

Chapter 11 - Endocrine System

11.1 Introduction

- A. The endocrine system is made up of the cells, tissues, and organs that secrete hormones into body fluids.
- B. The body has two kinds of glands, exocrine (secretes products into ducts) and endocrine (secrete products into body fluids to affect target cells).

11.2 General Characteristics of the Endocrine System (Fig. 11.1; Table 11.1)

- A. The endocrine system's function is to communicate with cells using chemicals called hormones.
- B. Endocrine glands and their hormones regulate a number of metabolic processes within cells, and the whole body.
- C. Their actions are precise, they only affect specific target cells.
- D. Endocrine glands include the pituitary gland, thyroid gland, parathyroid glands, adrenal glands, pancreas, and other hormone-secreting glands and tissues.

11.3 Hormone Action (Table 11.2)

- A. Hormones are steroids, amines, peptides, proteins, or glycoproteins.
- B. They can influence target cells even if they are present only in minute concentrations.
- C. Steroid Hormones (Fig. 11.3)
 - 1. Steroid hormones are lipid-soluble and can pass through cell membranes.
 - 2. Receptors for steroid hormones are located in the target cell's nucleus.
 - 3. The hormone-receptor complex binds with the DNA and activates specific genes that, in turn, direct the synthesis of specific proteins.
- D. Nonsteroid Hormones (Fig. 11.4)
 - 1. Nonsteroid hormones combine with receptors in target cell membranes; the receptors have a binding site and an activity site.
 - 2. The hormone-receptor complex (as first messenger) triggers a cascade of biological activity.
 - 3. The hormone-receptor complex generally activates a G protein, which then activates the enzyme adenylate cyclase that is bound to the inner cell membrane.
 - 4. This enzyme removes two phosphates from ATP to produce cyclic AMP (the second messenger), which in turn activates protein enzymes that activate proteins.
 - 5. These activated proteins induce changes in the cell.
 - 6. Not all nonsteroid hormones use cAMP; others use diacylglycerol (DAG) or inositol triphosphate (IP₃).
- E. Prostaglandins
 - 1. Prostaglandins are locally-produced lipids that affect the organ in which they are produced.
 - 2. Prostaglandins produce a variety of effects: some relax smooth muscle, others contract smooth muscle, some stimulate secretion of other hormones, and others influence blood pressure and inflammation.

11.4 Control of Hormonal Secretions

- A. Hormone levels are very precisely regulated.
- B. Control Mechanisms
 - 1. Release of tropic hormones from the hypothalamus controls secretions of the anterior pituitary.
 - 2. The nervous system influences certain endocrine glands directly.
 - 3. Other glands respond directly to changes in the internal fluid composition.
- C. Negative Feedback Systems (Figs. 11.5-11.6)
 - 1. Commonly, negative feedback mechanisms control hormonal releases.
 - 2. In a negative feedback system, a gland is sensitive to the concentration of the

3. substance it regulates or which regulates it.
3. When the concentration of the regulated substance reaches a certain level (high or low), it inhibits the gland from secreting more hormone until the concentration returns to normal.

