Getting Started

Objectives
34.2.1 Identify the functions of the major endocrine glands.
34.2.2 Explain how endocrine glands are controlled.

Student Resources
Study Workbooks A and B, 34.2 Worksheets
Spanish Study Workbook, 34.2 Worksheets
Lesson Overview • Lesson Notes • Assessment: Self-Test, Lesson Assessment

Build Background
Ask students to brainstorm ways that people on different continents might work together on a project. (Sample answers: conference calls on the telephone, teleconferencing, emailing)

Ask Is it helpful to have a manager to coordinate the efforts? Explain. (Yes. Managers make sure everyone is working together efficiently.)

Then, ask students to discuss how this analogy may relate to how endocrine glands work together.

THINK ABOUT IT Organs in most body systems are connected to each other, but that’s not the case with the endocrine system. Endocrine glands are scattered throughout the body, many of them with no apparent connection to each other. How does the body control and regulate so many separate organs so that they act together as a single system?

The Human Endocrine Glands
What are the functions of the major endocrine glands?
The human endocrine system regulates a wide variety of activities. The major glands of the endocrine system include the pituitary gland, the hypothalamus, the adrenal glands, the pancreas, the thyroid gland, the parathyroid glands, and the reproductive glands.

Pituitary Gland The pituitary gland is a bean-size structure that dangles on a slender stalk of tissue at the base of the brain. As you can see in Figure 34–4, the gland is divided into two parts: the anterior pituitary and the posterior pituitary. The pituitary gland secretes hormones that directly regulate many body functions or control the actions of other endocrine glands.

Proper function of the pituitary gland is essential. For example, if the gland produces too much growth hormone (GH) during childhood, the body grows too quickly, resulting in a condition called gigantism. Too little GH during childhood causes pituitary dwarfism, which can be treated with GH produced by genetically engineered bacteria.

Hypothalamus The hypothalamus, which is attached to the posterior pituitary, is the link between the central nervous system and the endocrine system. The hypothalamus controls the secretions of the pituitary gland. The activities of the hypothalamus are influenced by the levels of hormones and other substances in the blood and by sensory information collected by other parts of the central nervous system.

The hypothalamus contains the cell bodies of neurosecretory cells whose axons extend into the posterior pituitary. Antidiuretic hormone, which stimulates the kidney to absorb water, and oxytocin, which stimulates contractions during childbirth, are made in the cell bodies of the hypothalamus and stored in the axons entering the posterior pituitary. When the cell bodies are stimulated, axons in the posterior pituitary release these hormones into the blood.

ENDURING UNDERSTANDING The human body is a complex system. The coordinated functions of its many structures support life processes and maintain homeostasis.

GUIDING QUESTION What life processes are regulated by hormones?

EVIDENCE OF UNDERSTANDING After completing the lesson, assign this assessment to show student understanding of how the human endocrine system works, including its many glands and the hormones they secrete. Have students work individually or in small groups to make a crossword puzzle that contains all of the lesson vocabulary terms as well as the names of each endocrine gland. The clues for the terms should be scientifically accurate.
In contrast, the hypothalamus has indirect control of the anterior pituitary. The hypothalamus produces releasing hormones, which are secreted into blood vessels leading to the anterior pituitary. The hypothalamus produces a specific releasing hormone that controls the secretion of each anterior pituitary hormone. Hormones released by the anterior pituitary gland are listed in Figure 34–5.

### Adrenal Glands

The adrenal glands are pyramid-shaped structures that sit on top of the kidneys. The adrenal glands release hormones that help the body prepare for—and deal with—stress. As shown in Figure 34–6, the outer part of the gland is called the adrenal cortex and the inner part is the adrenal medulla.

About 80 percent of an adrenal gland is its adrenal cortex. The adrenal cortex produces more than two dozen steroid hormones called corticosteroids (kawr tih koh STEER oydz). One of these hormones, aldosterone (al DAWH tuh rohn), regulates blood volume and pressure. Its release is stimulated by dehydration, excessive bleeding, or Na⁺ deficiency. Another hormone, called cortisol, helps control the rate of metabolism of carbohydrates, fats, and proteins. Cortisol is released during physical stress such as intense exercise.

