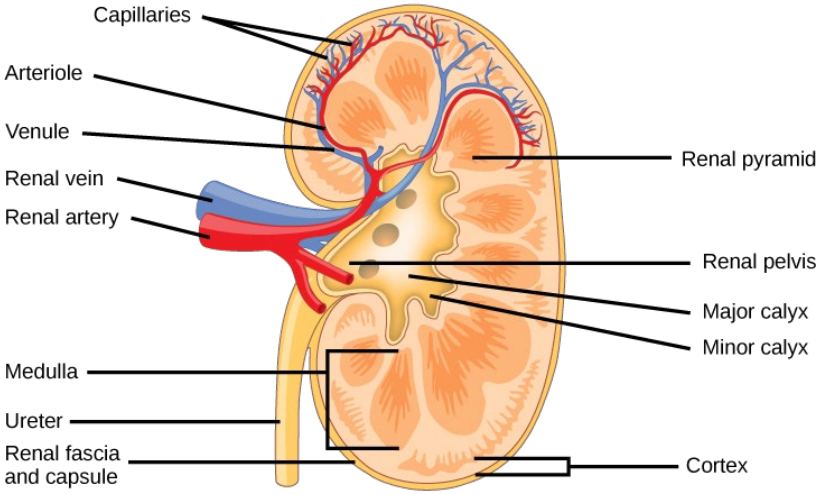
Biology 2e
Unit 7: Animal Structure and Function
Chapter 41: Osmotic Regulation and Excretion

