Chapter 13

Control and Movement

Photo Credit: Anne-Marie Keppel

13.1 Hormones

While the nervous system handles rapid actions and reactions for the human body, the hormones of the endocrine system regulate activities that take place over longer time periods. For example, hormones regulate your growth and development, prepare you for reproduction, determine how quickly you metabolize food, and tell you whether it is time to be awake or asleep. Hormones also play an important role in maintaining homeostasis in the body. So, what exactly are hormones and how do they work?

A **hormone** is a molecule that gives instructions to the body. Hormones are produced in one place in the body, released into the bloodstream, and then received by target cells elsewhere in the body. Hormones come in two types. **Protein hormones** are, as their name suggests, proteins or modified amino acids. **Steroid hormones** are made from cholesterol.

Protein hormones and steroid hormones work in different ways. Protein hormones bind to receptors on the cell membranes of their target cells. This binding starts a series of chemical reactions that result in the target cells' response to the hormone (Figure 13.1a). Steroid hormones cross the cell membrane and bind to receptors inside target cells—a steroid hormone's receptors may be in a target cell's cytoplasm or nucleus. The steroid hormone-receptor complex then binds to DNA in the nucleus and directly affects gene transcription (Figure 13.1b).

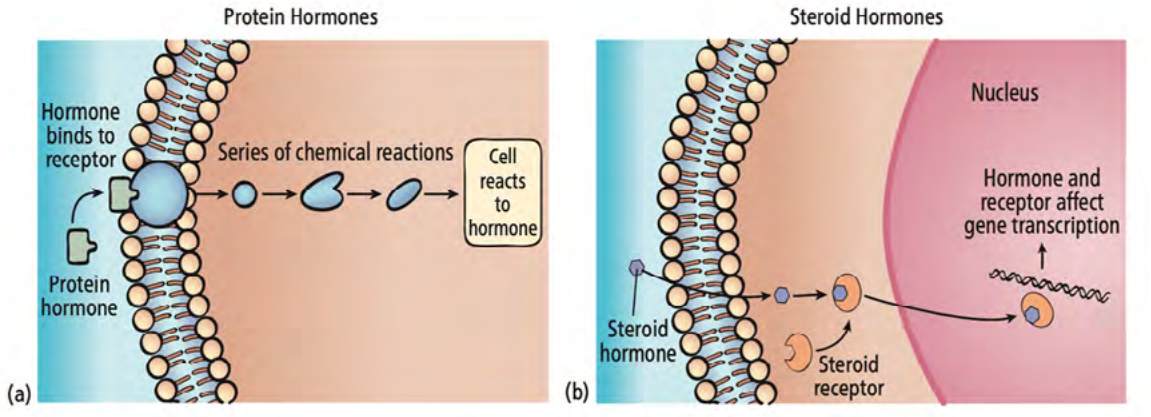

FIGURE 13.1

(a) Protein hormones bind to receptors in the cell membranes of target cells. This starts a sequence of events that result in the target cells' response to the hormone. (b) Steroid hormones enter target cells and bind to receptors in the cytoplasm or nucleus. Together, the steroid hormone and receptor directly affect gene transcription.

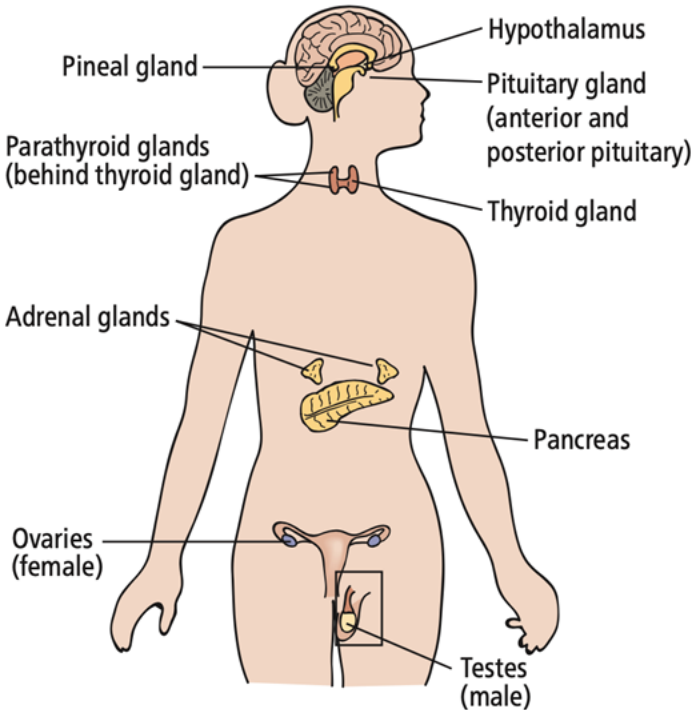

FIGURE 13.2

Human endocrine organs include the hypothalamus, pituitary gland (anterior and posterior pituitary), thyroid gland, parathyroid glands, adrenal glands, pancreas, ovaries and testes, and pineal gland.

