PowerPoint® Lecture Slide Presentation
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The Urinary System

15 PART B

Ureters

- **Slender tubes attaching the kidney to the bladder**
  - Continuous with the renal pelvis
  - Enter the posterior aspect of the bladder
- **Runs behind the peritoneum**
- **Peristalsis aids gravity in urine transport**

Organs of the Urinary System

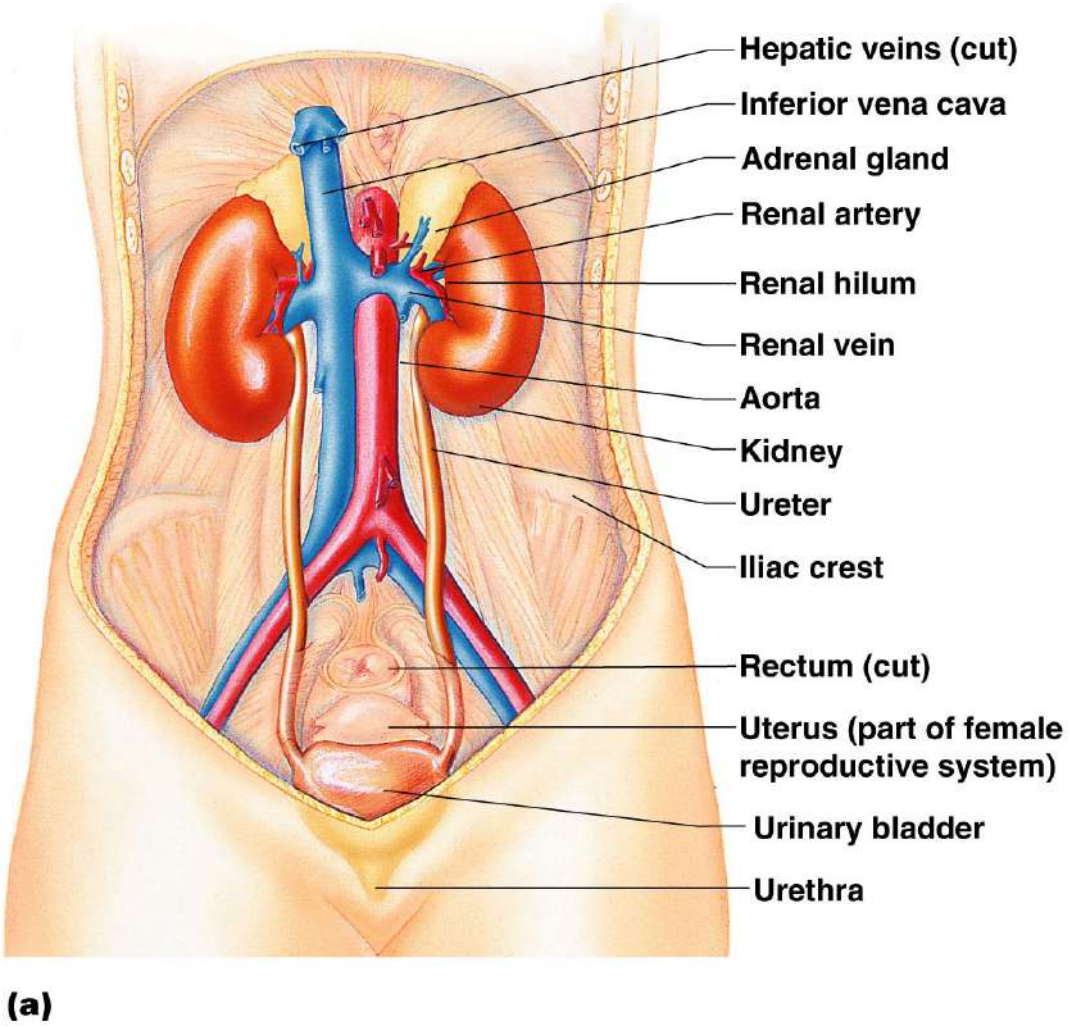

Figure 15.1a

Urinary Bladder

- Smooth, collapsible, muscular sac
- Temporarily stores urine
- Trigone—triangular region of the bladder base
  - Three openings
    - Two from the ureters
    - One to the urethra
  - In males, the prostate gland surrounds the neck of the bladder

Female Urinary Bladder and Urethra

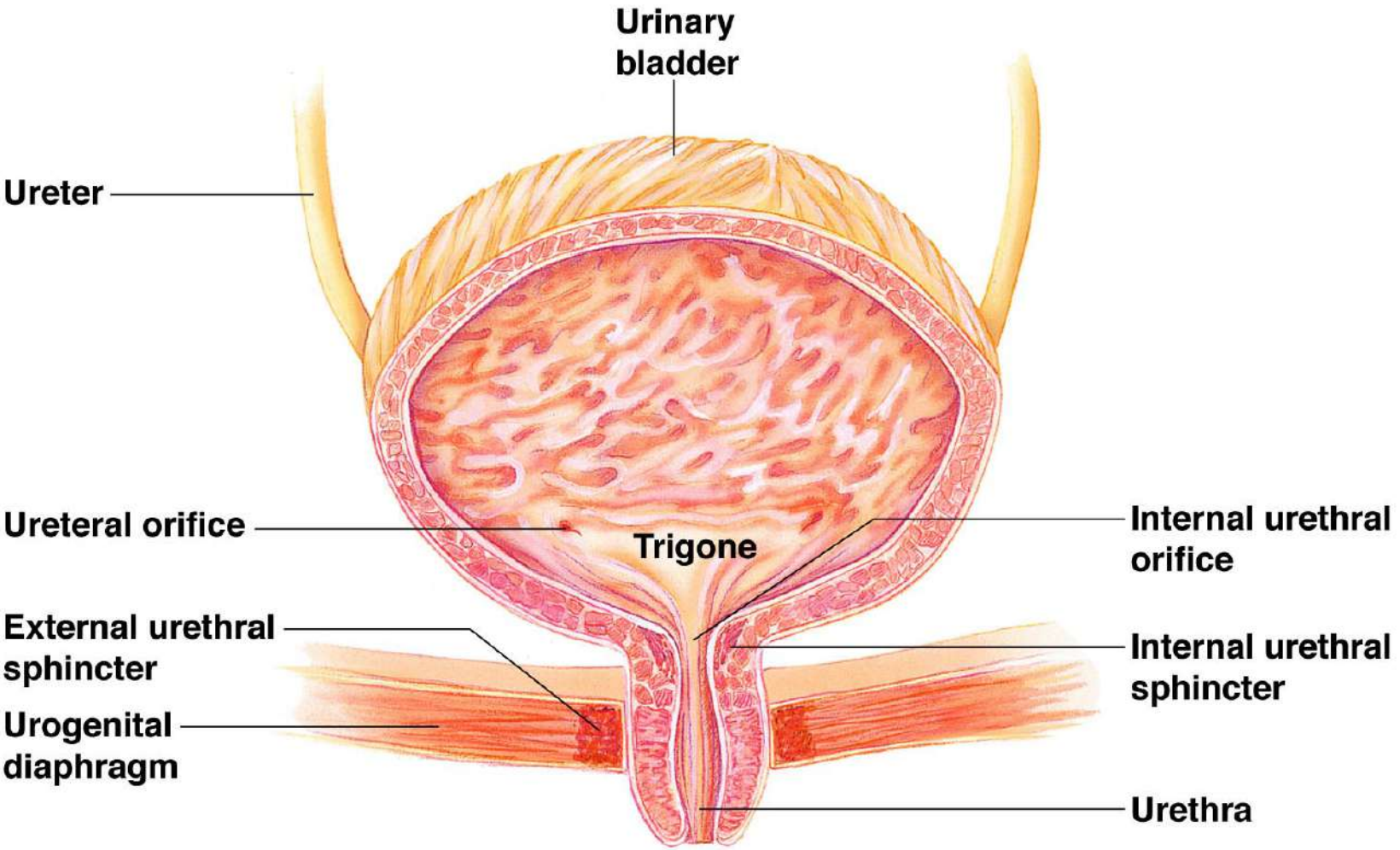

Figure 15.6

Urinary Bladder Wall

- Three layers of smooth muscle collectively called the detrusor muscle
- Mucosa made of transitional epithelium
- Walls are thick and folded in an empty bladder
- Bladder can expand significantly without increasing internal pressure

Urinary Bladder Capacity

- A moderately full bladder is about 5 inches long and holds about 500 mL of urine
- Capable of holding twice that amount of urine

