11.2: Overview of Fluid and Electrolyte Balance

Skills to Develop

• Define osmosis.

A human body is made up of mostly water. An adult consists of about 37 to 42 liters of water or about eighty pounds. Fortunately, humans have compartmentalized tissues; otherwise, we might just look like a water balloon! Newborns are approximately 70 percent water. Adult males typically are composed of about 60 percent water and females are about 55 percent water. (This gender difference reflects the differences in body-fat content since body fat is practically water-free. This also means that if a person gains weight in the form of fat the percentage of total body water content declines.) As we age total body water content also diminishes so that by the time we are in our eighties the percent of water in our bodies has decreased to around 45 percent. Does the loss in body water play a role in the aging process? Alas, no one knows. But, we do know that dehydration accelerates the aging process whereas keeping hydrated decreases headaches, muscle aches, and kidney stones. Additionally, a study conducted at the Fred Hutchinson Cancer Research Center in Seattle found that women who drank more than five glasses of water each day had a significantly decreased risk of developing colon cancer. Shannon J. E. et al. “Relationship of Food Groups and Water Intake to Colon Cancer Risk.” Cancer Epidemiol Biomarkers Prev 5, no. 7 (1996): 495–502. http://cebp.aacrijournals.org/content/5/7/495.long.

• Fluid and Electrolyte Balance

Although water makes up the largest percentage of body volume, it is not actually pure water but rather a mixture of cells, proteins, glucose, lipoproteins, electrolytes, and other substances. Electrolytes are substances that, when dissolved in water, disassociate into charged ions. Positively charged electrolytes are called cations and negatively charged electrolytes are called anions. For example, in water sodium chloride (the chemical name for table salt)
disassociates into sodium cations (Na\(^+\)) and chloride anions (Cl\(^-\)). Solutes refer to all dissolved substances in a fluid, which may be charged, such as sodium (Na\(^+\)), or uncharged, such as glucose. In the human body, water and solutes are distributed into two compartments: inside cells, called intracellular, and outside cells, called extracellular (about 40% of total body water). The extracellular water compartment is subdivided into the spaces between cells (interstitial) and intravascular or blood plasma and other bodily fluids (such as cerebrospinal fluid which surrounds and protects the brain and spinal cord). The composition of solutes differs between the fluid compartments. For instance, more protein is inside cells than outside and more chloride anions exist outside of cells than inside.

- Osmoregulation

One of the essential homeostatic functions of the body is to maintain fluid balance and the differences in solute composition between cells and their surrounding environment. Osmoregulation is the control of fluid balance and composition in the body. The processes involved keep fluids from becoming too dilute or too concentrated. Fluid compartments are separated by selectively permeable membranes, which allow some things, such as water, to move through while other substances require special transport proteins, channels, and often energy. The movement of water between fluid compartments happens by osmosis, which is simply the movement of water through a selectively permeable membrane from an area where it is highly concentrated in an area where it is not so concentrated. Water is never transported actively; that is, it never takes energy for water to move between compartments. Although cells do not directly control water movement, they do control movement of electrolytes and other solutes and thus indirectly regulate water movement by controlling where there will be regions of high and low concentrations.

Video 11.2.1: Osmosis

This is a short animation of osmosis.(click to see video)

Cells maintain their water volume at a constant level, but the composition of solutes in a cell is in a continuous state of flux. This is because cells are bringing nutrients in, metabolizing them, and disposing of waste products. To maintain water balance a cell controls the movement of electrolytes to keep the total number of dissolved particles, called osmolality the same inside and outside (Figure 7.1). The total number of dissolved substances is the same inside and outside a cell, but the composition of the fluids differs between compartments. For example, sodium exists in extracellular fluid at fourteen times the concentration as compared to that inside a cell.

![Hypertonic Isotonic Hypotonic](Image)

Figure \(\PageIndex{1}\): Cells maintain water volume by actively controlling electrolyte concentrations. Image used with permission (Public Domain; LadyofHats)
If a cell is placed in a solution that contains fewer dissolved particles (known as a hypotonic solution) than the cell itself, water moves into the more concentrated cell, causing it to swell (Figure 11.2.1). Alternatively, if a cell is placed in a solution that is more concentrated (known as a hypertonic solution) water moves from inside the cell to the outside, causing it to shrink. Cells keep their water volume constant by pumping electrolytes in and out in an effort to balance the concentrations of dissolved particles on either side of their membranes. When a solution contains an equal concentration of dissolved particles on either side of the membrane, it is known as an isotonic solution.

Key Takeaways

- A human body is mostly water.
- Movement of water is regulated by controlling the movement of electrolytes between fluid compartments.
- While water makes up the largest percentage of body volume it is not pure water but a mixture of water, cells, proteins, glucose, lipoproteins, electrolytes and other substances.
- In the human body water and solutes are distributed into two compartments; inside cells, called intracellular, and outside cells, called extracellular.
- One of the essential homeostatic functions, called osmoregulation of the body is to maintain fluid balance and the differences in composition between fluid compartments.
- The movement of water between fluid compartments happens by the process of osmosis.
- Water is never transported actively; that is, it never takes special proteins and energy for water to move between compartments, it simply flows from an area of high concentration to an area where its concentration is lower.
- Under normal circumstances, a cell maintains its water volume at a constant level, but the composition of solutes in a cell is in a continuous state of flux.
- To maintain water balance a cell controls the movement of electrolytes to keep the total number of dissolved particles the same inside and outside.

Discussion Starters

1. If the membrane surrounding a cell was permeable to sodium what would happen to the concentration of sodium inside and outside a cell?
2. Discuss why maintaining fluid homeostasis is a dynamic process.