20.1 Endocrine Glands

The endocrine system consists of glands and tissues that secrete hormones. **Hormones** are chemical signals that affect the activity of other glands or tissues. Hormones influence the metabolism of cells, the growth and development of body parts, and homeostasis. **Endocrine glands** are ductless; they secrete their hormones directly into the bloodstream for distribution throughout the body. They can be contrasted with exocrine glands, which have ducts and secrete their products into these ducts for transport to body cavities. For example, the salivary glands send saliva into the mouth by way of the salivary ducts.

Figure 20.1 depicts the locations of the endocrine glands in the body, and Table 20.1 lists the hormones they release. Each type of hormone has a different composition. Even so, hormones can be categorized as either peptides (which will include proteins, glycoproteins, and modified amino acids) or steroids. Protein hormones, such as insulin, must be administered by injection. If these hormones were taken orally, they would be acted on by digestive enzymes. Steroid hormones, such as those in birth control pills, can be taken orally.

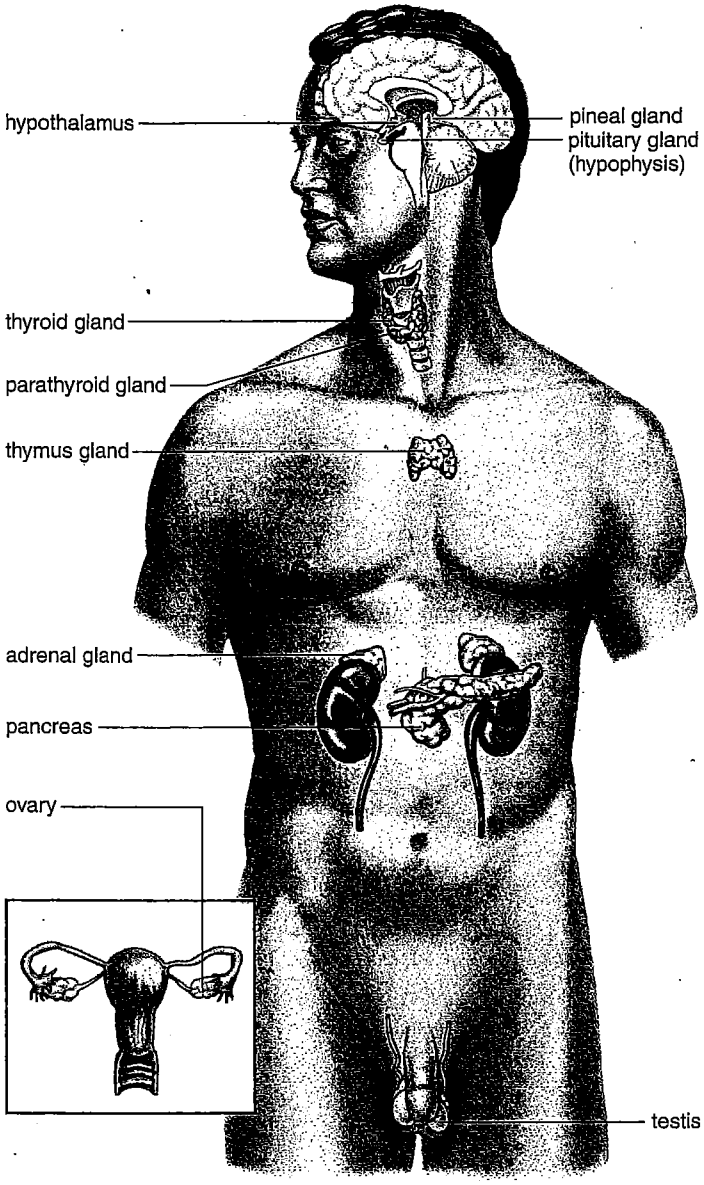


Figure 20.1 The endocrine system.
Anatomical location of major endocrine glands in the body. The hypothalamus and pituitary gland are located in the brain, the thyroid and parathyroids are located in the neck, and the adrenal glands and pancreas are located in the pelvic cavity. The gonads include the ovaries in females, located in the pelvic cavity, and the testes in males, located outside this cavity in the scrotum. Also shown are the pineal gland, located in the brain, and the thymus gland, which lies ventral to the thorax.

