Chapter 44: Osmoregulation and Excretion

44.1 Summarize the osmotic challenges facing animals living in marine, freshwater, and terrestrial habitats.

44.2 Describe the advantages and disadvantages of the major forms of nitrogenous waste in different animal habitats.

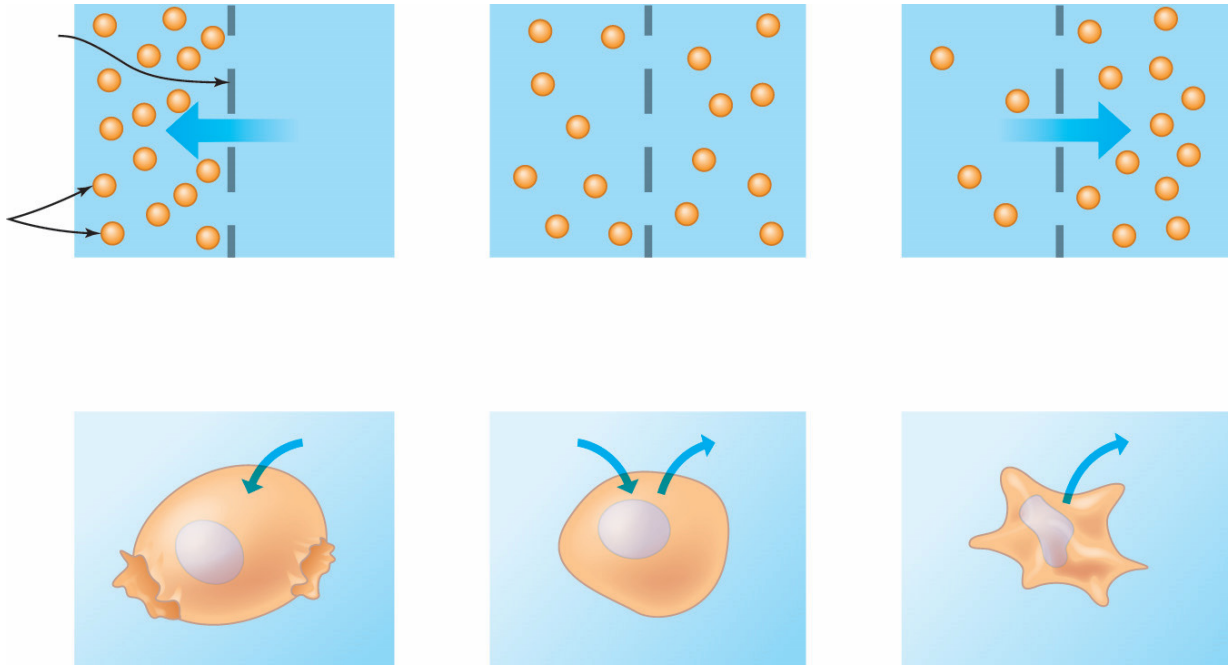
44.3 Compare and contrast the four major stages of excretory system function in worms, insects, and vertebrates.

44.4 Review the function of each region of the nephron in the processing of filtrate.

44.5 Outline the major hormonal circuits that bring about homeostasis in the kidney.

The steady-state physiological condition that organisms must maintain is termed *homeostasis*. Osmoregulation and excretion are frequently cited examples of homeostasis and are the central ideas in this chapter.

Study Tip: Figure 44.1 is a review of passive transport initially covered in Concept 7.3, p. 132. If the material in Figure 44.1 is new to you, it would be worth your time to study Concept 7.3. Label and explain the osmotic concepts in the figure below, noting the net flow of water in each panel. Notice the slight switch in terms when dealing specifically with *osmolarity*; for example, isotonic becomes isoosmotic.



1. Define these two terms.

   osmoregulation

   excretion

2. Why are nitrogenous wastes associated with nucleic acids and proteins, but not with lipids or carbohydrates? (You may need to review Chapter 5, where you learned about organic molecules.)