Endocrine Organs and Their Hormones

Let's look at the human endocrine organs (Figure 13.2) and the hormones they make.

The *hypothalamus* is a part of the brain; it is the endocrine system's control center. Many of the hypothalamus's hormones regulate the activity of another nearby endocrine organ, the pituitary gland. The pituitary gland has two major parts: the anterior pituitary and the posterior pituitary.

Hormones released by the hypothalamus cause the anterior pituitary to act in certain ways, such as by producing and releasing hormones of its own. Meanwhile, hormones released by the hypothalamus can also be stored for later release by the posterior pituitary. Let's take a closer look.

The **anterior pituitary** is sometimes called the "master gland." This is because many of its hormones regulate the activity of other endocrine organs. For example, anterior pituitary hormones tell the thyroid gland, sex organs, and adrenal glands to release their hormones. The anterior pituitary also makes growth hormone and prolactin. **Growth hormone** does what its name suggests—it promotes growth. Too little growth hormone results in dwarfism, and too much results in gigantism (Figure 13.3). *Prolactin* stimulates milk production in nursing mothers.

The *posterior pituitary* stores and controls the release of hormones made by the hypothalamus. **Antidiuretic hormone** helps regulate the amount of water in the body. Specifically, it helps the body conserve water by instructing the kidneys to produce urine that is more concentrated. Alcohol inhibits the release of antidiuretic hormone. This is why people produce more urine—and sometimes become dehydrated—when they consume alcohol. *Oxytocin* stimulates contraction of the uterus during childbirth. Women whose labor does not progress, or who need to have labor induced, may be given pitocin, a synthetic form of oxytocin, to stimulate contractions.

FIGURE 13.3

This composite picture shows dwarfism (upper left) and gigantism (center) relative to a person of normal size (right). Dwarfism and gigantism result from too little or too much growth hormone respectively.

The *thyroid gland* makes thyroid hormones. *Thyroid hormones* are involved in metabolism, growth, and development. For example, thyroid hormones are necessary for proper brain development during childhood. Thyroid hormones contain iodine, and getting too little iodine can result in developmental problems. This is why iodine is added to many brands of table salt. The thyroid gland also makes *calcitonin*, which decreases calcium levels in the blood.

The *parathyroid glands*, which lie behind the thyroid gland, make parathyroid hormone. *Parathyroid hormone* increases calcium levels in the blood. It does this in three ways: It causes calcium to be released from bones, increases calcium absorption in the intestine, and decreases calcium excretion in urine. Maintaining appropriate calcium levels in the blood is important for many reasons. For example, you will see later in this chapter that muscles require just the right amount of calcium to function properly.

The *adrenal glands*, located above the kidneys, make epinephrine (also called adrenaline) and norepinephrine. *Epinephrine* and *norepinephrine* are involved in the "fight or flight" response. Signals from the sympathetic nervous system trigger the release of these hormones. The adrenal glands also produce glucocorticoids and mineralocorticoids. *Glucocorticoids* increase glucose levels in the blood; at certain times, your blood needs to deliver more glucose, the molecule that gives you energy, to your body's cells. *Mineralocorticoids* help regulate water and salt levels in the body.

The *pancreas* makes insulin and glucagon. These hormones regulate the amount of glucose in the blood. **Insulin** decreases blood glucose levels in two ways: It tells body cells to take in glucose, and it tells the liver to convert glucose into the storage substance glycogen. Glucagon increases blood glucose levels. *Glucagon* tells the liver to break down glycogen and release glucose. The control of blood glucose levels is an example of negative feedback and homeostasis: High blood glucose levels cause insulin to be released, and insulin causes blood glucose to decrease back to normal. Low blood glucose levels cause glucagon to be released, and glucagon causes blood glucose to increase back to normal (Figure 13.4).