Position and Shape of a Distended and an Empty Urinary Bladder in an Adult Man

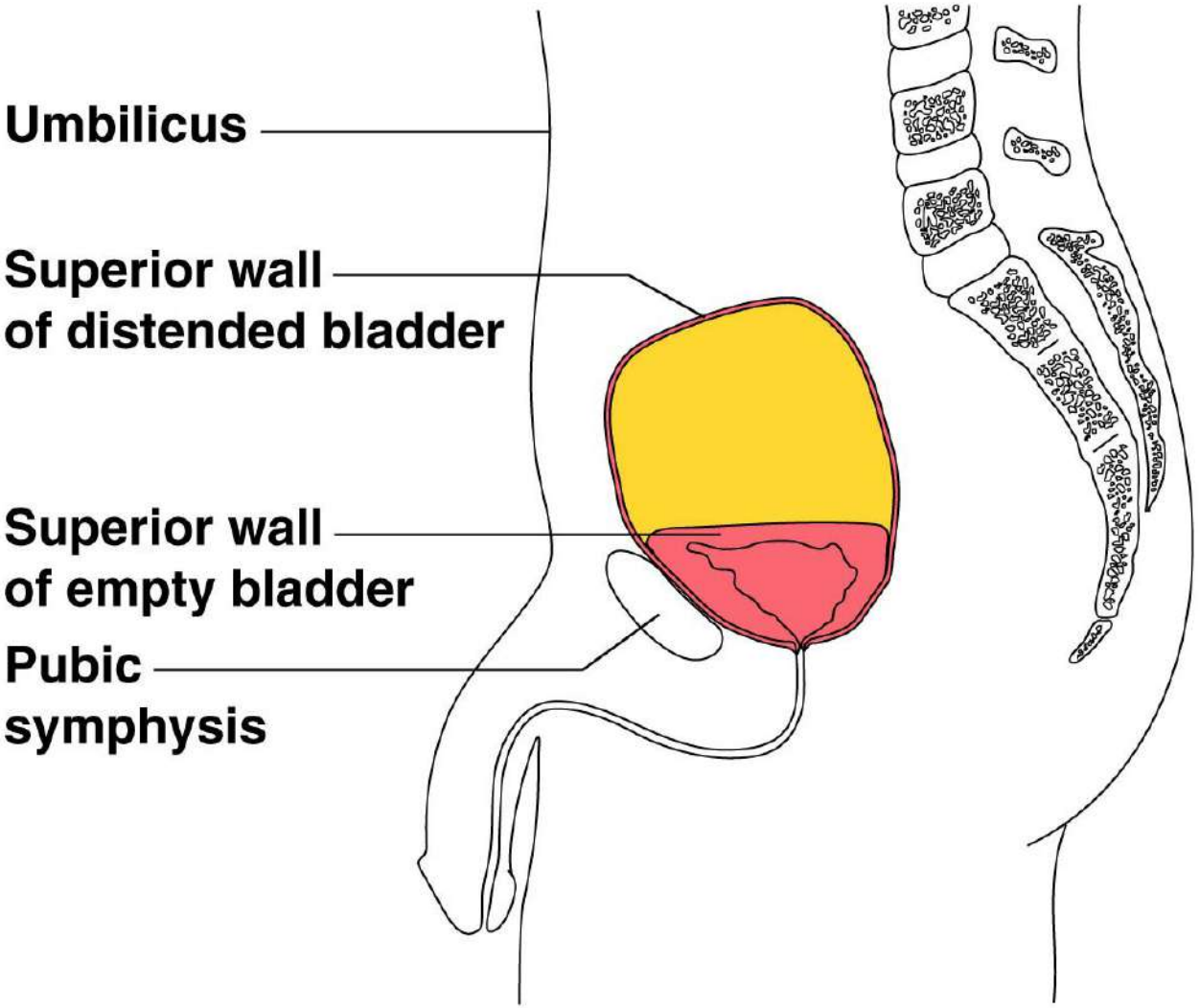

Figure 15.7

Urethra

- Thin-walled tube that carries urine from the bladder to the outside of the body by peristalsis
- Release of urine is controlled by two sphincters
  - Internal urethral sphincter
    - Involuntary and made of smooth muscle
  - External urethral sphincter
    - Voluntary and made of skeletal muscle

Female Urinary Bladder and Urethra

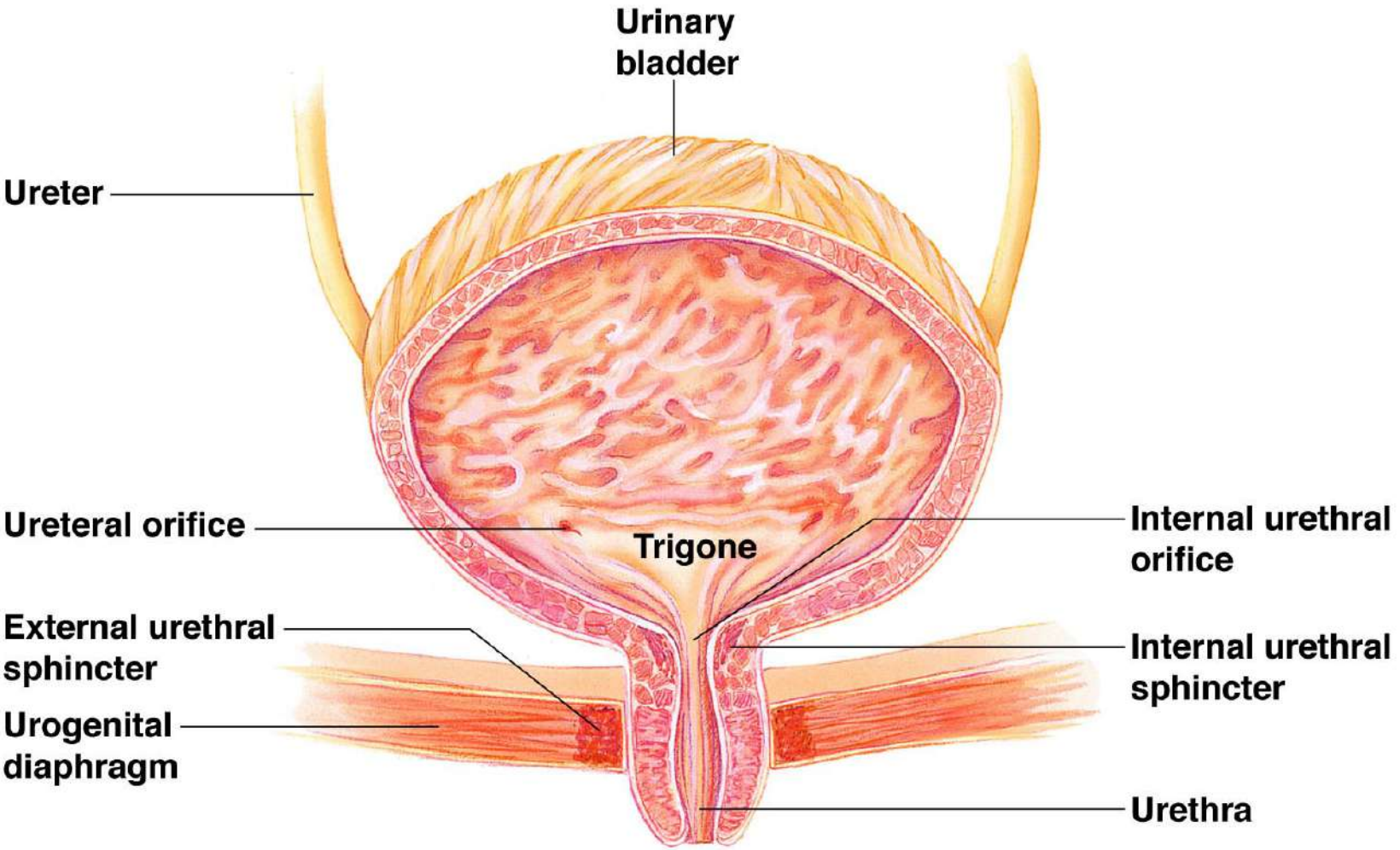

Figure 15.6

Urethra Gender Differences

- **Length**
  - Females is 3–4 cm (1 inch)
  - Males is 20 cm (8 inches)
- **Location**
  - **Females—along wall of the vagina**
  - **Males—through the prostate and penis**

Urethra Gender Differences

- Function
  - Females—only carries urine
  - Males—carries urine and is a passageway for sperm cells

Micturition (Voiding)