Concept 44.1 Osmoregulation balances the uptake and loss of water and solutes

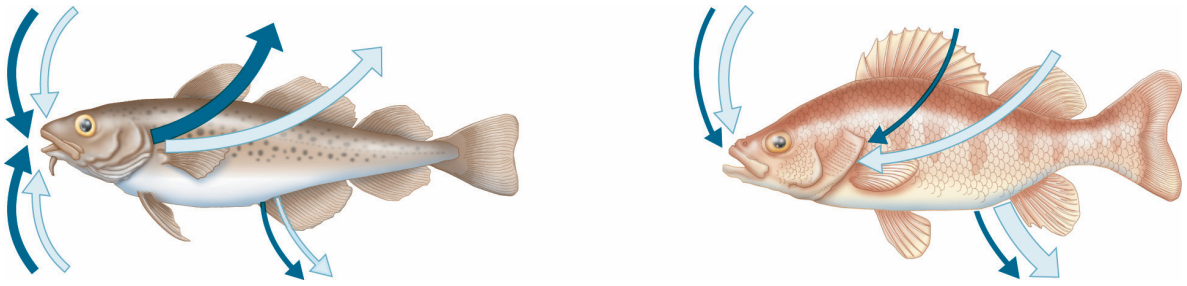
LO 44.1: Summarize the osmotic challenges facing animals living in marine, freshwater, and terrestrial habitats.

3. a. Explain water movement in an *isoosmotic* condition.

   b. When two solutions separated by a membrane differ in osmolarity, in which direction does water flow?

4. An animal can maintain water balance in two ways. Explain the difference between *osmoconformers* and *osmoregulators*.

5. Use Figure 44.3 in your text to label and explain *osmoregulation* in saltwater (marine) and freshwater fish.



6. Why do many organisms have a body fluid composition adapted to the salinity of their environment?

7. What is *anhydrobiosis* and what role does the sugar trehalose play?

8. Turn to p. 982 in your text and study Figure 44.6. Notice that the flow of blood and flow of the salty fluid in the secretory tubule are in different directions. This is an example of *countercurrent* flow. Apply your knowledge of osmolarity to explain why an albatross can consistently drink seawater and still maintain homeostasis but a human cannot.

Concept 44.2 An animal's nitrogenous wastes reflect its phylogeny and habitat

LO 44.2: Describe the advantages and disadvantages of the major forms of nitrogenous waste in different animal habitats.

9. What are the three forms in which animals excrete nitrogenous wastes?

10. Describe the characteristics of the following nitrogenous waste molecules, and name animal groups that excrete each.

Nitrogenous Waste	Characteristics	Animal Groups That Excrete This Form
Ammonia		
Urea		
Uric acid		

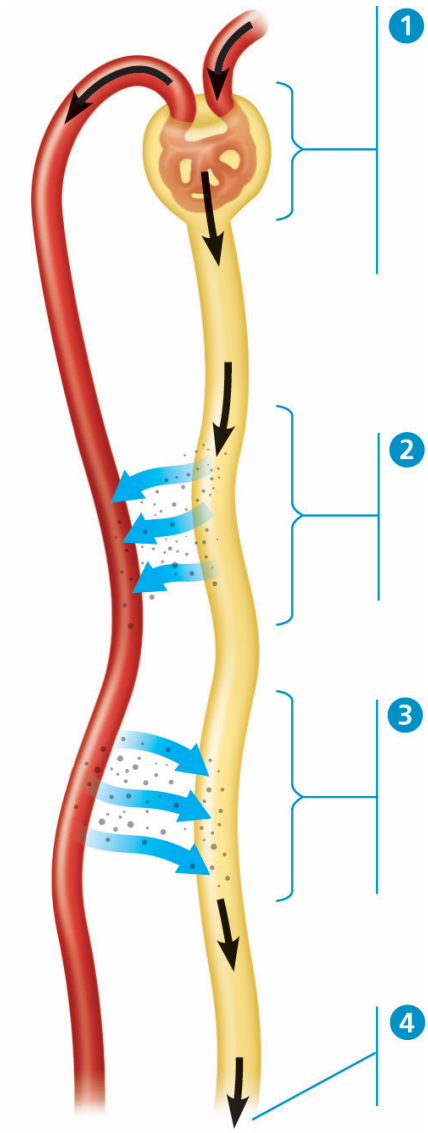
11. Why do many egg-laying animals excrete uric acid as their nitrogenous waste?

12. Explain why endotherms produce more nitrogenous waste than ectotherms, and why predators excrete more than herbivores.

Concept 44.3 Diverse excretory systems are variations on a tubular theme

LO 44.3: Compare and contrast the four major stages of excretory system function in worms, insects, and vertebrates.

