

## Chapter 27: Water, Electrolytes, and Acid-Base Balance

### I. Body Fluids

#### A. Intracellular Fluid Compartment

1. The intracellular fluid compartment includes all the fluid in \_\_\_\_\_  
\_\_\_\_\_
2. The intracellular fluid from all cells has a \_\_\_\_\_ composition
3. Intracellular fluid accounts for how much of the total body weight? \_\_\_\_\_

#### B. Extracellular Fluid Compartment

1. The extracellular fluid compartment includes all of the fluid \_\_\_\_\_  
\_\_\_\_\_ and constitutes about \_\_\_\_\_ of total body weight
2. The extracellular fluid compartment is subdivided into \_\_\_\_\_
  - a. The two major subcompartments are:
    1. \_\_\_\_\_
    2. \_\_\_\_\_
  - b. Other subcompartments include:
    1. \_\_\_\_\_
    2. \_\_\_\_\_
    3. \_\_\_\_\_
3. Where is interstitial fluid found? \_\_\_\_\_  
\_\_\_\_\_
4. Where is plasma found? \_\_\_\_\_
5. All the other subcompartments constitute relatively \_\_\_\_\_

#### C. Movement Between Subcompartments

1. How does the composition of extracellular fluid compare in different subcompartments? \_\_\_\_\_
2. Movement does occur between subcompartments:
  - a. Water \_\_\_\_\_
  - b. Small molecules and ions \_\_\_\_\_  
\_\_\_\_\_
  - c. Large molecules \_\_\_\_\_

## II. Regulation of Body Fluid Concentration and Volume

### A. Regulation of Water Content

1. The total volume of the water in the body \_\_\_\_\_
  - a. Volume of water taken into body equals \_\_\_\_\_
2. Changes in the water volume in the body fluids alter:
  - a. Osmolality \_\_\_\_\_
  - b. Blood \_\_\_\_\_
  - c. Interstitial \_\_\_\_\_
3. About 90% of the water entering the body comes from \_\_\_\_\_ and some comes from \_\_\_\_\_
4. About 10% of the water entering the body comes from \_\_\_\_\_
5. The movement of water across the wall of the gastrointestinal tract depends on \_\_\_\_\_
6. The volume of water entering the body depends on \_\_\_\_\_
  - a. If a large volume of dilute liquid is consumed \_\_\_\_\_
  - b. If a small volume of concentrated liquid is consumed \_\_\_\_\_
7. The sensation of thirst results from:
  - a. Increase in the \_\_\_\_\_
  - b. Reduction in \_\_\_\_\_
    1. Detected by cells in the \_\_\_\_\_ within \_\_\_\_\_
    2. Initiate activity in neural circuits that results in \_\_\_\_\_
  - c. When do baroreceptors influence the sensation of thirst? \_\_\_\_\_
8. Angiotensin II opposes a decrease in blood pressure by:
  - a. Acting on the brain to \_\_\_\_\_
  - b. Acting on the adrenal cortex \_\_\_\_\_
  - c. Acting on blood vessels \_\_\_\_\_

9. When dehydrated people drink, they do not usually drink large volumes of water all at once but drink \_\_\_\_\_
- This is because the thirst sensation is temporarily interrupted by:
    - Wetting of the oral mucosa causes sensory neurons to \_\_\_\_\_
    - Stretch of the gastrointestinal wall:
      - Initiates \_\_\_\_\_
      - Sensory neurons \_\_\_\_\_
      - Temporarily \_\_\_\_\_
  - Since water absorption from the gastrointestinal tract takes \_\_\_\_\_ temporarily suppressing thirst prevents \_\_\_\_\_
  - When osmolality and blood pressure are within normal ranges \_\_\_\_\_
10. Water loss from the body occurs through three major routes:
- 61% is lost through \_\_\_\_\_
  - 35% of water loss occurs through \_\_\_\_\_ from:
    - \_\_\_\_\_
    - Water that \_\_\_\_\_
    - \_\_\_\_\_
  - 4% is lost in the \_\_\_\_\_
11. The volume of water lost through the respiratory system depends on:
- \_\_\_\_\_ & \_\_\_\_\_ of the air
  - Body \_\_\_\_\_
  - Volume \_\_\_\_\_
12. What is insensible perspiration? \_\_\_\_\_
- It plays a role in \_\_\_\_\_
  - How much water is lost for each degree of body temperature? \_\_\_\_\_
13. Sweat or sensible perspiration is secreted by the \_\_\_\_\_ and contains \_\_\_\_\_
- The composition of sweat resembles \_\_\_\_\_

