Opening Activity — General
Hormonal Imbalance Show the class photographs of people who obviously have a permanent or temporary hormonal imbalance (for example, someone who is extremely short or tall, or a bearded female.) Ask students if they know the type of molecule that is responsible (hormone). Tell students that hormones are very important to maintaining homeostasis. They are secreted in tiny concentrations in the blood or extracellular fluid. Either too much or too little of a hormone can have serious consequences. **Visual**

Identifying Misconceptions
Students do not often recognize that hormones act on cells in a very specific manner. Tell students that, in this chapter, they will learn how hormones transmit messages that change cell activity in a predictable way.

Quick Review Answers
1. Glycogen is a polysaccharide made of chains of glucose and is used for energy storage.
2. Enzymes lower the activation energy needed to start a chemical reaction. Enzymes are specific in the reactions they catalyze.
3. Most receptor proteins are embedded in the lipid bilayer. They function by recognizing and binding to signal molecules outside the cell.
4. DNA stores the genetic information for the cell. mRNA carries the DNA code to ribosomes in the cytoplasm to be translated into proteins.
5. The sympathetic nervous system is important during times of physical or emotional stress. It increases blood pressure, heart rate, breathing rate, and directs blood flow toward heart and skeletal muscles in the “fight-or-flight” response.

Reading Activity Answers
Students may know that glands produce hormones, and that hormones are a major factor in bodily changes at puberty. They may be familiar with some of the more common hormones such as testosterone, estrogen, and insulin.
Focus overview

Before beginning this section review with your students the objectives listed in the Student Edition. This section introduces students to the chemicals called hormones. It describes what hormones are, what they do, and why it is important that hormones are carefully regulated in the body.

Bellringer

At the beginning of a class, while students are settling down and paying little attention to you, make a loud, startling noise. Immediately afterward, ask students to make a list of their feelings in response to the noise. List responses on the board or overhead. At intervals, ask if anyone still feels jittery. Tell students that the effects they felt were the result of a hormone.

Identifying preconceptions

Ask students what the difference is between the nervous system and the endocrine system. (In general, the nervous system sends electrical signals, while the endocrine system sends chemical signals.) After discussion, point out to students that, although it is convenient to distinguish between the endocrine and nervous systems, the lines between these two systems are blurred. There is considerable overlap and coordination between them, and this helps the body maintain homeostasis.

Motivate

Identifying preconceptions

Ask students what the difference is between the nervous system and the endocrine system. (In general, the nervous system sends electrical signals, while the endocrine system sends chemical signals.) After discussion, point out to students that, although it is convenient to distinguish between the endocrine and nervous systems, the lines between these two systems are blurred. There is considerable overlap and coordination between them, and this helps the body maintain homeostasis.

Cooperation of Activities

Reacting to fear, growing taller, and developing male or female characteristics are all activities in the body that are partially regulated by hormones (HAWR mohnz). Hormones are substances secreted (released) by cells that act to regulate the activity of other cells in the body.

You—and the cyclist shown in Figure 1—make hormones that keep your body functioning properly. The functions of hormones include the following:

1. Regulating growth, development, behavior, and reproduction
2. Coordinating the production, use, and storage of energy
3. Maintaining homeostasis (temperature regulation, metabolism, excretion, and water and salt balance)
4. Responding to stimuli from outside the body

Hormones act as chemical messengers, carrying instructions that cause cells to change their activities. For example, some hormones cause the cells of the heart to increase the rate at which the heart is beating. In the past, it was thought that hormones, once secreted from a cell, had to be transported through the bloodstream to reach the cells they were to act on. Today, we know that some hormones act directly on adjacent cells without traveling through the blood.

The instructions a hormone carries are determined by both the hormone itself and the cell it affects. For example, a hormone may instruct a cell to make a specific protein or to activate a specific enzyme. The same hormone can also instruct a different cell to alter the permeability of its cell membrane or even to release another hormone. Hormones can instruct muscle cells to relax and nerve cells to fire action potentials.

Each hormone is very specific about which types of cells can receive its instructions. Each hormone acts like a key that opens a lock on or inside the cell. A hormone will act only on cells with the right lock. The locks, as discussed later in this chapter, are receptors on or inside the cell.
Endocrine Glands and Tissues

A gland is an organ whose primary function is to secrete materials into other regions of the body. **Endocrine (EN doh krihn) glands** are ductless organs that secrete hormones directly into either the bloodstream or the fluid around cells (extracellular fluid). In addition to endocrine glands, several other organs contain cells that secrete hormones. These organs include the brain, stomach, small intestine, kidney, liver, and heart.

All of the endocrine glands and hormone-secreting tissues collectively make up the endocrine system, shown in Figure 2. The endocrine system coordinates all of the body’s sources of hormones.

Some organs, such as the pancreas, are both endocrine and exocrine (EHKS oh krihn) glands. Exocrine glands deliver substances through ducts (tubelike structures). The ducts transport the substances to specific locations inside and outside the body. Sweat glands, mucous glands, salivary glands, and other digestive glands are examples of exocrine glands. The exocrine part of the pancreas produces digestive enzymes and delivers them to the small intestine through ducts. The endocrine part of the pancreas secretes two hormones into the bloodstream that regulate blood glucose levels.

**Hormones and Neurotransmitters Are Chemical Messengers**

As you learned in the previous chapter, the nervous system is also involved in coordinating the body's activities. The endocrine system and nervous system interact in this shared role. However, with some exceptions, each system acts through different chemical messengers and in different ways.

The chemical messengers of the nervous system are known as neurotransmitters, while the chemical messengers of the endocrine system are called hormones. Some nerve cells, however, are capable of secreting hormones, and several chemicals serve as both hormones in the endocrine system and neurotransmitters in the nervous system. For example, epinephrine is both a neurotransmitter and a hormone. When secreted from a nerve cell, epinephrine conveys messages to other neurons. When secreted from an endocrine cell in the adrenal gland, epinephrine acts as a “fight-or-flight” hormone.

**Endocrinologist** Invite a medical professional who specializes in hormone therapy to discuss hormones, hormone disorders, and treatments available. Ask the guest to bring photographs of people with endocrine disorders and micrographs of endocrine tissues, if possible. In addition, ask the guest speaker to discuss her or his education, and job opportunities in this field of work. In advance, have the class prepare a list of questions they would like to have answered. Also have them jot down and ask any questions they might think of during the presentation.