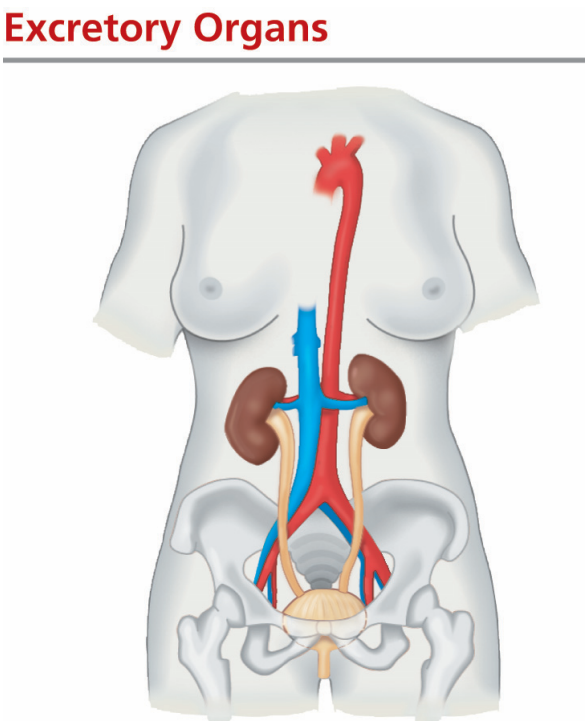
13. Excretion is an essential process to maintain homeostasis of water and solutes. In order to regulate these, the process of excretion usually requires four steps. Label each step shown in Figure 44.8 and specifically describe its role in the maintenance of homeostasis. This figure is important as a summary of excretion, and you will return to it later in the chapter.



14. The major types of excretory organs listed in the chart are examples of evolutionary variation on the theme that complex networks of tubules provide a large surface area for the excretion of nitrogenous wastes. For each excretory system give a brief description of how the excretory system functions, followed by examples, including phyla and common names where possible.

Excretory Organ	Description	Examples
Protonephridia		
Metanephridia		
Malpighian tubules		
Kidneys		

15. Understanding the workings of the mammalian kidney requires knowledge of the anatomy of the excretory system and then an understanding of how structure fits the function of excretion. Using Figure 44.12, label all the excretory organs and major blood vessels.



16. Describe the function of the following components of the human excretory system.

    a. **kidney**

    b. **ureters**

    c. **bladder**

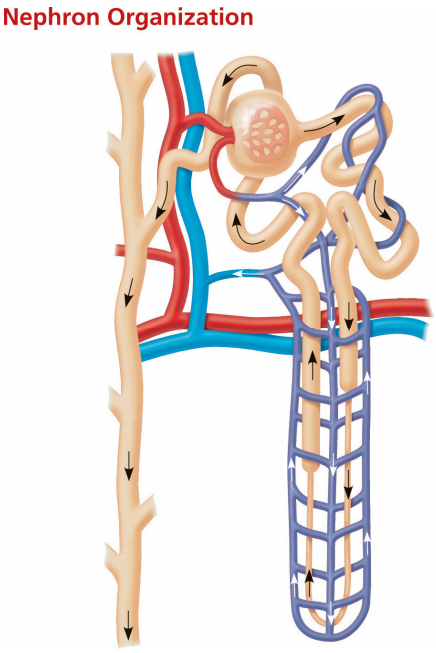
    d. **urethra**

    e. **nephron**

17. Draw the human kidney (use Figure 44.12 in your text, Kidney Structure) and label *the renal medulla*, *renal cortex*, *renal pelvis*, *renal artery*, *renal vein* and *ureter.*

18. What is the functional difference between a *cortical nephron* and a *juxtamedullary nephron*?

19. Try the following to help unravel the complicated anatomy involved with filtrate and blood flow. First, label the following structures: *glomerulus*, *Bowman's capsule*, *proximal tubule*, *loop of Henle*, *collecting duct*, and *renal pelvis*. Second, use colored pencils and shade each structure a different color. Finally, label the following blood vessels: *afferent arterioles*, *efferent arterioles*, *peritubular capillaries*, and *vasa recta.*