- b. Solutes in the sweat include:
1. \_\_\_\_\_
  2. \_\_\_\_\_
  3. \_\_\_\_\_
  4. \_\_\_\_\_
- a. The major solute component is \_\_\_\_\_
14. What determines the volume of sweat produced? \_\_\_\_\_
- \_\_\_\_\_
- a. The volume produced increases substantially under:
1. Conditions of \_\_\_\_\_
  2. Elevated \_\_\_\_\_ or
  3. \_\_\_\_\_
15. The loss of a large volume of hyposmotic sweat causes:
- a. Decrease in \_\_\_\_\_
  - b. Increase in \_\_\_\_\_
  - c. Fluid volume is lost primarily from \_\_\_\_\_ leads to
    1. Increased \_\_\_\_\_
    2. Reduction in \_\_\_\_\_
    3. Increase in \_\_\_\_\_
  - d. During severe dehydration this can cause blood viscosity to
    - a. \_\_\_\_\_
      1. This causes the heart to have an \_\_\_\_\_
16. Why is little water lost from the gastrointestinal tract? \_\_\_\_\_
- \_\_\_\_\_
- a. A large volume of fluid loss can occur due to severe \_\_\_\_\_ and \_\_\_\_\_
17. What are the primary organs for regulating the composition and volume of body fluids? \_\_\_\_\_
- B. Regulation of Extracellular Fluid Osmolality
1. The osmolality, or concentration of a solution, is changed by:
    - a. Adding water \_\_\_\_\_
    - b. Removing water \_\_\_\_\_

2. An increase in the osmolality of the extracellular fluid triggers \_\_\_\_\_ and \_\_\_\_\_ secretion
  - a. Water that is consumed, as a result of thirst, is \_\_\_\_\_ and enters \_\_\_\_\_
  - b. ADH acts on the \_\_\_\_\_ and \_\_\_\_\_ to \_\_\_\_\_ from \_\_\_\_\_
    1. Both mechanisms result in increased water entering the extracellular fluid that causes a \_\_\_\_\_
  - c. The ADH and thirst mechanisms are sensitive to \_\_\_\_\_
  - d. Larger increases in extracellular fluid osmolality results in \_\_\_\_\_
3. A decrease in extracellular fluid osmolality inhibits \_\_\_\_\_ and \_\_\_\_\_ secretion
  - a. Less water is \_\_\_\_\_
  - b. Less water is \_\_\_\_\_ from \_\_\_\_\_
    1. Therefore, more water is lost as a \_\_\_\_\_
    2. Result is an \_\_\_\_\_ in osmolality of extracellular fluid

### C. Regulation of Extracellular Fluid Volume

1. Even if the osmolality of the extracellular fluid is within a narrow range of values, the extracellular fluid volume can \_\_\_\_\_ or \_\_\_\_\_
2. What type of receptors are important in regulation of extracellular fluid volume? \_\_\_\_\_
  - a. These receptors include:
    1. Carotid sinus and aortic arch \_\_\_\_\_ monitor \_\_\_\_\_
    2. Juxtaglomerular apparatuses monitor \_\_\_\_\_
    3. Receptors in the walls of the atria and large veins are sensitive to \_\_\_\_\_
3. These receptors activate \_\_\_\_\_ and \_\_\_\_\_ that regulate extracellular fluid volume

## a. Neural Mechanisms

1. What do neural mechanisms change? \_\_\_\_\_

\_\_\_\_\_

2. When baroreceptors detect an increase in arterial & venous pressure:

a. Frequency of action potentials \_\_\_\_\_

b. Afferent arterioles \_\_\_\_\_

c. Increases \_\_\_\_\_

d. Resulting in an \_\_\_\_\_

e. Increase in \_\_\_\_\_ volume

f. Increase in \_\_\_\_\_ volume

3. When baroreceptors detect a decrease in arterial & venous pressure:

a. Frequency of action potentials \_\_\_\_\_

b. Afferent arterioles \_\_\_\_\_

c. Decreases \_\_\_\_\_, \_\_\_\_\_ volume, and \_\_\_\_\_ volume

## b. Renin-Angiotensin-Aldosterone Mechanism

1. This mechanism responds to \_\_\_\_\_

2. When juxtaglomerular cells detect increases in blood pressure:

a. Decrease the rate of \_\_\_\_\_ secretion

b. Results in decreased conversion of \_\_\_\_\_ to

\_\_\_\_\_

c. Reduced \_\_\_\_\_ causes

d. Decrease in rate of \_\_\_\_\_ secretion from adrenal cortex

e. Decreased \_\_\_\_\_ levels reduce the rate of

\_\_\_\_\_ reabsorption

1. Primarily in the \_\_\_\_\_ & \_\_\_\_\_

f. Therefore more \_\_\_\_\_ remains in the filtrate

g. This increases the \_\_\_\_\_ of the filtrate and reduces the ability of the kidney to \_\_\_\_\_