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**REAL WORLD CONNECTION**

Although prostaglandins are known for increasing pain, they play a vital role in labor and delivery. Prostaglandins not only stimulate uterine muscle contractions, but also promote blood clotting. Blood clotting is important during childbirth because it minimizes hemorrhaging during and after delivery. Prostaglandin-inhibiting drugs, such as aspirin and ibuprofen, may delay labor, or they may inhibit blood clotting and promote excessive bleeding, which could result in severe blood loss or even death.
Another difference between the endocrine and nervous systems is that neurotransmitters are fast-acting and usually short-lived messengers. Hormones are usually slower-acting and longer-lived. The effects of some can last for days, weeks, or even years.

Finally, neurotransmitters are released from nerve cells directly to adjacent target cells. Endocrine cells can release hormones into the bloodstream, where they travel to the cell they are to act on, or into the extracellular fluid to act on nearby cells.

**Hormonelike Substances**

The human body has many substances that regulate cellular activities much as hormones do. These substances were not initially considered hormones because they are not secreted into the bloodstream. However, most scientists today classify them as hormones. These substances include a large number of chemicals called neuropeptides, which are secreted by the nervous system, as well as chemicals called prostaglandins, which are secreted by most cells.

There are several different groups of neuropeptides. Enkephalins (en keHF uh libnz), which were discussed in the previous chapter, are a group of neuropeptides that inhibit pain messages traveling toward the brain. Endorphins (en DOHR uh libnz), which are thought to regulate emotions, influence pain, and affect reproduction, are another important group of neuropeptides. Unlike neurotransmitters, enkephalins and endorphins tend to affect many cells near the nerve cells that release them.

Prostaglandins are modified fatty acids that have a variety of functions. They tend to accumulate in areas where tissues are disturbed or injured. There are dozens of different prostaglandins, and they produce a variety of effects. For example, some prostaglandins cause the constriction of blood vessels. The constricted blood vessels in turn affect blood pressure and body temperature. Other prostaglandins cause blood vessels to dilate, producing inflammation. A headache may result when blood vessels swell and their walls press against nerves in the brain.
Target Cells

After hormones are released from the cell in which they are made, they bind to and act only on target cells. A target cell is a specific cell that a hormone binds to and acts on (carries the message to). Imagine what would happen if hormones were not specific. All the cells in the body would respond to the hormone, resulting in uncoordinated activities, such as activation of many enzymes.

A hormone recognizes a target cell because the target cell has specific receptors. The receptors are located either on the surface of the target cell (on the cell membrane) or inside the cell (in the cytoplasm or nucleus). Recall that a receptor is a protein to which a molecule binds. A hormone's shape matches that of a particular receptor protein much like a key fits into a lock, as shown in Figure 3. Thus, a hormone binds only to cells that have a particular receptor protein, ignoring all other cells.

Types of Hormones

Most hormones are classified as either amino-acid-based or steroid hormones. Amino-acid-based hormones are hormones made of amino acids (either a single modified amino acid or a protein composed of 3 to 200 amino acids). Most amino-acid-based hormones are water soluble. Steroid hormones are lipid hormones that the body makes from cholesterol. Steroid hormones are fat soluble.

Figure 3  Hormones act on target cells. Hormones travel in the blood or in the fluid around cells to reach their target cells. The binding of the hormone with its receptor signals the target cell to change its activity.
Receptors
When a hormone binds to a specific receptor on a target cell, the hormone brings the target cell a message. What happens after the hormone binds, however, depends on the type of hormone.

Amino-Acid-Based Hormones
Amino-acid-based hormones are not fat soluble, and most bind to cell membrane receptors, as shown in Figure 4.

Step 1 When an amino-acid-based hormone binds to a receptor, the shape of the receptor changes.

Step 2 This change in shape eventually activates a second messenger, a molecule that passes the message from the first messenger (the hormone) to the cell. For example, when glucagon, a hormone secreted by the pancreas, binds to a receptor, an enzyme is activated that converts ATP to a second messenger called cyclic AMP (cAMP).

Step 3 The second messenger then activates or deactivates certain enzymes in a cascade fashion. That is, one enzyme activates another enzyme, which activates yet another, and so on. In the case of glucagon, the second messenger cAMP activates a series of enzymes that breaks down glycogen into glucose.

Step 4 Eventually the activity of the target cell is changed by the final enzyme in the cascade—even though the hormone never enters the cell!

Figure 4

How Amino-Acid-Based Hormones Work
Most amino-acid-based hormones, such as glucagon, bind to cell-membrane receptors, which activate second messengers that relay the hormone’s message.

1. Glucagon binds to a receptor protein on the cell membrane.
2. The binding activates an enzyme, which converts ATP to cyclic AMP.
3. Cyclic AMP starts a cascade of enzyme activations.
4. Eventually, glycogen is broken down into individual glucose molecules.

Real Life
How Hormones Work
Alfred Gilman and Martin Rodbell were two of the first scientists to determine how one of the amino-acid-based hormones works. They received the Nobel Prize for medicine in 1994 for their discoveries.

Teach, continued

Teaching Tip: Types of Hormones
Have students organize information about the two main classes of hormones in a Graphic Organizer similar to the one at the bottom of this page.

Receptor Sites
Ask students if they can think of any other molecule that has a highly specific place (an active site) to which a protein or other substrate must bind in order to complete its function. Enzyme-substrate interactions, like hormone-receptor protein interactions, are highly specific.

Using the Figure
Have students examine Figure 4. Point out that the hormone is the “first messenger” because it is the first molecule to bring the message to the cell telling the cell what it must do. In Step 1, the hormone binds to a receptor located on the cell membrane. When the hormone binds to the receptor, the receptor changes its shape. This shape change eventually results in the conversion of ATP to cyclic AMP, as shown in Step 2. Cyclic AMP, in turn acts as the “second messenger” by initiating a series of enzyme activations (or deactivations, depending on the hormone) as shown in Step 3. In the example of the figure, Step 4 illustrates how cyclic AMP starts the activation of enzymes that catalyze the breakdown of glycogen to individual glucose molecules.
Steroid and Thyroid Hormones

Because steroid and thyroid hormones are fat soluble, they readily pass through the cell membranes of their target cells. Steroid hormones bind to receptors located in a target cell’s cytoplasm or its nucleus; thyroid hormones bind to receptors in a target cell’s nucleus.

Cortisol is a steroid hormone made in the adrenal glands and released in response to stressful situations, such as the one shown in Figure 5. How steroid hormones such as cortisol work is summarized in Figure 6.

Step 1 The hormone diffuses through the cell membrane and binds to its receptor. The hormone and receptor form a hormone-receptor complex in the cytoplasm.

Step 2 The hormone-receptor complex enters the nucleus of the cell and binds to DNA.

