Urinary Tract System

- **Kidney**
  - Produces urine

- **Ureter**
  - Transports urine toward the urinary bladder

- **Urinary bladder**
  - Temporarily stores urine prior to elimination

- **Urethra**
  - Conducts urine to exterior; in males, transports semen as well

*Anterior view*
Gross Anatomy of the Kidney

(a) Schematic diagram of a kidney showing the renal cortex, renal medulla, renal pyramid, connection to minor calyx, minor calyx, major calyx, renal pelvis, hilum, renal lobe, ureter, and fibrous capsule.

(b) Photograph of a kidney showing the renal pyramids, renal sinus, renal pelvis, major calyx, minor calyx, renal papilla, hilum, renal lobe, and fibrous capsule.
Gross Microanatomy of the Nephron

**NEPHRON**

- **Proximal convoluted tubule**
  - Reabsorption of water, ions, and all organic nutrients

- **Distal convoluted tubule**
  - Secretion of ions, acids, drugs, toxins
  - Variable reabsorption of water, sodium ions, and calcium ions (under hormonal control)

**COLLECTING SYSTEM**

- **Collecting duct**
  - Variable reabsorption of water and reabsorption or secretion of sodium, potassium, hydrogen, and bicarbonate ions

**Renal corpuscle**

- Production of filtrate

**KEY**

- Water
- Solutes
- Filtrate
- Variable reabsorption or secretion

**Nephron loop**

- Further reabsorption of water (descending limb) and both sodium and chloride ions (ascending limb)

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Renal Corpuscle

- Glomerular capsule
- Capsular space
- Glomerular capillary
- Capsular epithelium
- Visceral epithelium (podocyte)
- Efferent arteriole
- Distal convoluted tubule
- Macula densa
- Juxtaglomerular cells
- Juxtaglomerular complex
- Afferent arteriole
- Proximal convoluted tubule

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# Microscopic Anatomy of the Nephron

## SUMMARY TABLE 26-1  The Organization of the Nephron and Collecting System

<table>
<thead>
<tr>
<th>Region</th>
<th>Length</th>
<th>Diameter</th>
<th>Primary Function</th>
<th>Histological Characteristics</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>NEPHRON</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Renal corpuscle</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Capsular space</td>
<td>150–250 μm (spherical)</td>
<td>150–250 μm</td>
<td>Filtration of plasma</td>
<td>Glomerulus (capillary knot), mesangial cells, and dense layer, enclosed by the glomerular capsule; visceral epithelium (podocytes) and capsular epithelium separated by capsular space</td>
</tr>
<tr>
<td>Capsular epithelium</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Capillaries of glomerulus</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Visceral epithelium</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Renal tubule</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Proximal convoluted tubule (PCT)</td>
<td>14 mm</td>
<td>60 μm</td>
<td>Reabsorption of ions, organic molecules, vitamins, water, secretion of drugs, toxins, acids</td>
<td>Cuboidal cells with microvilli</td>
</tr>
</tbody>
</table>

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Proximal Convoluted Tubule

Diagram showing the flow of tubular fluid and the processes involved in reabsorption and secretion in the proximal convoluted tubule. The diagram includes various components such as the Glomerulus, Bowman's capsule, Proximal convoluted tubule, Distal convoluted tubule, Collecting duct, and Urine storage and elimination. The cellular processes include leak channel, countertransport, exchange pump, cotransport, diffusion, reabsorption, and secretion.

KEY:
- Leak channel
- Countertransport
- Exchange pump
- Cotransport
- Diffusion
- Reabsorption
- Secretion

Chemical reactions in the tubular fluid include:

- $H^+ + HCO_3^- \rightarrow H_2CO_3 \rightarrow CO_2 + H_2O$
- Processes involving $Na^+$, $K^+$, $H^+$, $CO_2$, and $HCO_3^-$

Cells of proximal convoluted tubule

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Loop of Henle

Proximal convoluted tubule

Glomerulus

Glomerular capsule

Distal convoluted tubule

Collecting duct

Nephron loop

Urine storage and elimination

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<table>
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<th>Histological Characteristics</th>
</tr>
</thead>
<tbody>
<tr>
<td>Nephron loop</td>
<td>30 mm</td>
<td>15 μm</td>
<td>Descending limb: reabsorption of water from tubular fluid</td>
<td>Squamous or low cuboidal cells</td>
</tr>
<tr>
<td></td>
<td></td>
<td>30 μm</td>
<td>Ascending limb: reabsorption of ions; assists in creation of a concentration gradient in the medulla</td>
<td></td>
</tr>
<tr>
<td>Distal convoluted tubule (DCT)</td>
<td>5 mm</td>
<td>30–50 μm</td>
<td>Reabsorption of sodium ions and calcium ions; secretion of acids, ammonia, drugs, toxins</td>
<td>Cuboidal cells with few if any microvilli</td>
</tr>
</tbody>
</table>
Distal Convoluted Tubule

KEY
- = Exchange pump
- = Cotransport
- = Countertransport
- = Diffusion
- = Reabsorption
- = Secretion
- = Leak channel

(a) Sodium and chloride reabsorption
(b) Sodium–potassium exchange
### SUMMARY TABLE 26–1 The Organization of the Nephron and Collecting System

<table>
<thead>
<tr>
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<tbody>
<tr>
<td>COLLECTING SYSTEM</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Collecting duct</td>
<td>15 mm</td>
<td>50–100 μm</td>
<td>Reabsorption of water, sodium ions; secretion or reabsorption of bicarbonate ions or hydrogen ions</td>
<td>Cuboidal to columnar cells</td>
</tr>
<tr>
<td>Papillary duct</td>
<td>5 mm</td>
<td>100–200 μm</td>
<td>Conduction of tubular fluid to minor calyx; contributes to concentration gradient of the medulla</td>
<td>Columnar cells</td>
</tr>
</tbody>
</table>
Collecting Duct

COLLECTING SYSTEM

Collecting duct

Variable reabsorption of water and reabsorption or secretion of sodium, potassium, hydrogen, and bicarbonate ions

Papillary duct

Delivery of urine to minor calyx

Minor calyx

KEY
- Water
- Solute
- Filtrate
- Variable reabsorption or secretion

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Urinary Tract System

11th and 12th ribs
Minor calyx
Major calyx

Ureter
Urinary bladder
Renal pelvis
Kidney

Copyright © 2009 Pearson Education, Inc., publishing as Pearson Benjamin Cummings.
Urinary Tract System

Kidney
- Produces urine

Ureter
- Transports urine toward the urinary bladder

Urinary bladder
- Temporarily stores urine prior to elimination

Urethra
- Conducts urine to exterior; in males, transports semen as well
Ureters

(c) Female urethra  
LM x 50

Lumen of urethra  
Stratified squamous epithelium of mucosa

Smooth muscle

(b) Urinary bladder  
LM x 30

Lumen of urinary bladder  
Transitional epithelium  
Lamina propria  
Submucosa

Detrusor muscle  
Visceral peritoneum

(a) Ureter  
LM x 56

Transitional epithelium  
Lamina propria  
Smooth muscle  
Outer connective tissue layer

Mucosa
Male Urinary Tract System

- Peritoneum
- Urinary bladder
- Pubic symphysis
- Prostate gland
- External urethral sphincter
- Spongy urethra
- External urethral orifice
- Left ureter
- Rectum
- Urethra [see part c]
- Urogenital diaphragm

(a) Male