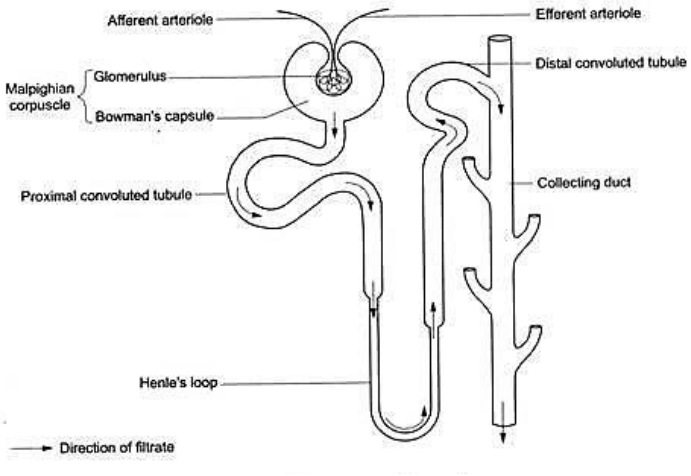
Structure of Nephron



Nephrons are the **functional** units of the kidneys. Each nephron consists of two parts: **a renal corpuscle**, where blood plasma is filtered, and **a renal tubule** into which the filtered fluid passes. The two components of a renal corpuscle are the **glomerulus** (capillary network) and the **glomerular (Bowman's) capsule**, a double-walled epithelial cup that surrounds the glomerular capillaries. Blood plasma is filtered in the glomerular capsule, and then the filtered fluid passes into the renal tubule, which has three main sections. In the order that fluid passes through them, the renal tubule consists of a **(1) proximal convoluted tubule, (2) loop of Henle (nephron loop), and (3) distal convoluted tubule.** Proximal denotes the part of the tubule attached to the glomerular capsule, and distal denotes the part that is further away. Convoluted means the tubule is tightly coiled rather than straight. the loop of Henle connects the proximal and distal convoluted tubules. The first part of the loop of Henle dips into the renal medulla, where it is called the **descending limb of the loop of Henle.** It then makes that hairpin turn and returns to the renal cortex as the **ascending limb of the loop of Henle.** The distal convoluted tubules of several nephrons empty into a single **collecting duct.**

Physiology of urine formation

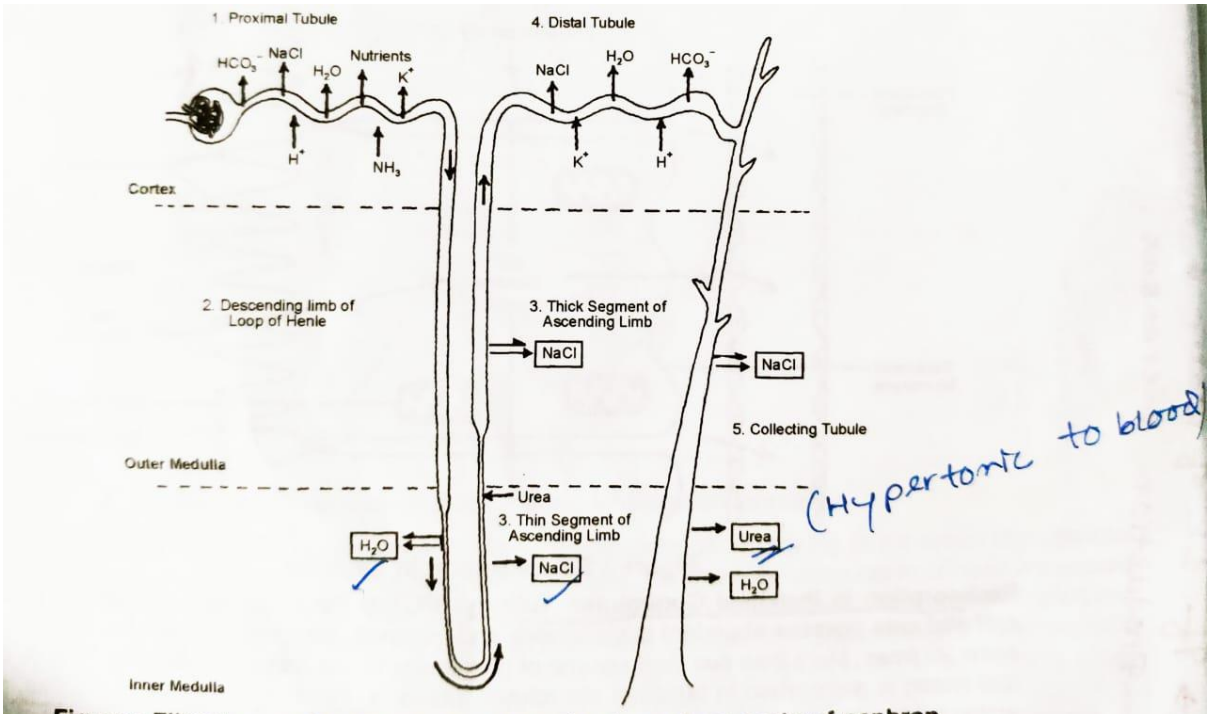


Figure : Filtration, reabsorption and secretion in various parts of nephron

Urine formation occurs in three steps.