- Both sphincter muscles must open to allow voiding
- The internal urethral sphincter is relaxed after stretching of the bladder
- Pelvic splanchnic nerves initiate bladder to go into reflex contractions
- Urine is forced past the internal urethra sphincter and the person feels the urge to void
- The external urethral sphincter must be voluntarily relaxed to void

Fluid, Electrolyte, and Acid-Base Balance

- **Blood composition depends on three factors**
  - Diet
  - Cellular metabolism
  - Urine output

Fluid, Electrolyte, and Acid-Base Balance

- Kidneys have four roles in maintaining blood composition
  - Excretion of nitrogen-containing wastes (previously discussed)
  - Maintaining water balance of the blood
  - Maintaining electrolyte balance of the blood
  - Ensuring proper blood pH

Maintaining Water Balance

- **Normal amount of water in the human body**
  - Young adult females = 50%
  - Young adult males = 60%
  - Babies = 75%
  - The elderly = 45%
- **Water is necessary for many body functions, and levels must be maintained**

Distribution of Body Fluid

- **Intracellular fluid (ICF)**
  - Fluid inside cells
  - About two-thirds of body fluid
- **Extracellular fluid (ECF)**
  - **Fluids outside cells that includes**
    - **Interstitial fluid**
    - **Blood plasma**

Major Fluid Compartments of the Body

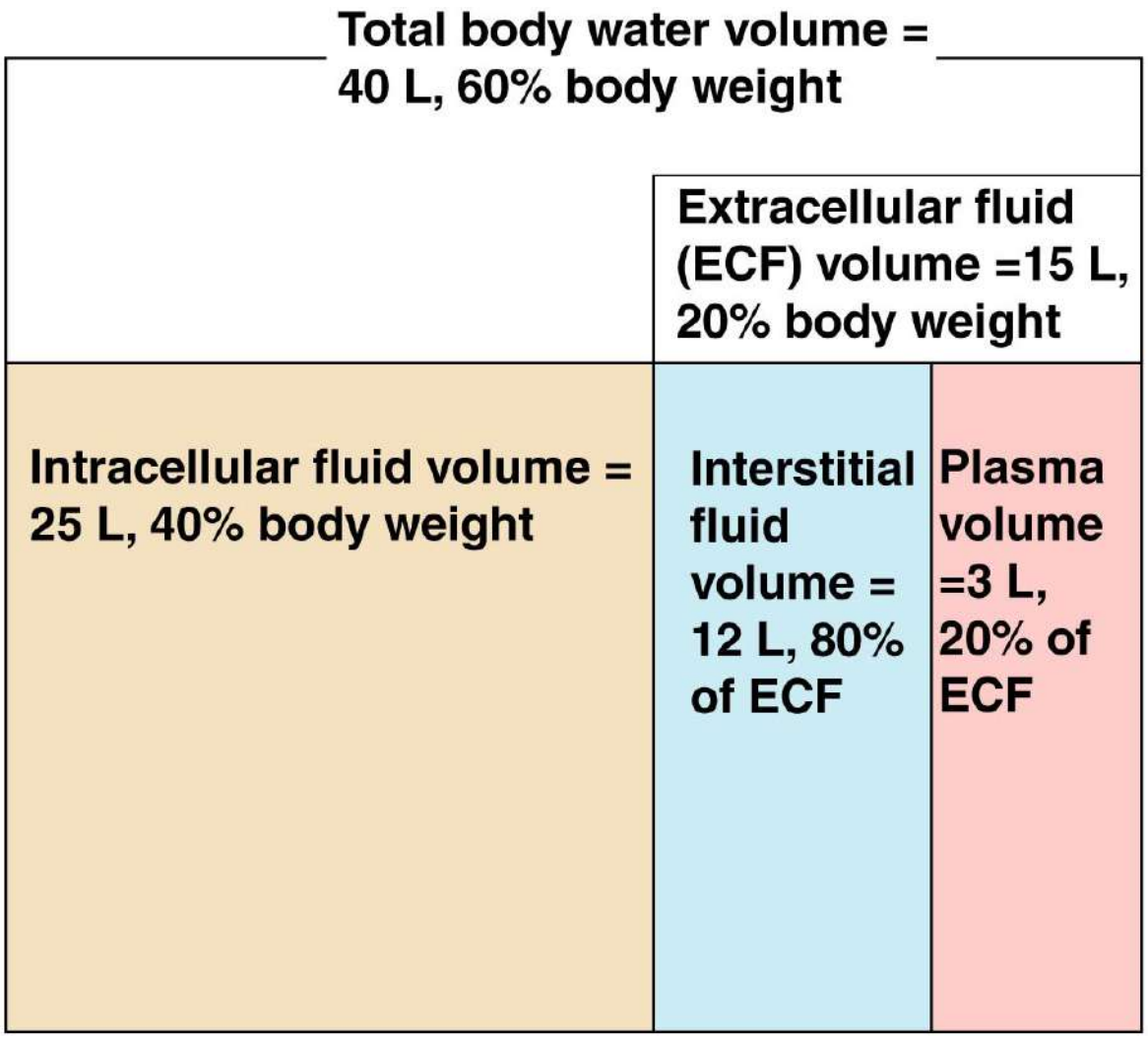

Figure 15.8

The Continuous Mixing of Body Fluids

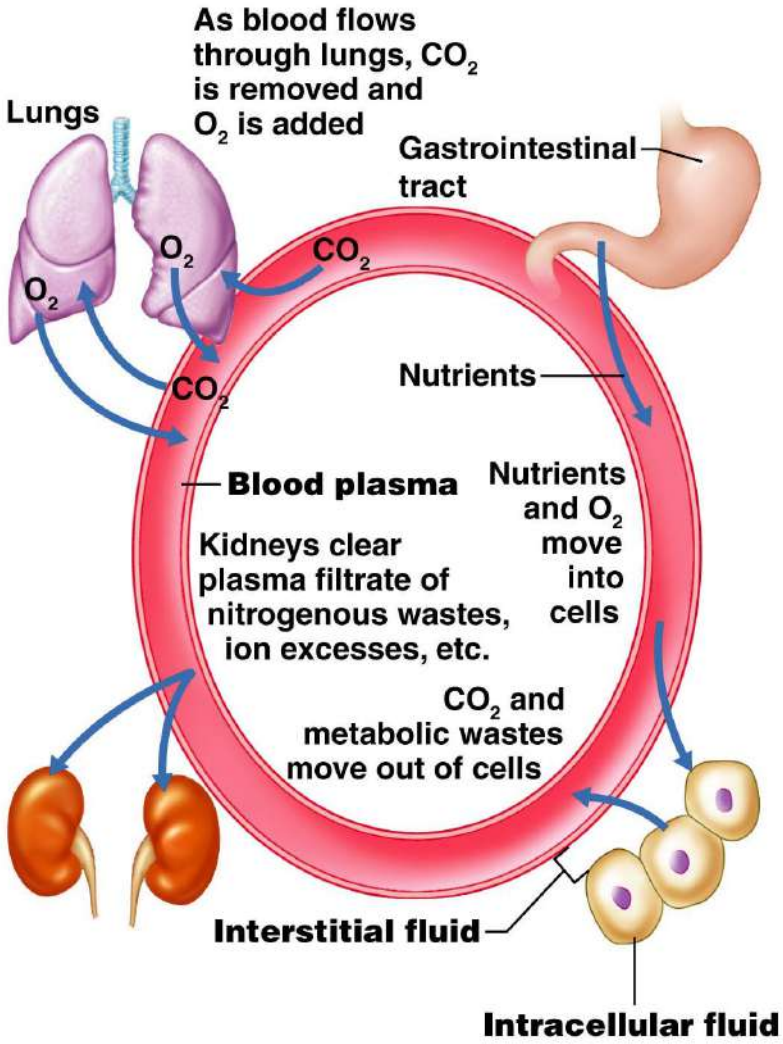

Figure 15.9

The Link Between Water and Salt

- Solutes in the body include electrolytes like sodium, potassium, and calcium ions
- Changes in electrolyte balance causes water to move from one compartment to another
  - Alters blood volume and blood pressure
  - Can impair the activity of cells

Maintaining Water Balance

- **Water intake must equal water output**
- **Sources for water intake**
  - Ingested foods and fluids
  - Water produced from metabolic processes
- **Thirst mechanism is the driving force for water intake**

Maintaining Water Balance

- Sources for water output
  - Vaporization out of the lungs
  - Lost in perspiration
  - Leaves the body in the feces
  - Urine production