Step 3 Depending on the hormone and the target cell, the binding either activates or inactivates a gene. That is, either the gene is transcribed and the resulting mRNA is translated into protein, or transcription and translation are inhibited.

Step 4 The target cell’s activities are altered. For example, cortisol stimulates the making of enzymes that break down proteins and fats into glucose.

If the receptor for a steroid or thyroid hormone is located in the nucleus, the hormone enters the nucleus and binds to the receptor there. The hormone-receptor complex then binds to and affects the DNA in the same manner as it does with receptors in the cytoplasm.

How Steroid Hormones Work

The steroid hormone–receptor complex binds to DNA in the nucleus and activates or inactivates transcription and translation of a gene.

1. Cortisol diffuses through the cell membrane and binds to its receptor.
2. The hormone-receptor complex enters the nucleus and binds to DNA.
3. Genes are activated.
4. Enzymes are made that alter cell activities.

Integrating Physics and Chemistry

Check students’ understanding of the nature of solutes and solvents and the ability to form a solution by asking them to explain why amino-acid hormones, which are generally water-soluble, bind to the cell membrane of target cells, while steroid hormones, which are fat-soluble, pass through the cell membrane of target cells. If they need assistance, review cell membrane structure, polar/non-polar concepts, and the “like dissolves like” rule.

Steroid Hormones and Transplant Patients

The class of steroid hormones called corticosteroids inhibits the immune system when the hormones are present at high levels. Patients who undergo a transplant operation might receive a corticosteroid, such as cortisol, to reduce the immune defenses of the body. This allows the patient’s body to accept, rather than reject, the transplanted organ.

Demonstration

Obtain 4 small glass beakers or flasks, water, plain gelatin (a protein), light-colored cooking oil, and vitamin E capsules (oil-filled). To demonstrate that lipids are fat soluble and many proteins are not, place a small amount of gelatin in each of two flasks, one half-filled with water and one half-filled with cooking oil. Repeat the procedure using separate flasks, with the vitamin E capsules. Swirl the liquids in the flasks until each substance has dissolved in one of the liquids. Ask students which substance is fat-soluble. (The vitamin E.) Which is not? (The protein—it is water-soluble.) Which type of substance can pass through a plasma membrane by diffusion? (A fat-soluble substance.) Why? (The plasma membrane has a double layer of phospholipids.) Could the gelatin enter a cell? (No.) Tell students that like gelatin, protein-based peptide hormones cannot enter cells, while fat-soluble steroid hormones can.

Using the Figure

Have students compare Figures 4 and 6. Point out that because steroid hormones are fat-soluble, they penetrate the cell membrane to bind to a receptor either in the cytoplasm (as shown in Step 1) or in the nucleus (not shown). Once the hormone binds to the receptor, the hormone-receptor complex binds to DNA and activates a gene. Depending on the hormone, a gene can also be deactivated. In the figure, the gene is activated, mRNA transcribed, and a new protein is synthesized (Step 4).

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Feedback Loops

Teach, continued

Teaching Tip

Feedback Loops Have students describe what would happen if part of the endocrine system were damaged and began to function as a positive feedback system, wherein a change in one direction promoted continued change in the same direction. (There would be a constant secretion of those hormones.) Logical

SKILL BUILDER

Interpreting Graphics Have students examine Figure 7. Ask them what the graph would most likely look like if the graph were extended for double the current length. (The red line would most likely drop because of the low level of stimulating substance, and the yellow line would begin to rise because of the falling level of the stimulating substance.) Logical

Teaching Tip

Sex Hormones Tell students that the gonads produce three main types of sex hormones: androgens (testosterone), estrogens (estradiol), and progestins (progesterone). These sex hormones are found in both males and females, but in different proportions. Females have a high ratio of estrogens to androgens, and males have a high ratio of androgens to estrogens. Ask students what might happen if the hormone ratio were disrupted. (The male body could be more feminized, showing breast development, higher voice, and smaller muscle development; the female body could be masculinized, with such traits as beard growth and deeper voice.) Logical

Figure 7 Negative feedback. In negative feedback, a secondary substance inhibits production of its initial stimulating substance.

Positive Feedback

The word oxytocin is from the Greek oys, meaning “quick,” and tokos, meaning “childbirth.”

Feedback Mechanisms

The human body makes more than 40 hormones, and the body must regulate the release of the hormones. Nerve impulses alone can increase or decrease secretion of some hormones. For example, a baby nursing on a mother’s breast stimulates the release of the hormone oxytocin, which in turn stimulates the release of milk from the mother’s mammary glands.

Recall that homeostasis is essential in all living things. The endocrine system plays an important role in homeostasis. Different hormones moving through the bloodstream affect specific target tissues, and the amounts of various hormones must be maintained within a very narrow range.

In many cases the level of a hormone in the blood turns production of the hormone off and on through feedback mechanisms. Feedback mechanisms detect the amount of hormones in circulation or the amount of other chemicals produced because of hormone action. The endocrine system then adjusts the amount of hormones being made or released.

If high levels of a hormone stimulate the output of even more hormone, the regulation is called positive feedback. For example, the hormone that stimulates egg release also regulates the female hormone estrogen. A rise in estrogen levels, however, will stimulate the release of more of the regulatory hormone.

In humans, the release of most hormones is regulated through negative feedback, as shown in Figure 7. In negative feedback, a change in one direction stimulates the control mechanism to counteract further change in the same direction. For example, high levels of a hormone inhibit the production of more hormone, whereas low levels of a hormone stimulate the production of more hormone. The liver also plays a role in negative feedback by removing hormones from the blood and breaking them down. Negative feedback works like a person trying to maintain a certain speed in a car by pressing or releasing the gas pedal (accelerator).

Heart Hormones

The first heart hormone was discovered in the early 1990s. This hormone, atrial natriuretic factor, results in lower blood volume and pressure. In 1999, three more heart hormones were discovered: vessel dilator, which removes sodium and lowers blood pressure; long-acting natriuretic peptide, which removes salt from the blood; and kaliuretic peptide, which removes potassium from the blood. Researchers are currently testing whether one or more of these heart hormones can be used to treat congestive heart failure.
Many athletes use anabolic (protein-building) steroids and other hormone therapies to increase the size of their muscles and improve their performance. The unnatural use of steroids disrupts the feedback mechanisms that regulate hormone concentrations in the body.