Hormones and Homeostasis

The chapter will give many examples of the close association between the endocrine and nervous systems. Like the nervous system, the endocrine system is intimately involved in homeostasis, the relative stability of the internal environment. Notice in Table 20.1 that several hormones directly affect the blood glucose, calcium, and sodium levels. Other hormones are involved in the maturation and function of the reproductive organs.

The secretion of hormones involved in maintaining homeostasis is usually controlled in two ways: by negative feedback and/or by antagonistic hormonal actions. When controlled by negative feedback, an endocrine gland can be sensitive to either the condition it is regulating or the blood level of the hormone it is producing. For example, when the blood glucose level rises, the pancreas produces insulin, which causes the liver to store glucose. The stimulus for the production of insulin is thereby inhibited, and the pancreas stops producing insulin. On the other hand, when the blood level of thyroid hormones rises, the anterior pituitary stops producing thyroid-stimulating hormones. These examples illustrate regulation by negative feedback.

The effect of a hormone can be controlled by the presence of an antagonistic hormone. The effect of insulin, for example, is offset by the production of glucagon by the pancreas. Insulin lowers the blood glucose level while glucagon raises it. Also, the thyroid lowers the blood calcium level, but the parathyroids raise the blood calcium level. In subsequent sections of this chapter, we will point out other instances in which hormones work opposite to one another, and thereby bring about the regulation of a substance in the blood.

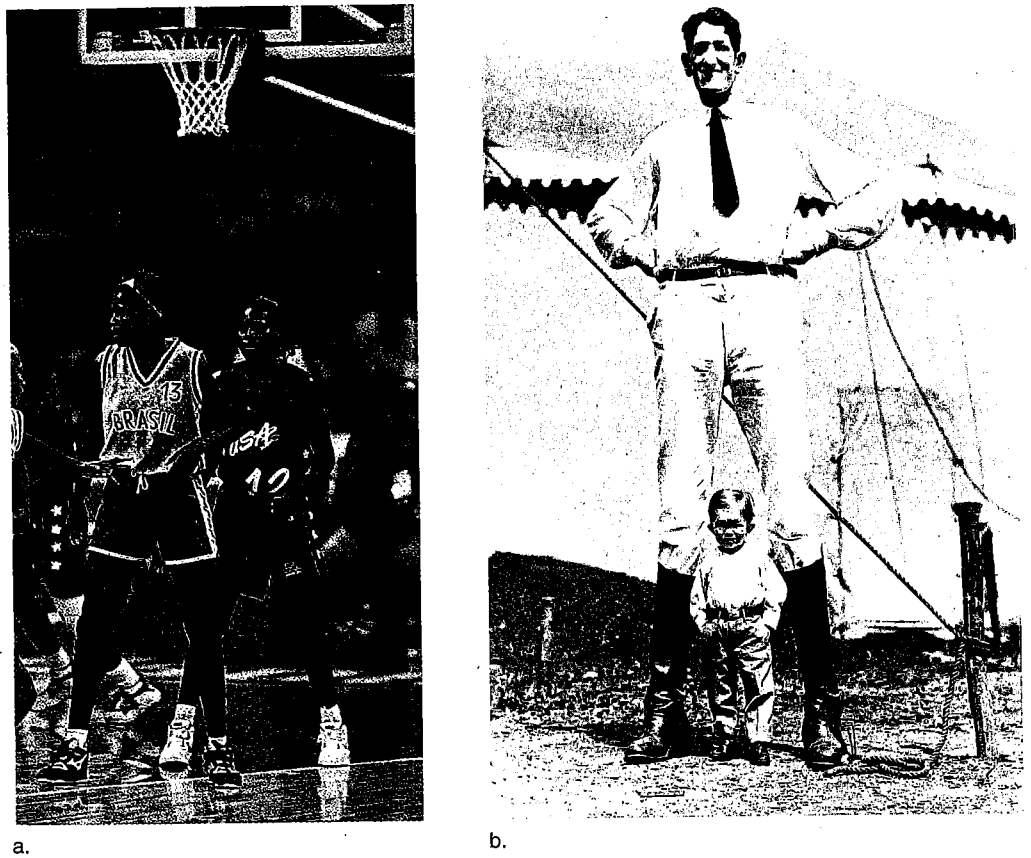
The effect of hormones is usually controlled in two ways: (1) negative feedback opposes their release, and (2) antagonistic hormones oppose each other's actions. The result is maintenance of a bodily substance or function within normal limits.

