**Water Balance**

- If water intake increases, urine output increases
- If exercise increases or water intake decreases, urine output is decreased
- These homeostatic adjustments require the interaction of the nervous system and the endocrine system

**Regulating ADH**

- A hormone, antidiuretic hormone (ADH) helps regulate the osmotic pressure of body fluids by causing the kidneys to increase water absorption
- When ADH (produced in the hypothalamus) is released, a more concentrated urine is produced (conserving water)
- Specialized nerve receptors, called osmoreceptors, located in the hypothalamus detect changes in osmotic pressure
- When water levels are low (through sweat, decreased intake or frequent urination) blood solutes become more concentrated, increasing osmotic pressure
- Water moves into the bloodstream, causing cells in the hypothalamus to shrink (see Fig. 1, p.353)
- A nerve message is sent to the pituitary, signalling the release of ADH, carried by the bloodstream to the kidneys
- The kidneys reabsorb more water, creating more concentrated urine, and preventing further water loss
- This also causes a sensation of thirst
- If more water is taken in, the concentration of solutes in the blood decreases, lowering the osmotic pressure of the blood
- Fluids will move into the hypothalamus and cells will swell, sending a message to reduce ADH secretion (negative feedback)

**ADH and Nephrons**

- 85% of the water filtered in the nephron is reabsorbed in the proximal tubule (the only part of the nephron that is permeable to water)
- The descending loop of Henle is permeable to water and ions, but the ascending tubule is only permeable to NaCl
- Active transport of Na⁺ ions from the ascending section of the loop concentrate solutes within the medulla of the kidney
- Without ADH, the rest of the tubule remains impermeable to water, but continues to actively transport Na⁺ ions from the tubules
- The remaining 15% of water will be lost if no ADH is present
- ADH makes the upper part of the distal tubule and the collecting duct permeable to water - the high concentration of NaCl in the intercellular spaces creates an osmotic pressure that draws water from the upper section of the distal tubule and collecting duct
- The urine remaining in the nephron becomes more concentrated
- NOTE: the kidneys can only control 15% of water reabsorption

**Kidneys and Blood Pressure**
The kidneys help to regulate BP by adjusting for blood volume

A hormone, called **aldosterone**, acts on the nephrons to increase Na\(^+\) reabsorption (see Fig. 2, p. 354)

This hormone is produced in the cortex of the adrenal glands which lies above the kidneys

As NaCl reabsorption increases, the osmotic gradient increases, and more water moves out of the nephron by osmosis

If fluid is lost, blood pressure will decrease reducing the delivery of \(O_2\) and nutrients to tissues

BP receptors detect low blood pressure, signalling the release of **angiotensin** (an activated enzyme)

Angiotensin causes constriction of blood vessels and stimulates the release of aldosterone (increasing Na\(^+\) transport) both increase blood pressure

**pH Balance**

The kidneys also regulate pH, maintaining a constant level of 7.3-7.5

pH can fluctuate because of foods and through cellular respiration (\(CO_2\) dissolves to form carbonic acid)

Carbonic acid and other excess acids ionize to produce H\(^+\) ions (lowers pH)

An acid-base balance is maintained by buffer systems that absorb excess H\(^+\) ions or ions that act as bases

Excess H\(^+\) ions are buffered by bicarbonate ions in the blood, producing carbonic acid (a weak acid) (see Fig. 3, p. 355)

Carbonic acid breaks down to form carbon dioxide and water

The kidneys help restore the buffer by reversing the reaction

\(CO_2\) is actively transported from the peritubular capillaries, which surround the nephron, into the cells that line the nephron

The \(CO_2\) combines with \(H_2O\) to initiate the reverse reaction, generating \(HCO_3^-\) and H\(^+\) ions

The bicarbonate ions diffuse back into the blood, restoring the buffer

The H\(^+\) ions recombine with either phosphate ions or ammonia and are excreted with the filtrate from the nephron

**Homework**

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