**Which Steroid Hormones Are Used?**
The steroids used by athletes include synthetic hormones that mimic the male sex hormone testosterone. Many precursors to testosterone (such as androstenedione) are also used. Testosterone is secreted during puberty, when it stimulates many of the characteristics associated with being a man. For example, hair grows on the face, the underarms, and the pubic area; the voice deepens; and bigger muscles develop in the arms, legs, shoulders, and elsewhere.

**Answers to Section Review**

1. Structures that allow hormones to recognize target cells are called receptors.
2. When an amino-acid-based hormone binds to a receptor protein, that receptor protein changes shape. This causes the activation of a second messenger, which then activates or deactivates enzymes in a cascading fashion.
3. Steroid or thyroid hormones enter the cell and bind to receptors in the cell. The hormone-receptor complexes then bind to DNA, initiating or inhibiting gene transcription.
4. In a negative feedback system, high hormone levels cause hormone production to be reduced, and low hormone levels cause production to increase.
5. A. Incorrect. See answer B. B. Correct. As Y decreases, the production of X is no longer inhibited. C. Incorrect. See answer B. D. Incorrect. As Y decreases, the production of X is no longer inhibited. The resulting increase in X will stimulate production of Y.

**Do Steroids Really Improve an Athlete’s Performance?**
When athletes inject steroids, they are trying to stimulate the production of proteins in the muscle cells as a way of increasing muscle mass and strength. In large doses, steroids can promote increases in mass, strength, and endurance.

**Many Side Effects Are Associated with the Use of Steroids.**
There are many side effects that accompany steroid use. When steroids are used before the skeleton matures completely, they stop the bones from growing. The body never reaches adult height and may look distorted. Liver cancer and other liver disorders may also result from steroid use. Some males who use anabolic steroids develop enlarged breasts and shriveled testes. Females who use these chemicals may develop facial hair, deepening of the voice, and male-pattern baldness. Finally, the virus that causes AIDS can be transmitted if shared needles are used to inject the steroids. The long-term risks to health are often greater than any benefits from the use of steroids.

**Anabolic Steroids Are Dangerous**

**Teaching Strategies**
Have students bring in articles about athletes who have been disqualified from competitions because of steroid use.

**Discussion**
- Why do you think anabolic steroids are banned from athletic events? (They are dangerous, and they give an athlete an unfair advantage.)
- What side effects are associated with steroid use? (Side effects include liver cancer, enlarged breasts, and shrunk testes in men; facial hair and deeper voices in women.)
- Should there be more drug testing of athletes? (Answers will vary.)

**Alternative Assessment**
Have students use a large piece of paper to make a diagram of a negative feedback loop. Diagrams should include drawings of the glands and/or organs involved, and clear explanations about what is happening next to each step of the loop.
Before beginning this section review with your students the objectives listed in the Student Edition. Endocrine glands have a tremendous impact on the daily functioning of the body. This section looks at the major endocrine glands, the hormones they secrete, and the effect they have on target cells and the body in general. The consequences of overproduction or underproduction of hormones can be quite serious, as is discussed in this section.

Bellringer
Before class, acquire 6–8 photos of people with hormone disorders. Tape them on the wall. Include some obvious disorders such as gigantism or dwarfism. Have students number a sheet of paper with corresponding numbers. Make a list of several hormones on the board or overhead. Have students write on their paper the name of the hormone they think caused the disorder pictured. Go through each photo and ask students for their answers. Discuss each disorder and identify the hormone (or lack thereof) that caused the disorder.

Focus

Overview
Before beginning this section review with your students the objectives listed in the Student Edition. Endocrine glands have a tremendous impact on the daily functioning of the body. This section looks at the major endocrine glands, the hormones they secrete, and the effect they have on target cells and the body in general. The consequences of overproduction or underproduction of hormones can be quite serious, as is discussed in this section.

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Objectives
- Evaluate the roles of the hypothalamus and the pituitary gland in controlling other hormones.
- Summarize the roles of the thyroid and parathyroid hormones.
- Compare the roles of the hormones secreted in each area of the adrenal gland.
- Relate how each of the two hormones secreted by the pancreas regulates blood glucose levels.
- Describe the roles of reproductive hormones and of melatonin.

Key Terms
- hypothalamus
- pituitary gland
- adrenal gland
- epinephrine
- norepinephrine
- insulin
- glucagon
- diabetes mellitus
- Stress
- Hypothalamus releases corticotropin releasing hormone (CRH)
- Anterior pituitary gland releases adrenocorticotropic hormone (ACTH)
- Adrenal glands release cortisol
- Increased blood glucose level

Endocrine Control
Feedback mechanisms fine-tune the levels of hormones in circulation, but two endocrine glands control the initial release of many hormones. The hypothalamus (HIE poh THAL uh nuhs) and the pituitary (pi TOO uh teh ee) gland, shown in Figure 8, together serve as a major control center for the rest of the endocrine system.

The Hypothalamus
The hypothalamus is the area of the brain that coordinates the activities of the nervous and endocrine systems. It controls many body functions, including body temperature, blood pressure, and emotions. The hypothalamus receives information about external and internal conditions from other brain regions. The hypothalamus responds to these signals from the nervous system as well as to blood concentrations of circulating hormones. The hypothalamus responds by issuing instructions—in the form of hormones—to the pituitary gland.

Figure 8 The hypothalamus and pituitary gland
Many hormones are released in a cascade starting with the release of hormones from the hypothalamus.

Transparencies
- TR Bellringer
- TR J83 The Hypothalamus and Pituitary Gland
- TR J84 Hormones Secreted by the Pituitary Gland
- TR J85 The Adrenal Gland

Chapter Resource File
- Directed Reading BASIC
- Active Reading GENERAL
- Data Sheet for Math Lab GENERAL
**The Pituitary Gland**

As shown in Figure 8, the pituitary gland is an endocrine gland suspended from the hypothalamus by a stalk. The pituitary gland secretes many hormones, including some that control endocrine glands elsewhere in the body.

The nerve cells in the hypothalamus make at least six hormones that are released into a special network of blood vessels between the hypothalamus and the pituitary gland. Some of these hormones are "releasing" hormones, which cause the front part of the pituitary gland, the anterior pituitary, to make and then release a corresponding pituitary hormone. "Inhibiting" hormones signal the anterior pituitary to stop secretion of one of its hormones.

Certain pituitary hormones travel to a distant endocrine gland and cause the gland to begin producing its particular hormone. One example of this cascade of events is shown in Figure 8. Other pituitary hormones act directly on organs and tissues that are not endocrine glands, as summarized in Table 1.

