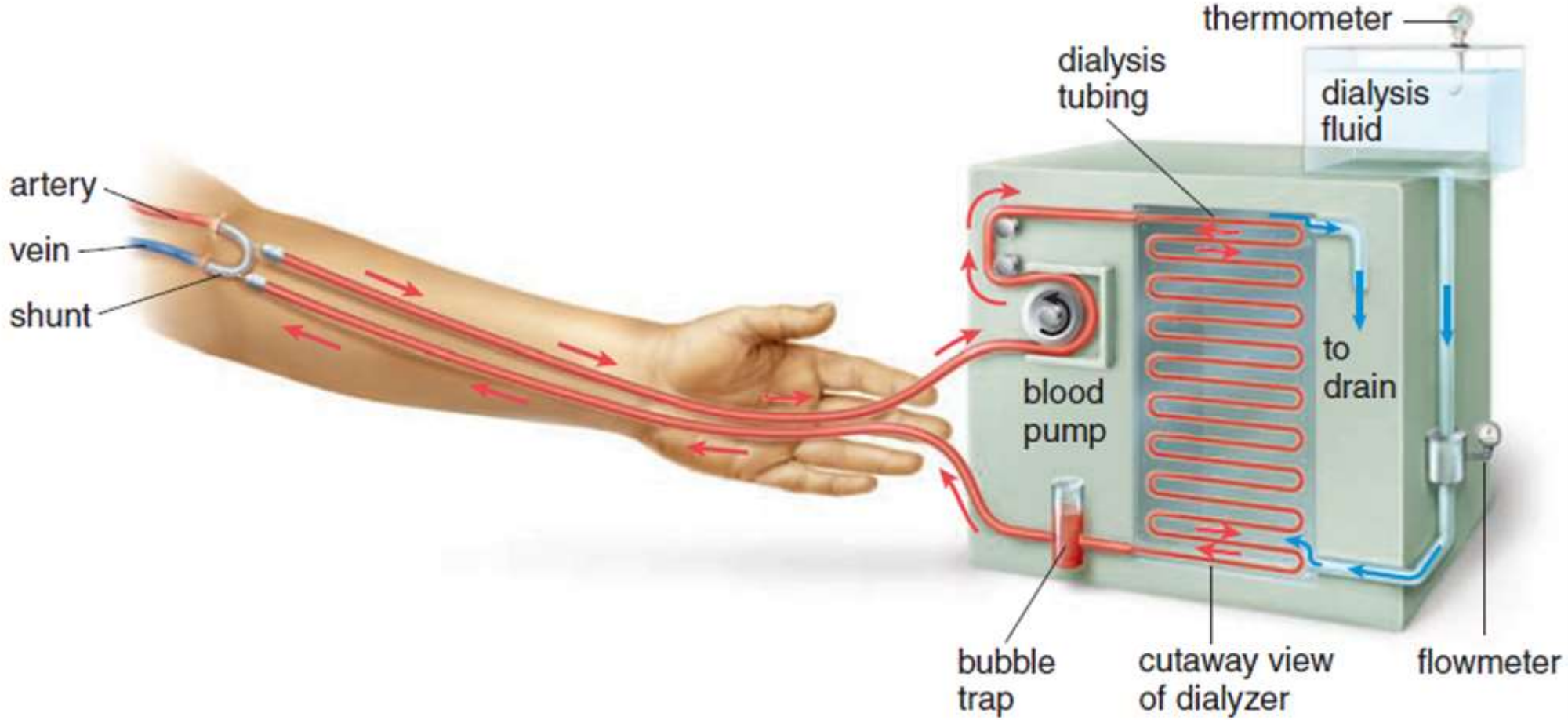
- If a red blood cell is placed in an isotonic NaCl solution, called physiological saline solution, the red blood cells retain their same size and shape because the osmotic pressure inside and outside the cell is the same (Figure 7.7a). What happens if a red blood cell is placed in a solution having a different osmotic pressure?
- In a hypotonic solution, the concentration of particles outside the cell is lower than the concentration of particles inside the cell. In other words, the concentration of water outside the cell is higher than the concentration of water inside the cell, so water diffuses inside (Figure 7.7b). As a result, the cell swells and eventually bursts. This swelling and rupture of red blood cells is called hemolysis.
- In a hypertonic solution, the concentration of particles outside the cell is higher than the concentration of particles inside the cell. In other words, the concentration of water inside the cell is higher than the concentration of water outside the cell, so water diffuses out of the cell (Figure7.7c). As a result, the cell shrinks. This process is called crenation.

6.2 Dialysis

- Dialysis is also a process that involves the selective passage of substances across a semipermeable membrane, called a dialyzing membrane. In dialysis, however, water, small molecules, and ions can travel across the membrane; only large biological molecules like proteins and starch cannot.
- In the human body, blood is filtered through the kidneys by the process of dialysis. Each kidney contains over a million nephrons, tubelike structures with filtration membranes. These membranes filter small molecules—glucose, amino acids, urea, ions, and water—from the blood. Useful materials are then reabsorbed, but urea and other waste products are eliminated in urine.



Body fluids are dialyzed by passage through the kidneys, which contain more than a million nephrons that filter out small molecules and ions from the blood. Useful materials are then reabsorbed while urea and other waste products are eliminated in urine.



When a patient's kidneys no longer function properly, periodic dialysis treatments are used to remove waste products from the blood. Blood is passed through a dialyzer, which contains a membrane that allows small molecules to pass through, thus acting as an artificial kidney. Each treatment takes several hours. Patients usually require two to three treatments per week.

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