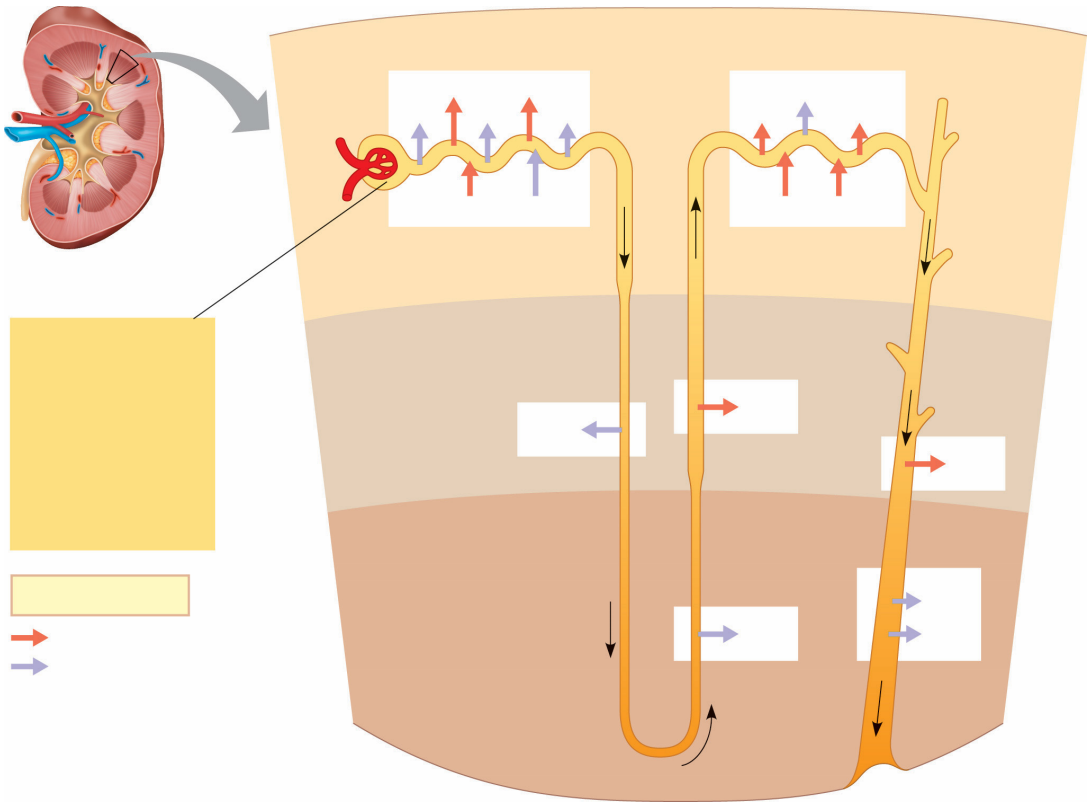


20. The first step of excretion is *filtration*. Carefully read the information accompanying the figure of a nephron on p. 987. Describe how filtration occurs.

Concept 44.4 The nephron is organized for stepwise processing of blood filtrate

LO 44.4: Review the function of each region of the nephron in the processing of filtrate.

21. Tired? No wonder. In the last 24 hours you have filtered 1,600 L of blood through your kidneys yielding about 180 L of initial filtrate! Fortunately for your spare time, the processing of initial filtrate reduced the volume to 1.5 L of urine. The process of converting blood filtrate to urine requires four steps, as you learned in question 13. Label Figure 44.13 then identify where each of these four steps occurs.



22. The four steps of excretion are listed in the following chart. For each step, explain where and how the process occurs in the mammalian kidney. Refer to Figures 44.8 and 44.13 and text pp. 988–989 for help.

Steps of Excretion	Location	Description/Explanation of Process
Filtration		
Reabsorption		
Secretion		
Excretion		

23. In order to prevent dehydration, most of the water in the initial filtrate is retained in the body as the urine is concentrated. To achieve this, notice in Figure 44.14 in your text that the flow of the filtrate through the tubules results in a *countercurrent multiplier system*. Describe how this helps concentrate urine and reduce water loss.

24. Explain how urine can be isoosmotic to the inner medulla's interstitial fluid but hyperosmotic to blood and interstitial fluid elsewhere in the body.

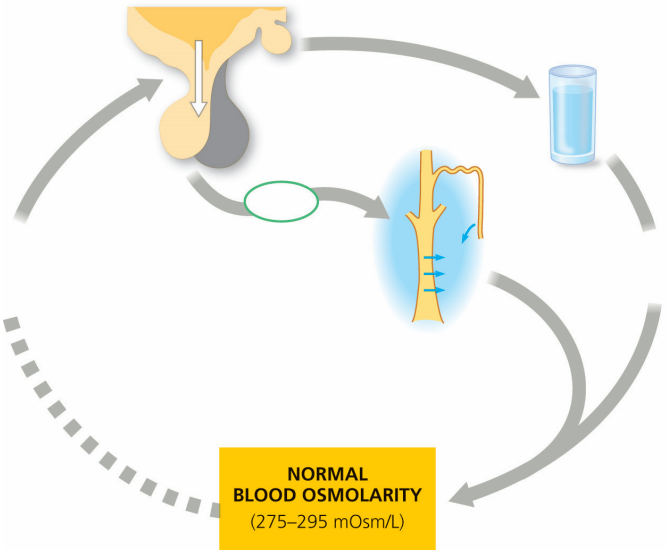
25. Among mammals, differences in nephron structure have evolved that reflect the habitat of the species. Explain why the loops of Henle of desert mammals are very long, whereas those of beavers are very short.

