Metabolism of nutrients by body cells produces various wastes such as carbon dioxide and nitrogenous wastes (creatinine, urea, and ammonia), as well as imbalances of water and essential ions. The **metabolic wastes** and excesses must be eliminated from the body. Essential substances are retained to ensure proper body functioning.

Although several organ systems are involved in excretory processes, the urinary system bears the primary responsibility for removing **nitrogenous wastes** from the blood. In addition to this purely excretory function, the kidneys maintain the electrolyte, acid-base, and fluid balances of the blood. Thus, kidneys are major **homeostatic organs** of the body. Malfunction of the kidneys leads to a failure of homeostasis, resulting (unless corrected) in death.

Activities in this chapter are concerned with identification of urinary system structures and with examining urine composition and physiological processes involved in urine formation. It also focuses on the composition of the body’s fluid compartments and the water, electrolyte, and acid-base balance of these compartments.

1. Complete the following statements by inserting your answers in the answer blanks.

The kidney is referred to as an excretory organ because it excretes a. ______________ wastes. It is also a major homeostatic organ because it maintains the electrolyte, b. ______________, and c. ______________ balance of the blood. Urine is continuously formed by the d. ______________ and is routed down the e. ______________ by the mechanism of f. ______________ to a storage organ called the g. ______________. Eventually the urine is conducted to the body exterior by the h. ______________. In males, this tubelike structure is about j. ______________ inches long; in females, it is approximately l. ______________ inches long.

In the space below, list the four nitrogenous wastes filtered and eliminated by the kidneys.

m.

n.

o.

p.
Location and Structure

2. Figure 15-1 is an anterior view of the entire urinary system. Label the following organs on the figure.

- **Kidney**
- **Bladder**
- **Ureters**
- **Urethra**

![Figure 15-1](image-url)
3. Figure 15-2 is a longitudinal section of a kidney. First, using the correct anatomical terminology, label the following regions/structures indicated by leader lines on the figure.

a. Fibrous membrane immediately surrounding the kidney

b. Basin-like area of the kidney that is continuous with the ureter

c. Cup-like extension of the pelvis that drains the apex of a pyramid

d. Area of cortex-like tissue running through the medulla

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Miss School, Miss Out!
Nephrons, Urine Formation, and Control of Blood Composition

4. Figure 15-3 is a diagram of the nephron and associated blood supply. First, label each numbered item. Then label the structures on the figure that contains podocytes; the filtering apparatus; the capillary bed that directly receives the reabsorbed substances from the tubule cells; the structure into which the nephron empties its urine product; and the tubule area that is the primary site of tubular reabsorption.

![Figure 15-3](image-url)
5. Figure 15-4 is a diagram of a nephron. Add colored arrows on the figure as instructed to show the location and direction of the following processes.

*Identify* the site of filtrate formation

*Identify* the major site of amino acid and glucose reabsorption

*Identify* the sites most responsive to action of ADH (show direction of water movement)

*Identify* the sites most responsive to the action of aldosterone (show direction of Na+ movement)

*Identify* the site of tubular secretion

Then, label the proximal convoluted tubule (PCT), distal convoluted tubule (DCT), loop of Henle, glomerular capsule, and glomerulus on the figure. Also label the collecting duct (not part of the nephron).

*Figure 15-4*
6. Label the following diagram.

![Diagram of the urinary system](image)

7. Several specific terms are used to indicate the presence of abnormal urine constituents. Identify each of the following abnormalities by inserting the term that names the condition in the spaces provided. Then for each condition, provide one possible cause of the condition in the remaining spaces.

   a. Presence of red blood cells: ____________________ Cause: __________________________
   
   b. Presence of ketones: ______________________ Cause: __________________________
   
   c. Presence of albumin: _______________________ Cause: __________________________
   
   d. Presence of pus: __________________________ Cause: __________________________
   
   e. Presence of bile: __________________________ Cause: __________________________
   
   f. Presence of "sand": _______________________ Cause: __________________________
   
   g. Presence of glucose: ______________________ Cause: __________________________

   **URETERS, URINARY BLADDER, AND URETHRA**

8. Using the key choices, identify the structures that best fit the following descriptions. Insert the correct term(s) or corresponding letter(s) in the answer blanks.