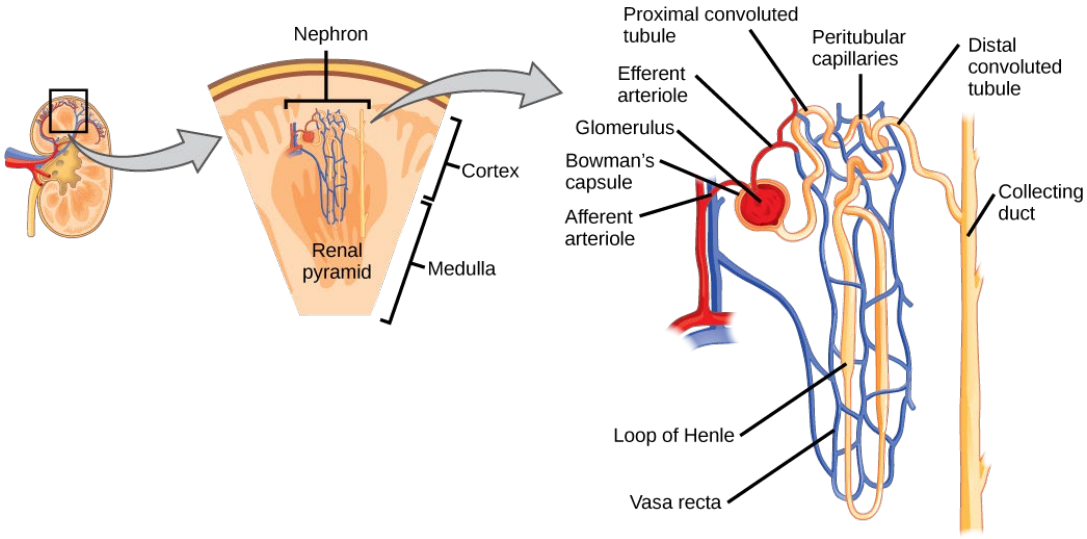
Visual Connection Questions

1. Which of the following statements about the kidney is false?



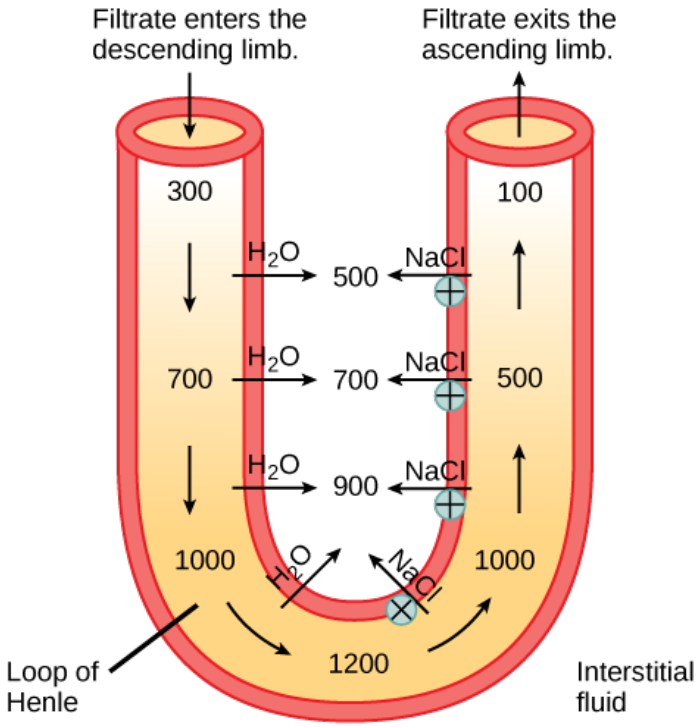
c. The cortex covers the capsule.

2. Which of the following statements about the nephron is false?



a. The collecting duct empties into the distal convoluted tubule.

3. Loop diuretics are drugs sometimes used to treat hypertension. These drugs inhibit the reabsorption of Na^+ and Cl^- ions by the ascending limb of the loop of Henle. A side effect is that they increase urination. Why do you think this is the case?



Loop diuretics decrease the excretion of salt into the renal medulla, thereby reducing its osmolality. As a result, less water is excreted into the medulla by the descending limb, and more water is excreted as urine.

Review Questions

4. When a dehydrated human patient needs to be given fluids intravenously, he or she is given:
b. saline at a concentration that is isotonic with respect to body fluids

5. The sodium ion is at the highest concentration in:
b. extracellular fluid

6. Cells in a hypertonic solution tend to:
a. shrink due to water loss

7. The macula densa is/are:
c. cells present in the DCT and collecting tubules.

8. The osmolarity of body fluids is maintained at _____.
b. 300 mOsm

9. The gland located at the top of the kidney is the _____ gland.
a. adrenal

10. Active transport of K^+ in Malpighian tubules ensures that:
c. both a and b (water follows K^+ to make urine and osmotic balance is maintained between waste matter and bodily fluids)

11. Contractile vacuoles in microorganisms:
d. both b and c (can perform many functions, one of which is excretion of metabolic wastes and originate from the cell membrane)

12. Flame cells are primitive excretory organs found in _____.
d. flatworms

13. BUN is _____.
a. blood urea nitrogen

14. Human beings accumulate _____ before excreting nitrogenous waste.
c. urea

15. Renin is made by _____.
a. granular cells of the juxtaglomerular apparatus

16. Patients with Addison's disease _____.
c. lose salts and water

17. Which hormone elicits the “fight or flight” response?
a. epinephrine

Critical Thinking Questions

18. Why is excretion important in order to achieve osmotic balance?
Excretion allows an organism to rid itself of waste molecules that could be toxic if allowed to accumulate. It also allows the organism to keep the amount of water and dissolved solutes in balance.

19. Why do electrolyte ions move across membranes by active transport?
Electrolyte ions often require special mechanisms to cross the semi-permeable membranes in the body. Active transport is the movement against a concentration gradient.

20. Why are the loop of Henle and vasa recta important for the formation of concentrated urine?
The loop of Henle is part of the renal tubule that loops into the renal medulla. In the loop of Henle, the filtrate exchanges solutes and water with the renal medulla and the vasa recta (the peritubular capillary network). The vasa recta acts as the countercurrent exchanger. The

kidneys maintain the osmolality of the rest of the body at a constant 300 mOsm by concentrating the filtrate as it passes through the loop of Henle.