Water Intake and Output

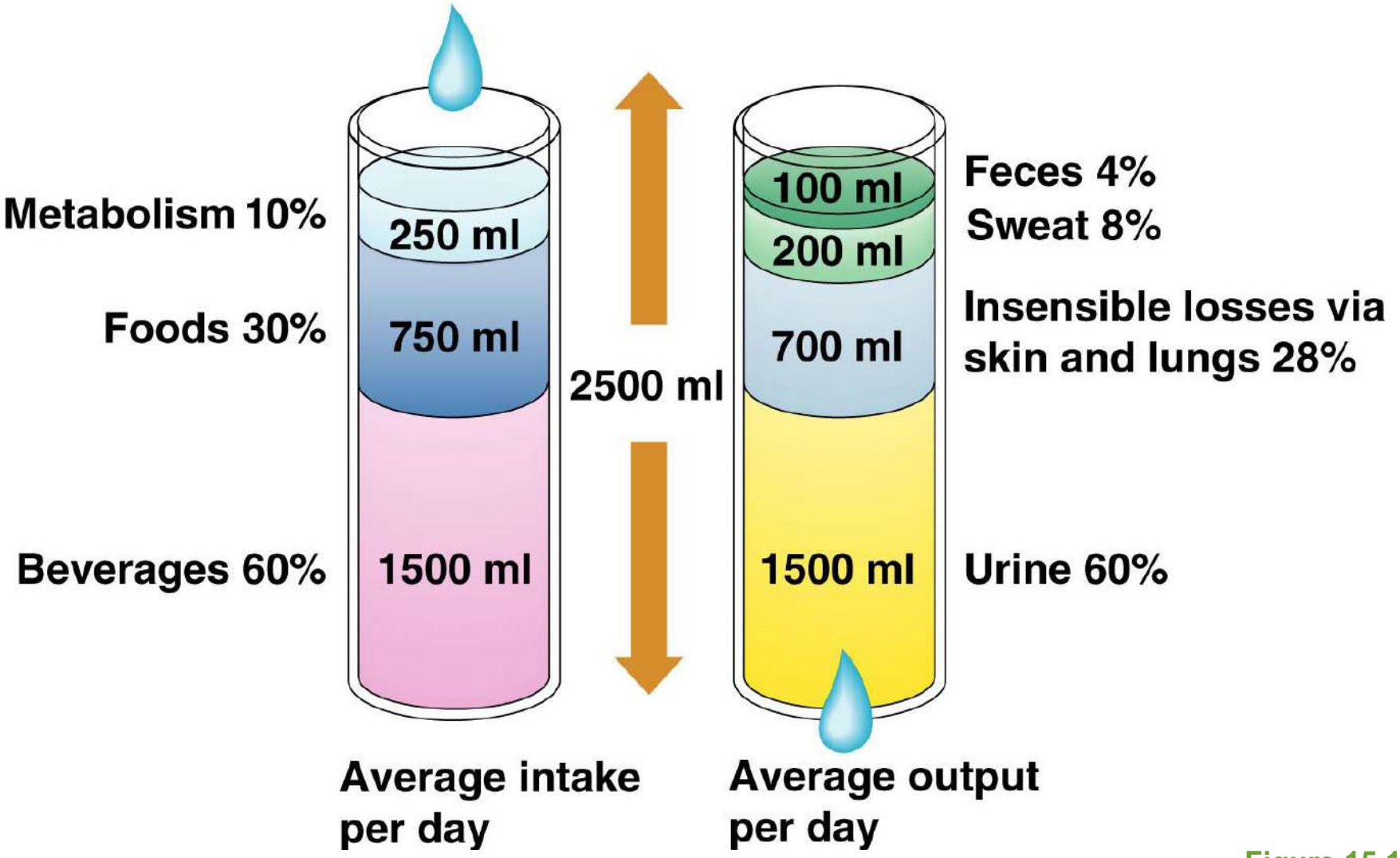

Figure 15.10

Maintaining Water Balance

- Dilute urine is produced if water intake is excessive
- Less urine (concentrated) is produced if large amounts of water are lost
- Proper concentrations of various electrolytes must be present

Regulation of Water and Electrolyte Reabsorption

- Osmoreceptors
  - Cells in the hypothalamus
  - React to changes in blood composition by becoming more active

Regulation of Water and Electrolyte Reabsorption

- Regulation occurs primarily by hormones
  - Antidiuretic hormone (ADH)
    - Prevents excessive water loss in urine
    - Causes the kidney's collecting ducts to reabsorb more water
  - Diabetes insipidus
    - Occurs when ADH is not released
    - Leads to huge outputs of dilute urine

Regulation of Water and Electrolyte Reabsorption

- Regulation occurs primarily by hormones (continued)
  - Aldosterone
    - Regulates sodium ion content of ECF
    - Sodium is the electrolyte most responsible for osmotic water flows
    - Aldosterone promotes reabsorption of sodium ions
    - Remember, water follows salt!

Regulation of Water and Electrolyte Reabsorption

- Renin-angiotension mechanism
  - Mediated by the juxtaglomerular (JG) apparatus of the renal tubules
  - When cells of the JG apparatus are stimulated by low blood pressure, the enzyme renin is released into blood
  - Renin produces angiotension II
  - Angiotension causes vasconstriction and aldosterone release
  - Result is increase in blood volume and blood pressure