Effects of Growth Hormone

GH is produced by the anterior pituitary. The quantity is greatest during childhood and adolescence, when most body growth is occurring. If too little GH is produced during childhood, the individual has **pituitary dwarfism,** characterized by perfect proportions but small stature. If too much GH is secreted, a person can become a giant (Fig. 20.3). Giants usually have poor health, primarily because GH has a secondary effect on the blood sugar level, promoting an illness called diabetes mellitus (see p. 403).

On occasion, GH is overproduced in the adult, and a condition called **acromegaly** results. Since long bone growth is no longer possible in adults, only the feet, hands, and face (particularly the chin, nose, and eyebrow ridges) can respond, and these portions of the body become overly large (Fig. 20.4).

The amount of growth hormone produced during childhood affects the height of an individual.



a. b.

Figure 20.3 Effect of growth hormone.
a. The amount of growth hormone produced by the anterior pituitary during childhood affects the height of an individual. Plentiful growth hormone produces very tall basketball players. **b.** Too much growth hormone can lead to giantism, while an insufficient amount results in limited stature and even pituitary dwarfism.

Age 9 Age 16 Age 33 Age 52

Figure 20.4 Acromegaly.
Acromegaly is caused by overproduction of GH in the adult. It is characterized by enlargement of the bones in the face, the fingers, and the toes as a person ages.

20.3 Thyroid and Parathyroid Glands

The **thyroid gland** is a large gland located in the neck, where it is attached to the trachea just below the larynx (see Fig. 20.1). The parathyroid glands are embedded in the posterior surface of the thyroid gland.

Thyroid Gland

The thyroid gland is composed of a large number of follicles, each a small spherical structure made of thyroid cells filled with triiodothyronine (T_3), which contains three iodine atoms, and **thyroxine (T_4)**, which contains four iodine atoms.

Effects of Thyroid Hormones

To produce thyroxine and triiodothyronine, the thyroid gland actively acquires iodine. The concentration of iodine in the thyroid gland can increase to as much as 25 times that of the blood. If iodine is lacking in the diet, the thyroid gland is unable to produce the thyroid hormones. In response to constant stimulation by the anterior pituitary, the thyroid enlarges, resulting in a **simple goiter** (Fig. 20.5). Some years ago, it was discovered that the use of iodized salt allows the thyroid to produce the thyroid hormones, and therefore helps prevent simple goiter.

Thyroid hormones increase the metabolic rate. They do not have a target organ; instead, they stimulate all cells of the body to metabolize at a faster rate. More glucose is broken down and more energy is utilized.

If the thyroid fails to develop properly, a condition called **cretinism** results (Fig. 20.6). Individuals with this condition are short and stocky and have had extreme hypothyroidism (undersecretion of thyroid hormone) since infancy or childhood. Thyroid hormone therapy can initiate growth, but unless treatment is begun within the first two months of life, mental retardation results. The occurrence of hypothyroidism in adults produces the condition known as **myxedema,** which is characterized by lethargy, weight gain, loss of hair, slower pulse rate, lowered body temperature, and thickness and puffiness of the skin. The administration of adequate doses of thyroid hormones restores normal function and appearance.

