KEY CONCEPT

4.2 The endocrine system helps regulate body conditions.

BEFORE, you learned

- Many body systems function without conscious control
- The body systems work automatically to maintain homeostasis
- Homeostasis is important to an organism's survival

NOW, you will learn

- About the role of hormones
- About the functions of glands
- How the body uses feedback mechanisms to help maintain homeostasis

VOCABULARY

endocrine system p.110
hormone p.111
gland p.111

THINK ABOUT

How does your body react to surprise?

In a small group, determine how your body responds to a surprising situation. Have one student in the group pretend he or she is responding to a surprise. The other group members should determine how the body reacts physically to that event. How do your respiratory system, digestive system, circulatory system, muscle system, and skeletal system react?

CHOOSE YOUR OWN STRATEGY
Begin taking notes on the main idea: *Hormones are the body's chemical messengers.* Use a strategy from an earlier chapter or one of your own. Include a definition of *hormone* in your notes.

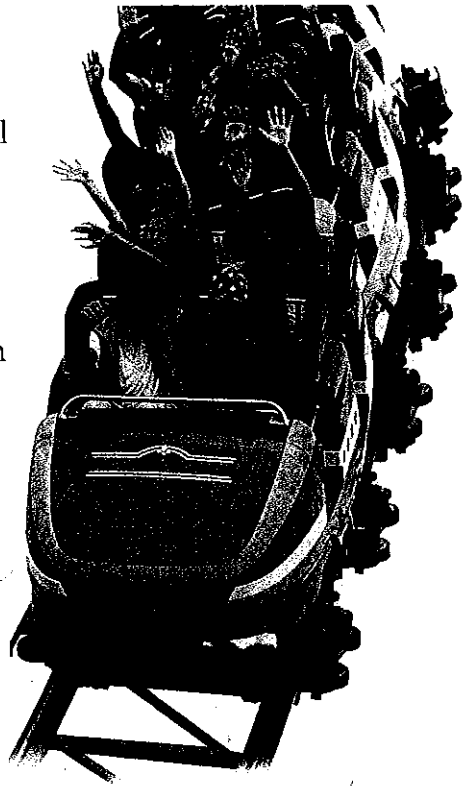
Hormones are the body's chemical messengers.

Imagine you're seated on a roller coaster climbing to the top of a steep incline. In a matter of moments, your car drops one hundred feet. You might notice that your heart starts beating faster. You grab the seat and notice that your palms are sweaty. These are normal physical responses to scary situations. The **endocrine system** controls the conditions in your body by making and releasing chemicals that are transported thoughout the body. Most responses of the endocrine system are controlled by the autonomic nervous system.

Hormones are chemicals that are made in one organ, travel through the blood, and produce an effect in target cells. Target cells have structures that allow them to respond to the chemical. Many hormones, as you can see in the table below, affect all the cells in the body.

Because hormones are made at one location and function at another, they are often called chemical messengers. In order for a hormone to have an effect, it binds to receptors on the surface of or inside the cells. There the hormone begins the chemical changes that cause the target cells to function in a specific way. All of the functions of the endocrine system work automatically, without your conscious control.

Different types of hormones perform different jobs. Some of these jobs are to control the production of other hormones, to regulate the balance of chemicals such as glucose and salt in your blood, or to produce responses to changes in the environment. Some hormones are made only during specific times in a person's life. For example, hormones that control the development of sexual characteristics are not produced in significant amounts during childhood. During adolescence, high levels of these hormones cause major changes in a person's body.



The individuals on this roller coaster are experiencing a burst of the hormone adrenaline.

CHECK YOUR READING How are hormones like messengers?