Maintaining Water and Electrolyte Balance

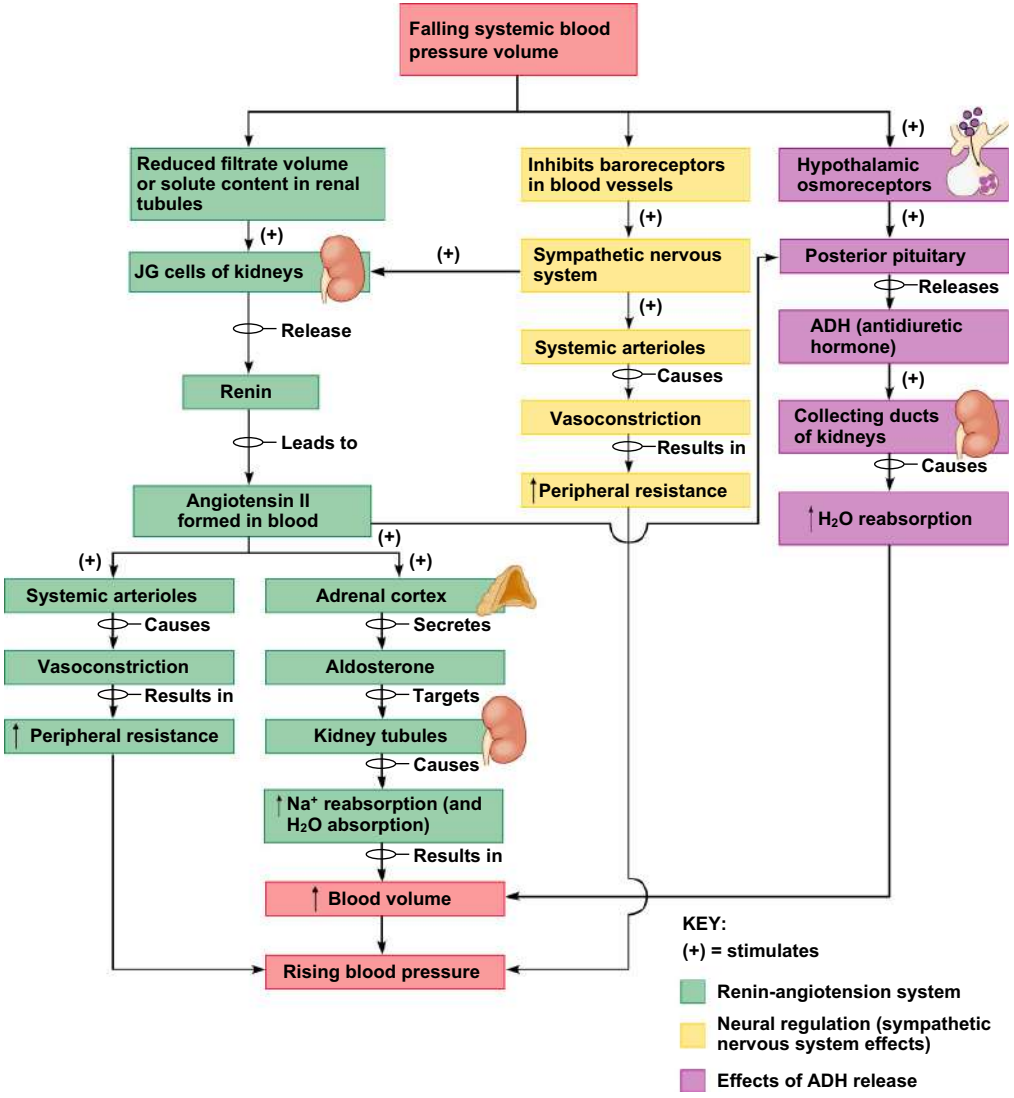

Figure 15.11

Maintaining Water and Electrolyte Balance

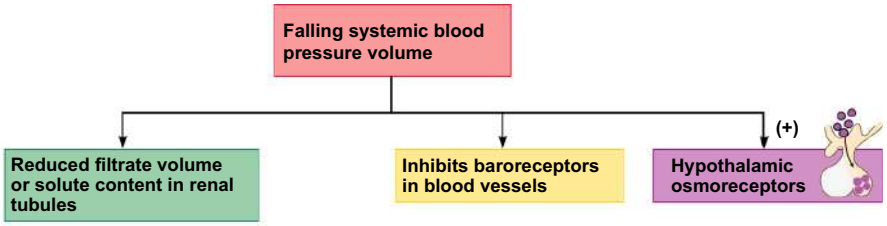

Figure 15.11, step 1

Maintaining Water and Electrolyte Balance

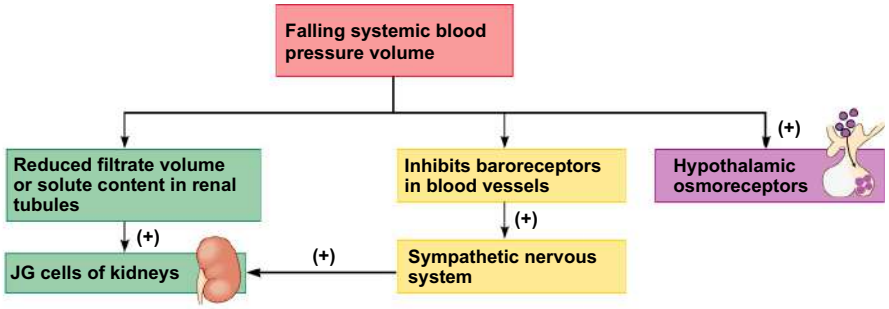

Figure 15.11, step 2

Maintaining Water and Electrolyte Balance

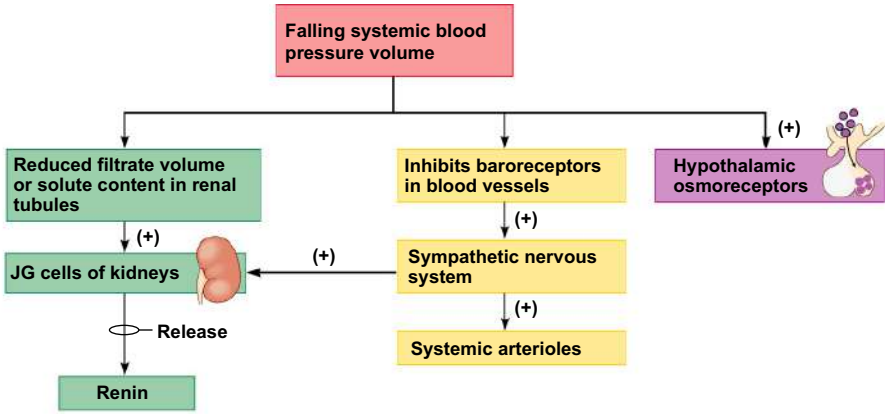

Figure 15.11, step 3

Maintaining Water and Electrolyte Balance

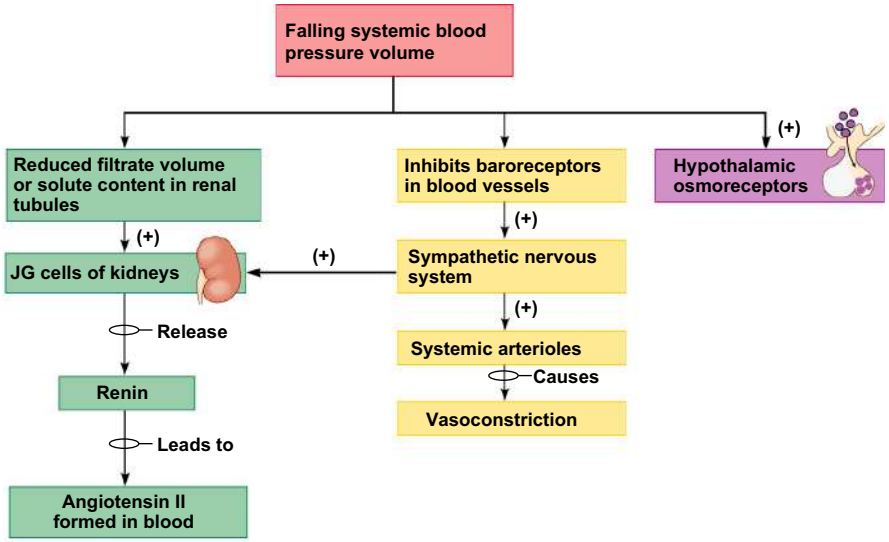

Figure 15.11, step 4

