THE RENAL SYSTEM(L3)

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2nd stage

PHYSIOLOGY #II
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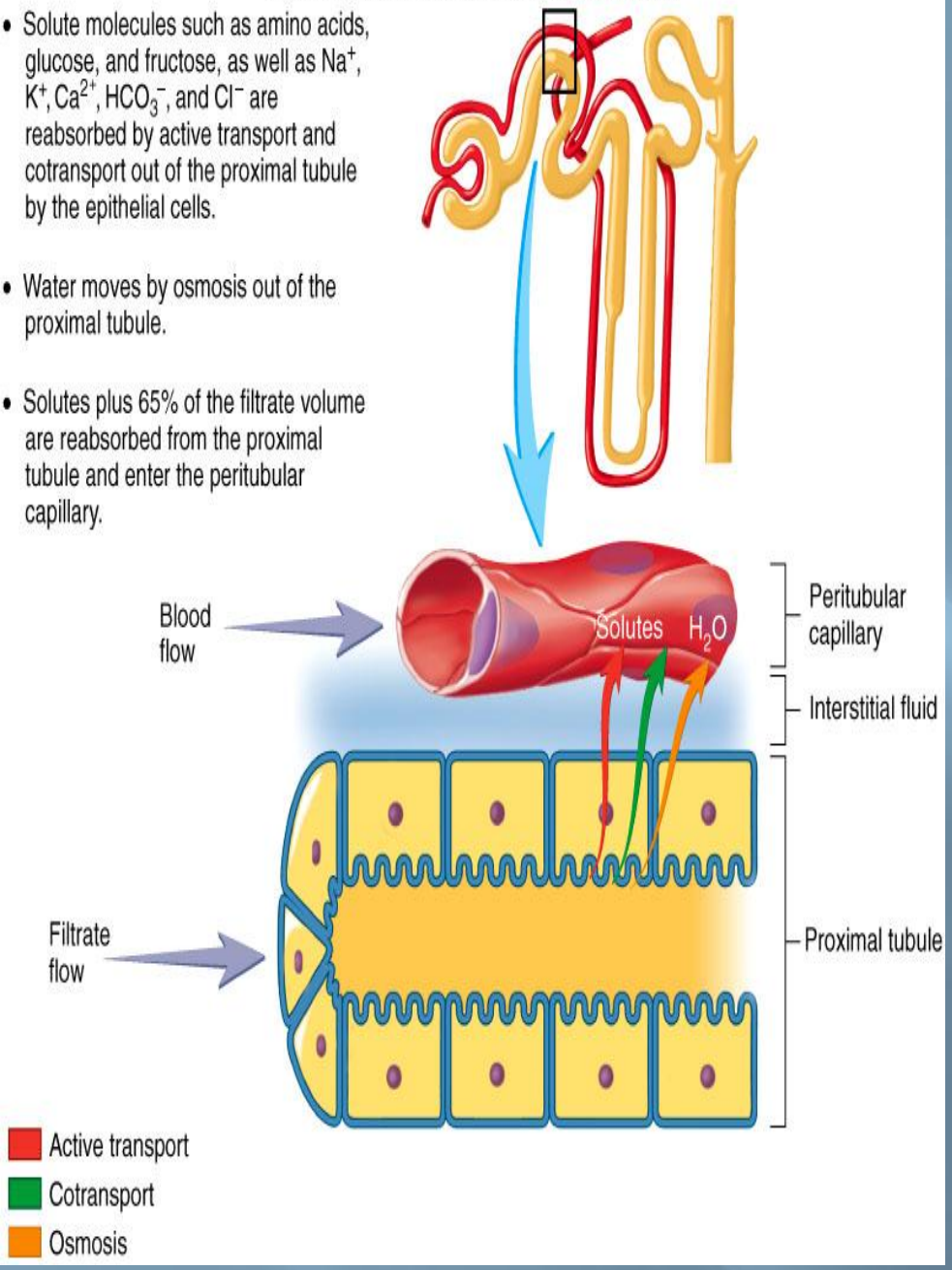
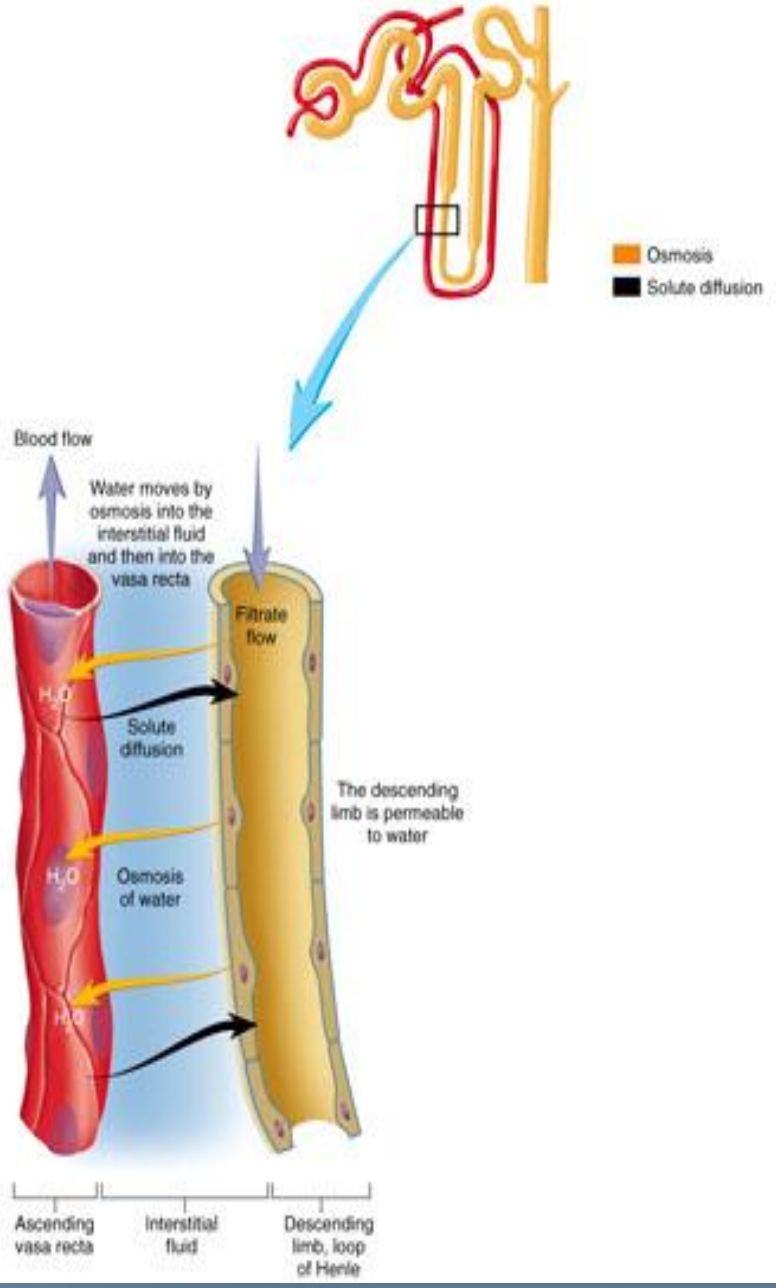
- **Reabsorption and secretion in the tubules**
- The filtrate entering the nephrons flows through the following tubules:
- The proximal tubule
- The loop of Henele
- The distal tubule
- The collecting tubule
- The collecting duct.
- Substances are selectively reabsorbed or secreted by the tubular epithelium.
- Reabsorption plays greater role than does secretion in the formation of urine, but secretion is important in the determining the amounts of K^+ and H^+.
- The resulting fluid entering the pelvis is urine
- The tubules separate the substances that are to be conserved in the body from those be eliminated in the urine.
- Water in the glomerular filtrate is reabsorbed in about 99% as it passes through the tubules.
- Glucose and amino acids are entirely reabsorbed.

