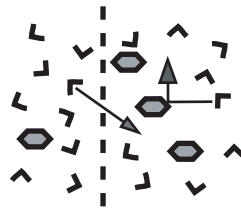




Water Movement

(Part 1)

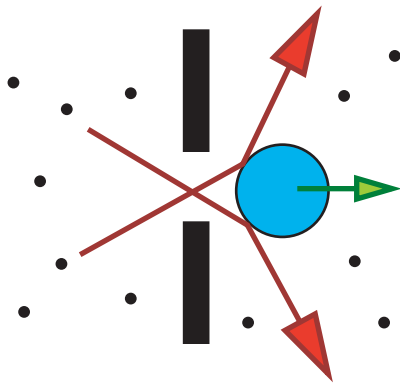
An Introduction to
Mechanisms behind Osmosis
and the importance and regulation of
Sodium and Potassium
in *Water Balance*



By Noel Ways

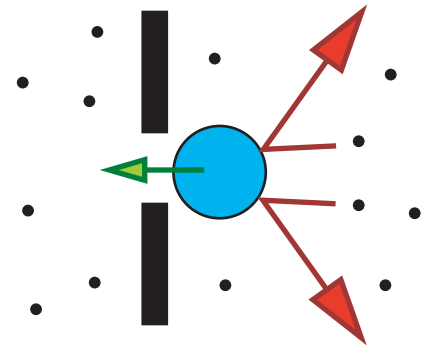
Osmosis

Osmosis is the movement of a solvent through a semi-permeable membrane into a region of higher solute concentration. To understand this, it must be first understood that any such system is in constant motion. Water molecules, as well as the solute, are in constant movement and this random movement increases when the temperature increases.

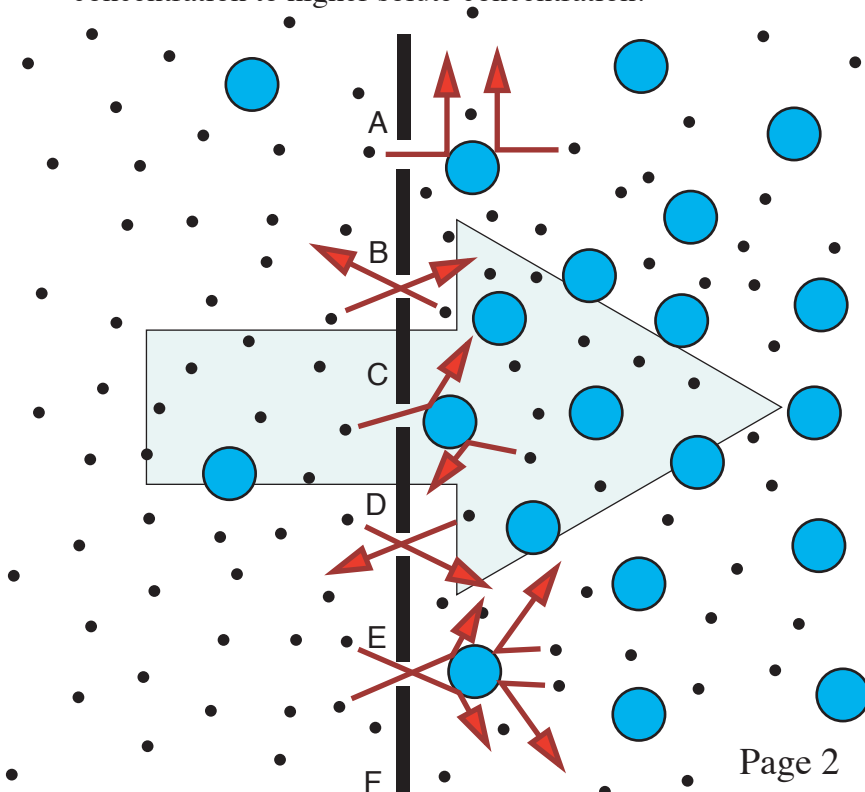


Consider the diagram at left. A solute molecule in close proximity to a pore permits water to pass through the pore into the other side of the membrane. The solute will also move in such manner so as to allow additional water to pass to the right.