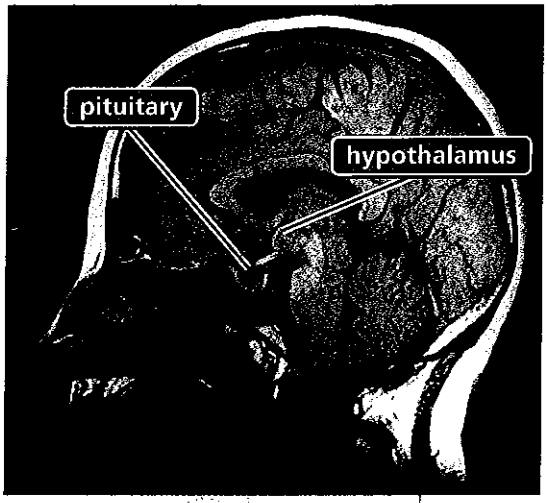
Hormones

Name	Where produced	Produces responses in
Growth hormone	pituitary gland	all body cells
Antidiuretic hormone	pituitary gland	kidneys
Thyroxine	thyroid gland	all body cells
Cortisol	adrenal glands	all body cells
Adrenaline	adrenal glands	heart, lungs, stomach, intestines, glands
Insulin	pancreas	all body cells
Testosterone (males)	testes	all body cells
Estrogen (females)	ovaries	all body cells

Glands produce and release hormones.

The main structures of the endocrine system are groups of specialized cells called **glands.** Many glands in the body produce hormones and release them into your circulatory system. As you can see in the illustration on page 113, endocrine glands can be found in many parts of your body. However, all hormones move from the cells in which they are produced to cause effects in target cells.

RESOURCE CENTER
CLASSZONE.COM
Learn more about the endocrine system.



The hypothalamus and the pituitary are important endocrine glands.

Pituitary Gland The pituitary (pih-TOO-ih-TEHR-ee) gland can be thought of as the director of the endocrine system. The pituitary gland is the size of a pea and is located at the base of the brain—right above the roof of your mouth. Many important hormones are produced in the pituitary gland, including hormones that control growth, sexual development, and the absorption of water into the blood by the kidneys.

Hypothalamus The hypothalamus (HY-poh-THAL-uh-muhs) is attached to the pituitary gland and is the primary connection between the nervous and endocrine systems. All of the secretions of the pituitary gland are controlled by the hormones produced in the hypothalamus.

Pineal Gland The pineal (PIHN-ee-uhl) gland is a tiny organ about the size of a pea. It is buried deep in the brain. The pineal gland is sensitive to different levels of light and the hormone it produces is essential to rhythms such as sleep, body temperature, reproduction, and aging.

Thyroid Gland You can feel your thyroid gland if you place your hand on the part of your throat called the Adam's apple and swallow. What you feel is the cartilage surrounding your thyroid gland. The thyroid releases hormones necessary for growth and metabolism. The tissue of the thyroid is made of millions of tiny pouches, which store the thyroid hormones. The thyroid gland also produces the hormone calcitonin, which is involved in the regulation of calcium in the body.

Thymus The thymus is located in your chest. It is relatively large in the newborn baby and continues to grow until puberty. Following puberty, it gradually decreases in size. The thymus helps the body fight disease by controlling the production of white blood cells called T cells.

Adrenal Glands The adrenal glands are located on top of your kidneys. The adrenal glands secrete about 30 different hormones that regulate carbohydrate, protein, and fat metabolism and water and salt levels in your body. Some other hormones produced by the adrenal glands help you fight allergies. Roller coaster rides, loud noises, or stress can activate your adrenal glands to produce adrenaline, the hormone that makes your heart beat faster.

Pancreas The pancreas is part of both the digestive and the endocrine systems. The pancreas secretes two hormones, insulin and glucagon. These hormones regulate the level of glucose in your blood. The pancreas sits beneath the stomach and is connected to the small intestine.