- **Reabsorption.**
- **The Proximal tubule**
- Useful substances are reabsorbed by **active transport and cotransport**. Thus the cells of the proximal tubule have microvilli (give a large surface area) and large numbers of mitochondria (ATP for active transport).
- Separate pumps are found for each of the different types of foods e.g. glucose, fructose, aminoacids, and for different ions e.g. Na^{+}, Ca^{2+}, HCO_3^{-}. Foods are thus normally completely reabsorbed, unless the capability of the pump is exceeded. Thus the maximum reabsorption of glucose produces a blood concentration of 150mg/ 100ml, so if a higher level of glucose enters the kidney (after eating too many sweets), the excess will be excreted in the urine.

- The ionic pumps increase the concentrations of ions outside the nephron and produce a low concentration inside the tubule. This produces an osmotic pressure sucking water out of the tubule into the plasma surrounding the tubule. In this way,
- **65% of the water** in the filtrate is reabsorbed by osmosis. The reabsorbed substances are taken up by the peritubular capillaries and so removed from the cortex back in to the blood.
- The filtrate leaving the **proximal tubule is isotonic** (has the same osmotic pressure as the blood plasma = **300 mOsm**). This is because salt and water were removed at the same rate from the filtrate.

- Solute molecules such as amino acids, glucose, and fructose, as well as Na^+, K^+, Ca^{2+}, HCO_3^-, and Cl^- are reabsorbed by active transport and cotransport out of the proximal tubule by the epithelial cells.
- Water moves by osmosis out of the proximal tubule.
- Solutes plus 65% of the filtrate volume are reabsorbed from the proximal tubule and enter the peritubular capillary.





- **Loop of Henle**
- The loop of Henle consists of a descending loop, descending deep in to the medulla, and an ascending loop, returning back towards the cortex. The ascending loop is subdivided into a short section of thin segment and a longer thick segment.
- The medulla has **high concentrations of NaCl + small quantities of urea** (that have leaked out of the collecting ducts), so that its osmotic pressure increases from 300 mOsm (near the cortex) to 1200 near the central pelvis. This is because the vasa recta only remove water from the medulla, leaving behind most of the salt (unlike the peritubular capillaries of the cortex).

- **Thus water reabsorption occurs in 3 stages:**
- The **descending loop** has walls **permeable to water**, but only a very low permeability to salts. As the filtrate descends in to progressively higher and higher OP's, water is sucked out, but only small quantities of salt can diffuse in.
- By the **bottom** of the loop, the OP of the filtrate has increased to **1200 mOsm**. **15% of the water is reabsorbed in the descending loop of Henle**, so the volume of filtrate is now only 20% of the original.

- In the **thin segment** of the ascending loop, the walls are not permeable to water, so as it moves up through progressively lower salt concentrations, some **salt will diffuse out**, to reduce its OP (but not change its volume).

- In the **thick segment** of the ascending loop, there are Na^+ pumps (like in the proximal tubule). **Na^+ is pumped out**, while **Cl^- follows passively**; **K^+ also moves out by cotransport**. This progressively dilutes the filtrate (water will not be removed because the walls throughout the ascending loop are not permeable). By the **top** of the loop (as the tubule re-enters the cortex), the filtrate will now be hypotonic (**100 mOsm**).

- The descending loop thus loses water (and thus reduces its volume); the ascending loop loses salt (no further change in volume