In the diagram to the right, water molecules heading for the same pore hit a solute molecule and bounce off of it, and are not permitted pass through. Furthermore, the solute moves toward the pore and will make more difficult the passage of any other water molecules from right to left.



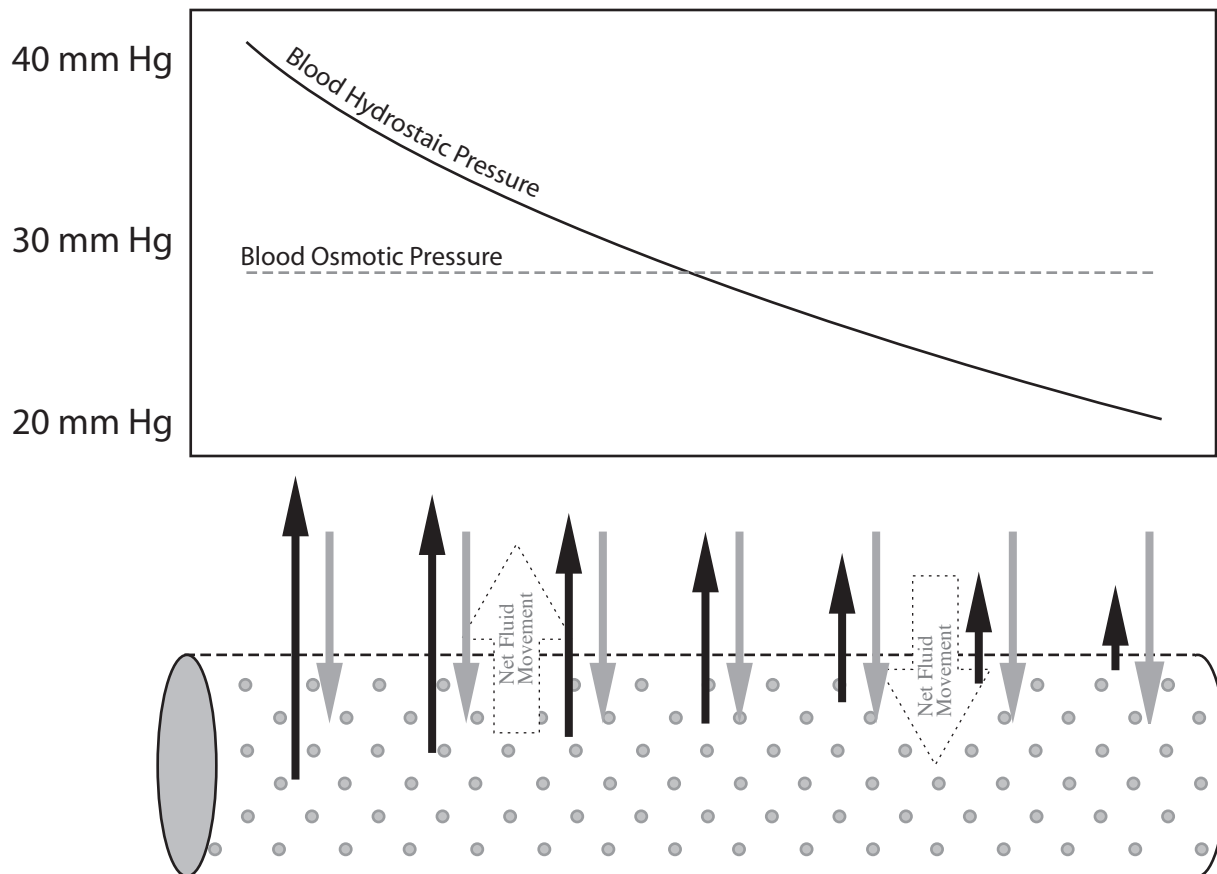
In short, the pore - solute system is acting like a one-way valve!! It is important to realize that all movement is random, and indeed some water will slip in the other way. But for certain, the net movement of water (the solvent) will always be from lower solute concentration to higher solute concentration.



In the diagram at left, the higher solute concentration is clearly on the right side and the many "one-way valves" cause a net movement of water from the left to the right. Although there may be "one-way valves" on both sides of the semi-permeable membrane, the side with the greater concentration will see a greater movement of water to that side.

