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CHAPTER 9

HANDOUT

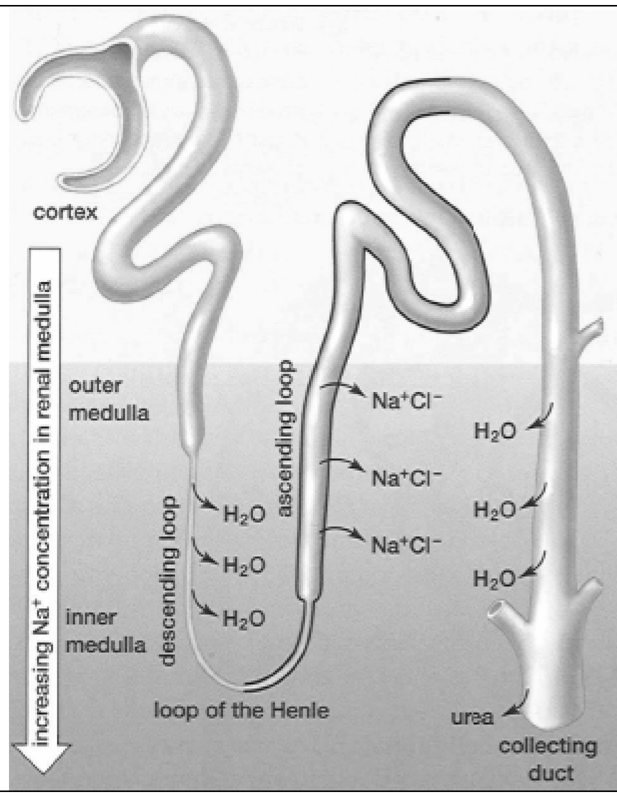
Water Conservation in the Nephron

BLM 9.2.4

Urine is a solution of cellular wastes and excess substances dissolved in water. Therefore, the elimination of these wastes inevitably causes water loss from the body. This is a disadvantage when water is scarce. Fortunately, nephrons are adapted to withdraw a great deal of water from the urine when osmotic pressure of body fluids is high, producing highly concentrated urine. When this occurs, the urine is scant and has a deep yellow colour.

Osmosis can occur between solutions of different concentrations until the solutions are isotonic to each other. But urine leaving the kidneys is rarely isotonic to body fluids. In humans, urine can be up to four times more concentrated because it has lost water by osmosis in a region of the kidney where fluids surrounding the nephron are unusually hypertonic.

Where do the fluids encounter such hypertonic surroundings? The answer lies in the medulla of the kidney, where the nephron loops and the collecting ducts are found.



In the diagram above, you see that the concentration of salts in the medulla is much greater than in other body tissues because of the active transport of sodium ions from the ascending nephron loop. Because this section of the nephron is impermeable to water, salts become very concentrated in the medullary tissue.

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The filtrate makes its final journey on the way to becoming urine by passing through the collecting ducts in the medulla. Here, water is withdrawn by osmosis from the filtrate into the surrounding “salty” environment, as the filtrate approaches isotonicity with the medulla. In this way, the filtrate is transformed into highly concentrated urine and valuable water is conserved in the body.

An extreme example of this mechanism is found in the kidneys of kangaroo rats. These are small rodents so well adapted to desert life that they never need to drink water. The nephron loops in their kidneys are extremely long, an adaptation that provides a very large surface area through which to reabsorb sodium and chloride ions. This makes the medullary region extremely hypertonic, creating urine that is up to 17 times more concentrated than body fluids.

But what if there is excess water in our body fluids? Drinking plenty of water creates body fluids in which osmotic pressure is lower than optimum. What prevents osmosis from reabsorbing water into the salty medulla when in fact the appropriate action would be elimination of water? How much water is to be reabsorbed or eliminated is influenced by whether the walls of the collecting ducts allow osmosis to occur as the filtrate passes through the salty medulla. The permeability of the collecting duct walls is controlled by a homeostatic mechanism.