h. The \_\_\_\_\_ remains with the excess \_\_\_\_\_ in the filtrate

i. Volume of urine produced \_\_\_\_\_ and the

extracellular fluid volume \_\_\_\_\_

- j. Reestablishing homeostasis
3. When juxtaglomerular cells detect decreases in blood pressure:
- The increase in \_\_\_\_\_ secretion
  - Results in increased conversion of \_\_\_\_\_ to \_\_\_\_\_
  - Increased \_\_\_\_\_ causes an
  - Increase in rate of \_\_\_\_\_ secretion from the adrenal cortex
  - Increased \_\_\_\_\_
  - Increases the rate of \_\_\_\_\_ reabsorption
    - Primarily from the \_\_\_\_\_ & \_\_\_\_\_
  - Therefore, less \_\_\_\_\_ remains in the filtrate
  - Decreases the \_\_\_\_\_ of the filtrate
  - Increases the ability of the kidney to \_\_\_\_\_ & to increase \_\_\_\_\_
  - The volume of urine produced \_\_\_\_\_ and the extracellular fluid volume and blood pressure \_\_\_\_\_
- b. Atrial Natriuretic Hormone (ANH) Mechanism
- Most important in responding to \_\_\_\_\_
  - An increase in atrial blood pressure usually results from an increase in \_\_\_\_\_
    - Stimulates secretion of \_\_\_\_\_
    - Decreases \_\_\_\_\_ in the \_\_\_\_\_ & \_\_\_\_\_
    - Increases the rate of \_\_\_\_\_ & \_\_\_\_\_ loss in the urine
    - Therefore increased ANH secretion decreases \_\_\_\_\_
  - ANH does not respond strongly to \_\_\_\_\_
  - A decrease in atrial blood pressure \_\_\_\_\_ the secretion of ANH
    - Decreases the inhibition of \_\_\_\_\_ in the \_\_\_\_\_ & \_\_\_\_\_
    - Rate of \_\_\_\_\_ & \_\_\_\_\_ reabsorption increases

- c. Which is consistent with \_\_\_\_\_ urine volume and \_\_\_\_\_ extracellular fluid volume
- c. Antidiuretic Hormone (ADH) Mechanism
1. Plays an important role in regulating \_\_\_\_\_ in response to \_\_\_\_\_
  2. An increase in blood pressure results in:
    - a. Decrease in \_\_\_\_\_ secretion
    - b. Reabsorption of \_\_\_\_\_ decreases in the \_\_\_\_\_ & \_\_\_\_\_
    - c. Results in a \_\_\_\_\_ volume of \_\_\_\_\_ urine
    - d. Response helps decrease \_\_\_\_\_ & \_\_\_\_\_
  3. A decrease in blood pressure results in:
    - a. Increase in \_\_\_\_\_ secretion
    - b. Reabsorption of \_\_\_\_\_ increases in the \_\_\_\_\_ & \_\_\_\_\_
    - c. Resulting in a \_\_\_\_\_ volume of \_\_\_\_\_ urine
    - d. Response helps increase \_\_\_\_\_ & \_\_\_\_\_

### III. Regulation of Intracellular Fluid Composition

#### A. Plasma Membrane

1. Plasma membranes are \_\_\_\_\_
  - a. Relatively impermeable to \_\_\_\_\_ & other \_\_\_\_\_
  - b. Have limited permeability to \_\_\_\_\_ & \_\_\_\_\_
2. Most large molecules synthesized within cells remain \_\_\_\_\_
3. Some substances are \_\_\_\_\_ across the plasma membrane
  - a. Their concentrations in the intracellular fluid are determined by:
    1. \_\_\_\_\_ & \_\_\_\_\_
    2. \_\_\_\_\_ difference across the plasma membrane



**B. Water**

1. What controls water movement across the plasma membrane? \_\_\_\_\_
2. Net movement of water is affected by changes in the \_\_\_\_\_ of \_\_\_\_\_ in the \_\_\_\_\_ & \_\_\_\_\_ fluids
3. As dehydration develops:
  - a. Concentration of solutes in extracellular fluid \_\_\_\_\_
  - b. Results in water movement by osmosis from \_\_\_\_\_ to \_\_\_\_\_
    1. If enough water moves the cells may function \_\_\_\_\_
4. After dehydration, when water intake increases:
  - a. Concentration of solutes in extracellular fluid \_\_\_\_\_
  - b. Results in water movement \_\_\_\_\_