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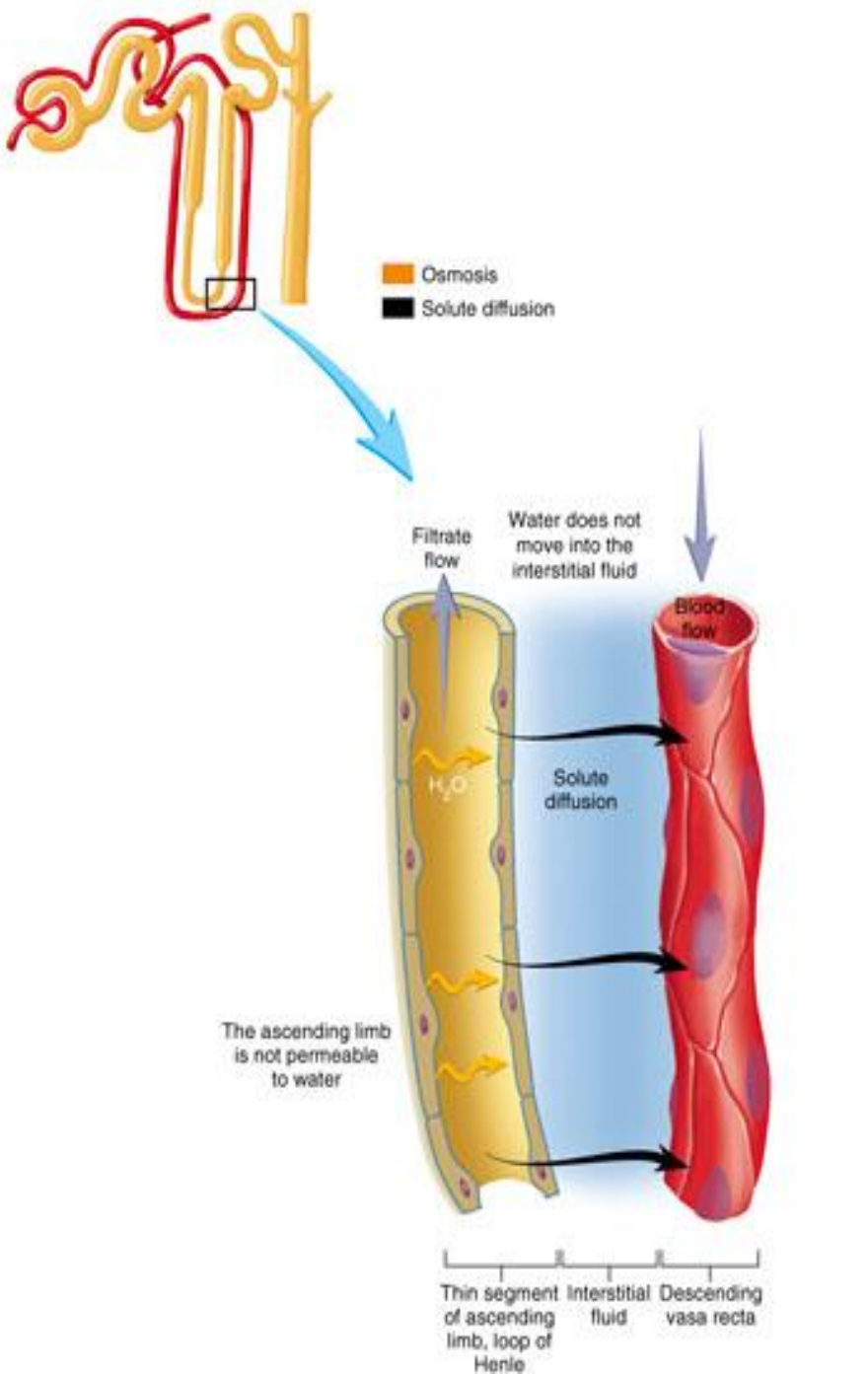
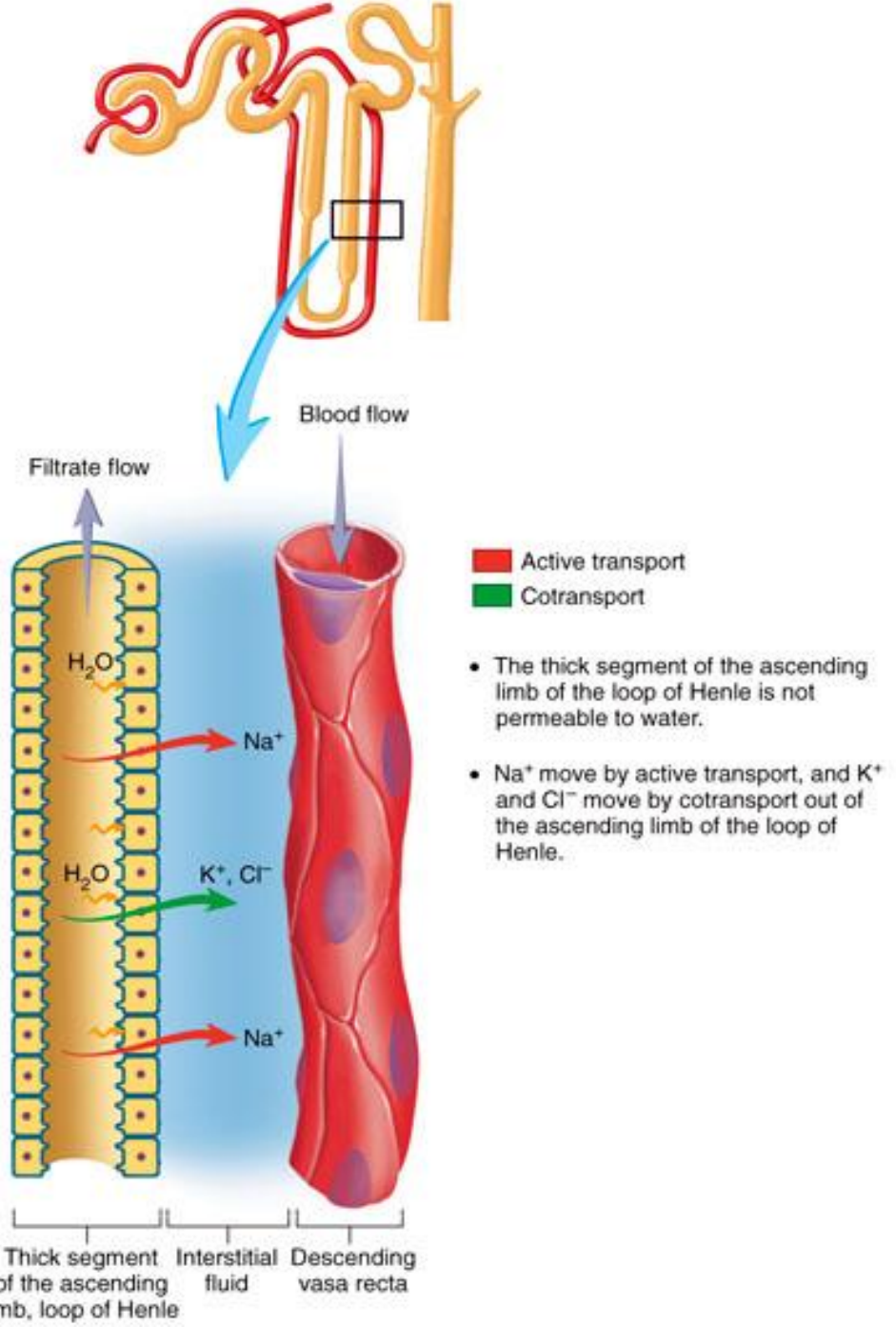