1. **Glomerular filtration (Ultrafiltration):** Occurs in the glomerulus, a network of capillaries in the Bowman's capsule of the nephron.
   a) **Pressure-Driven Process**: Renal artery blood enters the glomerulus under pressure.
   b) **Filtration Contents**: Pressure forces water, ions, and small solutes (e.g., glucose, urea, electrolytes) out of blood into the Bowman's capsule.
   c) **Resulting Fluid**: Known as "glomerular filtrate," it resembles blood plasma but lacks larger proteins and blood cells.
2. **Tubular reabsorption**: Second step of urine formation in renal tubules. Glomerular filtrate moves through proximal convoluted tubules, loop of Henle, distal convoluted tubules, and collecting ducts. Here, essential substances (e.g., glucose, water, electrolytes) are reabsorbed from filtrate into bloodstream. The reabsorption occurs primarily in the proximal tubules. This process helps the body to retain important nutrients and maintain electrolyte balance, preventing loss in urine.
3. **Tubular excretion:** Third step in urine formation, mainly in distal convoluted tubules and collecting ducts. During this process, waste products (H+, K+), drugs, and excess substances actively move from blood into renal tubules. This helps the body eliminate these substances from the bloodstream and excrete them in the urine. Tubular secretion is crucial for maintaining the body's acid-base balance, electrolyte balance, and eliminating toxins.

Counter current mechanism

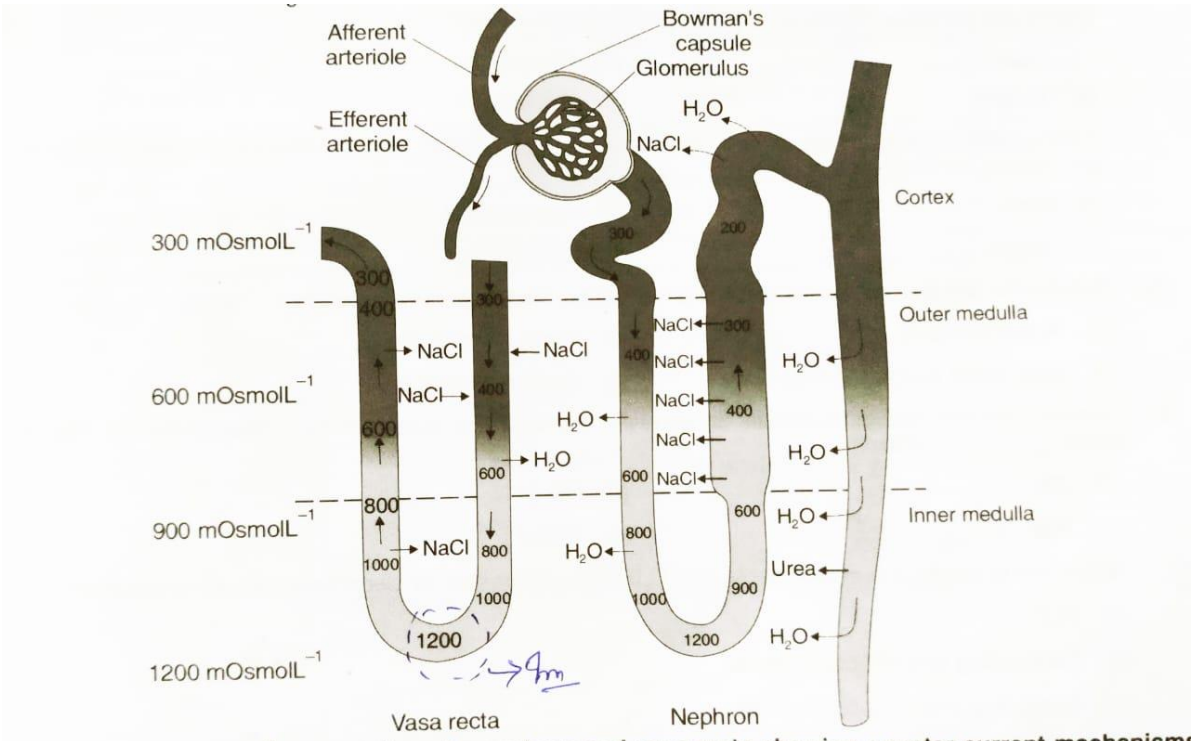


Figure: Diagrammatic representation of a nephron and vasa recta showing counter current mechanisms

The counter current mechanism in urine concentration refers to the process by which the kidney generates a concentrated urine by creating a concentration gradient in the renal medulla, the inner part of the kidney. This mechanism primarily involves **the loop of Henle and the vasa recta**, which are specialized structures within the nephrons. This process is essential for maintaining proper fluid and electrolyte balance in the body.

Loop of Henle: As filtrate from the glomerulus passes through the descending limb, it becomes more concentrated as water is reabsorbed, and solutes like sodium and chloride are retained. The descending limb is permeable to water but not to solutes. As the filtrate descends deeper into the medulla, water is continuously reabsorbed into the surrounding tissues, concentrating the remaining filtrate. The ascending limb, particularly the thick ascending limb, is impermeable to water but actively transports sodium and chloride ions out of the filtrate and into the surrounding tissues. This creates a concentration gradient in the renal medulla.

Vasa Recta: The vasa recta are specialized capillaries that run alongside the loop of Henle. As the vasa recta descend into the medulla, they pick up the concentrated salt from the surrounding tissues. As the vasa recta ascend back toward the cortex, they release the salt back into the interstitial fluid and reabsorb water, preventing the washout of concentrated solutes from the medulla.