**IV. Regulation of Specific Electrolytes in Extracellular Fluid**

What are electrolytes? \_\_\_\_\_

**A. Regulation of Sodium Ions**

1. Sodium ions are the \_\_\_\_\_ cations
2. Because of their abundance they exert \_\_\_\_\_
  - a. How much of extracellular osmotic pressure is due to Na<sup>+</sup> and associated anions? \_\_\_\_\_
3. The kidneys are the major route for Na<sup>+</sup> \_\_\_\_\_
  - a. Na<sup>+</sup> readily passes through the filtration membrane so its concentration in the filtrate is the \_\_\_\_\_ in the plasma
  - b. The concentration of Na<sup>+</sup> excreted in the urine is determined by \_\_\_\_\_
    1. \_\_\_\_\_
    2. \_\_\_\_\_
  - c. The rate of Na<sup>+</sup> transport in the proximal tubule is \_\_\_\_\_
  - d. Na<sup>+</sup> transport mechanisms of the \_\_\_\_\_ & \_\_\_\_\_ are under hormonal control
    1. When aldosterone is present \_\_\_\_\_
    2. When aldosterone is absent \_\_\_\_\_

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4.  $\text{Na}^+$  is also excreted from the body in \_\_\_\_\_
    - a. Normally only a \_\_\_\_\_
    - b. The amount increases during conditions of \_\_\_\_\_ in a \_\_\_\_\_
    - c. As the body temperature increases:
      1. Thermoreceptor neurons within the \_\_\_\_\_
      2. Respond by increasing the \_\_\_\_\_
      3. As the rate of sweat production increases \_\_\_\_\_  
\_\_\_\_\_ decreases to keep \_\_\_\_\_
  5. The primary mechanisms that regulate  $\text{Na}^+$  concentration in the extracellular fluid are sensitive to changes in:
    - a. Extracellular \_\_\_\_\_
    - b. Blood \_\_\_\_\_
  6. If the quantity of  $\text{Na}^+$  increases the osmolality of extracellular fluid \_\_\_\_\_
    - a. Stimulates \_\_\_\_\_ secretion
    - b. Increases the \_\_\_\_\_ by the kidney
    - c. Causes a \_\_\_\_\_ volume of \_\_\_\_\_ urine to be produced
    - d. It also increases the \_\_\_\_\_
    - e. There is an \_\_\_\_\_ volume
  7. If the quantity of  $\text{Na}^+$  decreases the osmolality of extracellular fluid \_\_\_\_\_
    - a. Inhibits \_\_\_\_\_ secretion
    - b. Stimulates a \_\_\_\_\_ volume of \_\_\_\_\_ urine to be produced
    - c. \_\_\_\_\_ the sensation of thirst
    - d. Extracellular fluid volume \_\_\_\_\_
  8. By regulating extracellular fluid osmolality and extracellular fluid volume the concentration of \_\_\_\_\_
  9. Elevated blood pressure under resting conditions \_\_\_\_\_  
\_\_\_\_\_
  10. If blood pressure is low \_\_\_\_\_

- a. Mechanisms such as the \_\_\_\_\_  
are activated
1. Increase \_\_\_\_\_ &
  2. Water \_\_\_\_\_ in the \_\_\_\_\_
11. ANH is secreted in response to \_\_\_\_\_ within the right atrium
- a. ANH acts on the kidneys to \_\_\_\_\_ urine production by  
\_\_\_\_\_ the reabsorption of \_\_\_\_\_
  - b. ANH also inhibits \_\_\_\_\_ secretion and the effect of \_\_\_\_\_ on  
the \_\_\_\_\_ & \_\_\_\_\_ in the kidneys
12. What is hypernatremia? \_\_\_\_\_
13. What is hyponatremia? \_\_\_\_\_
- B. Regulation of Chloride Ions
1. The electrical attraction of anions and cations makes it difficult to \_\_\_\_\_  
\_\_\_\_\_
  2. Therefore, the mechanisms that regulate concentration of cations in the  
extracellular fluid also \_\_\_\_\_
  3. The mechanisms that regulate \_\_\_\_\_, \_\_\_\_\_, and \_\_\_\_\_ levels in the body  
are important in influencing \_\_\_\_\_
- C. Regulation of Potassium Ions
1. The concentration gradient of  $K^+$  across the plasma membrane has a major  
influence on the \_\_\_\_\_
  - a. What cells are highly sensitive to changes in this concentration gradient?  
\_\_\_\_\_
  2. An increase in extracellular  $K^+$  leads to \_\_\_\_\_
  3. A decrease in extracellular  $K^+$  leads to \_\_\_\_\_
  4. What is hyperkalemia? \_\_\_\_\_
  5. What is hypokalemia? \_\_\_\_\_
  6. In the kidney:
    - a. \_\_\_\_\_ through the filtration membrane
    - b. They are \_\_\_\_\_ in the proximal tubules
    - c. They are \_\_\_\_\_ in the distal tubules & collecting ducts