Maintaining Water and Electrolyte Balance

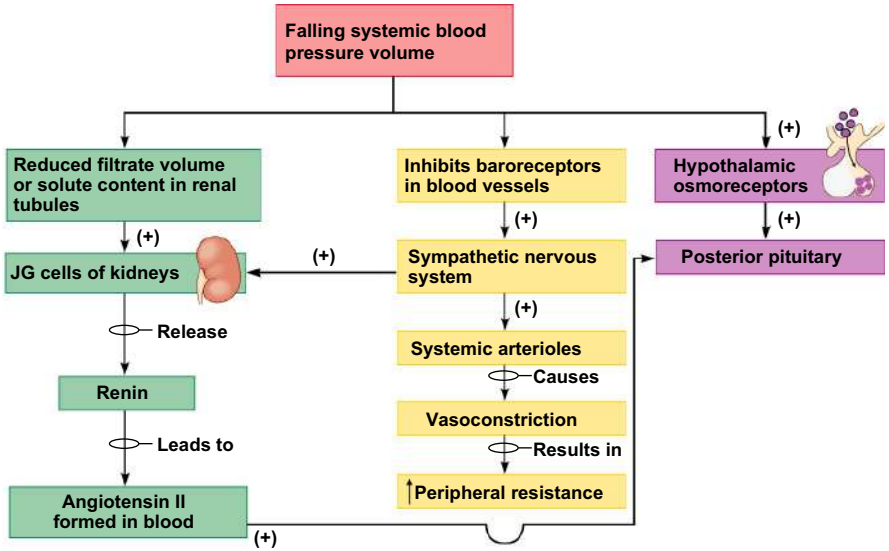

Figure 15.11, step 5

Maintaining Water and Electrolyte Balance

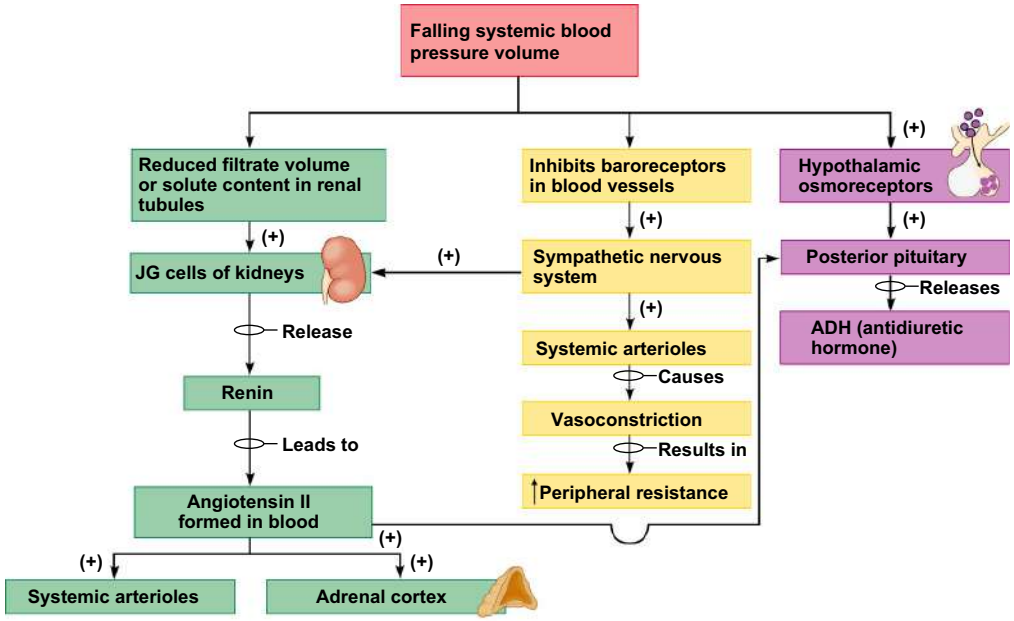

Figure 15.11, step 6

Maintaining Water and Electrolyte Balance

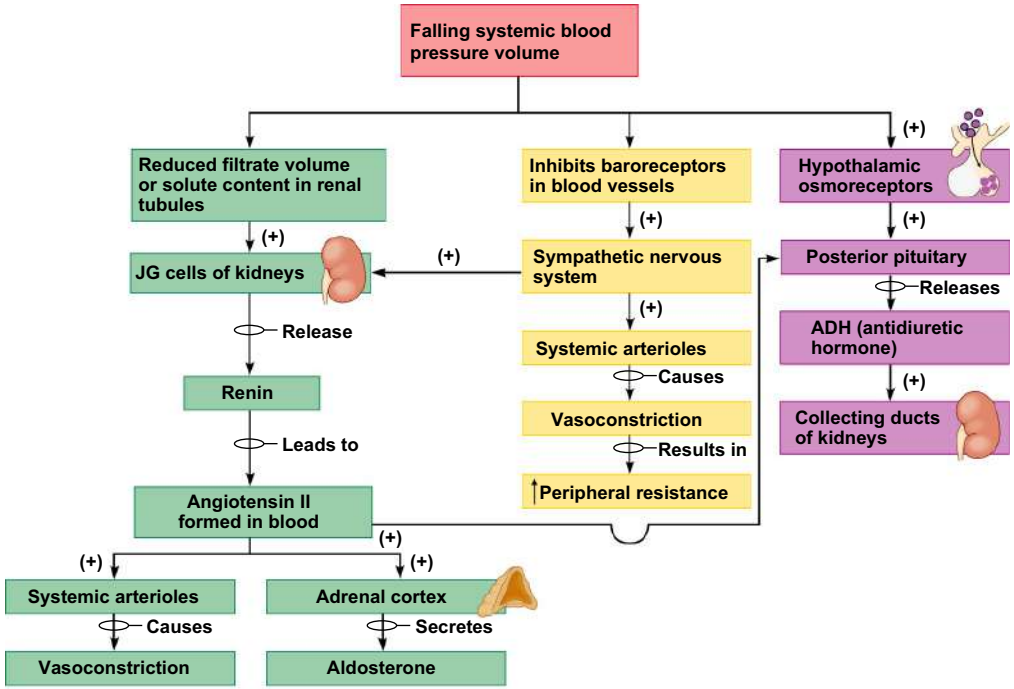

Figure 15.11, step 7

Maintaining Water and Electrolyte Balance

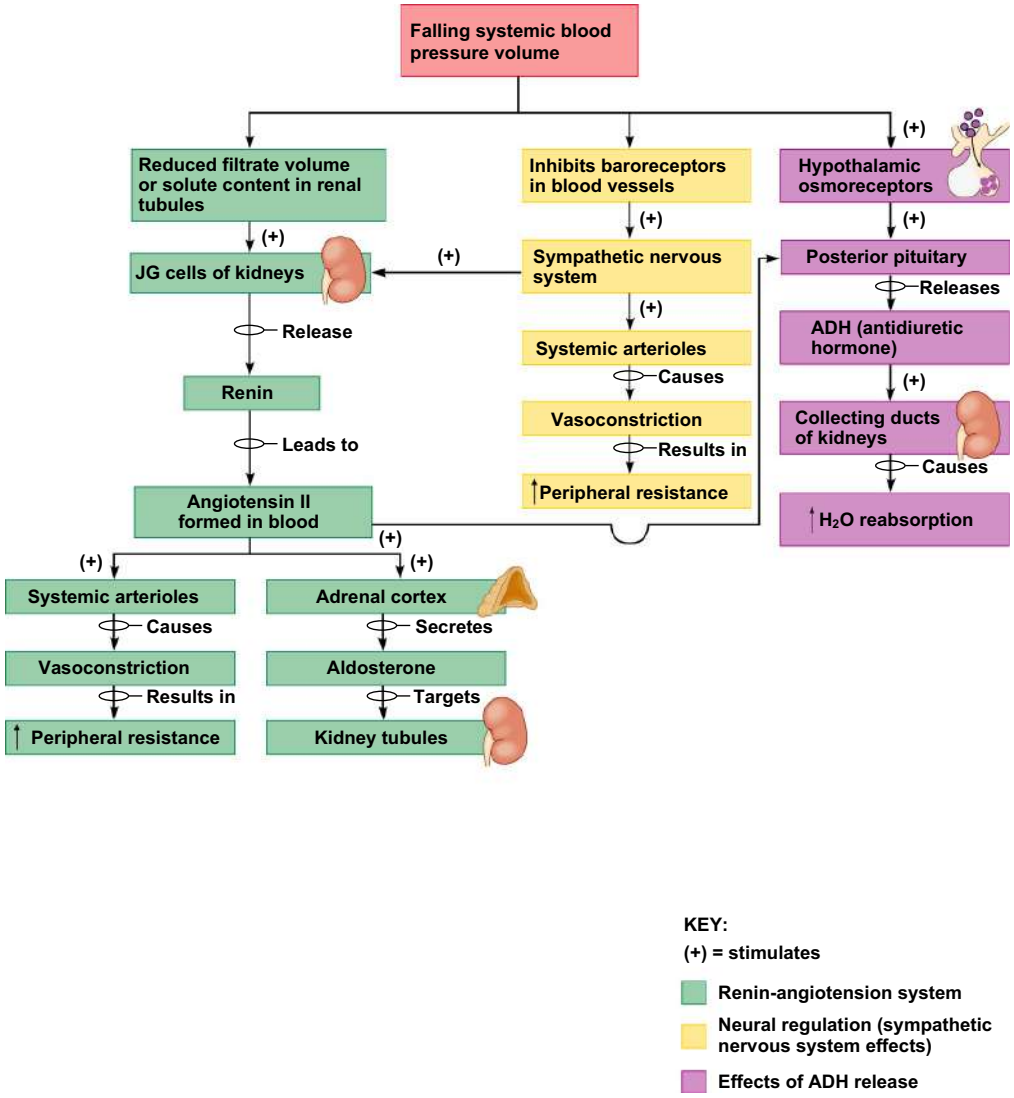

Figure 15.11, step 8

Maintaining Water and Electrolyte Balance

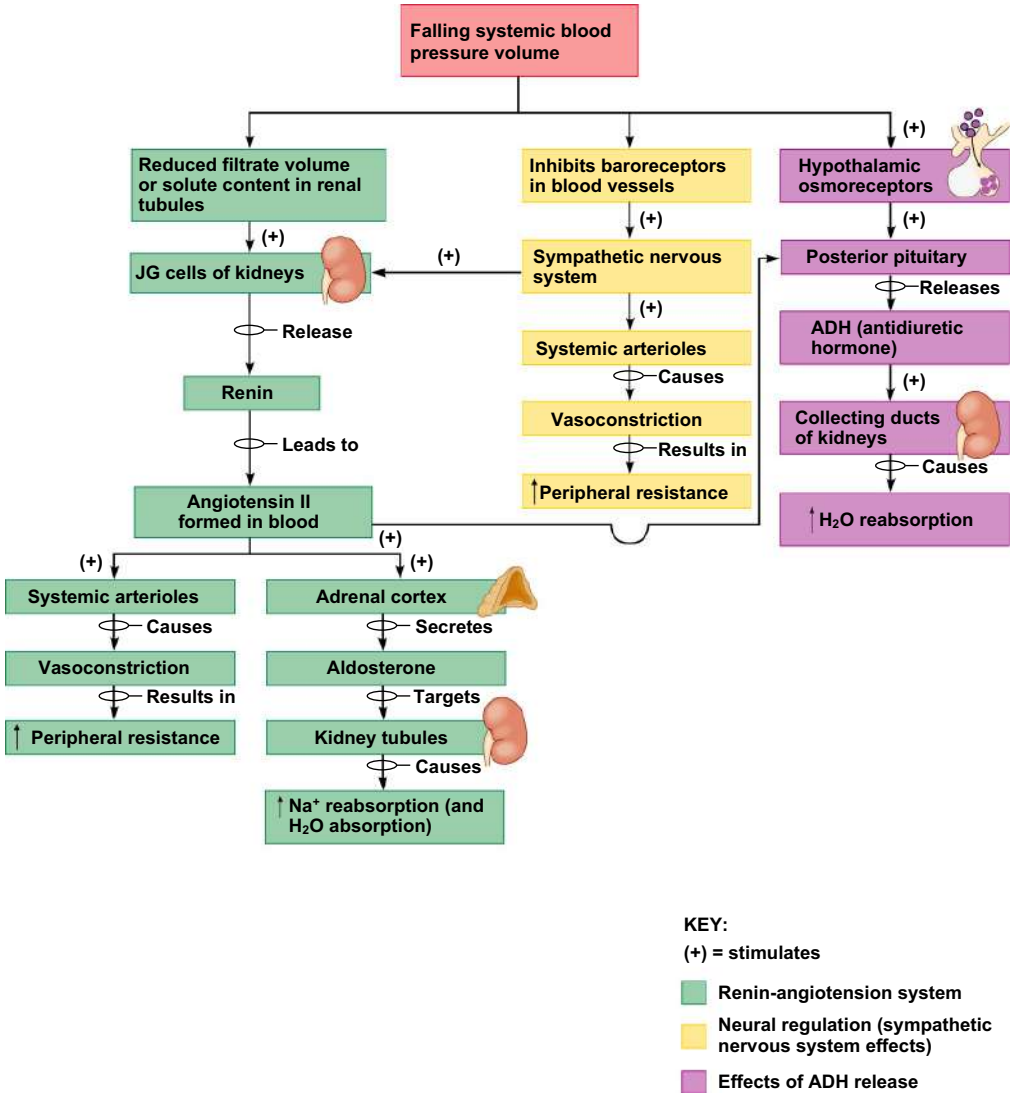

