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EXPLAIN URINE FORMATION AND CONCENTRATION

The kidneys filter unwanted substances from the blood and produce urine to excrete them. There are three main steps of urine formation: glomerular filtration, reabsorption, and secretion. These processes ensure that only waste and excess water are removed from the body.

1. The Glomerulus Filters Water and Other Substances from the Bloodstream

Each kidney contains over 1 million tiny structures called **nephrons**. Each nephron has a **glomerulus**, the site of blood filtration. The glomerulus is a network of capillaries surrounded by a cuplike structure, the glomerular capsule (or Bowman's capsule). As blood flows through the glomerulus, blood pressure pushes water and solutes from the capillaries into the capsule through a filtration membrane. This glomerular filtration begins the urine formation process.

2. The Filtration Membrane Keeps Blood Cells and Large Proteins in the Bloodstream

Inside the glomerulus, blood pressure pushes fluid from capillaries into the glomerular capsule through a specialized layer of cells. This layer, the **filtration membrane**, allows water and small solutes to pass but blocks blood cells and large proteins. Those components remain in the bloodstream. The filtrate (the fluid that has passed through the membrane) flows from the glomerular capsule further into the nephron.

3. Reabsorption Moves Nutrients and Water Back into the Bloodstream

The glomerulus filters water and small solutes out of the bloodstream. The resulting filtrate contains waste, but also other substances the body needs: essential ions, glucose, amino acids, and smaller proteins. When the filtrate exits the glomerulus, it flows into a duct in the nephron called the **renal tubule**. As it moves, the needed substances and some water are reabsorbed through the tube wall into adjacent capillaries. This reabsorption of vital nutrients from the filtrate is the second step in urine creation.

4. Waste Ions and Hydrogen Ions Secreted from the Blood Complete the Formation of Urine

The filtrate absorbed in the glomerulus flows through the renal tubule, where nutrients and water are reabsorbed into capillaries. At the same

time, waste ions and hydrogen ions pass from the capillaries into the renal tubule. This process is called **secretion**. The secreted ions combine with the remaining filtrate and become urine. The urine flows out of the nephron tubule into a collecting duct. It passes out of the kidney through the renal pelvis, into the ureter, and down to the bladder

Urine Concentration

The main role of mammalian kidneys is to maintain water and sodium balance of the body, in a way regulating blood osmolality. The nephrons of kidney play a vital role in concentrating the urine and enabling water retention in the body. The availability of water is not continuous to many mammals; hence, water retention is a necessity for sustaining life. On the contrary, to strike electrolyte balance in the blood, excretion of sodium and its ions becomes invariable to maintain the blood osmolality. The **concentrating mechanism of urine** by nephrons helps mammals in striking the balance between the water retention and sodium excretion.

Anatomy of Nephrons

The nephrons, being the basic functional unit of kidney, are composed of renal corpuscle and renal tubule. The very structure of the nephrons is the main reason to perform the function of urine concentration. The urine formation starts in glomerular capsule where it filters the blood supplied by the tuft of capillaries. The glomerular filtrate passes through the renal tubules where the water is reabsorbed and urine concentrated

by a mechanism known as **countercurrent multiplication mechanism**. To understand the mechanism, it is essential to be aware of renal tubular structure, which comprises

• Proximal convoluted tubule (located in cortex);

• Loop of Henle (LOH; U-shaped loop located in medulla):

○ Descending limb of LOH—permeable to water and impermeable to solutes;

○ Ascending limb of LOH—practically impermeable to water and permeable to solutes:

▪ Thin ascending limb of LOH;

▪ Thick ascending limb of LOH (reentering the cortex);

• Distal convoluted tubule.