1. Secretion in the distal tubules and collecting ducts is \_\_\_\_\_  
\_\_\_\_\_ and primarily responsible for controlling the  
\_\_\_\_\_
  7. Aldosterone plays a major role in regulating  $K^+$  concentration in the extracellular fluid by \_\_\_\_\_
    - a. Aldosterone secretion from the adrenal cortex is stimulated by:
      1. Elevated \_\_\_\_\_
      2. Increased \_\_\_\_\_
    - b. Elevated aldosterone levels in the circulatory system:
      1. Increase \_\_\_\_\_
      2. Lowering \_\_\_\_\_
  8. Circulatory system shock causes the extracellular  $K^+$  to be more \_\_\_\_\_  
\_\_\_\_\_
    - a. This stimulates \_\_\_\_\_ from the adrenal cortex
    - b. The low blood pressure associated with circulatory system shock will stimulate the \_\_\_\_\_ mechanism which also stimulates secretion of \_\_\_\_\_
    - c. Homeostasis is reestablished as:
      1. \_\_\_\_\_ increases
      2. \_\_\_\_\_ and \_\_\_\_\_ reabsorption results in an increase in \_\_\_\_\_ that dilutes the \_\_\_\_\_
      3. Blood pressure \_\_\_\_\_ toward normal as
        - a. Water \_\_\_\_\_
        - b. Angiotensin II stimulates \_\_\_\_\_
- D. Regulation of Calcium Ions
1. What is hypocalcemia? \_\_\_\_\_
  2. What is hypercalcemia? \_\_\_\_\_
  3. Decreases and increases in the extracellular concentration of  $Ca^{2+}$  markedly affect the \_\_\_\_\_
    - a. Hypocalcemia \_\_\_\_\_ the permeability of plasma membranes to  $Na^+$

1. This results in nerve and muscle tissues \_\_\_\_\_  
\_\_\_\_\_
- b. Hypercalcemia \_\_\_\_\_ the permeability of plasma membranes to  $\text{Na}^+$ 
  1. Preventing normal \_\_\_\_\_
4. High extracellular  $\text{Ca}^{2+}$  levels cause the \_\_\_\_\_  
in soft tissues, resulting in \_\_\_\_\_
5. What structures are important in maintaining extracellular  $\text{Ca}^{2+}$  levels?
  - a. \_\_\_\_\_
  - b. \_\_\_\_\_
  - c. \_\_\_\_\_
6. How much of the total body calcium is contained in bone? \_\_\_\_\_
  - a. Therefore part of extracellular  $\text{Ca}^{2+}$  regulation involves regulation of:
    1. \_\_\_\_\_ into bone
    2. \_\_\_\_\_ from bone
7. Long-term regulation of  $\text{Ca}^{2+}$  levels depends on a balance between:
  - a. \_\_\_\_\_ in the intestinal tract
  - b. \_\_\_\_\_ by the kidneys
8. Functionally parathyroid hormone:
  - a. Increases \_\_\_\_\_
  - b. Reduces \_\_\_\_\_
9. The rate of parathyroid secretion is regulated by \_\_\_\_\_
  - a. Elevated  $\text{Ca}^{2+}$  levels \_\_\_\_\_ secretion
  - b. Reduced  $\text{Ca}^{2+}$  levels \_\_\_\_\_ secretion
10. Actions of parathyroid hormone include:
  - a. Increased \_\_\_\_\_ which results in the  
\_\_\_\_\_ of bone and the release of \_\_\_\_\_ and  
\_\_\_\_\_ into body fluids
  - b. Increases the rate of \_\_\_\_\_ in the kidneys
  - c. Increases the concentration of \_\_\_\_\_ in the urine
  - d. Increases the rate of Vitamin D conversion to \_\_\_\_\_  
\_\_\_\_\_

1. Active vitamin D acts on the intestinal tract to \_\_\_\_\_  
\_\_\_\_\_
11. A lack of parathyroid hormone secretion results in \_\_\_\_\_  
\_\_\_\_\_ that is caused by:
- Reduction in \_\_\_\_\_
  - Increased \_\_\_\_\_ &
  - Reduced \_\_\_\_\_
  - Could result in death because of \_\_\_\_\_
12. Vitamin D
- Can be obtained from \_\_\_\_\_ or from \_\_\_\_\_
  - Why does lack of exposure to sunlight decrease vitamin D biosynthesis?  
\_\_\_\_\_
  - Without vitamin D, the transport of \_\_\_\_\_  
the intestinal tract is \_\_\_\_\_
    - Leads to inadequate \_\_\_\_\_ even though the diet  
may contain large amounts
  - Normal  $\text{Ca}^{2+}$  absorption depends on both:
    - Consumption of \_\_\_\_\_ &
    - Presence of \_\_\_\_\_
13. The hormone calcitonin \_\_\_\_\_ levels
- Calcitonin is most effective when \_\_\_\_\_
  - Calcitonin has its major effect on \_\_\_\_\_ by:
    - Inhibit \_\_\_\_\_ &
    - Prolong \_\_\_\_\_
  - By these actions calcitonin:
    - Decreases bone \_\_\_\_\_
    - Increases bone \_\_\_\_\_
  - Calcitonin secretion is:
    - Stimulated by \_\_\_\_\_
    - Inhibited by \_\_\_\_\_

