Digestion, Absorption and Water Movement

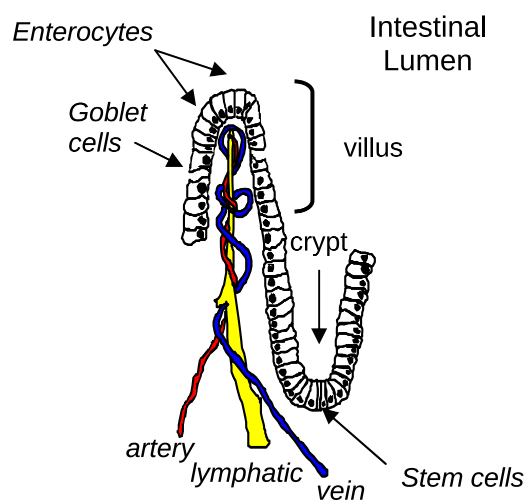
From Electrolyte & Water Balance in Calves
Developed by Rob Costello, Technical Specialist

This section describes how water moves into and out of the small intestine relative to ingestion, digestion and absorption of nutrients. An overview of intestinal mucosa structure and function is provided. The role of sodium in water movement and the relationships among sodium, amino acid and glucose absorption are also discussed. These are key concepts necessary for understanding electrolyte function, water loss, rehydration therapy and electrolyte formulation.

In healthy animals, large amounts of water are regularly secreted into the small intestine to help digest and absorb nutrients. Most of this water is recovered as the nutrients are digested and absorbed. Nearly twice the total volume of water in an animal's blood stream cycles into and out of its digestive tract each day.

The mucosa, or lining of the small intestine, is made up of villi and crypts. Figure 1. Villi project into the open space, or lumen, of the small intestine and are mainly involved in nutrient absorption. Each villus is well supplied with blood and lymph vessels that rapidly move absorbed nutrients away from the digestive tract and into the body. Crypt cells, on the other hand, are primarily concerned with secretion of substances, including water, into the intestinal lumen.

Figure 1.

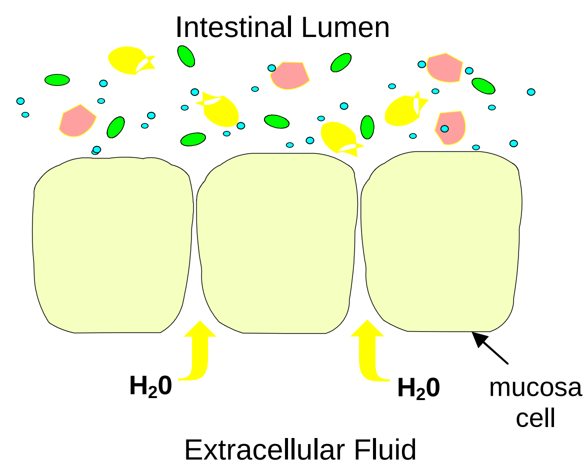


adapted from Austgen et al

Water movement into the small intestine. As food enters the small intestine, water readily "leaks" between the mucosa cells of the upper small intestine into the lumen. During digestion large food particles are broken down to small absorbable nutrients, increasing the concentration of particles inside the intestine. This concentration, referred to as osmotic pressure, is much greater inside the intestine than it is in the cells and fluids of the body surrounding the digestive tract. Since water flows toward areas of high osmotic pressure, water moves from the body into the intestinal lumen. Figure 2.

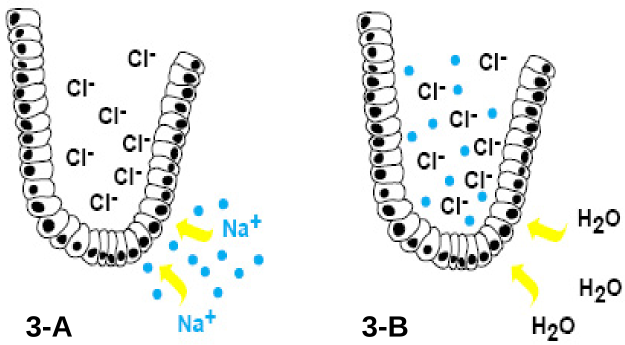
Figure 2.