The nerve cells of the hypothalamus also have axons that extend to the back part of the pituitary gland, the posterior pituitary. The nerve cells in the hypothalamus make two hormones that are stored in the posterior pituitary and released when needed: oxytocin (ahks ih TOH sihn) and antidiuretic hormone (ADH or vasopressin). Oxytocin triggers milk ejection during nursing and uterine contractions during childbirth. ADH causes the kidneys to form more-concentrated urine, thereby conserving water in the body.

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**Table 1 Hormones Secreted by the Pituitary Gland**

<table>
<thead>
<tr>
<th>Hormone</th>
<th>Target tissue</th>
<th>Effects</th>
</tr>
</thead>
<tbody>
<tr>
<td>Adrenocorticotropic hormone (ACTH)</td>
<td>Adrenal glands</td>
<td>Stimulates the release of cortisol and other steroid hormones from the adrenal cortex</td>
</tr>
<tr>
<td>Follicle-stimulating hormone (FSH)</td>
<td>Ovaries and testes</td>
<td>Regulates the development of male and female gametes</td>
</tr>
<tr>
<td>Luteinizing hormone (LH)</td>
<td>Ovaries and testes</td>
<td>Stimulates the release of an egg (ovulation) from an ovary; stimulates secretion of sex hormones from ovaries and testes</td>
</tr>
<tr>
<td>Prolactin</td>
<td>Mammary glands</td>
<td>Stimulates milk production in breasts</td>
</tr>
<tr>
<td>Growth hormone (GH)</td>
<td>Many tissues</td>
<td>Stimulates protein synthesis and bone and muscle growth</td>
</tr>
<tr>
<td>Thyroid-stimulating hormone (TSH)</td>
<td>Thyroid gland</td>
<td>Stimulates synthesis and release of the thyroid hormones by the thyroid gland</td>
</tr>
<tr>
<td>Antidiuretic hormone (ADH)</td>
<td>Kidneys, blood vessels</td>
<td>Stimulates reabsorption of water from the kidney; constricts blood vessels</td>
</tr>
<tr>
<td>Oxytocin</td>
<td>Mammary glands, uterus</td>
<td>Stimulates uterine contractions and milk secretion</td>
</tr>
</tbody>
</table>

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**Real Life**

**What happens when excess growth hormone is secreted?**

Excess amounts of growth hormone (GH) can result in a disorder called gigantism. The tallest known human, Robert Wadlow, who grew to a height of 2.7 m (8 ft 11 in.), had a pituitary tumor that secreted excess GH during childhood.

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**Motivate**

**Demonstration**

Ask students what kinds of things are added to our foods to help us avoid diseases. (Answers will vary, but students may mention things like Vitamin C and fiber.) Hold up a can of milk that says “Vitamin D.” Ask students why vitamin D is added to our milk. (It helps our intestines absorb calcium. Lack of vitamin D causes rickets, a bone deformity.) Hold up a salt container that reads, “iodized salt.” Ask students why iodine is added to our salt. (Iodine is a necessary component of thyroid hormones. Lack of iodine causes the thyroid gland to enlarge in an attempt to produce more. This enlargement, called a goiter, is shown in Figure 10.)

---

**Teach**

**Teaching Tip**

**Growth Hormone**

Tell students that growth hormone (GH) promotes the growth and division of many body cells, although its major targets are bone and muscle cells. GH enables protein synthesis, cellular uptake of amino acids from the blood, and the mobilization of fat in the blood to areas of high energy demand. Point out the connection between the hypothalamus and pituitary gland by telling students that the release of GH is itself controlled by two hypothalamic hormones: growth hormone releasing hormone (GHRH), and growth hormone inhibiting hormone (GHIH). Ask students what they think the relationship is between these two hypothalamic hormones. (As the names imply, they are antagonistic hormones.)

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**Attention Grabber**

Some synthetic chemicals can disrupt hormones in humans and other animals. These chemicals are known as endocrine disruptors or hormone mimics. Many of these chemicals have structures similar to estrogens, androgens, or thyroid hormones. By binding to hormone receptors, they can disrupt or enhance the message normally sent to a cell. Endocrine disruptors include pesticides such as DDT, and manufacturing by-products such as PCBs (polychlorinated biphenyls) and dioxins. They are thought to cause reproductive abnormalities, cancer, birth defects, and immune problems in developing organisms.

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**MEDICINE CONNECTION**

**Growth Hormones**

Choh Hao Li, a Chinese-American endocrinologist, isolated and identified five hormones of the pituitary gland. He discovered that growth hormone consists of a chain of 256 amino acids. In 1970, he discovered a method for synthesizing the hormone, and set the record for creating the largest synthesized protein molecule.
Paired Summarizing
Pair students with a partner. Have each student read silently about the various types of hormones and their functions. Read only one red-titled section at a time. Then have one student summarize aloud what has been read without referring to the text. The partner should listen without interrupting and be prepared to point out any inaccuracies or omissions in the summary. At this point students can refer to the text. Have students switch roles for each red-titled section.

Auditory Teaching Tip
Hyperthyroidism
Tell students that thyroid hormones play an important role in homeostasis. Thyroid hormones help maintain heart rate, digestion, blood pressure, muscle tone, and reproductive functions. Show the class a photograph of a person with pronounced bulging eyes (exophthalmos). Point out that hyperthyroidism causes fluid to accumulate in the fat behind the eyes, making them protrude. Other symptoms of hyperthyroidism include profuse sweating, weight loss, irritability, and intolerance to heat. Ask students to relate each of these symptoms to the functions of thyroid hormones in maintaining homeostasis.

Teach, continued
Teaching Tip
Hyperthyroidism
Tell students that thyroid hormones play an important role in homeostasis. Thyroid hormones help maintain heart rate, digestion, blood pressure, muscle tone, and reproductive functions. Show the class a photograph of a person with pronounced bulging eyes (exophthalmos). Point out that hyperthyroidism causes fluid to accumulate in the fat behind the eyes, making them protrude. Other symptoms of hyperthyroidism include profuse sweating, weight loss, irritability, and intolerance to heat. Ask students to relate each of these symptoms to the functions of thyroid hormones in maintaining homeostasis.

The Thyroid and Parathyroid Glands
As shown in Figure 9, the thyroid gland is an endocrine gland shaped like a shield of armor. It is located just below the Adam's apple in the front of the neck. The name thyroid comes from the Greek word thyros, which means "shield."

Regulating Metabolism and Development
The thyroid gland makes and releases thyroid hormones. Thyroid hormones regulate the body's metabolic rate and promote normal growth of the brain, bones, and muscles during childhood. Thyroid hormones also affect reproductive functions and maintain mental alertness in adults.

