39–2 Human Endocrine Glands

The endocrine glands are scattered throughout the body. Generally, they do not have direct connections to one another. Like signals that are beamed throughout the country from a broadcast station, the hormones released from the endocrine glands into the bloodstream travel throughout the body, reaching almost every cell.

The human endocrine system regulates a wide variety of activities. Any improper functioning of an endocrine gland may result in a disease or a disorder. The major glands of the endocrine system include the pituitary gland, the hypothalamus, the thyroid gland, the parathyroid glands, the adrenal glands, the pancreas, and the reproductive glands.

Pituitary Gland

The pituitary gland is a bean-sized structure that dangles on a slender stalk of tissue at the base of the skull. As you can see in Figure 39–6, the gland is divided into two parts: the anterior pituitary and the posterior pituitary. The pituitary gland secretes nine hormones that directly regulate many body functions and controls the actions of several other endocrine glands.

Normal function of the pituitary gland is essential to good health. For example, if the pituitary gland produces too much growth hormone (GH) during childhood, the body grows too quickly and a condition called gigantism results. Too little GH during childhood causes a condition known as pituitary dwarfism, which can be treated by administering growth hormone. Growth hormone used to be in short supply. Today, however, genetically engineered bacteria are able to produce GH in large quantities.

Figure 39–6 The pituitary gland, which controls many other endocrine glands, is located below the hypothalamus in the brain. The pituitary gland has two lobes: an anterior lobe and a posterior lobe.
Chapter 39

Prepare a graphic organizer sim-

(Hypothalamus)

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The hypothalamus is the part of the brain above and attached to the posterior pituitary. The hypothalamus controls the secretions of the pituitary gland. The activity of the hypothalamus is influenced by the levels of hormones in the blood and by sensory information collected by other parts of the central nervous system. Interactions between the nervous system and the endocrine system take place at the hypothalamus.

The posterior pituitary is made up of axons belonging to cells called neurosecretory cells, whose cell bodies are in the hypothalamus. When these cell bodies are stimulated, the axons in the posterior pituitary release their hormones into the bloodstream. In a way, the posterior pituitary is an extension of the hypothalamus.

In contrast, the hypothalamus has indirect control of the anterior pituitary. The hypothalamus produces small amounts of chemicals called releasing hormones, which are secreted directly into blood vessels. The releasing hormones are carried by the circulatory system to the anterior pituitary, where they control the production and release of hormones.

The close connection between the hypothalamus and the pituitary gland means that the nervous and endocrine systems can act together to help coordinate body activities. Hormones released by the pituitary gland are listed in Figure 39–7.

What is the role of releasing hormones?

Figure 39–7. The hypothalamus controls the secretions of the pituitary gland. Notice the effect that each hormone produced by the pituitary gland has on the body.

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What is the role of releasing hormones?
Thyroid Gland
If you look at Figure 39–8, you can see that the thyroid gland is located at the base of the neck and wraps around the upper part of the trachea. The thyroid gland has the major role in regulating the body’s metabolism. Cells in the thyroid gland produce thyroxine, which is made up of the amino acid tyrosine and the mineral iodine. Remember that thyroxine affects nearly all of the cells of the body by regulating their metabolic rates. Thyroxine increases the rate of protein, carbohydrate, and fat metabolism as well as the rate of cellular respiration, which means that the cells release more heat and energy. Decreased levels of thyroxine can decrease the rate of cellular respiration and the amount of heat and energy released.

The homeostatic activities of the thyroid gland are so well controlled that you may never become aware of them. However, if the thyroid gland produces too much thyroxine, a condition called hyperthyroidism occurs. Hyperthyroidism results in nervousness, elevated body temperature, increased metabolic rate, increased blood pressure, and weight loss. Too little thyroxine causes a condition called hypothyroidism. Lower metabolic rates and body temperature, lack of energy, and weight gain are characteristics of this condition. In some cases, hypothyroidism can cause a goiter, an enlargement of the thyroid gland.

The importance of proper thyroid activity can be seen in parts of the world where food lacks enough iodine for the thyroid to produce normal amounts of thyroxine. Unable to produce the thyroxine needed for normal development, iodine-deficient infants suffer from a condition called cretinism (KREE-tuh-niz-um), in which neither the skeletal system nor the nervous system develops properly. Two effects of cretinism are dwarfism and severe mental retardation. Cretinism usually can be prevented by the addition of small amounts of iodine to table salt or other items in the food supply.