Water Movement Into the Small Intestine



Water can also be moved into the intestine through specific action of crypt cells. By pumping chloride ions (Cl^-) into the crypt space of the intestine, crypt cells actively draw water into the intestine. These Cl^- ions attract sodium ions (Na^+) into the crypt space, Figure 3-A, increasing the local osmotic pressure. As the osmotic pressure increases, water is pulled into the intestine. Figure 3-B.

Figure 3. Water Secretion Into the Crypt Space



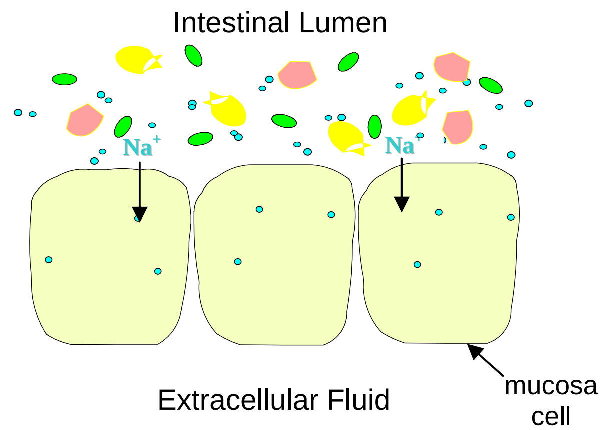
Some bacteria, such as *E. coli*, produce enterotoxins that trigger this pumping mechanism causing hyper-secretion of water. Cholera, which has resulted in the deaths of millions of humans, is perhaps the most infamous of these organisms that lock this pump system in the "ON" position.

Water resorption from the small intestine. Water is resorbed from the digestive tract as a result of nutrient absorption, with sodium (Na^+) playing an important role in this process. As a rule: ***water follows sodium.*** Sodium is free to move across mucosa cell membranes in response to osmotic differences, moving from areas of higher osmotic pressure to areas of lower osmotic pressure. Figure 4.

Although this passive diffusion of Na^+ results in water movement out of the digestive tract, it is insufficient for adequate water resorption. Sodium is also actively moved across the mucosa cell membrane along with other nutrients.

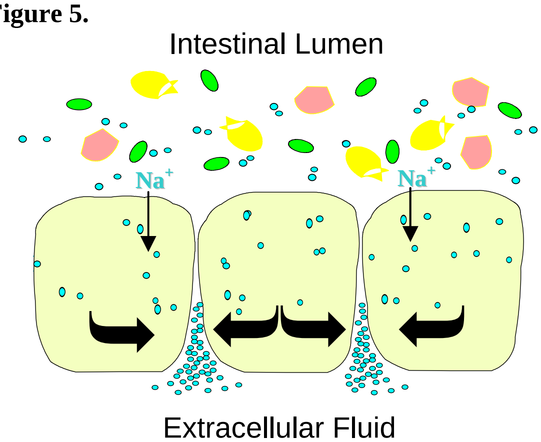
For example, amino acids and carbohydrates are co-transported with Na^+ out of the lumen and into the mucosa cells of the small intestine.

Figure 4. Sodium Movement



Once inside the cell, Na^+ is rapidly pumped into the extracellular fluid surrounding the cell, away from the intestinal lumen. As a result of these nutrient movements, a series of osmotic gradients are created which move water from the lumen into the cell, and then from the cell into the extracellular fluid. Figure 5. The Na^+ and water then diffuse into the bloodstream.

Figure 5.



The ability to concentrate Na^+ in the extracellular fluid surrounding mucosa cells, drawing water from the digestive tract, increases as food particles move through the small intestine. By the time food reaches the large intestine, about 80% of the water has been resorbed.

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