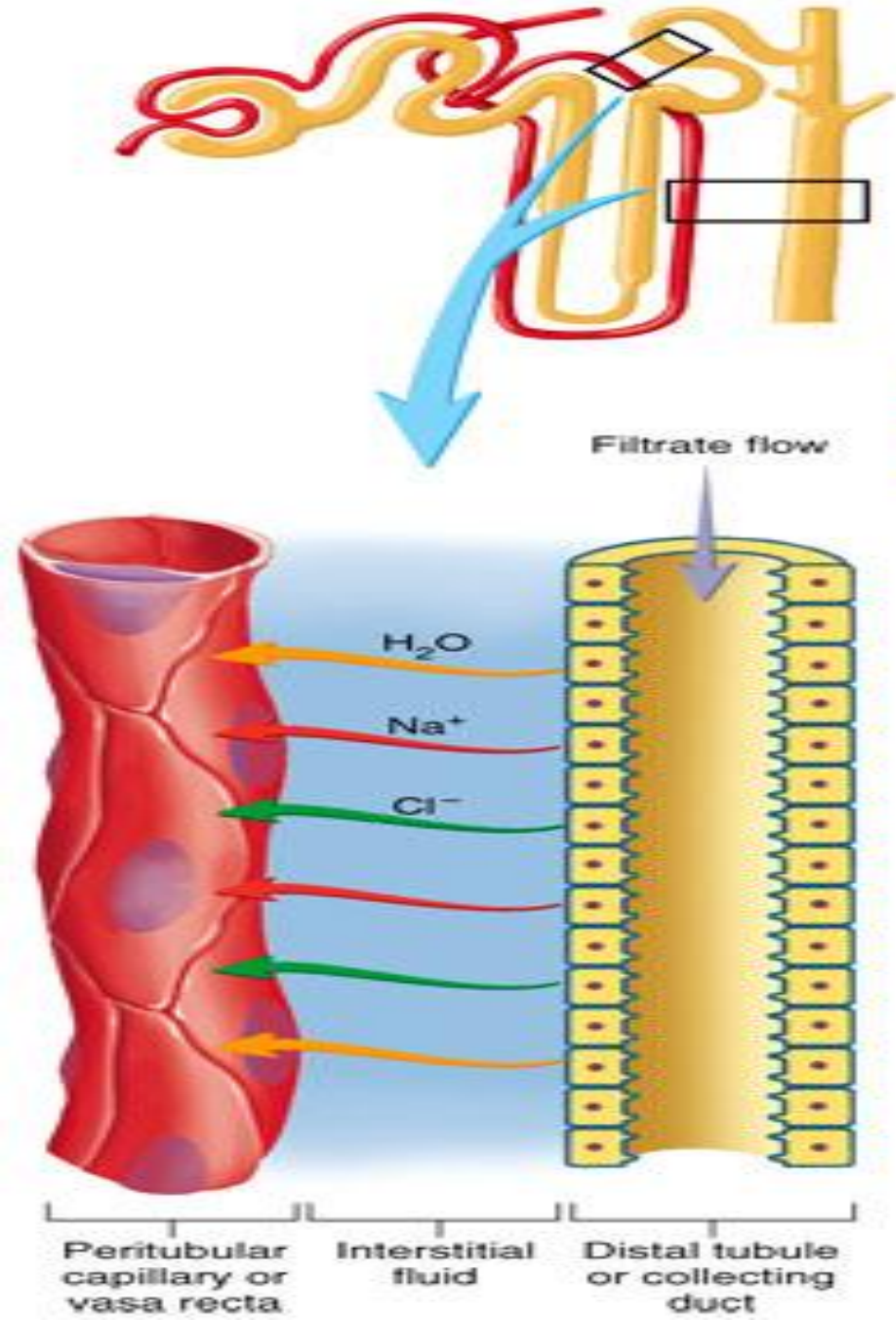