Parathyroid Glands
The four parathyroid glands are found on the back surface of the thyroid gland. Hormones from the thyroid gland and the parathyroid glands act to maintain homeostasis of calcium levels in the blood. Parathyroid glands secrete parathyroid hormone (PTH). Recall that PTH and calcitonin have opposite effects on the body. PTH regulates the calcium levels in the blood by increasing the reabsorption of calcium in the kidneys and by increasing the uptake of calcium from the digestive system. Parathyroid hormone also affects other organ systems, promoting proper nerve and muscle function and bone structure.

**Effects of a faulty thyroid**

Iodine deficiencies severe enough to cause thyroid problems once occurred largely in mountainous inland regions, such as the Alps or Andes. However, iodine deficiency is not the only cause of abnormal thyroid activity. Two autoimmune diseases, both more common in females than in males, also cause thyroid problems. One disease is Hashimoto’s disease, which is the second most common cause of hypothyroidism, or underproduction of thyroid hormones. Some of the signs and symptoms of hypothyroidism are enlarged thyroid gland, slow heart rate, dry skin, fatigue, and weight gain. The other disease is Graves’ disease. It causes hyperthyroidism, or overproduction of thyroid hormone. Symptoms of hyperthyroidism include enlarged thyroid gland, rapid heart rate, bulging eyes, hand tremor, and weight loss.

**Thyroid Gland**

**Make Connections**

**Health Science** Explain that low levels of iodine in the diet may cause the thyroid gland to compensate by increasing in size and producing a noticeable swelling in the throat called a goiter. If possible, show students pictures of people with goiters. Also explain that lack of thyroxine in adults does not produce cretinism but a condition called myxedema, which is characterized by lethargy, puffiness, and mental dullness. Point out that people with myxedema can recover from the condition with no lasting effects. Ask: Why are the effects of iodine deficiency permanent in young children but not in adults? (The effects are permanent in children because the hormone deficiency interferes with normal development, leaving the child with abnormal brain and body conditions when growth is complete.)

**Parathyroid Glands**

**Build Science Skills**

**Applying Concepts** Challenge students to apply the concept of homeostasis to the parathyroid glands. Have them create a simple diagram, similar to the one in Figure 39–4 on page 1000, to show how the parathyroid glands regulate the calcium level in the blood. Their diagrams should show that a high blood calcium level leads to the secretion of parathyroid hormone, or PTH, which, in turn, stimulates the kidneys to reabsorb more calcium and the digestive system to take up more calcium.

**Endocrine and Reproductive Systems**

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Adrenal Glands

Use Visuals

Figure 39–9 Point out the adrenal glands’ location on top of the kidneys. Have students find the kidneys in Figure 39–2 if they do not know where they are located. Then, have students find the two parts of the adrenal gland in Figure 39–9. Tell them that the term cortex refers to the outer part of an organ or gland. Ask: What do you think the term medulla refers to? (The inner part of an organ or gland) Besides location, what relationship is there between the kidneys and the adrenal glands? (The adrenal cortex secretes aldosterone, which regulates the reabsorption of sodium ions and the excretion of potassium ions by the kidneys.)

Make Connections

Health Science Explain to students that when someone is under constant stress, the adrenal medulla may be continually stimulated to produce its “fight or flight” hormones. Ask: What effect do you think this might have on the body over the long run? (The increased heart rate and blood pressure and other responses to epinephrine and norepinephrine would put wear and tear on the body and could lead to illness.)

Adrenal Glands

The adrenal glands are two pyramid-shaped structures that sit on top of the kidneys, one gland on each kidney, as shown in Figure 39–9. The adrenal glands release hormones that help the body prepare for and deal with stress. An adrenal gland has an outer part called the adrenal cortex and an inner part called the adrenal medulla. These parts contain different types of tissues.

Adrenal Cortex 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-DAH-suh-roehn), regulates the reabsorption of sodium ions and the excretion of potassium ions by the kidneys. Another hormone, called cortisol, helps control the rate of metabolism of carbohydrates, fats, and proteins.