Hormones released from the adrenal medulla produce the heart-pounding, anxious feeling you get when excited or frightened—commonly known as the “fight or flight” response. When you are under this sort of stress, impulses from the sympathetic nervous system stimulate cells in the adrenal medulla to release large amounts of epinephrine (commonly referred to as adrenaline) and norepinephrine. These hormones increase heart rate and blood pressure. They also cause air passages to widen, allowing for an increase in oxygen intake, and stimulate the release of extra glucose. If your heart rate speeds up and your hands sweat when you take a test, it’s your adrenal medulla at work!

### Anterior Pituitary Gland Hormones

<table>
<thead>
<tr>
<th>Hormone</th>
<th>Action</th>
</tr>
</thead>
<tbody>
<tr>
<td>Follicle-stimulating hormone (FSH)</td>
<td>Stimulates production of mature eggs in ovaries and sperm in testes</td>
</tr>
<tr>
<td>Luteinizing hormone (LH)</td>
<td>Stimulates ovaries and testes; prepares uterus for implantation of fertilized egg</td>
</tr>
<tr>
<td>Thyroid-stimulating hormone (TSH)</td>
<td>Stimulates the synthesis and release of thyroid hormone from the thyroid gland</td>
</tr>
<tr>
<td>Adreno-corticotropic hormone (ACTH)</td>
<td>Stimulates release of some hormones from the adrenal cortex</td>
</tr>
<tr>
<td>Growth hormone (GH)</td>
<td>Stimulates protein synthesis and growth in cells</td>
</tr>
<tr>
<td>Prolactin</td>
<td>Stimulates milk production in nursing mothers</td>
</tr>
<tr>
<td>Melanocyte-stimulating hormone (MSH)</td>
<td>Stimulates melanocytes in the skin to increase the production of the pigment melanin</td>
</tr>
</tbody>
</table>
Inuntreated diabetes mellitus, the body does not produce insulin or does not properly respond to it, so blood glucose levels remain high.
Thyroid and Parathyroid Glands  The thyroid gland is located at the base of the neck and wraps around the upper part of the trachea. **The thyroid gland has a major role in regulating the body's metabolism.** Recall that metabolism is the sum of all the chemical reactions that occur in the body. The thyroid gland produces the hormone **thyroxine**, which increases the metabolic rate of cells throughout the body. Under the influence of thyroxine, cells become more active, use more energy, and produce more heat.

Iodine is needed to produce thyroxine. In parts of the world where diets lack iodine, severe health problems may result. Low levels of thyroxine in iodine-deficient infants produce a condition called **cretinism** (kree tuh niz um), in which neither the skeletal system nor the nervous system develops properly. Iodine deficiency usually can be prevented by the addition of small amounts of iodine to table salt or other food items.

Thyroid problems are a fairly common disorder. If the thyroid produces too much thyroxine, a condition called **hyperthyroidism** occurs. Hyperthyroidism results in nervousness, elevated body temperature, increased blood pressure, and weight loss. Too little thyroxine causes a condition called **hypothyroidism**. Lower body temperature, lack of energy, and weight gain are signs of this condition. A goiter, as shown in Figure 34–9, can be a sign of hypothyroidism.

The thyroid also produces calcitonin, a hormone that reduces blood calcium levels. **Calcitonin** signals the kidneys to reabsorb less calcium from filtrate, inhibits calcium's absorption in the small intestine, and promotes calcium's absorption into bones. Its opposing hormone is parathyroid hormone, which is released by the four parathyroid glands located on the back surface of the thyroid. **Parathyroid hormone** (PTH) increases the calcium levels in the blood by promoting the release of calcium from bone, the reabsorption of calcium in the kidneys, and the uptake of calcium from the digestive system. The actions of PTH promote proper nerve and muscle function and proper bone structure.

**In Your Notebook**  Summarize how blood-calcium levels are regulated.

Reproductive Glands  The gonads—ovaries and testes—are the body's reproductive glands. **The gonads serve two important functions: the production of gametes and the secretion of sex hormones.** In females, ovaries produce eggs and secrete a group of hormones called estrogens. In males, the testes produce sperm and secrete the hormone testosterone. You’ll learn more about the gonads and their hormones in the next lesson.

**FIGURE 34–9 Thyroid Gland** A goiter is an enlargement of the thyroid gland. A goiter may be the result of iodine deficiency. Without iodine, the thyroid cannot finish producing thyroxine, but its precursor continues to build up in the gland.

**Endocrine and Reproductive Systems** 985

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**Check for Understanding**

**HAND SIGNALS**

Present students with the following questions, and ask them to show a thumbs-up sign if they understand, a thumbs-down sign if they are confused, or a waving-hand sign if they partially understand.