Thyroid hormones are modified amino acids produced by the addition of iodide to the amino acid tyrosine. If iodide salts are lacking in the diet, the thyroid gland becomes greatly enlarged. An enlarged thyroid gland, like the one shown in Figure 10, is called a goiter (GOY tuhr). Goiters resulting from iodide deficiency are now rare in the United States because iodide is added to commercially available table salt.

The underproduction of thyroid hormones is known as hypothyroidism. In childhood hypothyroidism, an underproduction of thyroid hormones can cause permanently stunted growth, mental retardation, or both. In adults, hypothyroidism can cause a lack of energy, dry skin, and weight gain. Overproduction of thyroid hormones, or hyperthyroidism, can cause nervousness, sleep disorders, an irregular heart rate, and weight loss.

Regulating Calcium Levels
A high level of calcium in the blood stimulates the thyroid gland to produce a hormone called calcitonin. Calcitonin causes calcium to be deposited in bone tissue rapidly, lowering the blood-calcium level. Calcium is used for different purposes. For example, calcium ions are required for muscle contraction and for the release of certain substances from cells.

Parathyroid hormone (PTH) is a hormone that is produced by four parathyroid glands attached to the back part of the thyroid gland, as shown in Figure 9. PTH is made and released in response to a falling level of calcium in the blood. PTH acts in three ways to raise calcium levels. First, it stimulates bone cells to break down bone tissue and release calcium into the blood. Second, it causes the kidneys to reabsorb calcium ions from urine. Third, PTH leads to activation of vitamin D, which is necessary for calcium absorption by the intestine.
The Adrenal Glands

The body has two adrenal glands, which are endocrine organs located above each kidney. Each almond-size adrenal gland is actually two glands in one, as seen in Figure 11: an inner core, called the adrenal medulla, and an outer shell, called the adrenal cortex.

Immediate Response to Stress

The adrenal medulla acts as a warning system in times of stress by releasing the “fight-or-flight” hormones epinephrine (ihp uh NEHF rihn) and norepinephrine (formerly called adrenaline and noradrenaline, respectively). The effects of these hormones, which prepare the body for action in emergencies, are identical to the effects of the sympathetic nervous system in response to a stressful situation, but longer lasting. In stressful situations the fight-or-flight hormones increase heart rate, blood pressure, blood glucose level, and blood flow to the heart and lungs.

Longer-Term Response to Stress

The adrenal cortex makes several hormones, including cortisol and aldosterone. The adrenal cortex hormones provide a slower, more long-term response to stress than epinephrine and norepinephrine. Cortisol makes more energy available to the body. For example, cortisol causes the body to increase the level of blood glucose and to break down proteins for energy. A high level of cortisol, such as occurs when the body is under stress for a long period of time, suppresses the immune system. Artificial derivatives of this hormone, such as prednisone (PREHD nih sohn), are widely used as anti-inflammatory drugs.

Aldosterone (al DAHS tuh rohn) helps reabsorb sodium ions from the fluids removed by the kidneys so that these ions are not lost in the urine. In contrast, aldosterone stimulates the kidneys to secrete potassium ions into the urine. When the aldosterone level is too low, potassium ions in the blood may accumulate to a dangerous level. The overall effect of aldosterone to prolonged stress is that the volume of blood is increased, which raises blood pressure.

Figure 11 The adrenal gland

Each adrenal gland has two parts—the adrenal medulla and the adrenal cortex—which secrete different hormones.

Real Life

Can women have beards?

The adrenal cortex normally secretes very small concentrations of male sex hormones. However, if a tumor in the adrenal cortex of a woman or a deficiency of an enzyme involved in cortisol synthesis can result in increased production of male sex hormones in women. High levels of male sex hormones may cause male secondary sex characteristics, such as facial hair, to develop.

Edward Kendall synthesized the first artificial corticosteroid in 1944. Prior to this time, a physician named Philip Showalter Hench had been studying rheumatoid arthritis. He observed that symptoms of rheumatoid arthritis often abate when the body is subjected to stresses such as pregnancy or jaundice. After further research, he suspected that corticosteroids were responsible. In 1949, Hench began using cortisone as a treatment for rheumatoid arthritis. In 1950, Kendall, Hench, and a third contributor to corticosteroid research, Tadeus Reichstein, received a Nobel Prize for their work.

Group Activity

Riddles Have students write riddles about the effects of a specific hormone. They can then trade riddles and try to solve them. For example, “No matter how hard I try, I cannot lose weight. I’m always tired and never have any energy. I went to the doctor, and she told me I have a very low metabolic rate. What hormone is my body underproducing?” (Thyroxine.)

Pituitary Hormones Have students work in groups of two to four. Before class, use copies of Table 1 to cut out the name of each hormone, target tissue, and effect.

Make an envelope for each group containing all the cutout segments in the table. On a piece of construction paper, have each group make four columns, labeled “Hormone,” “Target Tissue,” and “Effects,” as in Table 1. Do not let students use their textbooks for this activity. Hand out the envelopes for each group, and on your signal, have them open them and arrange the cutouts on the construction paper so they describe the correct target tissues and hormonal effects for each hormone. If possible, provide some type of reward for the first group to accurately assemble their pituitary hormone chart.
The Pancreas and Other Organs

In addition to those mentioned so far, several other organs and glands produce hormones. For example, the stomach, small intestine, thymus, kidney, liver, and heart all contain endocrine cells. Recall that the stomach and small intestine secrete hormones, such as gastrin, that regulate the release of acids and digestive enzymes.

Regulating Blood Glucose Levels

The pancreas contains specialized cells, called the islets (IE litz) of Langerhans (LAHG uhr hahns), shown in Figure 12. Two hormones made by the islets interact to control the level of glucose in the blood. Insulin is a hormone that lowers blood glucose levels by promoting the accumulation of glycogen in the liver. Insulin also stimulates muscle cells to take up glucose and convert it into glycogen. Glucagon has the opposite effect of insulin—it raises blood glucose levels. Glucagon causes liver cells to release glucose that was stored as glycogen.

Analyzing Blood Glucose Regulation

Background

Eating simple sugars causes glucose to enter the bloodstream faster than eating complex carbohydrates or proteins. The rise in sugar levels triggers the secretion of insulin, which decreases blood glucose levels.

Different Meals and Blood Glucose Levels

![Graph showing blood glucose levels for different meals and insulin and glucagon release.]

Analysis

1. **Identify** which meal causes a faster rise in blood glucose.
2. **Critical Thinking** Inferring Determine which meal has complex carbohydrates and proteins that allow glucose to be released into the bloodstream more slowly.
3. **Critical Thinking** Applying Hypoglycemic people have low blood glucose levels. They are often advised to eat six small meals a day containing little or no simple sugars. Why are these individuals given such advice?