21. Describe the structure of the kidney.

Externally, the kidneys are surrounded by three layers. The outermost layer is a tough connective tissue layer called the renal fascia. The second layer is called the perirenal fat capsule, which helps anchor the kidneys in place. The third and innermost layer is the renal capsule. Internally, the kidney has three regions—an outer cortex, a medulla in the middle, and the renal pelvis in the region called the hilum of the kidney, which is the concave part of the "bean" shape.

22. Why might specialized organs have evolved for excretion of wastes?

The removal of wastes, which could otherwise be toxic to an organism, is extremely important for survival. Having organs that specialize in this process and that operate separately from other organs provides a measure of safety for the organism.

23. Explain two different excretory systems other than the kidneys.

(1) Microorganisms engulf food by endocytosis—the formation of vacuoles by involution of the cell membrane within the cells. The same vacuoles interact and exchange metabolites with the intracellular environment. Cellular wastes are excreted by exocytosis when the vacuoles merge with the cell membrane and excrete wastes into the environment. (2) Flatworms have an excretory system that consists of two tubules. The cells in the tubules are called flame cells; they have a cluster of cilia that propel waste matter down the tubules and out of the body. (3) Annelids have nephridia which have a tubule with cilia. Excretion occurs through a pore called the nephridiopore. Annelids have a system for tubular reabsorption by a capillary network before excretion. (4) Malpighian tubules are found in some species of arthropods. They are usually found in pairs, and the number of tubules varies with the species of insect. Malpighian tubules are convoluted, which increases their surface area, and they are lined with microvilli for reabsorption and maintenance of osmotic balance. Metabolic wastes like uric acid freely diffuse into the tubules. Potassium ion pumps line the tubules, which actively transport out K^+ ions, and water follows to form urine. Water and electrolytes are reabsorbed when these organisms are faced with low-water environments, and uric acid is excreted as a thick paste or powder. By not dissolving wastes in water, these organisms conserve water.

24. In terms of evolution, why might the urea cycle have evolved in organisms?

It is believed that the urea cycle evolved to adapt to a changing environment when terrestrial life forms evolved. Arid conditions probably led to the evolution of the uric acid pathway as a means of conserving water.

25. Compare and contrast the formation of urea and uric acid.

The urea cycle is the primary mechanism by which mammals convert ammonia to urea. Urea is made in the liver and excreted in urine. The urea cycle utilizes five intermediate steps, catalyzed by five different enzymes, to convert ammonia to urea. Birds, reptiles, and insects, on the other

hand, convert toxic ammonia to uric acid instead of urea. Conversion of ammonia to uric acid requires more energy and is much more complex than conversion of ammonia to urea.

26. Describe how hormones regulate blood pressure, blood volume, and kidney function.

Hormones are small molecules that act as messengers within the body. Different regions of the nephron bear specialized cells, which have receptors to respond to chemical messengers and hormones. The hormones carry messages to the kidney. These hormonal cues help the kidneys synchronize the osmotic needs of the body. Hormones like epinephrine, norepinephrine, renin-angiotensin, aldosterone, anti-diuretic hormone, and atrial natriuretic peptide help regulate the needs of the body as well as the communication between the different organ systems.

27. How does the renin-angiotensin-aldosterone mechanism function? Why is it controlled by the kidneys?

The renin-angiotensin-aldosterone system acts through several steps to produce angiotensin II, which acts to stabilize blood pressure and volume. Thus, the kidneys control blood pressure and volume directly. Renin acts on angiotensinogen, which is made in the liver and converts it to angiotensin I. ACE (angiotensin converting enzyme) converts angiotensin I to angiotensin II. Angiotensin II raises blood pressure by constricting blood vessels. It triggers the release of aldosterone from the adrenal cortex, which in turn stimulates the renal tubules to reabsorb more sodium. Angiotensin II also triggers the release of anti-diuretic hormone from the hypothalamus, which leads to water retention. It acts directly on the nephrons and decreases GFR.