- How does the thyroid help regulate the body's metabolism?
- How do thyroid problems affect homeostasis in the body?

**ADJUST INSTRUCTION**

If students are struggling with one or both questions, ask them to work in small groups to discuss the topics. Have students raise their hands when their group has discussed both of the questions. After all students have raised their hands, call on several students to share their group’s responses.

**Use Models**

Tell students that blood calcium levels are controlled by two hormones with opposing actions. Have students make a feedback loop diagram of how these hormones keep blood calcium levels in a normal range. Tell students to use Figures 34–7 and 34–10 as models when they make their diagrams. Have several students share their completed diagrams with the class.

**DIFFERENTIATED INSTRUCTION**

**L1 Struggling Students** Before students begin drawing their feedback diagrams, have pairs read through the paragraph on blood calcium regulation. Point out that the names of the two hormones involved in blood calcium regulation are vocabulary words. Then, have pairs organize the information into a feedback loop diagram.

**LPR Less Proficient Readers** After students have completed their feedback loop diagrams, explain that the regulation of blood calcium levels is only one function of the thyroid gland. Challenge students to find a sentence on this page that describes another function of the thyroid gland. *(The thyroid gland has a major role in regulating the body's metabolism.)* Have volunteers restate this sentence in their own words.

**IN YOUR NOTEBOOK**  Calcitonin signals kidneys to excrete calcium, the small intestine to absorb less calcium, and bones to absorb more of it. These actions lower blood calcium levels. Parathyroid hormone has the opposite effects, and, therefore, raises blood calcium levels.
Connect to Health

Discuss the importance of fluid intake during physical activity. Explain that some individuals drink water during physical activity, while others prefer sports drinks. Ask students to bring in a variety of labels from sports drinks. Have them analyze the ingredients, Calories per serving, and other information found on the sports drink labels. Then, have them debate the advantages and disadvantages of drinking water versus a sports drink. You may want to bring in articles about sports drinks to share with the class. Students should understand that people lose more than just water in sweat.

After the activity is completed, discuss with students the important distinction between sports drinks and energy drinks. Tell students that energy drinks, many of which contain large amounts of caffeine, should not be used to replenish fluids during or after physical activity. This can be dangerous because caffeine can increase a person’s heart rate and fluid loss.

DIFFERENTIATED INSTRUCTION

**Advanced Students** Have students find out more about hyponatremia, a serious medical condition that can be caused by rapid and massive fluid intake. Ask students to write a short report that describes the condition and relates it to the concept of water balance in the body.

**Check for Understanding**

**FIGURE 34–10** The hypothalamus controls the posterior pituitary gland with nervous signals sent via neurosecretory cells that connect the hypothalamus and posterior pituitary.

**Answers**

**FIGURE 34–10** The hypothalamus controls the posterior pituitary gland with nervous signals sent via neurosecretory cells that connect the hypothalamus and posterior pituitary.

**Control of the Endocrine System**

**How are endocrine glands controlled?**

Even though the endocrine system is one of the master regulators of the body, it, too, must be controlled. Like most systems of the body, the endocrine system is regulated by feedback mechanisms that function to maintain homeostasis.

Recall that feedback inhibition occurs when an increase in any substance “feeds back” to inhibit the process that produced the substance in the first place. Home heating and cooling systems, controlled by thermostats, are examples of mechanical feedback loops. The actions of glands and hormones of the endocrine system are biological examples of the same type of process.

**Maintaining Water Balance** Homeostatic mechanisms regulate the levels of a wide variety of materials dissolved in the blood and in extracellular fluids. These materials include hydrogen ions; minerals such as sodium, potassium, and calcium; and soluble proteins such as serum albumin, which is found in blood plasma. Most of the time, homeostatic systems operate so smoothly that we are scarcely aware of their existence. However, that is not the case with one of the most important homeostatic processes, the one that regulates the amount of water in the body. Figure 34–10 illustrates the water balance mechanism.

When you exercise strenuously, you lose water as you sweat. If this water loss continued, your body would soon become dehydrated. Generally, that doesn’t happen, because your body’s homeostatic mechanisms swing into action.

The hypothalamus contains cells that are sensitive to the concentration of water in the blood. As you lose water, the concentration of dissolved materials in the blood rises. The hypothalamus responds in two ways. First, the hypothalamus signals the posterior pituitary gland to release a hormone called antidiuretic hormone (ADH). ADH molecules are carried by the blood to the kidneys, where the removal of water from the blood is quickly slowed down. Later, you experience a sensation of thirst—a signal that you should drink to restore lost water.