Adrenal Medulla The release of hormones from the adrenal medulla is regulated by the sympathetic nervous system. The sympathetic nervous system prepares the body for energy-intensive activities. The two hormones released by the adrenal medulla are epinephrine and norepinephrine. Epinephrine, which is more powerful than norepinephrine, makes up about 80 percent of the total secretions of the adrenal medulla.

The adrenal medulla produces the “fight or flight” response to stress. This response is the feeling you get when you are excited or frightened. Nerve impulses from the sympathetic nervous system stimulate cells of the adrenal medulla. This stimulation causes the cells to release large amounts of epinephrine and norepinephrine. These hormones increase heart rate, blood pressure, and blood flow to the muscles. They cause air passages to open wider, allowing for an increase in the intake of oxygen. They also stimulate the release of extra glucose into the blood to help produce a sudden burst of energy. The result of all these actions is a general increase in body activity, which can serve as preparation for intense physical activity. If your heart rate speeds up and your hands begin to perspire when you take a test, you are feeling the effects of your adrenal medulla!

HISTORY OF SCIENCE

From dog urine to crystals

In 1889, scientists removed the pancreas from laboratory dogs and found, by chance, that the dogs’ urine attracted bees. The scientists inferred that the urine contained sugar, which was also known to be true of the urine of people with diabetes mellitus. The scientists concluded that the pancreas must produce a substance that was involved somehow in the disease. The substance was named insulin after insula, the Latin word for “island,” because it was thought to be produced by the islets of Langerhans. In 1922, insulin was isolated and identified by Sir Frederick Banting and Charles Best. Banting received a Nobel prize for the discovery the following year. Banting and Best also determined insulin’s role in carbohydrate metabolism and diabetes mellitus. In 1969, the English chemist Dorothy Crowfoot Hodgkin used crystallography to determine insulin’s crystal structure.
Pancreas

The pancreas is an unusual gland that has both exocrine and endocrine functions. Recall that the pancreas is a digestive gland whose enzyme secretions help to break down food. These secretions are released into the pancreatic duct and flow into the small intestine. This makes the pancreas an exocrine gland. However, different cells in the pancreas release hormones into the blood, making the pancreas an endocrine gland as well.

The hormone-producing portion of the pancreas consists of clusters of cells that resemble islands. These clusters of cells are called islets of Langerhans after their discoverer, the German anatomist Paul Langerhans. Each islet includes beta cells, which secrete a hormone called insulin, and alpha cells, which secrete another hormone called glucagon.

Insulin and glucagon help to keep the level of glucose in the blood stable. Insulin stimulates cells in the liver and muscles to remove sugar from the blood and store it as glycogen or fat. Glucagon stimulates the liver to break down glycogen and release glucose back into the blood. It also stimulates the release of fatty acids from stored fats.

Maintaining Blood Sugar Levels When blood glucose levels rise after eating, the pancreas releases insulin. Insulin stimulates cells throughout the body to take glucose out of the bloodstream. Insulin’s major target cells are found in the liver, skeletal muscles, and fat (adipose) tissue. Glucose taken out of circulation is stored as glycogen in the liver and skeletal muscles. In fat tissue, glucose molecules are converted to lipids. Insulin prevents the level of glucose in the blood from rising too rapidly and ensures that excess glucose is stored for future use.

Within one or two hours after eating, when the level of blood glucose drops, glucagon is released from the pancreas. Glucagon stimulates the cells of the liver and skeletal muscles to break down glycogen and increase glucose levels in the blood. Glucagon also causes fat cells to break down fats so that they can be used for the production of carbohydrates. These actions make more chemical energy available to the body and help raise the blood glucose level back to normal.

Diabetes Mellitus When the pancreas fails to produce or properly use insulin, a condition known as diabetes mellitus occurs. In diabetes mellitus, the amount of glucose in the blood may rise so high that the kidneys actually excrete glucose in the urine. Very high blood glucose levels can damage almost every system and cell in the body, including the coronary artery, shown in Figure 39–10.

There are two types of diabetes mellitus. Type I diabetes is an autoimmune disorder that usually develops in people before the age of 15. In this type of diabetes, there is little or no secretion of insulin. People with this type of diabetes must follow a strict diet and get daily injections of insulin to keep their blood glucose levels under control.