- e. Increased secretion of calcitonin \_\_\_\_\_ of  $\text{Ca}^{2+}$  but it is not as important in controlling  $\text{Ca}^{2+}$  levels as \_\_\_\_\_
- E. Regulation of Magnesium Ions
1. Most of the magnesium in the body is \_\_\_\_\_ or in the \_\_\_\_\_
  2. How much magnesium is found in the extracellular fluid? \_\_\_\_\_
    - a. About one-half of these are \_\_\_\_\_ and one-half are \_\_\_\_\_
  3.  $\text{Mg}^{2+}$  are cofactors for \_\_\_\_\_ such as the \_\_\_\_\_ involved in \_\_\_\_\_
  4. In the kidneys:
    - a.  $\text{Mg}^{2+}$  passes through the \_\_\_\_\_ into the filtrate
    - b. How much of these ions are reabsorbed? \_\_\_\_\_
    - c. Where is most of the  $\text{Mg}^{2+}$  reabsorbed in the kidney? \_\_\_\_\_
    - d. The capacity of the kidney to reabsorb  $\text{Mg}^{2+}$  is \_\_\_\_\_
      1. If the level of free  $\text{Mg}^{2+}$  increases in the extracellular fluid there is an \_\_\_\_\_
      2. If the level of free  $\text{Mg}^{2+}$  decreases in the extracellular fluid there is an \_\_\_\_\_
    - e. Decreased extracellular concentration of  $\text{Mg}^{2+}$  causes a \_\_\_\_\_ in the nephron
- F. Regulation of Phosphate Ions
1. About 85% of phosphate is in the form of \_\_\_\_\_ in bone ( \_\_\_\_\_ ) and teeth
  2. Most of the remaining phosphate is \_\_\_\_\_
    - a. Many phosphate ions are covalently bound to \_\_\_\_\_
    - b. Phosphate ions are important components of \_\_\_\_\_, \_\_\_\_\_, & \_\_\_\_\_
    - c. Phosphates also play important roles in regulation of \_\_\_\_\_
    - d. Phosphate ions dissolved in the intracellular fluid act as \_\_\_\_\_
  3. The capacity of the kidneys to reabsorb phosphate ions is \_\_\_\_\_
    - a. Therefore if the level of phosphate ions increases in the extracellular fluid
      1. Excess \_\_\_\_\_ in the filtrate

2. Increase in the rate of \_\_\_\_\_ in the urine
4. Over time a low phosphate intake can \_\_\_\_\_
  - a. Most of the phosphate that enters the filtrate \_\_\_\_\_
5. Parathyroid hormone can play a \_\_\_\_\_
  - a. Promotes bone \_\_\_\_\_
  - b. Large amounts of \_\_\_\_\_ & \_\_\_\_\_ are released
  - c. PTH decreases the \_\_\_\_\_ from renal tubules so that a \_\_\_\_\_ is lost in urine
6. If phosphate levels in the extracellular fluid increase above normal levels, \_\_\_\_\_ in soft tissues

## V. Regulation of Acid-Base Balance

### A. Hydrogen Ions

1.  $H^+$  affect the activity of \_\_\_\_\_ & interact with \_\_\_\_\_
2. Most chemical reactions are \_\_\_\_\_
3. The major mechanisms that regulate  $H^+$  concentration are:
  - a. \_\_\_\_\_
  - b. \_\_\_\_\_
  - c. \_\_\_\_\_

### B. Acids and Bases

1. What are acids? \_\_\_\_\_
2. What are bases? \_\_\_\_\_
  - a. Many bases release \_\_\_\_\_ which react with \_\_\_\_\_ to form \_\_\_\_\_
3. Strong acids and bases completely \_\_\_\_\_
4. Weak acids dissociate but most \_\_\_\_\_
  - a. The proportion of weak acid molecules that release  $H^+$  into solution is
    1. Very \_\_\_\_\_ & is
    2. Influenced by \_\_\_\_\_
5. Weak acids are:
  - a. Common in \_\_\_\_\_



