CHAPTER 25

Hormones*†

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OBJECTIVES

1. Define the following terms:
   Endocrinology
   Steroid hormone
   Peptide hormone
   Amino acid–derived hormone
   Adenohypophysis
   Neurohypophysis
   Hypothalamic-pituitary axis
   Hormone receptor
2. List three physiological functions of hormones and discuss the mechanisms involved in the regulation of hormone secretion.
3. Discuss the significance of free and bound hormone.
4. State the two types of receptor-hormone interaction and the specific effect each type produces in a cell.
5. List the hormones synthesized in the hypothalamus and anterior pituitary gland and describe their principal physiological actions.
6. List the hormones stored in the posterior pituitary gland and describe their principal physiological actions.
7. List six major causes of endocrine disorders.
8. Discuss three analytical techniques used to measure hormones in body fluids.

KEY WORDS AND DEFINITIONS

Adenohypophysis: The anterior glandular lobe of the pituitary gland.

Autocrine: A mode of hormone action in which a hormone binds to receptors on or in the cell type that produced it and thereby affects the function of that cell.

Biorhythm: The cyclic occurrence of physiological events, such as a circadian rhythm.

Chromaffin System: Cells of the body that stain with chromium salts.

Endocrine System: The system of glands that release their secretions (hormones) directly into the circulatory system. In addition to the endocrine glands, included are the chromaffin system and the neurosecretory systems.

Endocrinology: The scientific study of the function and pathology of the endocrine glands.

Half-Life: In endocrinology, the time required for a hormone to fall to half its original concentration in the circulation (blood) or other specified body fluid.

Homeostasis: The process of keeping the internal environment of the body stable.

Hormone: A chemical substance that has a specific regulatory effect on the activity of a certain organ or organs or cell types.

Hypothalamic Hormones: Hormones of the hypothalamus that exert control over other organs, primarily the pituitary gland.

Hypothalamo-Hypophyseal System: A system of neurons, fiber tracts, endocrine tissue, and blood vessels that are responsible for the production and release of pituitary hormones into the systemic circulation.

Paracrine: A type of hormone function in which hormone synthesized in and released from one type of cell binds to the hormones receptor in nearby cells of a different type and affects their function.

Receptor: A molecular structure within a cell or on the surface characterized by (1) selective binding of a specific substance and (2) a specific physiological effect that accompanies the binding; examples are cell surface receptors for peptide hormones, neurotransmitters, antigens, complement fragments, and immunoglobulins and cytoplasmic receptors for steroid hormones.

A **hormone** is a chemical substance produced in the body by an organ, cells of an organ, or scattered cells that has a specific regulatory effect on the activity of an organ or organs. They are produced at one site in the body and exert their action(s) at distant sites through what is called the **endocrine system**. It is increasingly recognized that many hormones exert actions locally through what is termed the **paracrine** system. Other hormones exert their action on the cells of origin, regulating their own synthesis and secretion via an **autocrine** system. The classic endocrine hormones include insulin, thyroxine, and cortisol. Neurotransmitters and neurohormones are examples of the paracrine system, and certain growth factors that stimulate synthesis and secretion of true hormones from the same cell are examples of autocrine systems. Figure 25-1 shows the location of several endocrine glands in the body, and Table 25-1 summarizes the types of hormone actions.

CLASSIFICATION

Hormones are generally classified as (1) polypeptide or protein, (2) steroid, or (3) amino acid derivatives.

Polypeptide or Protein Hormones

Insulin, parathyroid hormone (PTH) and adrenocorticotrophin (ACTH) (see Chapters 22, 38, and 39, respectively) are

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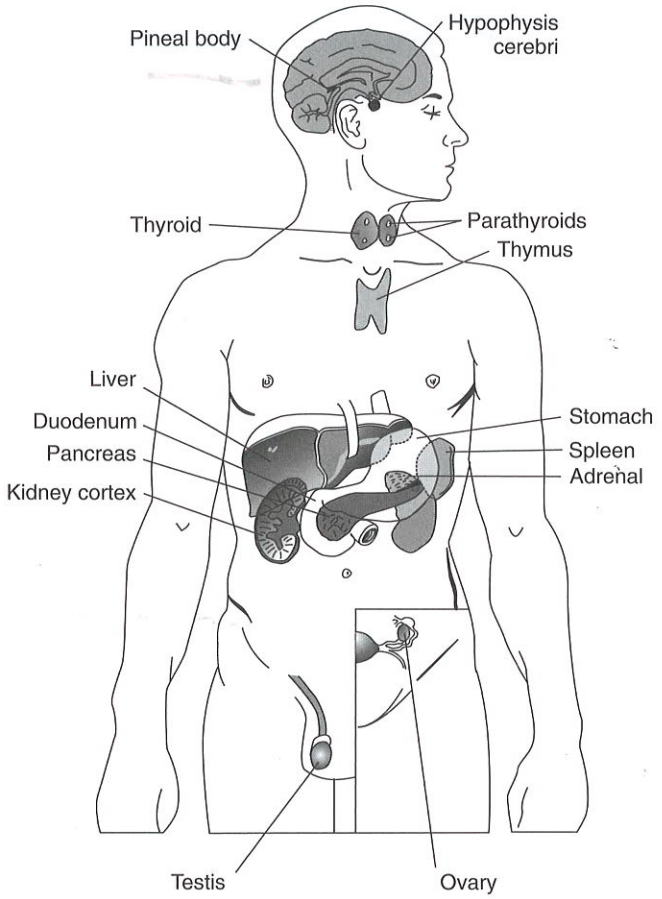