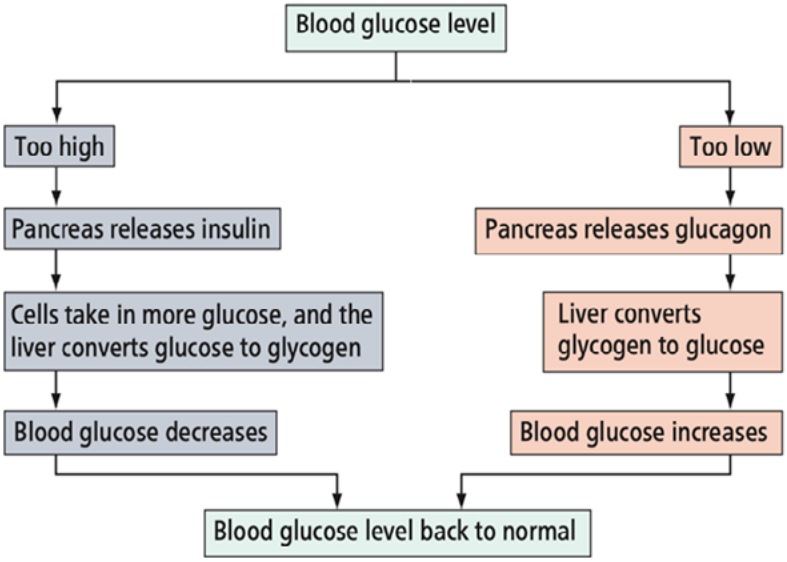

FIGURE 13.4

Negative feedback enables the body to maintain appropriate blood glucose levels. If blood glucose levels are too high or too low, the endocrine system responds and brings the levels back to normal.

The disease *diabetes* results when the pancreas doesn't make enough insulin or when the body's cells do not respond to insulin. In either case, blood glucose levels become abnormally high. Symptoms of diabetes include thirst, fatigue, weight loss, blurred vision, and nerve damage in the hands and feet.

People who have diabetes have to control their diets and monitor their blood glucose levels. Some require regular injections of insulin.

The sex organs—*ovaries* in women and *testes* in men—make sex hormones. Both women and men make all three types of sex hormones: estrogens, progestins, and androgens. Women make more **estrogens** and **progestins**.

These hormones regulate ovulation and the menstrual cycle and are involved in pregnancy. Estrogen also promotes breast development and fat storage in the hips and thighs. Men produce more **androgens**. Androgens such as testosterone are required for sperm production. Androgens also promote the development of male secondary sexual characteristics such as facial hair and increased muscle mass. It is this last effect of androgens that tempts some athletes to use anabolic steroids—synthetic versions of testosterone—to improve athletic performance. Unfortunately, steroids also have many negative side effects. They can cause aggressive behavior, mood swings, and irritability. In men, steroids also cause shrinking of the testicles, decreased sperm count, baldness, and breast development. In women, steroids disrupt the menstrual cycle, deepen the voice, and promote the growth of facial hair. In adolescents, steroids stunt growth and accelerate puberty.

The *pineal gland* produces the hormone melatonin. **Melatonin** regulates the body's internal clock, telling you when it is day and when it is night. Using light cues from the eyes, the pineal gland releases melatonin during the night hours. This is why some people use melatonin as a sleeping pill.

The major endocrine organs and the hormones they produce are summarized in Table 13.1.

Table 13.1 Major endocrine organs and the horomones they produce.

Endocrine Organ	Hormone	Hormone Type	Effect
Hypothalamus	Makes hormones that regulate the anterior pituitary and hormones released by the posterior pituitary (see below)		
Pituitary gland			
Anterior pituitary	Growth hormone	Protein	Stimulates growth
	Prolactin	Protein	Stimulates milk production
	Multiple hormones that stimulate other endocrine organs	Protein	Stimulate endocrine organs such as ovaries and testes, thyroid gland, and adrenal glands
Posterior pituitary (releases hormones made by hypothalamus)	Antidiuretic hormone	Protein	Promotes retention of water by kidneys
	Oxytocin	Protein	Stimulates contraction of uterus
Thyroid gland	Thyroid hormones	Protein	Stimulate growth and development; regulate metabolism
	Calcitonin	Protein	Decreases blood calcium levels
Parathyroid glands	Parathyroid hormone	Protein	Increases blood calcium levels
Adrenal glands	Epinephrine and norepinephrine	Protein	Promote "fight or flight" response
	Glucocorticoids	Steroid	Increase blood glucose levels
	Mineralocorticoids	Steroid	Regulate water and salt levels
Pancreas	Insulin	Protein	Decreases blood glucose levels
	Glucagon	Protein	Increases blood glucose levels
Sex organs			
Testes	Androgens	Steroid	Support sperm formation; promote male secondary sexual characteristics
Ovaries	Estrogens	Steroid	Maintain female reproductive system; promote female secondary sexual characteristics
	Progestins	Steroid	Promote uterine lining growth
Pineal gland	Melatonin	Protein	Regulates internal clock

READING CHECK

Some hormones come in pairs with opposing effects. Each pair helps maintain homeostasis in the body by regulating the amount of an important substance or molecule—often through feedback regulation. Name some pairs of hormones with opposing effects.

CHECK YOUR ANSWER

Calcitonin and parathyroid hormone together regulate blood calcium levels. Calcitonin decreases blood calcium levels, and parathyroid hormone increases blood calcium levels. Insulin and glucagon together regulate blood glucose levels. Insulin decreases blood glucose levels, and glucagon increases blood glucose levels.

To read more about hormones, check out the following websites:

http://www.biologyreference.com/Ho-La/Hormones.html

https://www.pituitary.org.uk/information/hormones/