Regulatory Functions of the Kidneys

The kidneys do much more than just filter the blood! As we already know, the kidneys regulate water concentration, remove nitrogenous wastes, and regulate blood pH and concentration of ions such as Na^+, K^+, Mg^{2+}, and HCO_3^-.

But first! Keep this information in mind…

Solute Gradients in the Nephron

- A solution moves from areas of **high** concentration to areas of **low** concentration (diffusion)
- Water easily moves across living membranes, following diffusion gradients (osmosis)
- By changing the solute concentration (e.g. salt), water concentration is affected
- **Raising** the solute concentration **lowers** the water concentration, even if the quantity of water if unchanged
- Membranes are **differentially** permeable (i.e. membranes can control the type of molecule transported and the directions of that transport).
- Active transport requires an input of **energy**. In the case of salt reabsorption in the kidney, the amount of energy consumed is considerable – about 1/3 of all non-muscular activity in the body.

Back to the kidneys….

1. Regulate volume of blood (i.e. water volume). This is done by two hormones: **anti-diuretic hormone (ADH)** and **aldosterone**

ADH: made by the **hypothalamus** and released from posterior pituitary gland (in brain); causes **increase** in urine concentration by stimulating the reabsorption of **water**.

How?

1. Cells in hypothalamus detect **low** water content of blood - send ADH to posterior pituitary gland (this amount depends on amount of water being diffused)
2. ADH released from posterior pituitary into the **blood** and targets cells in the collecting duct and distal convoluted tubule (these become more **permeable** to water in the presence of ADH)
3. Water is reabsorbed by the peritubular capillary network, volume of urine decreases
4. Blood volume **increases**
5. Blood becomes more **dilute**, reducing stimulation of the hypothalamus, ADHD secretion **stops** (negative feedback loop! = blood volume rises, detected by the hypothalamus and shuts of the release of ADH)

**Note: Diuretic drugs are prescribed for high blood pressure

Thinking question: What is a diuretic? How do you think diuretic drugs reduce blood pressure?

Diuretics are chemicals that increase the flow of urine. High blood pressure caused by too much water in the blood, to reduce amount of water in the blood, less reabsorption needs to take place; to reduce amount of water being reabsorbed diuretic drug is taken which inhibits ADH secretion (DCT and collecting duct aren't more permeable to water), no extra water gets reabsorbed into the blood stream, this lowers blood volume and therefore, blood pressure is lowered as well (causes increased urination, however)

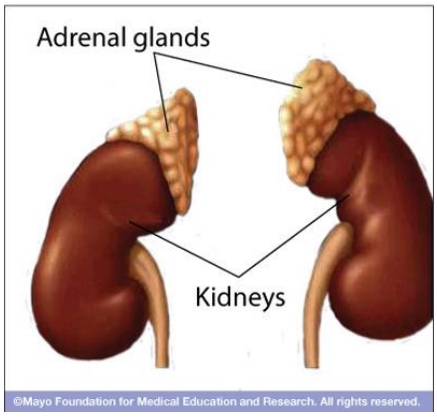
Alcohol and caffeine also **inhibit** ADH secretion – drinking alcohol or caffeine causes **increased** urination. (both diuretics)

Alcohol → increase urination → dehydration → hangover → horrible

Beer and alcohol cannot quench your thirst! You will urinate more liquid than you will take in.

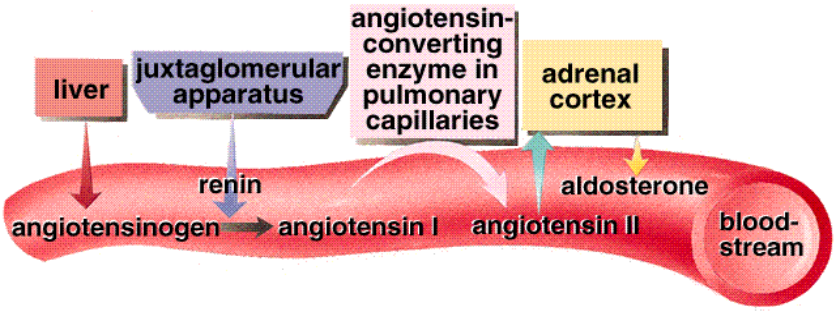
Aldosterone: released by the **adrenal cortex** (adrenal glands sit on top of the kidneys); acts on kidney to retain Na^+ and excrete K^+; causes an **increase** in both blood pressure and volume without changing the **concentration**.

