Functions of the urinary system

- **Excretion**
  - The removal of organic waste products from body fluids
- **Elimination**
  - The discharge of waste products into the environment
- **Homeostatic regulation of blood plasma**
  - Regulating blood volume and pressure
  - Regulating plasma ion concentrations
  - Stabilizing blood pH
  - Conserving nutrients

Figure 26.1 An introduction to the Urinary System

![Figure 26.1](image1)

Figure 26.2 The Position of the Kidneys

![Figure 26.2](image2)

Sectional anatomy of the kidneys

- Superficial outer cortex and inner medulla
- The medulla consists of 6-18 renal pyramids
- The cortex is composed of roughly 1.25 million nephrons
- Major and minor calyces along with the pelvis drain urine to the ureters

Figure 26.3 The Urinary System in Gross Dissection

![Figure 26.3](image3)

Figure 26.4 The Structure of the Kidney

![Figure 26.4](image4)
Figure 26.5 The Blood Supply to the Kidneys

Figure 26.5c, d

Figure 26.6 A Representative Nephron

Figure 26.6

Nephron functions include:
- Production of filtrate
- Reabsorption of organic nutrients
- Reabsorption of water and ions
- Secretion of waste products into tubular fluid

Two types of nephron

- Cortical nephrons
  - ~85% of all nephrons
  - Located in the cortex
- Juxtamedullary nephrons
  - Closer to renal medulla
  - Loops of Henle extend deep into renal pyramids
**Figure 26.7 Cortical and Juxtamedullary Nephrons**

- Proximal convoluted tubule (PCT)
  - Actively reabsorbs nutrients, plasma proteins and ions from filtrate
  - Released into peritubular fluid

- Loop of Henle
  - Descending limb
  - Ascending limb
  - Each limb has a thick and thin section

**Figure 26.8 The Renal Corpuscle**

- Distal convoluted tubule (DCT)
  - Actively secretes ions, toxins, drugs
  - Reabsorbs sodium ions from tubular fluid

**Functional anatomy of the nephron**

- Proximal convoluted tubule (PCT)
  - Actively reabsorbs nutrients, plasma proteins and ions from filtrate
  - Released into peritubular fluid

- Loop of Henle
  - Descending limb
  - Ascending limb
  - Each limb has a thick and thin section

**SECTION 26-3**

Principles of Renal Physiology
Urine production maintains homeostasis

- Regulating blood volume and composition
- Excreting waste products
  - Urea
  - Creatinine
  - Uric acid

Basic processes of urine formation

- Filtration
- Blood pressure
- Water and solutes across glomerular capillaries
- Reabsorption
- The removal of water and solutes from the filtrate
- Secretion
- Transport of solutes from the peritubular fluid into the tubular fluid

Carrier Mediated Transport

- Filtration in the kidneys modified by carrier mediated transport
  - Facilitated diffusion
  - Active transport
  - Cotransport
  - Countertransport
- Carrier proteins have a transport maximum ($T_m$)
  - Determines renal threshold

Reabsorption and secretion

- Accomplished via diffusion, osmosis, and carrier-mediated transport
- $T_m$ determines renal threshold for reabsorption of substances in tubular fluid

Figure 26.9 An Overview of Urine Formation

Figure 26.10 Glomerular Filtration
Figure 26.10  Glomerular Filtration

Factors controlling the GFR

- A drop in filtration pressure stimulates Juxtaglomerular apparatus (JGA)
- Releases renin and erythropoietin

Figure 26.11  The Response to a Reduction in the GFR

Sympathetic activation

- Produces powerful vasoconstriction of afferent arterioles
- Decreases GFR and slows production of filtrate
- Changes the regional pattern of blood flow
- Alters GFR
- Stimulates release of renin by JGA
Reabsorption and secretion at the PCT

• Glomerular filtration produces fluid similar to plasma without proteins
• The PCT reabsorbs 60-70% of the filtrate produced
  • Reabsorption of most organic nutrients
  • Active and passive reabsorption of sodium and other ions
  • Reabsorption of water
• Secretion also occurs in the PCT

The loop of Henle and countercurrent multiplication

• Countercurrent multiplication
  • Between ascending and descending limbs of loop
  • Creates osmotic gradient in medulla
  • Facilitates reabsorption of water and solutes before the DCT
  • Permits passive reabsorption of water from tubular fluid

Figure 26.12 Transport Activities at the PCT

Figure 26.13 Countercurrent Multiplication and Concentration of Urine
Reabsorption and secretion at the DCT

- DCT performs final adjustment of urine
- Active secretion or absorption
- Absorption
  - Tubular cells actively resorb Na\(^+\) and Cl\(^-\)
  - In exchange for potassium or hydrogen ions (secreted)

Figure 26.14 Tubular Secretion and Solute Reabsorption at the DCT

Reabsorption and secretion along the collecting system

- Water and solute loss is regulated by aldosterone and ADH
- Reabsorption
  - Sodium ion, bicarbonate, and urea are resorbed
- Secretion
  - pH is controlled by secretion of hydrogen or bicarbonate ions

Control of urine volume and osmotic concentration

- Urine volume and osmotic concentration are regulated by controlling water reabsorption
- Precise control allowed via facultative water reabsorption

Figure 26.15 The Effects of ADH on the DCT and Collecting Ducts
Figure 26.15  The Effects of ADH on the DCT and Collecting Ducts

- Removes solutes and water
- Balances solute reabsorption and osmosis in the medulla

Figure 26.16  A Summary of Renal Function