Figure 15.11, step 9

Maintaining Water and Electrolyte Balance

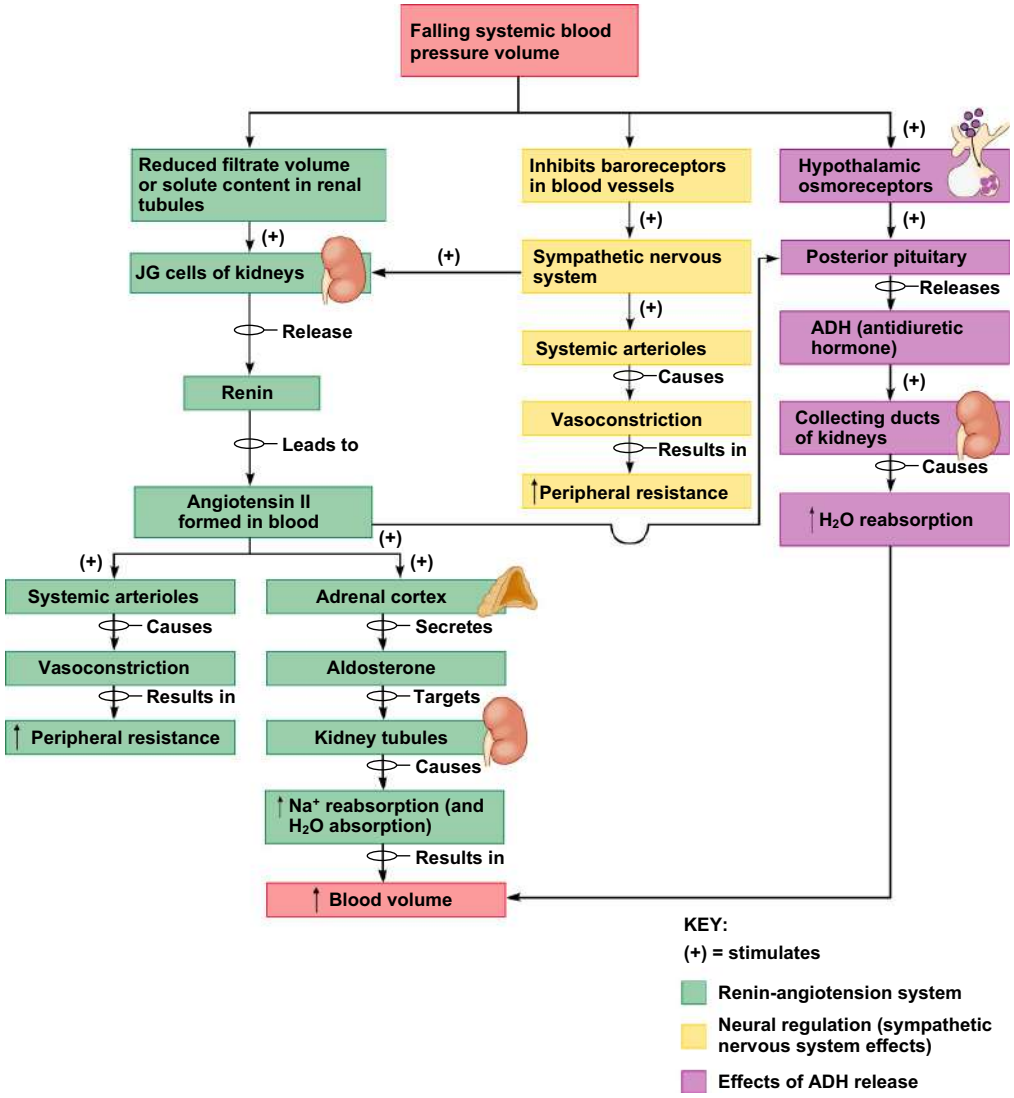

Figure 15.11, step 10

Maintaining Water and Electrolyte Balance

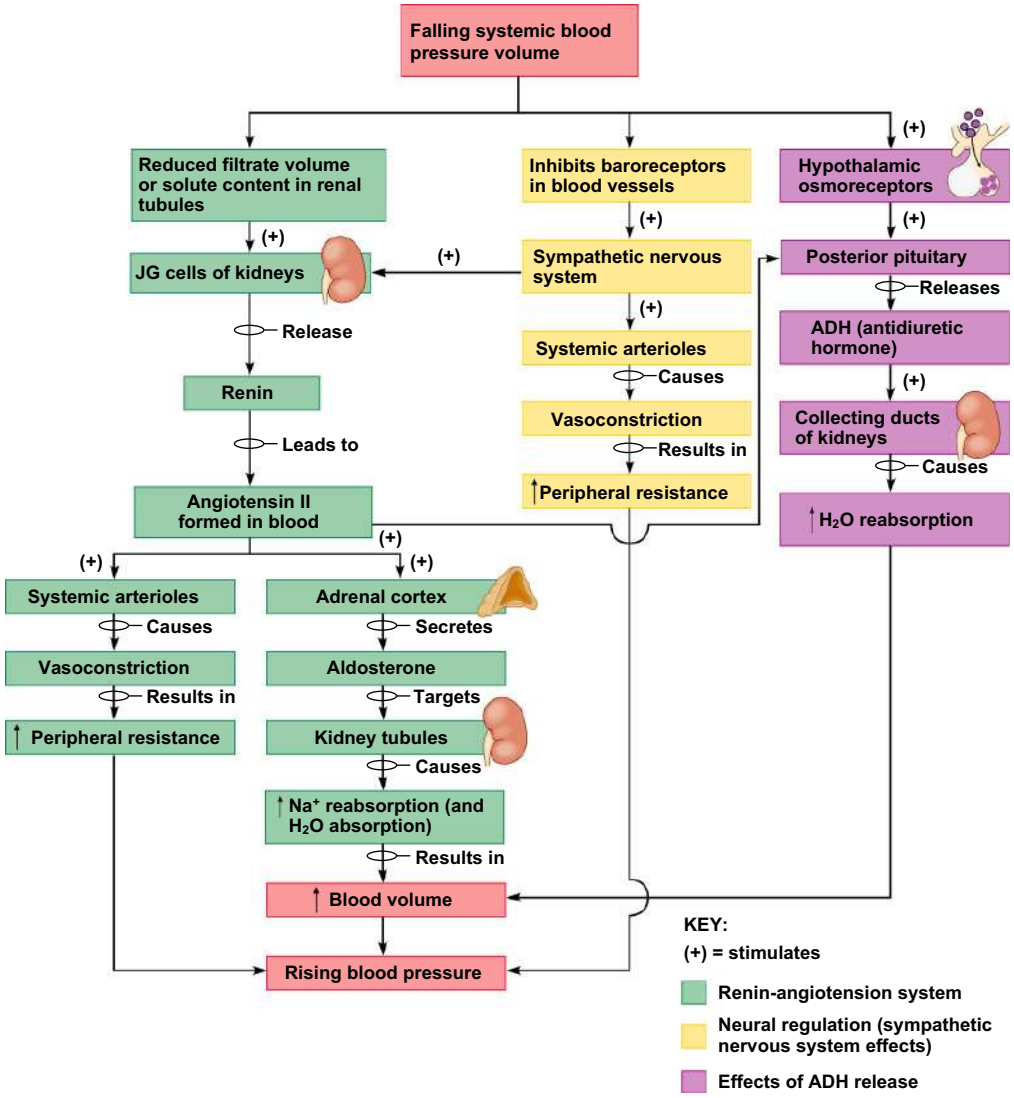

Figure 15.11, step 11

Maintaining Acid-Base Balance in Blood

- **Blood pH must remain between 7.35 and 7.45 to maintain homeostasis**
  - Alkalosis—pH above 7.45
  - Acidosis—pH below 7.35
  - Physiological acidosis—pH between 7.35 and 7.0
- **Most ions originate as by-products of cellular metabolism**