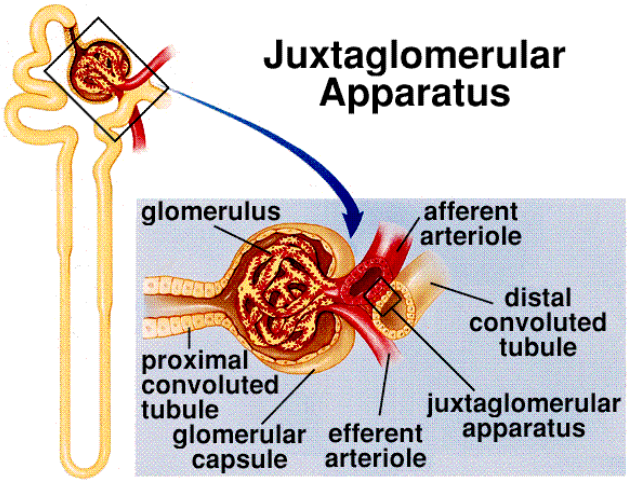
Concentration of sodium in the blood **regulates** secretion of aldosterone (negative feedback loop again!)

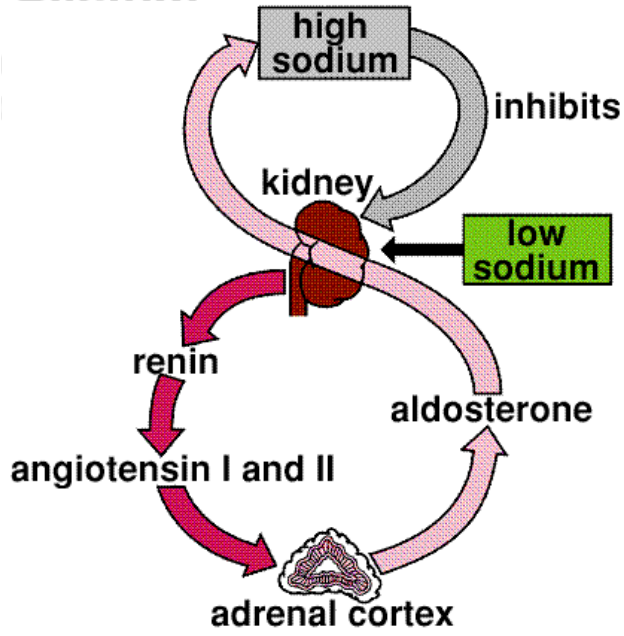


How?

1. **Low** blood pressure (too low for pressure filtration) stimulates release of **renin** in the juxtaglomerular apparatus near the afferent arteriole.
2. Renin circulates in the blood and activates a blood protein called **angiotensinogen** to angiotensin I
3. Angiotensin I is converted to **angiotensin II** which is a powerful vasoconstrictor (make blood vessels shrink in diameter) – this helps **raise** blood pressure
4. Angiotensin II stimulates the adrenal cortex to release **aldosterone**
5. Aldosterone affects DCT, **excretes** more K^+ and **reabsorbs** more Na^+ in the blood
6. As more Na^+ is reabsorbed, more water is **absorbed** because the blood is now hypertonic (contains more solute than the outside – so water diffuses in)
7. Results in **increased** blood volume and blood pressure







The rising levels of sodium in the blood are detected by the adrenal cortex and this **shuts off** the release of aldosterone (negative feedback).

Recall: reabsorption of water is driven by Na^+ concentration. More salt in peritubular space means concentration increases, drawing water along, which is reabsorbed.

Draw a diagram that summarizes the control of blood volume and pressure by Aldosterone and ADH. (*See pg. 419 of the textbook to help if you wish*)