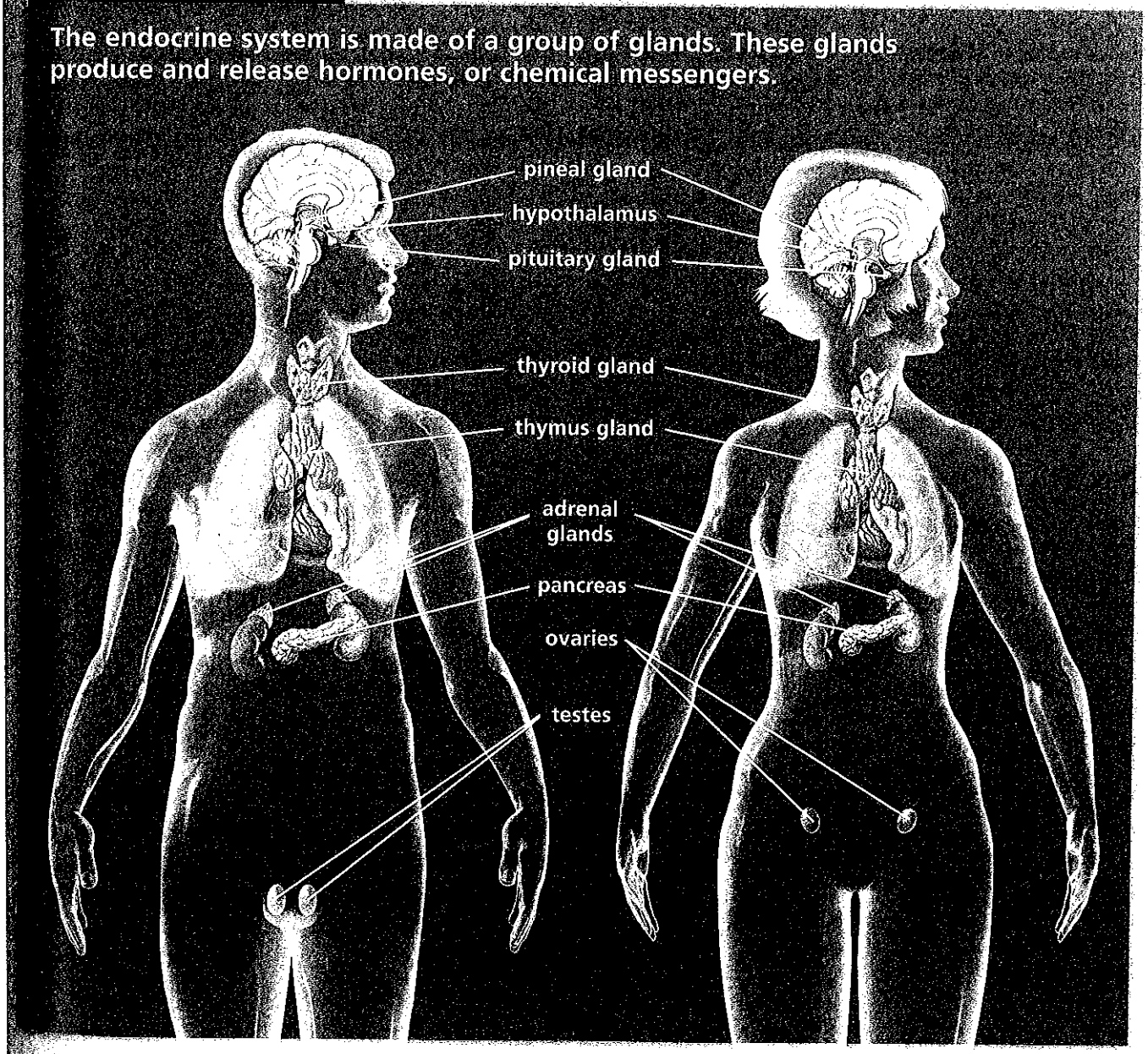
Ovaries and Testes The ovaries and testes secrete hormones that control sexual development.

Other Organs Some organs that are not considered part of the endocrine system do produce important hormones. The kidneys secrete a hormone that regulates the production of red blood cells. This hormone is secreted whenever the oxygen level in your blood decreases. Once the hormone has stimulated the red bone marrow to produce more red blood cells, the oxygen level of the blood increases. The heart produces two hormones that help regulate blood pressure. These hormones, secreted by one of the chambers of the heart, stimulate the kidneys to remove more salt from the blood.

CHECK YOUR READING Which glands and organs are part of the endocrine system?