- b. Play important roles in \_\_\_\_\_
- C. Buffer Systems
1. Buffers resist \_\_\_\_\_ of a solution
  2. Buffers within body fluids \_\_\_\_\_ by chemically
    - a. Binding to \_\_\_\_\_ when they are \_\_\_\_\_ to a solution
    - b. Releasing \_\_\_\_\_ begins to fall
  3. Carbonic Acid/Bicarbonate Buffer System
    - a. Is carbonic acid a strong or weak acid? \_\_\_\_\_
    - b. The carbonic acid/bicarbonate buffer system depends on the equilibrium that is \_\_\_\_\_ between:
      1. \_\_\_\_\_
      2. \_\_\_\_\_ &
      3. \_\_\_\_\_
    - c. Adding a small amount of a strong acid to a solution containing  $\text{H}_2\text{CO}_3$  increases  $\text{H}^+$ 
      1. In response a large \_\_\_\_\_ binds to \_\_\_\_\_ to form \_\_\_\_\_ and only a small \_\_\_\_\_
        - a. A large \_\_\_\_\_ is resisted by the buffer system
    - d. Adding a small amount of a strong base to a solution containing  $\text{H}_2\text{CO}_3$  removes  $\text{H}^+$ 
      1. Many of the \_\_\_\_\_ form \_\_\_\_\_ and \_\_\_\_\_
        - a. A large \_\_\_\_\_ is resisted by the buffer system
    - e. The carbonic acid/bicarbonate buffer system quickly responds to:
      1. During exercise the addition of substances such as \_\_\_\_\_ & \_\_\_\_\_
      2. Increased \_\_\_\_\_ & \_\_\_\_\_ production
      3. Consumption of large amounts of \_\_\_\_\_
    - f. The carbonic acid/bicarbonate buffer system plays an essential role in the control of body pH by both the \_\_\_\_\_ & the \_\_\_\_\_
  4. Protein Buffer System

- a. What protein molecules act as buffer molecules?
    1. \_\_\_\_\_
    2. \_\_\_\_\_
  - b. How much buffer capacity is provided by protein molecules? \_\_\_\_\_
  - c. Important intracellular proteins that act as buffers include:
    1. \_\_\_\_\_ in red blood cells
    2. \_\_\_\_\_ associated with nucleic acids
  - d. The capacity to act like buffers is due to functional groups such as:
    1. \_\_\_\_\_
    2. \_\_\_\_\_
  - e. Protein functional groups act like weak acids:
    1. As the  $H^+$  concentration increases \_\_\_\_\_
    2. When the  $H^+$  concentration decreases \_\_\_\_\_
5. Phosphate Buffer System
- a. Phosphate is an important \_\_\_\_\_ buffer system
  - b. Phosphate containing molecules such as \_\_\_\_\_, \_\_\_\_\_, \_\_\_\_\_, as well as \_\_\_\_\_ ions in solution act as buffers
  - c. Phosphate ions act as \_\_\_\_\_
- D. Mechanisms of Acid-Base Balance Regulation
1. Mechanisms of acid-base regulation depend on the regulation of \_\_\_\_\_ and \_\_\_\_\_ function
    - a. Which system responds more quickly? \_\_\_\_\_
    - b. Which system has a greater capacity to respond? \_\_\_\_\_
  2. Respiratory Regulation of Acid-Base Balance
    - a. The respiratory system regulates acid-base balance by influencing the \_\_\_\_\_
    - b. Carbon dioxide reacts with \_\_\_\_\_ to form carbonic acid which dissociates to form \_\_\_\_\_ and \_\_\_\_\_
      1. The chemical reaction is written as: \_\_\_\_\_

- c. The reaction is in \_\_\_\_\_ but shifts in response to changes in \_\_\_\_\_ levels
1. Increases in carbon dioxide:
    - a. Cause CO<sub>2</sub> to join with \_\_\_\_\_ and form more \_\_\_\_\_
    - b. The \_\_\_\_\_ then dissociates to \_\_\_\_\_ & \_\_\_\_\_
  2. Decreases in carbon dioxide cause the equilibrium to shift \_\_\_\_\_
    - a. \_\_\_\_\_ and \_\_\_\_\_ combine to form \_\_\_\_\_
    - b. Which then forms \_\_\_\_\_ and \_\_\_\_\_
- d. What is the function of carbonic anhydrase? \_\_\_\_\_  
\_\_\_\_\_
- e. Where is carbonic anhydrase located? \_\_\_\_\_  
\_\_\_\_\_
- f. Decreases in body fluid pH:
1. Stimulate neurons in the \_\_\_\_\_
  2. Cause the rate and depth of ventilation to \_\_\_\_\_
  3. This eliminates \_\_\_\_\_ at a greater rate
  4. The concentration of \_\_\_\_\_ decreases in \_\_\_\_\_
  5. As CO<sub>2</sub> levels decline the carbonic acid/bicarbonate buffer system:
    - a. \_\_\_\_\_ combine with \_\_\_\_\_ to form \_\_\_\_\_
    - b. The \_\_\_\_\_ then forms \_\_\_\_\_ & \_\_\_\_\_
  6. This results in concentration of \_\_\_\_\_ (pH increases) toward its normal range as \_\_\_\_\_ exits the lungs
- g. Increases in body fluid pH:
1. Inhibit neurons in the \_\_\_\_\_
  2. Cause the rate and depth of ventilation to \_\_\_\_\_
  3. Causes less \_\_\_\_\_ to be eliminated
  4. As \_\_\_\_\_ increases due to metabolism
  5. Body fluid concentration of \_\_\_\_\_ also increases
  6. As the increased \_\_\_\_\_ dissociates the concentration of H<sup>+</sup> increases and the pH \_\_\_\_\_