Fluid Movement at the Capillary

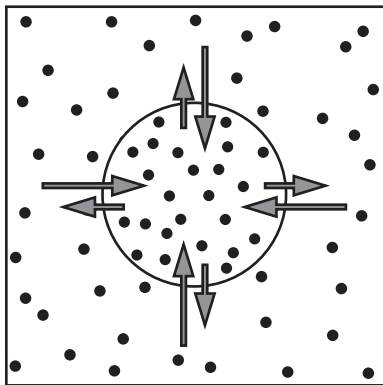
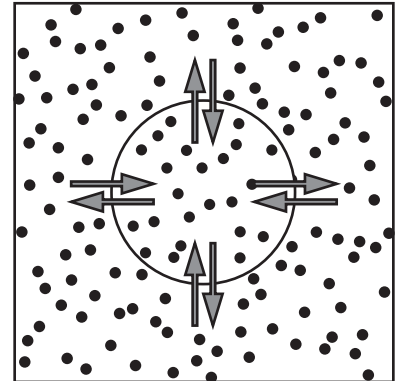
Ventricular contraction thrusts blood into elastic arteries, and these expanded arteries will then propel the blood through the circulatory system due to their elastic recoil. As the blood moves through the vessels, it meets resistance due to blood viscosity and lumen diameter. Such resistance lowers the hydrostatic pressure further along the vessel. Furthermore, at the capillaries, fluid movement into the interstitial spaces will likewise account for a continued diminishing of hydrostatic pressure.



Countering the hydrostatic pressure at the capillaries is a substantial osmotic pressure created by the osmotically active protein, albumin. However at the arterial end of a capillary, blood hydrostatic pressure will exceed blood osmotic pressure and this results in a net movement of fluid into the interstitial spaces. As the viscous blood continues to move through the capillary, the hydrostatic pressure will continue to diminish due to capillary wall resistance and fluid loss. At a certain point the hydrostatic pressure will be less than the osmotic pressure. Once blood hydrostatic pressure drops below plasma osmotic pressure, fluid will now return into the capillary. As the blood continues to move through the capillary at the venous end, blood hydrostatic pressure diminishes even more, and the net flow of interstitial fluid returning back into the capillary increases proportionally.

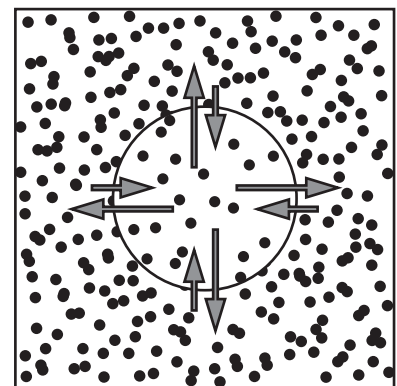
In the illustrations below, the dots represent solute, not water. The water is not seen, but inferred.

Solutes that enable osmosis are called, "osmotically active substances". If the concentration of an osmotically active substance is equal on either side of the membrane, then the solution surrounding the cell is said to be isotonic. The osmotic pressure will be equal on either side of the membrane. This is a stable situation in this model.

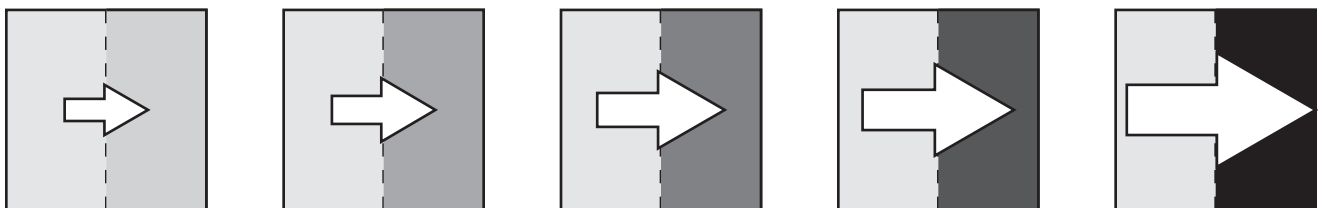


If the solution surrounding the membrane has a lower concentration of osmotically active substances, then the solution is said to be **hypotonic**. Here, there is a greater osmotic pressure drawing water into the cell. If the osmotic pressure is great enough, the cell will burst, sometimes called **hemolysis**.

