

## 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<sup>+</sup> 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<sup>+</sup> 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  $\text{Na}^+$  reabsorption (see Fig. 2, p. 354)
- This hormone is produced in the cortex of the adrenal glands which lies above the kidneys
- As  $\text{NaCl}$  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  $\text{O}_2$  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  $\text{Na}^+$  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 ( $\text{CO}_2$  dissolves to form carbonic acid)
- Carbonic acid and other excess acids ionize to produce  $\text{H}^+$  ions (lowers pH)
- An acid-base balance is maintained by buffer systems that absorb excess  $\text{H}^+$  ions or ions that act as bases
- Excess  $\text{H}^+$  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
- $\text{CO}_2$  is actively transported from the peritubular capillaries, which surround the nephron, into the cells that line the nephron
- The  $\text{CO}_2$  combines with  $\text{H}_2\text{O}$  to initiate the reverse reaction, generating  $\text{HCO}_3^-$  and  $\text{H}^+$  ions
- The bicarbonate ions diffuse back into the blood, restoring the buffer
- The  $\text{H}^+$  ions recombine with either phosphate ions or ammonia and are excreted with the filtrate from the nephron

### Homework

p.356 #1-10