Endocrine System

The endocrine system is made of a group of glands. These glands produce and release hormones, or chemical messengers.



INVESTIGATE Response to Exercise

SKILL FOCUS
Observing

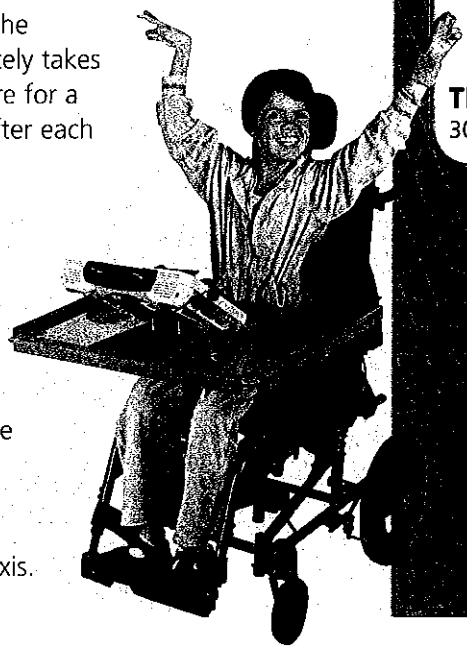
MATERIALS
- stopwatch or timing device
- notebook
- graph paper
- mercury-free thermometer
- rubbing alcohol or plastic thermometer covers

TIME
30 minutes

How does your body temperature change when you exercise?

PROCEDURE

1. Working in groups of two, read all the instructions in this activity first. Appoint one person to be the subject and one person to be the timer and note taker. Using a mercury-free thermometer, have the subject take his or her temperature. Record the temperature in your notebook.
2. While staying seated the subject begins to do sitting-down jumping jacks. The subject does the jumping jacks for 1 minute and then immediately takes his or her temperature. Continue this procedure for a total of 3 times, measuring the temperature after each minute of exercise.



WHAT DO YOU THINK?

- How did the subject's temperature change while exercising?
- What factors may contribute to the rate at which the temperature changed in each person?
- How did the subject's physical appearance change from the beginning of the activity to the end?

CHALLENGE Graph the results on a line graph, with temperature on the *x*-axis and time on the *y*-axis.

Control of the endocrine system includes feedback mechanisms.

As you might recall, the cells in the human body function best within a specific set of conditions. Homeostasis (HOH-mee-oh-STAY-sihs) is the process by which the body maintains these internal conditions, even though conditions outside the body may change. The endocrine system is very important in maintaining homeostasis.

CHECK YOUR READING Why is homeostasis important?

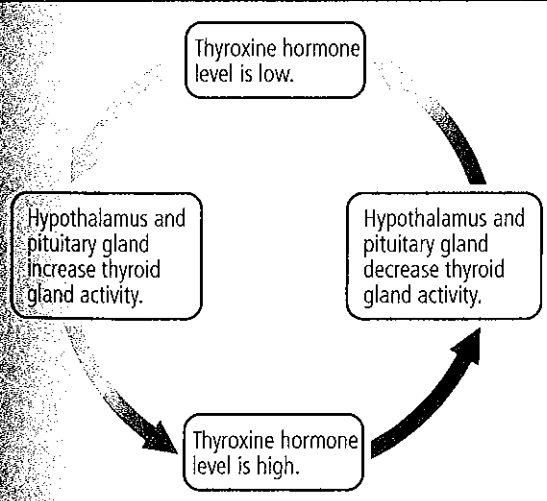
Because hormones are powerful chemicals capable of producing dramatic changes, their levels in the body must be carefully regulated. The endocrine system has several levels of control. Most glands are regulated by the pituitary gland, which in turn is controlled by the hypothalamus, part of the brain. The endocrine system helps maintain homeostasis through the action of negative feedback mechanisms.