In the case of hyperthyroidism (oversecretion of thyroid hormone), or Graves disease, the thyroid gland is overactive, and a goiter forms. This type of goiter is called **exophthalmic goiter.** The eyes protrude because of edema in eye socket tissues and swelling of the muscles that move the eyes. The patient usually becomes hyperactive, nervous, irritable, and suffers from insomnia. Removal or destruction of a portion of the thyroid by means of radioactive iodine is sometimes effective in curing the condition. Hyperthyroidism can also be caused by a thyroid tumor, which is usually detected as a lump during physical examination. Again, the treatment is surgery in combination with administration of radioactive iodine. The prognosis for most patients is excellent.

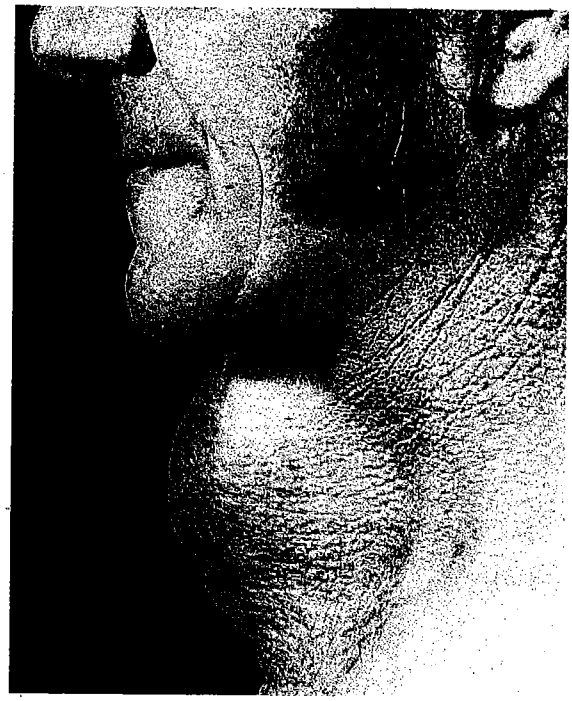


Figure 20.5 Simple goiter.
An enlarged thyroid gland is often caused by a lack of iodine in the diet. Without iodine, the thyroid is unable to produce its hormones, and continued anterior pituitary stimulation causes the gland to enlarge.

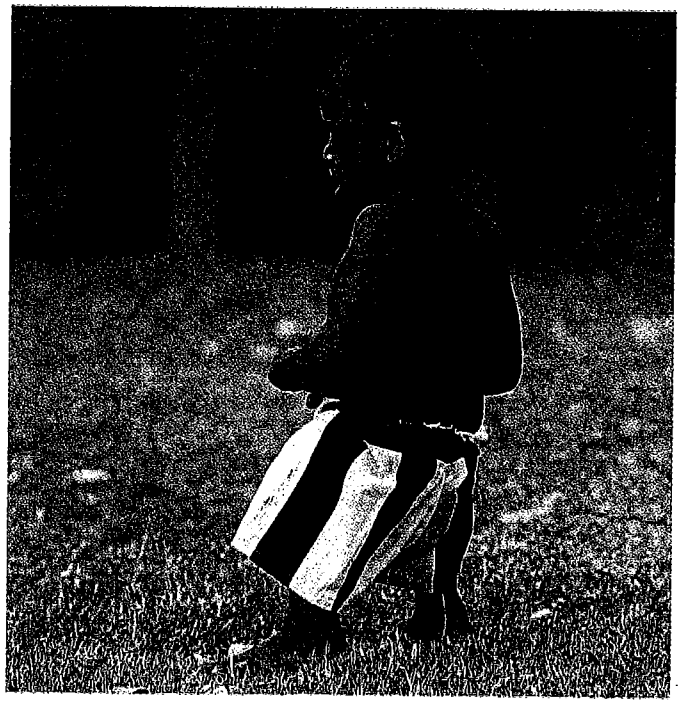


Figure 20.6 Cretinism.
Individuals who have hypothyroidism since infancy or childhood do not grow and develop as others do. Unless medical treatment is begun, the body is short and stocky; mental retardation is also likely.