- The thick segment of the ascending limb of the loop of Henle is not permeable to water.
- Na^+ move by active transport, and K^+ and Cl^- move by cotransport out of the ascending limb of the loop of Henle.

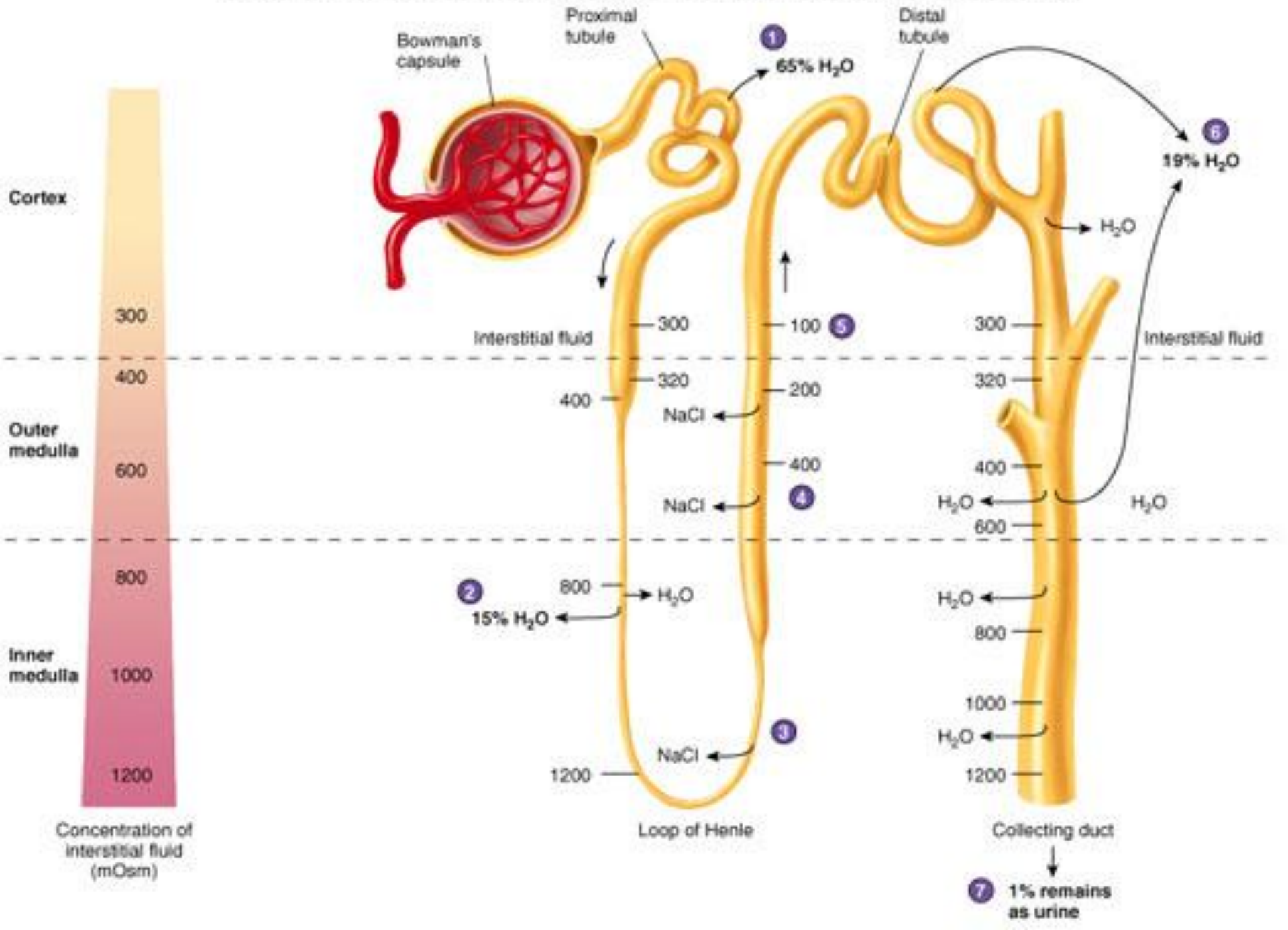


Active transport
Cotransport
Osmosis

- Na^+ move by active transport and Cl^- move by cotransport out of the distal tubule and collecting duct.
- Water moves by osmosis from the distal tubule and collecting duct.
- The reabsorbed water and solutes enter the peritubular capillaries and vasa recta.
- Approximately 19% of the filtrate is reabsorbed from the distal tubule and collecting duct.

- **Distal tubule.**
- Because the OP of the filtrate is now less than the surrounding plasma, **some water will diffuse out** (and some salt diffuse in) to return the OP to 300 mOsm. However, **aldosterone** can act in this section (and the collecting duct) by activating Na^+/K^+ pumps (so Na^+ out, but K^+ in - unlike loop of Henle)

- **Collecting duct.**
- The **collecting duct** re-enters the medulla, but this time passes right through the medulla. As it passes through the deepest layers of the medulla, which have the very highest concentrations of NaCl, the maximum reabsorption of water by osmosis will occur (raising the OP of the filtrate to over **1200 mOsm**). A further **19%** of the filtrate may be reabsorbed, leaving just 1% of the original remaining. However, the permeability to water of the collecting duct walls is controlled by the hormone **ADH**.



Active secretion.

- The distal tubule secretes **toxins** in to the tubule by **active transport**. These include **H^+** (which interferes with respiration and enzyme activity), **K^+** (nerve conduction requires a low conc of K^+ in the plasma), **histamine** (acts locally in the body, so should then be removed), **creatinine**, etc. In addition, some toxins, such as **ammonia** (produced by the breakdown of aminoacids), will passively diffuse into the tubule.

Thanks