26. Continuing with the theme that evolution shapes adaptations for maintaining homeostasis of water and nitrogenous wastes, select any of the examples on pp. 991–992 in your text to explain a particular environmental challenge and its solution.

Concept 44.5 Hormonal circuits link kidney function, water balance, and blood pressure

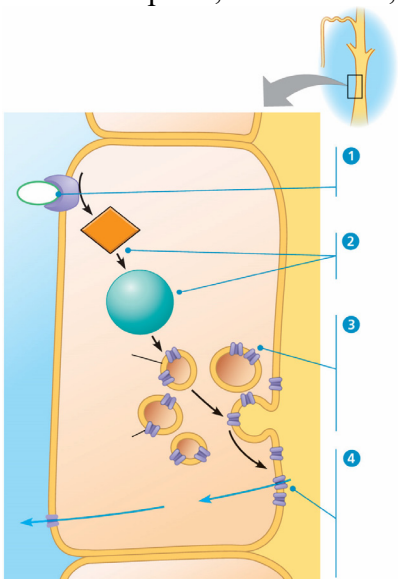
LO 44.5: Outline the major hormonal circuits that bring about homeostasis in the kidney.

27. Use the figure below to explain the general, systemic role of *antidiuretic hormone* (ADH) in maintaining blood osmolarity.

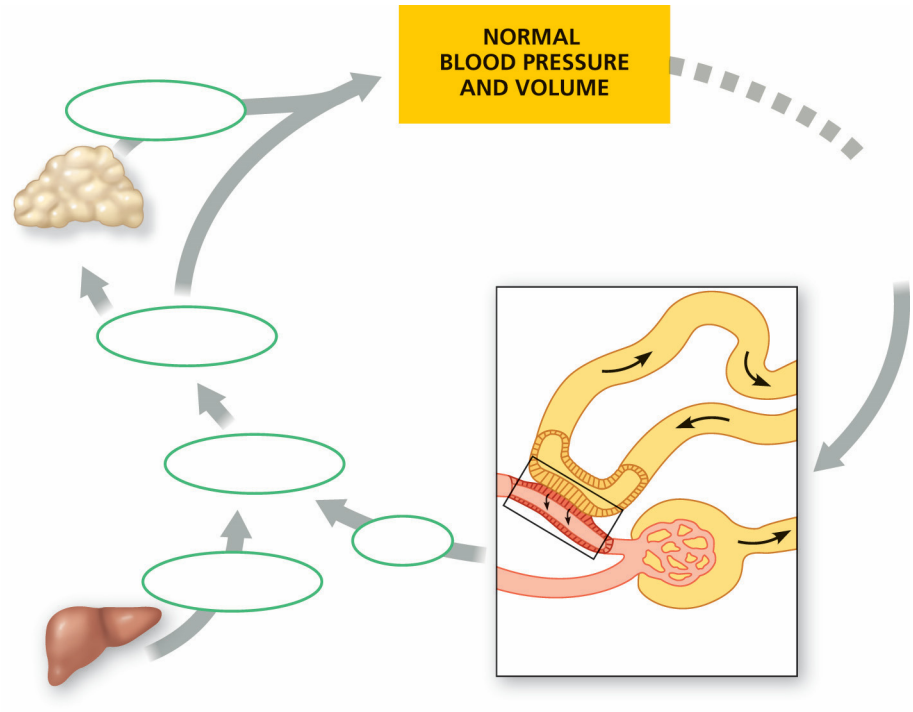


28. What type of feedback regulation is illustrated in the preceding question?

29. Your knowledge of cell signaling will clarify the cellular impact of ADH. Use the following figure to explain the four steps in the control of collecting duct permeability by ADH. Finally, show on the diagram where reception, transduction, and response occur.



30. Use Figure 44.21 in your text to explain how *RAAS* controls blood volume and blood pressure.



31. How would drugs that inhibit angiotensin converting enzyme activity (ACE inhibitors) help to control hypertension?

Study Tip

Review the chart on p. 997 of your text for Concept 44.1 as it gives an excellent summary of osmoregulation by animals in different habitats.

Test Your Understanding, p. 998.

1. _____ 2. _____ 3. _____ 4. _____ 5. _____ 6. _____