   **Key Choices**

<table>
<thead>
<tr>
<th>Bladder</th>
<th>Urethra</th>
<th>Ureter</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>1. Drains the bladder</td>
<td></td>
</tr>
<tr>
<td></td>
<td>2. Storage area for urine</td>
<td></td>
</tr>
<tr>
<td></td>
<td>3. Contains the trigone</td>
<td></td>
</tr>
<tr>
<td></td>
<td>4. In males has prostatic, membranous, and spongy parts</td>
<td></td>
</tr>
</tbody>
</table>

   Miss School, Miss Out!
5. Conducts urine by peristalsis

6. Substantially longer in males than in females

7. A common site of "trapped" renal calculi

8. Contains transitional epithelium

9. Also transports sperm in males

**FLUID, ELECTROLYTE, AND ACID-BASE BALANCE**

9. Figure 15-5 illustrates the three major fluid compartments of the body. Arrows indicate direction of fluid flow. Referring to Figure 15-5, respond to the statements that follow. If a statement is true, write **T** in the answer blank. If a statement is false, **change** the underlined word(s) and write the correct word(s) in the answer blank.

<table>
<thead>
<tr>
<th>Interstitial fluid (ECF)</th>
<th>Intracellular fluid</th>
<th>Plasma</th>
</tr>
</thead>
</table>

![Diagram of fluid compartments]

**Figure 15-5**

a. Exchanges between plasma and interstitial fluid compartments take place across the **capillary membranes**.

b. The fluid flow indicated by arrow A is driven by **active transport**.

c. If the osmolarity of the ECF is increased, the fluid flow indicated by arrow C will occur.

d. The excess of fluid flow at arrow A over that at arrow B normally enters the **tissue cells**.
e. Exchanges between the interstitial and intracellular fluid compartments occur across capillary membranes.

f. Interstitial fluid serves as the link between the body’s external and internal environments.

10. Match the pH values in Column B with the conditions described in Column A.

<table>
<thead>
<tr>
<th>Column A</th>
<th>Column B</th>
</tr>
</thead>
<tbody>
<tr>
<td>a. Normal pH of arterial blood</td>
<td>pH &lt; 7.00</td>
</tr>
<tr>
<td>b. Physiological alkalosis (arterial blood)</td>
<td>pH = 7.00</td>
</tr>
<tr>
<td>c. Physiological acidosis (arterial blood)</td>
<td>pH &lt; 7.35</td>
</tr>
<tr>
<td>d. Chemical neutrality; neither acidic nor basic</td>
<td>pH = 7.35</td>
</tr>
<tr>
<td>e. Chemical acidity</td>
<td>pH = 7.40</td>
</tr>
<tr>
<td></td>
<td>pH &gt; 7.45</td>
</tr>
</tbody>
</table>

11. Use the terms in Column B to complete the statements in Column A.

<table>
<thead>
<tr>
<th>Column A</th>
<th>Column B</th>
</tr>
</thead>
<tbody>
<tr>
<td>a. Acids are proton</td>
<td>Acceptors</td>
</tr>
<tr>
<td>b. A strong acid dissociates</td>
<td>Donors</td>
</tr>
<tr>
<td>c. A weak acid dissociates</td>
<td>Completely</td>
</tr>
<tr>
<td>d. Strong bases bind ___ quickly</td>
<td>Hydrogen ions</td>
</tr>
<tr>
<td></td>
<td>Incompletely</td>
</tr>
</tbody>
</table>

12. The activity of the bicarbonate buffer system of the blood is shown by the equation:

\[ CO_2 + H_2O \rightleftharpoons H_2CO_3 \rightleftharpoons H^+ + HCO_3^- \]

a. Which chemical formulas refer to ions?

b. Which formula refers a weak acid? Which is a weak base?

c. If more \( CO_2 \) enters the blood, the reaction shifts to the (right/left)? Explain.

d. Explain the impact of hyperventilation on this equation. Why was breathing into a bag suggested as a fix for hyperventilation?
Across
4. Chemical substance or system that minimizes changes in pH by releasing or binding hydrogen ions.
8. State of abnormally high hydrogen ion concentration in the extracellular fluid.
10. Substance released by the kidneys that is involved with raising blood pressure.
12. Double-walled cup at end of a renal tubule; encloses a glomerulus. Also called Bowman's capsule.
13. The indented region of an organ from which blood and/or lymph vessels and nerves enter and exit.
15. A substance capable of binding with hydrogen ions; a proton acceptor.
16. Passage of a solvent and dissolved substances through a membrane or filter.

Down
1. Structural and functional unit of the kidney; consists of the glomerulus and renal tubule.
2. Cluster of capillaries forming part of the nephron; forms filtrate.
3. A kidney stone.
5. System primarily responsible for water, electrolyte, and acid-base balance and removal of nitrogenous wastes.
6. Elimination of waste products from the body.
7. Urination, or voiding; emptying the bladder.
9. Canal through which urine passes from the bladder to outside the body.
11. Main nitrogen-containing waste excreted in urine.
14. Tube that carries urine from kidney to bladder.