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Question: 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.

5. **Urine Is 95% Water:**

   The nephrons of the kidneys process blood and create urine through a

process of filtration, reabsorption, and secretion. Urine is about 95% water and 5% waste products. Nitrogenous wastes excreted in urine include urea, creatinine, ammonia, and uric acid. Ions such as sodium, potassium, hydrogen, and calcium are also excreted.

Concentration of urine

The urine concentrating mechanism is believed to operate as follows in the outer medulla. NaCl is actively transported from the tubular fluid of thick ascending limbs of the loops of Henle into the surrounding interstitium, mediated by the Na-K-2Cl cotransporter NKCC2/BSC1 in the apical plasma membrane and Na-K-ATPase in the basolateral plasma membrane. This active NaCl reabsorption raises the osmolality of interstitial fluid and promotes the osmotic reabsorption of water from the tubular fluid of descending limbs and collecting ducts. Because of the reabsorption of fluid from descending limbs of the loops of Henle, the fluid delivered to the ascending limbs has a high NaCl concentration that favors transepithelial NaCl transport from ascending limb fluid. (There may also be some NaCl diffusion into descending limb fluid.) NaCl reabsorption dilutes the thick ascending limb tubular fluid, so that at each medullary level the fluid osmolality is less than that in the other tubules and vessels, and so that the fluid delivered to the cortex is dilute relative to blood plasma. The ascending limb fluid that enters the cortex is further diluted by active NaCl reabsorption from cortical thick ascending limbs, so that its osmolality is less than the osmolality of blood plasma. In the presence of vasopressin (antidiuretic hormone), cortical collecting ducts are highly water-permeable, and sufficient water is reabsorbed to return the fluid to isotonicity with blood plasma. This cortical water reabsorption greatly

reduces the load that is placed on the urine concentrating mechanism by the fluid that re-enters the medulla via the collecting ducts. In the absence of vasopressin, the entire collecting duct system has limited water permeable, and even though some water is reabsorbed due to the very large osmotic pressure gradient, fluid that is dilute relative to plasma is delivered by the collecting ducts to the border of the outer and inner medulla.