Figure 25-1 Location of the endocrine glands in humans. (Modified from Turner CD. General endocrinology, 4th ed, Philadelphia: WB Saunders, 1966.)

examples of peptide or protein hormones. These hormones are generally water soluble and circulate freely in plasma as the whole molecule or as active or inactive fragments. The **half-life** of these hormones in plasma is 10 to 30 minutes or less, and wide fluctuations in their concentrations may be seen in several physiological and pathological circumstances. These hormones initiate their response by binding to cell membrane receptors (on or in the membrane) and (usually) exciting a cellular "second messenger" system (such as ones involving cyclic adenosine monophosphate [AMP] within the cell) that brings about the specific actions of these hormones on the cell.

Steroid Hormones

Cortisol and estrogen are examples of steroid hormones (see Chapters 40 and 42, respectively). They are hydrophobic and insoluble in water. In plasma, these hormones circulate reversibly bound to transport proteins (e.g., cortisol binding globulin and sex-hormone binding globulin) with only a small fraction free or unbound available to exert physiological action.[4,6,12] The half-life of steroid hormones is 30 to 90 minutes. Free steroid hormones, being hydrophobic, enter the cell by passive diffusion and bind with intracellular receptors either in the cytoplasm or the nucleus.

Amino Acid–Related Hormones

Hormones that are amino acid derivatives, such as catecholamines and thyroxine (see Chapters 26 and 41, respectively), are water soluble, but circulate in plasma either free (catecholamines) or bound to proteins (thyroxine). For example, thyroxine binds avidly to three binding proteins and has a half-life of about 7 to 10 days, whereas the free catecholamines such as epinephrine have a very short half-life of a minute or less. Like the water-soluble peptide and protein hormones, these hormones interact with membrane-associated receptors and use a second messenger system.

THE ACTION OF HORMONES

The functions of hormones are broadly classified as (1) growth and development, (2) homeostatic control of metabolic pathways, and (3) regulation of energy production, use, and storage.

Growth and Development

Normal growth and development of the whole human organism is dependent on the complex integrative function of many hormones, including gonadal steroids (estrogen and androgen), growth hormone, cortisol, and thyroxine. Other hormones are responsible specifically for the growth and development of endocrine glands themselves and thus responsible for control of synthesis and secretion of other hormones. These are predominantly the hormones of the anterior pituitary gland and include the following:

- Gonadotrophins (luteinizing hormone [LH] and follicle-stimulating hormone [FSH]) regulate the development, growth, and function of the ovary and testis. These hormones in turn regulate pubertal growth; the development and maintenance of secondary sex characteristics; the growth, development, and maintenance of the skeleton and muscles; and the distribution of body fat (see Chapter 42).
- ACTH regulates the growth of the adrenal glands and the synthesis and secretion of adrenal gland hormones (see Chapter 39).
- Thyroid-stimulating hormone (TSH) regulates the growth of the thyroid gland and the iodination of amino acids to produce the thyroid hormones triiodothyronine and thyroxine (see Chapter 41).[1]

The production and release of these pituitary hormones are controlled by the **hypothalamic hormones** of the **hypothalamo-hypophyseal system.**

Homeostatic Control of Metabolic Pathways

Multiple metabolic pathways are under hormonal control. Important examples include regulation of blood glucose, and **homeostasis** of calcium, water, and electrolyte metabolism.

Regulation of Blood Glucose

In response to a glucose load, there is prompt release of insulin from the pancreas that regulates the dispersal of glucose into cells (fat, muscle, liver, brain) for the metabolism needed to produce energy from glucose. A number of counter-regulatory hormones come into play to further regulate this process to ensure that blood glucose levels do not become too low. These include glucagon, cortisol, epinephrine, and growth hormone.