When you finally get around to taking that drink, you might take in a liter of fluid. Most of that water is quickly absorbed into the blood. This volume of water could dilute the blood so much that the equilibrium between the blood and the body cells would be disturbed. Large amounts of water would diffuse across blood vessel walls into body tissues. Body cells would swell with the excess water.
Needless to say, this doesn’t happen, because the homeostatic mechanism controlled by the hypothalamus intervenes again. When the water content of the blood rises, the pituitary releases less ADH. In response to lower ADH levels, the kidneys remove water from the blood, restoring the blood to its proper concentration. This homeostatic system sets both upper and lower limits for blood water content. A water deficit stimulates the release of ADH, causing the kidneys to conserve water; an oversupply of water causes the kidneys to eliminate the excess water in urine.

Controlling Metabolism As another example of how internal feedback mechanisms regulate the activity of the endocrine system, let’s look at the thyroid gland and its principal hormone, thyroxine. Recall that thyroxine increases the metabolic activity of cells. Does the thyroid gland determine how much thyroxine to release on its own? No, the activity of the thyroid gland is instead controlled by the hypothalamus and the anterior pituitary gland. When the hypothalamus senses that the thyroxine level in the blood is low, it secretes thyrotropin-releasing hormone (TRH), a hormone that stimulates the anterior pituitary to secrete thyroid-stimulating hormone (TSH). TSH stimulates the release of thyroxine by the thyroid gland. High levels of thyroxine in the blood inhibit the secretion of TRH and TSH, which stops the release of additional thyroxine. This feedback loop keeps the level of thyroxine in the blood relatively constant.

The hypothalamus is also sensitive to temperature. When the core body temperature begins to drop, even if the level of thyroxine is normal, the hypothalamus produces extra TRH. The release of TRH stimulates the release of TSH, which stimulates the release of additional thyroxine. Thyroxine increases oxygen consumption and cellular metabolism. The increase in metabolic activity that results helps the body maintain its core temperature even when the outside temperature drops.

**34.2 Assessment**

**Review Key Concepts**

1. **a. Review** Describe the role of each major endocrine gland.
   
   **b. Explain** How is the hypothalamus an important part of both the nervous system and the endocrine system?
   
   **c. Compare and Contrast** Compare and contrast the two types of diabetes.

2. **a. Review** Explain how the endocrine system helps maintain homeostasis.
   
   **b. Explain** On a hot day, you play soccer for an hour and lose a lot of water in sweat. List the steps that your body takes to regain homeostasis.

3. **c. Predict** Suppose the secretion of a certain hormone causes an increase in the concentration of substance X in the blood. A low concentration of X causes the hormone to be released. What is the effect on the rate of hormone secretion if an abnormal condition causes the level of X in the blood to remain very low?

**BUILD Vocabulary**

**PREFIXES** The prefixes anti- and ante- can be easily confused. Anti-, as in antidiuretic, means “against” or “opposite.” Ante-, as in anterior, means “before.”

**Creative Writing**

3. Create a brochure that describes both types of diabetes. You may wish to include information on risk factors, treatment, and preventive measures that can be taken. Use images from magazines or the Internet to illustrate your brochure.

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**Assessment Answers**

1a. The pituitary gland regulates many body functions and controls the action of other endocrine glands. The hypothalamus controls the secretions of the pituitary gland. The adrenal glands help the body prepare for and deal with stress. The pancreas regulates blood glucose levels. The thyroid and parathyroid glands regulate blood calcium levels. The ovaries and testes secrete sex hormones.

1b. The hypothalamus serves as the body’s link between the nervous system and the endocrine system. Its activities are influenced by substances in the blood and information from the nervous system.

1c. Both types of diabetes result in problems with regulation of blood glucose levels. In Type I diabetes, the body’s immune system destroys the cells that make insulin; in Type II diabetes, the body does not respond efficiently to insulin.

2a. The endocrine system helps maintain homeostasis by signaling the body to respond to internal and external stimuli and by using feedback mechanisms.

2b. The hypothalamus signals the posterior pituitary to release ADH and causes thirst sensation. The ADH slows removal of water from the body. A thirst sensation prompts you to replace lost water.

2c. The level of hormone secretion would remain high.

3. Brochures should be assessed based on content and format. Check that facts are accurate and images are appropriate.