11.5 Pituitary Gland (Figs. 11.7-11.8; Table 11.3)

- A. The pituitary gland is attached to the base of the brain and has an anterior lobe (anterior pituitary) and a posterior lobe (posterior pituitary).
- B. The brain controls the activity of the pituitary gland.
 1. Releasing hormones from the hypothalamus control the secretions of the anterior pituitary.
 - a. The releasing hormones are carried in the bloodstream directly to the anterior pituitary by hypophyseal portal veins.
 2. The posterior pituitary releases hormones into the bloodstream in response to nerve impulses from the hypothalamus.
- C. Anterior Pituitary Hormones
 1. The anterior pituitary consists mostly of epithelial tissue arranged around blood vessels and enclosed in a capsule of collagenous connective tissue.
 2. Growth hormone (GH) stimulates body cells to grow and reproduce; it also speeds the rate at which cells use carbohydrates and fats.
 - a. Growth hormone-releasing hormone from the hypothalamus increases the amount of GH released, GH release-inhibiting hormone inhibits its release.
 - b. Nutritional status affects the release of GH; more is released when nutrients are insufficient.
 3. Prolactin (PRL) promotes milk production following the birth of an infant.
 - a. The effect of PRL in males is less-well understood, although it may cause a deficiency of male sex hormones.
 4. Thyroid-stimulating hormone (TSH) controls the secretion of hormones from the thyroid gland.
 - a. Thyrotropin-releasing hormone (TRH) from the hypothalamus regulates the release of TSH.
 - c. As blood concentrations of thyroid hormones increases, secretions of TRH and TSH decrease.
 5. Adrenocorticotrophic hormone (ACTH) controls the secretion of hormones from the adrenal cortex.
 - a. It is regulated by corticotropin-releasing hormone (CRH) from the hypothalamus, and stress can also increase its release.
 6. Follicle-stimulating hormone (FSH) and luteinizing hormone (LH) are gonadotropins affecting the male and female gonads (testes and ovaries).
- D. Posterior Pituitary Hormones
 1. The posterior lobe consists of nerve fibers and neuroglial cells that support nerve fibers arising in the hypothalamus.
 2. Neurons in the hypothalamus produce antidiuretic hormone and oxytocin, which are stored in the posterior pituitary.
 3. Antidiuretic hormone (ADH) produces its effect by causing the kidneys to conserve water.
 - a. The hypothalamus regulates the secretion of ADH based on the amount of water in body fluids.
 4. Oxytocin plays a role in childbirth by contracting muscles in the uterine wall, and in milk-letdown by forcing milk into ducts from the milk glands.
 - a. Stretching of the uterus in the latter stages of pregnancy stimulates release of oxytocin.

- b. Suckling of an infant at the breast stimulates release of oxytocin after childbirth.

11.6 Thyroid Gland (Fig. 11.10)

- A. The thyroid gland is located below the larynx and consists of two broad lobes connected by an isthmus.
- B. Structure of the Gland
 - 1. The thyroid consists of secretory parts called follicles filled with hormone-storing colloid.
- C. Thyroid Hormones (Table 11.4)
 - 1. The follicular cells produce two iodine-containing hormones, thyroxine (T_4) (tetraiodothyronine) and triiodothyronine (T_3), that together regulate energy metabolism.
 - a. These two hormones increase the rate at which cells release energy from carbohydrates, enhance protein synthesis, and stimulate the breakdown and mobilization of lipids.
 - b. These hormones are essential for normal growth and development.
 - c. The hypothalamus and pituitary gland control release of thyroid hormones.
 - 2. Extrafollicular cells of the thyroid secrete calcitonin, which lowers blood levels of calcium and phosphate ions when they are too high.
 - a. Calcitonin increases the rate at which calcium is stored in bones and excreted in the urine.
 - b. Calcitonin secretion is regulated by negative feedback involving blood concentrations of calcium.

11.7 Parathyroid Glands (Fig. 11.11)

- A. The four, tiny parathyroids are located on the posterior of the thyroid.
- B. Structure of the Glands
 - 1. Parathyroid glands consist of tightly packed secretory cells covered by a thin capsule of connective tissue.
- C. Parathyroid Hormone (Fig. 11.12)
 - 1. Parathyroid hormone (PTH) increases blood calcium ion concentration and decreases phosphate ion concentration.
 - 2. PTH stimulates bone resorption by osteoclasts, which releases calcium into the blood.
 - 3. PTH also influences the kidneys to conserve calcium and causes increased absorption of calcium in the intestines.
 - 4. A negative feedback mechanism involving blood calcium levels regulates release of PTH.
- D. Calcitonin and PTH exert opposite effects in regulating calcium ion levels in the blood.

11.8 Adrenal Glands (Fig. 11.13)

- A. The adrenal glands sit atop the kidneys enclosed in a layer of fat.
- B. Structure of the Glands
 - 1. The pyramid-shaped glands consist of an inner adrenal medulla and an outer adrenal cortex.
 - 2. The adrenal medulla is made up of modified postganglionic neurons that are connected to the sympathetic nervous system.
 - 3. The adrenal cortex makes up most of the adrenal glands and consists of epithelial cells in three layers — an outer, middle, and an inner zone.
- C. Hormones of the Adrenal Medulla (Table 11.5)
 - 1. The adrenal medulla secretes epinephrine and norepinephrine into the blood stream.
 - 2. The effects of these hormones resemble those of the sympathetic division neurotransmitters of the same name, except that they last up to 10 times longer