If the solution surrounding the membrane has a greater concentration of osmotically active substances, then the solution is said to be **hypertonic**. Now the osmotic pressure will be greater outside the membrane and water will be drawn out of the cell. The cell will shrivel up, a process called **crenation**.



Notice below, that as the concentration ("one-way valves") increases the osmotic pressure increases.



Sodium and Potassium in Water Balance

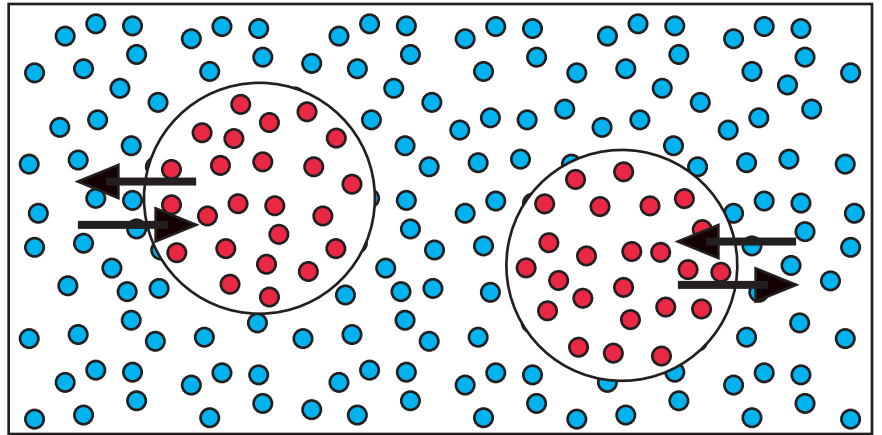
- Sodium
- Potassium

Both sodium and potassium are osmotically active ions. Potassium is found within cells and helps create osmotic pressure to draw water into the cell from interstitial fluid or plasma.

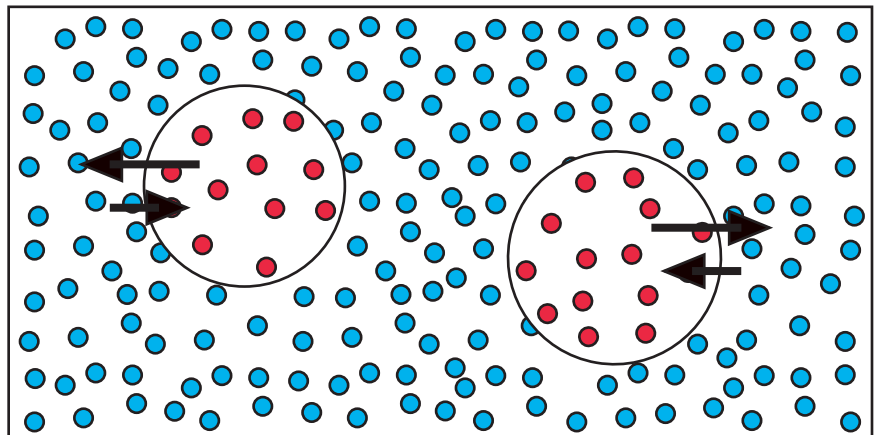
Sodium is found in substantial concentrations outside of the cell where it helps create osmotic pressure to draw water out of cells and into the interstitial fluid and plasma.

If the concentrations of osmotically active substances on either side of a semipermeable membrane (ie., cell membrane) are equal, the condition is isotonic, and water will move at equal rates in both directions.

If water is to be moved across the membrane, it is adjustments to the relative concentrations of Na and K that will do the job.



Should there be insufficient water within the plasma resulting in low blood pressure, the kidneys will adjust the location of water by altering the relative concentration of both Na and K. By retaining Na and excreting potassium in the urine, this will soon create a hypertonic condition, and water now leaves the cells and enters the plasma and blood pressure raises.



If blood pressure is excessive, then sodium will be excreted in the urine and potassium will be retained. This will soon create a hypotonic condition and water will move from the plasma into cells and blood pressure will lower.