Negative Feedback

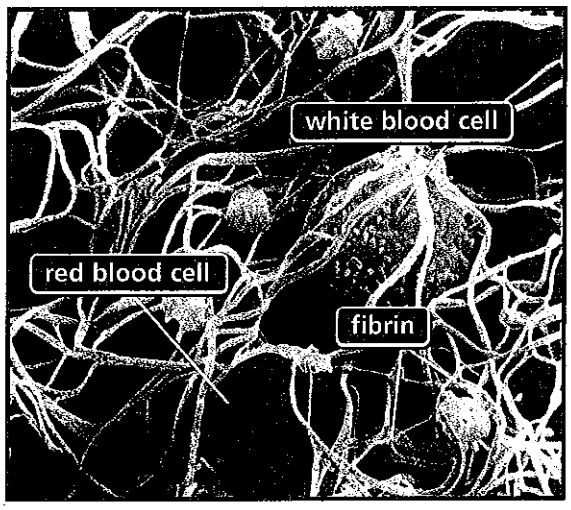
Most feedback mechanisms in the body are called negative mechanisms, because the final effect of the response is to turn off the response. An increase in the amount of a hormone in the body feeds back to inhibit the further production of that hormone.

The production of the hormone thyroxine by the thyroid gland is an example of a negative feedback mechanism. Thyroxine controls the body's metabolism, or the rate at which the cells in the body release energy by cellular respiration. When the body needs energy, the thyroid gland releases thyroxine into the blood to increase cellular respiration. However, the thyroid gland is controlled by the pituitary gland, which in turn is controlled by the hypothalamus. Increased levels of thyroxine in the blood inhibit the signals from the hypothalamus and the pituitary gland to the thyroid gland. Production of thyroxine in the thyroid gland decreases.

Negative and Positive Feedback



Negative feedback The process shown here regulates levels of thyroid hormone. Feedback keeps conditions within a narrow range to maintain homeostasis.



Positive feedback These red blood cells are surrounded by fibrin, a protein that allows them to clot.

Positive Feedback

Some responses of the endocrine system, as well as other body systems, are controlled by positive feedback. The outcome of a positive feedback mechanism is not to maintain homeostasis, but to produce a response that continues to increase. Most positive feedback mechanisms result in extreme responses that are necessary under extreme conditions.

For example, when you cut yourself, the bleeding is controlled by positive feedback. First, the damaged tissue releases a chemical signal.

The signal starts a series of chemical reactions that lead to the formation of threadlike proteins called fibrin. The fibrin causes the blood to clot, filling the injured area. Other examples of positive feedback include fever, the immune response, puberty, and the process of childbirth.

CHECK YOUR READING What is the difference between negative and positive feedback?

Balanced Hormone Action

In the body, the action of one hormone is often balanced by the action of another. When you ride a bicycle, you are able to ride in a straight line, despite bumps and dips in the road, by making constant steering adjustments. If the bicycle is pulled to the right, you adjust the handlebars by turning a tiny bit to the left.

Some hormones maintain homeostasis in the same way that you steer your bicycle. The pancreas, for example, produces two hormones. One hormone, insulin, decreases the level of sugar in the blood. The other hormone, glucagon, increases sugar levels in the blood. The balance of the levels of these hormones maintains stable blood sugar between meals.

Hormone Imbalance

Because hormones regulate critical functions in the body, too little or too much of any hormone can cause serious disease. When the pancreas produces too little insulin, sugar levels in the blood can rise to dangerous levels. Very high levels of blood sugar can damage the circulatory system and the kidneys. This condition, known as diabetes mellitus, is often treated by injecting synthetic insulin into the body to replace the insulin not being made by the pancreas.

4.2 Review

KEY CONCEPTS

1. List three different jobs that hormones perform.
2. Draw an outline of the human body. Add the locations and functions of the pituitary, thyroid, adrenal, and pineal glands to your drawing.
3. What is the function of a negative feedback mechanism?

CRITICAL THINKING

4. **Analyze** Explain why hormones are called chemical messengers.
5. **Analyze** List two sets of hormones that have opposing actions. How do the actions of these hormones help maintain homeostasis?

CHALLENGE

6. **Connect** Copy the diagram below and add three more stimuli and the resulting feedback mechanisms.