Cholesterol Is Not All Bad

The most important steroid is cholesterol, which has earned a bad reputation for its role in coronary artery diseases, but is absolutely essential for human survival. In fact, the body synthesizes cholesterol in the liver regardless of dietary intake of cholesterol. Cholesterol is not just a building block for the steroid hormones; it is also found in cell membranes, and is the precursor to vitamin D. Inform students that they take in cholesterol in a variety of foods, and the body makes cholesterol. The amount of cholesterol in one fast-food hamburger is much more than the body needs in a single day.
Synchronized Cycles are blocked. This suggests that effect." A study showed that synchronization of women living in the same dwelling tend to synchronize. This effect is called the “dormitory effect.” A study showed that synchronization does not occur in a new roommate if her nasal passages are blocked. This suggests that pheromones are responsible for the dormitory effect. Pheromones are small chemical signals that function in communication between animals and act like hormones in influencing physiology and behavior. The study involving the blocked nasal passages was the first time researchers had shown the possible existence of a human pheromone.

**Diabetes (die uh BEET eez) mellitus (MEH liet uhs)** is a serious disorder in which the body’s cells are unable to obtain glucose from the blood, resulting in high blood glucose levels. The kidneys excrete the excess glucose, and water follows, resulting in excessive volumes of urine and persistent thirst. Because cells cannot take up glucose, they use the body’s supply of fats and proteins for energy. The fat breakdown results in acidic products that accumulate in the blood, leading to low blood pH, coma, and, in extreme cases, death.

There are two kinds of diabetes mellitus. About 10 percent of affected individuals suffer from Type I diabetes, and 90 percent suffer from Type II diabetes. Type I diabetes is a hereditary autoimmune disease. The immune system attacks the islets of Langerhans, causing low insulin levels. Type I diabetes usually is treated with daily injections of insulin. It usually develops before age 20.

People with Type II diabetes may have normal levels of insulin in their blood. Their fat cells may produce a hormone that blocks insulin activation of glucose transport. This makes insulin ineffective. Type II diabetes often develops in people over age 40 due to obesity and an inactive lifestyle. Type II diabetes is usually treated with diet and exercise and, sometimes, medication other than insulin.

**Hormones and Body Fat**

- **People with very little body fat,** including many long-distance runners and gymnasts, often have disrupted reproductive systems. Very thin women may stop having menstrual periods, and very thin men may have lower testosterone levels.
- **During puberty,** girls accumulate body fat before their first menstrual period. If they are very thin, their first period may be delayed by a year or more. Scientists are searching for hormones that tie a person’s reproductive state to his or her body-fat content.

**Hormone Made by Fat Cells**

In 1994, researchers discovered that fat cells secrete a hormone called leptin that helps control metabolism. When injected into young female mice, leptin causes the mice to reach sexual maturity sooner. Mutant female mice that cannot make leptin do not produce eggs and thus are infertile. If the mutant mice are injected with leptin, they begin to produce eggs and can become pregnant.

The more body fat he or she has, the more leptin in his or her blood. Leptin is involved in regulating body weight. Scientists are unsure how leptin controls human reproduction. Cells in the ovaries and hypothalamus have leptin receptors.

**Female Hormones**

Some women suffer severe bone loss (osteoporosis). Women with more body fat tend to have stronger bones and are at lower risk for osteoporosis after menopause.

**Diabetes**

Type I diabetes often develops in people over age 40 due to obesity and an inactive lifestyle. Type II diabetes is usually treated with diet and exercise and, sometimes, medication other than insulin.

**Teaching Tip**

**Adrenal Cortex Sex Hormones**

Tell students that the adrenal cortex in both sexes produces sex hormones—the gonadocorticoids. Most of these hormones are androgens, but some female hormones (estrogen and progesterone) are also produced. Gonadocorticoid production is particularly high in the fetus and during puberty. Gonadocorticoids may function in maintaining the sex drive in adult women while supplying small amounts of estrogen after menopause. Production falls rapidly in late puberty and never again a significant factor in sex hormone production. Ask students what organs take over the job of sex hormone production after puberty. (The gonads—ovaries and testes.)

**Hormones and Body Fat**

- **Teaching Strategies**
  - Discuss the eating disorders anorexia nervosa and bulimia.
  - Tell students that researchers have discovered many other roles for leptin including triggering blood vessel growth.

- **Discussion**
  - Why do you think girls with eating disorders do not start menstruating, or stop menstruating? (They lack adequate body fat.)
  - What function does the hormone leptin serve in mice? (Female mice reach sexual maturity sooner.)
  - Why is body fat important in older women? (Enzymes in body fat convert testosterone into estrogen, which may help prevent osteoporosis.)

- **Verbal**
Regulating Reproduction
The ovaries and the testes, which also produce gametes, secrete hormones that regulate reproduction. The ovaries secrete estrogens and progesterone, and the testes produce testosterone. These hormones affect the formation of gametes and control sexual behavior and cycles. They also stimulate the development of secondary sex characteristics, such as breast size, hair growth, and muscle development.

Regulating Daily Rhythms
The pineal (Pee uh nl) gland is a pea-sized gland located in the brain. The pineal gland secretes the hormone melatonin, which is a modified form of the amino acid tryptophan.

Melatonin seems to be released by the human pineal gland as a response to darkness. Therefore, the pineal gland is thought to be involved in establishing daily biorhythms, such as the one shown in Figure 13. The pineal gland may also play a role in mood disorders such as seasonal affective disorder (SAD) syndrome and in a variety of aspects of sexual development.

Figure 13 A daily biorhythm. The daily variation in body temperature is an example of a biorhythm thought to be influenced by melatonin.

Daily Body Temperature Variation

<table>
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<td>36.0</td>
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<tr>
<td>6 P.M.</td>
<td>37.5</td>
</tr>
<tr>
<td>6 A.M.</td>
<td>35.0</td>
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</table>

Answers to Section Review
1. The hypothalamus and pituitary gland are considered the major control center of the endocrine system because they regulate other endocrine glands.
2. An underproduction of thyroid hormones during childhood can lead to stunted growth and mental retardation.
3. Glucagon increases blood sugar levels. Insulin decreases blood sugar levels, inducing storage of glucose in the form of glycogen in the liver.
4. Reproductive hormones affect gamete formation and control sexual cycles and secondary sex characteristics.
5. Students should disagree. Hormones from both the adrenal medulla and adrenal cortex are secreted in response to stress.