- when they are secreted as hormones.
 - 3. They are used in times of stress and for “fight or flight.”
 - 4. Release of medullary hormones is regulated by nervous impulses from the central nervous system.
- D. Hormones of the Adrenal Cortex (Table 11.6)
 - 1. The cells of the adrenal cortex produce over 30 different steroids, some of which are vital to survival, the most important of which are aldosterone, cortisol, and the sex hormones.
 - 2. Aldosterone
 - a. Aldosterone, a mineralocorticoid, causes the kidneys to conserve sodium ions and thus water, and to excrete potassium ions.
 - b. Aldosterone is secreted in response to decreasing blood volume and blood pressure as a result of changes in the kidney.
 - 3. Cortisol (Fig. 11.14)
 - a. Cortisol, a glucocorticoid, influences the metabolism of glucose, protein, and fat in response to conditions that stress the body and require a greater supply of energy in the bloodstream.
 - b. A negative feedback mechanism involving CRH from the hypothalamus and ACTH from the anterior pituitary controls the release of cortisol.
 - c. Stress, injury, or disease can also trigger increased release of cortisol.
 - 4. Adrenal Sex Hormones
 - a. Sex hormones, produced in the inner zone, are mostly of the male type, but can be converted to female hormones in the skin, liver, and adipose tissues.
 - b. These hormones supplement those released by the gonads and may stimulate early development of reproductive organs.

11.9 Pancreas (Fig. 11.15)

- A. The pancreas secretes hormones as an endocrine gland, and digestive juices to the digestive tract as an exocrine gland.
- B. Structure of the Gland (Figs. 11.15-11.16)
 - 1. The pancreas is an elongated organ posterior to the stomach.
 - 2. Its endocrine portions are the islets of Langerhans that include two cell types — alpha cells that secrete glucagon, and beta cells that secrete insulin.
- C. Hormones of the Pancreatic Islets (Fig. 11.17)
 - 1. Glucagon increases the blood levels of glucose by stimulating the breakdown of glycogen and the conversion of noncarbohydrates into glucose.
 - a. The release of glucagon is controlled by a negative feedback system involving low blood glucose levels.
 - 2. Insulin decreases the blood levels of glucose by stimulating the liver to form glycogen, increasing protein synthesis, and stimulating adipose cells to store fat.
 - a. The release of insulin is controlled by a negative feedback system involving high blood glucose levels.
 - 3. Insulin and glucagon coordinate to maintain a relatively stable blood glucose concentration.

11.10 Other Endocrine Glands

- A. Pineal Gland
 - 1. The pineal gland, near the upper portion of the thalamus, secretes melatonin, which is involved in the regulation of circadian rhythms of the body.
- B. Thymus Gland
 - 1. The thymus gland, lying between the lungs under the sternum, secretes thymosins that affect production and differentiation of T lymphocytes that are important in immunity.

- C. Reproductive Glands
 - 1. The ovaries produce estrogen and progesterone.
 - 2. The placenta produces estrogen, progesterone, and a gonadotropin.
 - 3. The testes produce testosterone.
- D. Digestive Glands
 - 1. The digestive glands secrete hormones associated with the processes of digestion.
- E. Other Hormone Producing Organs
 - 1. The heart secretes atrial natriuretic peptide affecting sodium and the kidneys secrete erythropoietin for blood cell production.

11.11 Stress and Health

- A. Factors that serve as stressors to the body produce stress and threaten homeostasis.
- B. Types of Stress
 - 1. Stress may be physical, psychological, or some combination of the two.
 - 2. Physical stress threatens the survival of tissues, such as extreme cold, prolonged exercise, or infections.
 - 3. Psychological stress results from real or perceived dangers, and includes feelings of anger, depression, fear, and grief; sometimes even pleasant stimuli cause stress.
- C. Response to Stress
 - 1. Responses to stress are designed to maintain homeostasis.
 - 2. The hypothalamus controls the general stress syndrome, which involves increased sympathetic activity and increased secretion of cortisol, glucagon, growth hormone, and antidiuretic hormone.