Maintaining Acid-Base Balance in Blood

- **Acids produced by the body**
  - Phosphoric acid, lactic acid, fatty acids
  - Carbon dioxide forms carbonic acid
  - Ammonia
- **Most acid-base balance is maintained by the kidneys**
- **Other acid-base controlling systems**
  - **Blood buffers**
  - **Respiration**

Blood Buffers

- **Acids are proton (H^+) *donors***
  - Strong acids dissociate completely and liberate all of their H^+ in water
  - Weak acids, such as carbonic acid, dissociate only partially
- **Bases are proton (H^+) *acceptors***
  - **Strong bases dissociate easily in water and tie up H^+**
  - **Weak bases, such as bicarbonate ion and ammonia, are slower to accept H^+**

Dissociation of Strong and Weak Acids

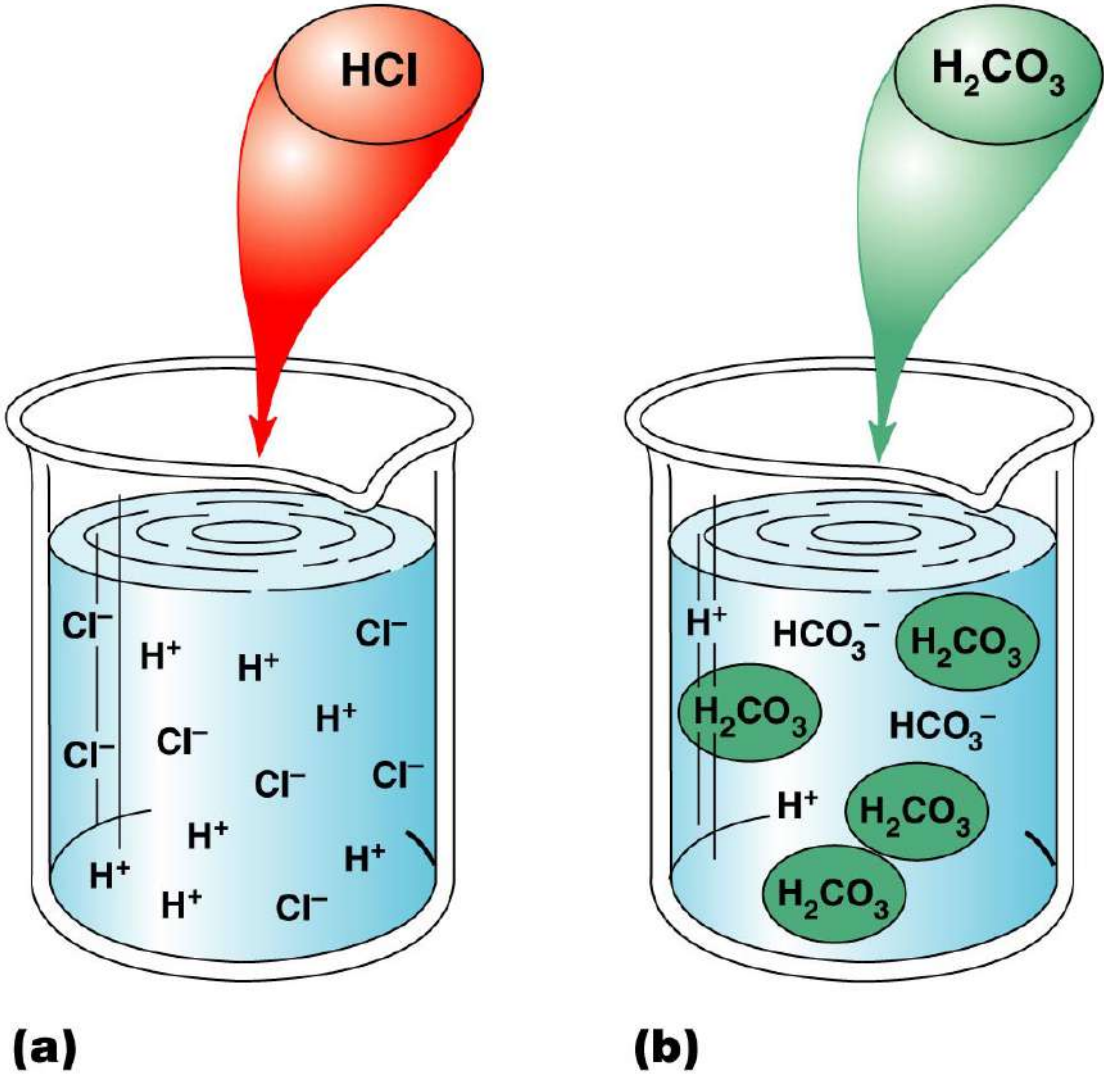

Figure 15.12

Blood Buffers

- **Molecules react to prevent dramatic changes in hydrogen ion (H^+) concentrations**
  - Bind to H^+ when pH drops
  - Release H^+ when pH rises
- **Three major chemical buffer systems**
  - **Bicarbonate buffer system**
  - **Phosphate buffer system**
  - **Protein buffer system**

The Bicarbonate Buffer System

- **Mixture of carbonic acid (H_2CO_3) and sodium bicarbonate ($NaHCO_3$)**
  - Carbonic acid is a weak acid that does not dissociate much in neutral or acid solutions
  - Bicarbonate ions (HCO_3^-) react with strong acids to change them to weak acids

$$HCl + NaHCO_3 \rightarrow H_2CO_3 + NaCl$$

strong acid weak base weak acid salt

The Bicarbonate Buffer System

- Carbonic acid dissociates in the presence of a strong base to form a weak base and water

$$NaOH + H_2CO_3 \rightarrow NaHCO_3 + H_2O$$

strong base weak acid weak base water

Respiratory System Controls of Acid-Base Balance

- Carbon dioxide in the blood is converted to bicarbonate ion and transported in the plasma
- Increases in hydrogen ion concentration produces more carbonic acid
- Excess hydrogen ion can be blown off with the release of carbon dioxide from the lungs
- Respiratory rate can rise and fall depending on changing blood pH

Renal Mechanisms of Acid-Base Balance

- Excrete bicarbonate ions if needed
- Conserve (reabsorb) or generate new bicarbonate ions if needed

Renal Mechanisms of Acid-Base Balance

- **When blood pH rises**
  - Bicarbonate ions are excreted
  - Hydrogen ions are retained by kidney tubules
- **When blood pH falls**
  - **Bicarbonate ions are reabsorbed**
  - **Hydrogen ions are secreted**
- **Urine pH varies from 4.5 to 8.0**

Developmental Aspects of the Urinary System

- Functional kidneys are developed by the third month
- Urinary system of a newborn
  - Bladder is small
  - Urine cannot be concentrated for first 2 months
  - Void 5 to 40 times per day

Developmental Aspects of the Urinary System

- Control of the voluntary urethral sphincter does not start until age 18 months
- Complete nighttime control may not occur until the child is 4 years old
- Urinary infections are the only common problems before old age
  - *Escherichia coli* (*E. coli*), a type of bacteria, accounts for 80% of UTI (urinary tract infections)

Aging and the Urinary System

- There is a progressive decline in urinary function
- The bladder shrinks and loses bladder tone with aging

Aging and the Urinary System

- Associated problems with aging
  - Urgency—feeling that it is necessary to void
  - Frequency—frequent voiding of small amounts of urine
  - Nocturia—need to get up during the night to urinate
  - Incontinence—loss of control
  - Urinary retention—common in males, often the result of hypertrophy of the prostate gland