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Pancreas

Address Misconceptions

Students are likely to have heard diabetes mellitus referred to simply as “diabetes.” Point out that the term diabetes actually refers to any disease that is characterized by excessive urination and thirst and that there is more than one type of diabetes. For example, diabetes insipidus is a type of diabetes caused by lack of the pituitary hormone ADH and not by lack of insulin. Ask: If diabetes mellitus is controlled by insulin injections, how do you think diabetes insipidus could be controlled? (By ADH injections)

Demonstration

Tell students that diabetes mellitus sometimes is diagnosed by detecting sugar in the urine. Give students glucose test strips and explain how they are used. Then, have students use the test strips to test either a mixture of water, yellow food coloring, and sugar or a mixture of water and yellow food coloring alone. Ask: Did your “urine” specimen contain sugar? (Answers will depend on which mixture was tested.) Check that students have correctly interpreted their test results.

Use Community Resources

Ask a nurse or other medical professional who is knowledgeable about diabetes mellitus to visit your class. Have the visitor explain why and when people with insulin-dependent diabetes mellitus must measure their blood glucose and why and when insulin must be taken. If possible, have the visitor demonstrate how a glucometer and an insulin kit are used. Urge students to prepare a list of questions in advance, such as: What dietary restrictions must diabetics follow? Is diabetes mellitus inherited?

Answers to . . .

Address: Corticosteroid hormones, such as aldosterone and cortisol, are released from the adrenal cortex. Epinephrine and norepinephrine are released from the adrenal medulla.

Figure 39–10 Blocked arteries increase blood pressure.
Reproductive Glands

Address Misconceptions

Students are likely to think that testosterone is produced only by males and estrogen only by females. Tell students that the adrenal glands produce small amounts of estrogen and testosterone in both females and males. Ask: Why do you think males do not show the effects of adrenal estrogen or females the effects of adrenal testosterone? (The amounts of hormones produced by the adrenal glands are small compared with the amounts produced by the gonads.)

3 ASSESS

Evaluate Understanding

Call on students to identify hormones produced by each endocrine gland. Call on other students to describe the function of each hormone.

Reteach

Divide the class into two teams. Play a quiz game in which you act as moderator and require students on alternating teams to identify hormones based on a description.

Writing in Science

Students' brochures should be assessed on the basis of both content and format. Check that the facts they list are accurate and that all of the relevant information is incorporated, including risk factors, treatment, and prevention. Students should use a brochure format with eye-catching illustrations. Encourage them to use a computer software program that creates brochures.

39-2 (continued)

Reproductive Glands

The second type of diabetes, Type II, most commonly develops in people after the age of 40. People with Type II diabetes produce low to normal amounts of insulin. However, their cells are unable to properly respond to the hormone because the interaction of the insulin receptors and the insulin is inefficient. In its early stages, Type II diabetes can often be controlled through diet and exercise. A diet high in complex carbohydrates and low in saturated fat and sugar can prevent blood sugar fluctuations.

Unfortunately, many people with Type II diabetes eventually require medication, as well. If the body stops producing insulin, the person will also need to have daily insulin injections.

Reproductive Glands

The gonads are the body's reproductive glands. The gonads serve two important functions: the production of gametes and the secretion of sex hormones. The female gonads—the ovaries—produce eggs (ova; singular: ovum). The male gonads—the testes (singular: testis)—produce sperm. The gonads also produce sex hormones.

The ovaries produce the female sex hormones, estrogen and progesterone. Estrogen is required for the development of eggs and for the formation of the physical characteristics associated with the female body. These characteristics include the development of the female reproductive system, widening of the hips, and development of the breasts. Progesterone prepares the uterus for the arrival of a developing embryo.

The testes produce testosterone (tes-TAHS-tuh-ron). Testosterone is required for normal sperm production and the development of physical characteristics associated with the male body. These characteristics include the growth of facial hair, increase in body size, and deepening of the voice. You will read more about these hormones in the next section.

39-2 Section Assessment

Writing in Science

Creating an Informational Brochure

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. Hint: Be sure to choose some high-interest images to make your brochure visually appealing.