### 3. Renal Regulation of Acid-Base Balance

- a. Cells of the kidney tubules directly regulate acid-base balance by increasing or decreasing the rate of:
  1. \_\_\_\_\_ into the filtrate
  2. \_\_\_\_\_ from the filtrate
- b. Carbonic anhydrase is present in the nephron cells and catalyzes the formation of \_\_\_\_\_ from \_\_\_\_\_ and \_\_\_\_\_
  1. The carbonic acid molecules dissociate to \_\_\_\_\_ & \_\_\_\_\_
  2. A countertransport system on the apical membrane then exchanges \_\_\_\_\_ for \_\_\_\_\_
    - a. Secreting \_\_\_\_\_ into the filtrate
    - b. Reabsorbing \_\_\_\_\_ from the filtrate
  3. The \_\_\_\_\_ and \_\_\_\_\_ are cotransported across the basal membrane and then diffuse into \_\_\_\_\_
- c. The reabsorbed \_\_\_\_\_ combine with excess \_\_\_\_\_ in the extracellular fluid to form \_\_\_\_\_
  1. This removes \_\_\_\_\_ and increases \_\_\_\_\_
- d. The rate of \_\_\_\_\_ secretion and \_\_\_\_\_ reabsorption increases when pH \_\_\_\_\_ and slows when pH \_\_\_\_\_
- e. Some of the  $H^+$  secreted into the filtrate combines with  $HCO_3^-$  to form \_\_\_\_\_ (The bicarbonate entered the filtrate in the form of \_\_\_\_\_ through the filtration membrane)
  1. The  $H_2CO_3$  then dissociates to form \_\_\_\_\_ and \_\_\_\_\_
  2. The \_\_\_\_\_ then diffuses from the \_\_\_\_\_ into the tubule cells
  3. Inside the tubule cells it reacts with \_\_\_\_\_ to form \_\_\_\_\_
  4. The  $H_2CO_3$  subsequently dissociates into \_\_\_\_\_ and \_\_\_\_\_
    - a. The \_\_\_\_\_ is transported into the filtrate in exchange for \_\_\_\_\_
    - b. And the \_\_\_\_\_ enter the extracellular fluid
  5. Therefore, many of the  $HCO_3^-$  entering the filtrate through glomerular filtration reenter the \_\_\_\_\_

- f.  $H^+$  secreted into the nephron normally exceed the amount of \_\_\_\_\_ that enter through the filtration membrane
1. Almost all of the  $HCO_3^-$  are \_\_\_\_\_
  2. Few  $HCO_3^-$  are lost in the urine unless \_\_\_\_\_
- g. If the pH of the body fluids increases:
1. The rate of  $H^+$  secretion into the filtrate \_\_\_\_\_
  2. The rate of  $HCO_3^-$  reabsorption into the extracellular fluid \_\_\_\_\_
- 
- a. As a result, the amount of bicarbonate filtered into the kidney tubules exceeds \_\_\_\_\_
  - b. The excess \_\_\_\_\_ pass into the urine
  - c. Diminishing the amount of \_\_\_\_\_ in the \_\_\_\_\_ fluid
    1. Allows extracellular \_\_\_\_\_ to increase and
    2. pH of body fluids \_\_\_\_\_ toward normal range
- h. If pH of the filtrate drops below 4.5 it inhibits \_\_\_\_\_
1. Buffers in the filtrate combine with \_\_\_\_\_
  2. What substances in the filtrate act as buffers?
    - a. \_\_\_\_\_
    - b. \_\_\_\_\_
    - c. \_\_\_\_\_
- i.  $NH_3$  is produced in the cells of the nephron when amino acids like \_\_\_\_\_ are \_\_\_\_\_
1.  $NH_3$  diffuses from the nephron cells into \_\_\_\_\_ and combines with \_\_\_\_\_ to form \_\_\_\_\_
  2. The rate of  $NH_3$  production increases when \_\_\_\_\_ days
  3. The elevated ammonia production:
    - a. Increases \_\_\_\_\_ filtrate
    - b. Allowing secretion of \_\_\_\_\_ urine