Critical Thinking Applying A classmate states that hormones from the adrenal medulla, but not from the adrenal cortex, are secreted in response to stress. Do you agree? Explain.

Standardized Test Prep Cortisol exerts negative feedback on the hypothalamic cells that release CRH. Which of the following results from a rise in the blood level of cortisol? A Blood glucose levels fall. C Stress levels rise. B Less ACTH is released. D More CRH is released.
Alternative Assessment

Have students work in cooperative groups. Each group should develop a question to send to a medical advice columnist dealing with any topic covered in this chapter. Collect the questions and redistribute them to other groups. Each group should then write an appropriate response to the question.

Interpersonal Co-op Learning

Answer to Concept Map

The following is one possible answer to Performance Zone item 15.

```
Endocrine system
  produces and secretes hormones which act on target cells
  is controlled by the hypothalamus
    interacts to control hormones made by the thyroid gland
    pituitary gland
      produces and secretes hormones made by the adrenal glands

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```
The glucagon receptors on the cell membrane could be faulty.

Anabolic steroids halt bone growth; contribute to liver disorders, including cancer; cause females to develop a deeper voice and facial hair; and cause males to develop enlarged breasts.

The health risks of being overweight, including stress on musculoskeletal and cardiovascular systems, outweigh the benefits.

One possible answer to the concept map is found at the bottom of the Study Zone page.

Critical Thinking

1. The receptor must fit in the hormone to control the secretion of other hormones.

2. The hypothalamus and pituitary gland

3. Thyroid hormones
   a. slow growth.
   b. inhibit insulin production.
   c. promote sperm production.
   d. control metabolic activities.

4. What adrenal cortex hormone acts, at high levels, to reduce inflammation?
   a. calcitonin
   b. prostaglandin
   c. aldosterone
   d. cortisol

5. Insulin leads to a. higher blood glucose levels. b. lower blood glucose levels. c. release of additional insulin. d. glycogen breakdown.

6. Which of the following endocrine glands secretes melatonin and is believed to be involved in establishing circadian rhythms?
   a. pituitary gland
   b. pineal gland
   c. thyroid gland
   d. adrenal gland

7. Summarizing Information Identify the endocrine gland labeled A, and name two hormones it makes.

8. BIOWatch Summarize the major side effects experienced by athletes who use anabolic steroids.

9. BIOWatch If having more body fat lowers a woman’s risk of developing osteoporosis, why don’t doctors advise their female patients to gain weight?

10. Concept Mapping Make a concept map that describes the endocrine system. Try to include the following terms in your map: hypothalamus, pituitary gland, thyroid gland, hormones, adrenal glands, and target cell.

Critical Thinking

11. Inferring Relationships Describe the importance of “fit” between a receptor protein and a hormone.

12. Applying Information Before iodide was added to table salt, goiters were common among people living in inland regions but rare among people living in coastal areas. Why do you think this was so?

13. Distinguishing Relevant Information During a medical examination, a person is found to be unable to move glucose, stored as glycogen, from the liver into the blood. Further tests show that glucagon levels are low but normal, as is the structure of the hormone. Why do you think glucagon is unable to carry out its function in this case?

Alternative Assessment

14. Career Focus Endocrinologist Research endocrinology, and write a report on your findings. Your report should include a job description, training required, kinds of employers, growth prospects, and starting salary.

15. Evaluating Information Interview several coaches at your school to determine their attitudes toward steroid testing. Write an article that discusses your findings and explains how steroids affect the body.

Alternative Assessment

Answers will vary. Endocrinologists are researchers that study hormones or physicians who care for patients with hormonal disorders. Endocrinologists who are researchers usually have postgraduate training. Endocrinologists who are physicians attend medical school after college, and must complete a residency in internal medicine, a fellowship in endocrinology, and become certified. Universities and research industries employ research endocrinologists. Endocrinologists who are physicians are employed in private practice, university health centers, and by hospitals and clinics.

The growth potential of endocrinology is excellent. Starting salary will vary by region.

Answers will vary. Side effects include stunted growth, liver problems, enlarged breasts and shivered testes in males, and facial hair and deepening voice in females.

Assignment Guide

<table>
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<tr>
<th>Section</th>
<th>Questions</th>
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<tr>
<td>3</td>
<td>2, 3, 4, 5, 6, 7, 8, 9, 10, 12, 13, 14, 15</td>
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</table>
Understanding Concepts

Directions (1–4): For each question, write on a separate sheet of paper the letter of the correct answer.

1. What are the chemical messengers of the endocrine system?
   A. blood cells
   B. carbohydrates
   C. hormones
   D. neurons

2. Which of the following is true of exocrine glands?
   F. function only after puberty
   G. include the brain and liver
   H. release products through ducts
   I. release products into the bloodstream

3. How may amino-acid-based hormones use cyclic AMP?
   A. as a coenzyme
   B. as a receptor
   C. as a second messenger
   D. as a target cell

4. What leads to an increase in hormone levels when hormone levels rise above normal?
   F. feedback inhibition
   G. negative feedback
   H. neutral feedback
   I. positive feedback

Directions (5–6): For each question, write a short response.

5. Analyze the relationship between transcription factors and steroid and thyroid hormones.

6. How are hormones and neurotransmitters alike and different?

Test Tip

When using a graph to answer a question, be sure to study the graph carefully before choosing a final answer. Some of the answer choices may be based on common misinterpretations of graphs.

Reading Skills

Directions (7): Read the passage below. Then answer the question.

The pineal gland secretes the hormone melatonin, which is a modified form of the amino acid tryptophan. The daily variation in body temperature is an example of a biorhythm thought to be influenced by melatonin. Melatonin seems to be released as a response to darkness. Soon after the melatonin is released, the person goes to sleep.

7. What type of disorder might be treated by using melatonin supplements?
   A. attention deficit
   B. bulimia
   C. depression
   D. insomnia

Interpreting Graphics

Directions (8): Base your answer to question 8 on the chart below.

Glucose Levels in Rats Injected with Hormones

The chart shows the effects of hormone injections on blood glucose levels in rats. Rats in groups 1 and 2 were injected with saline containing a hormone. Rats in the control group were injected with only saline. Which hormone was likely contained in the injection given to rats in group 1?

F. calcitonin
G. glucagon
H. insulin
I. oxytocin

Answers

1. C
2. H
3. C
4. I
5. These hormones act as transcription factors because they turn on or off gene expression when they bind to a gene.
6. A hormone is a chemical messenger in the endocrine system. A neurotransmitter is a chemical messenger in the nervous system.
7. D
8. G