# Chapter 13: Endocrine System

## I. Introduction

(Outcome 13.1.1) A. The endocrine glands secrete chemicals that act on other cells.

(Outcome 13.1.1) B. Hormones diffuse from the interstitial fluid into the bloodstream and eventually act on cells, called target cells, some distance away.

(Outcome 13.1.1) C. Paracrine secretions are enter the interstitial fl uid but affect only nearby cells.

(Outcome 13.1.1) D. Autocrine secretions are affect only the cell secreting the substance.

(Outcome 13.1.1) E. Exocrine glands secrete substances into body surfaces.

## II. General Characteristics of the Endocrine System

(Outcome 13.2.2) A. A hormone's target cells have specific receptors that other cells lack.

(Outcome 13.2.3) B. Endocrine glands and their hormones control the rates of certain chemical reactions; aid in transporting substances through membranes; and help regulate water balance, electrolyte balance, and blood pressure.

(Outcome 13.2.3) C. Endocrine hormones also play vital roles in reproduction, development, and growth.

(Outcome 13.2.3) D. The larger endocrine glands are the pituitary gland, thyroid gland, parathyroid glands, adrenal glands, and pancreas.

## III. Hormone Action

A. Introduction

(Outcome 13.3.4) 1. Hormones are released into the extracellular spaces surrounding endocrine cells.

(Outcome 13.3.4) 2. They diffuse into the bloodstream and are carried to all parts of the body.

B. Chemistry of Hormones

1. Introduction

(Outcome 13.3.4) a. Most hormones are organic compounds.

(Outcome 13.3.4) b. Nonsteroid hormones include amines, peptides, proteins, and glycoproteins.

2. Steroid Hormones

(Outcome 13.3.4) a. Steroids are lipids that include complex rings of carbon and hydrogen atoms.

(Outcome 13.3.4) b. Examples of steroid hormones are testosterone and the estrogens.

3. Nonsteroid Hormones

(Outcome 13.3.4) a. Examples of hormones called amines are norepinephrine and epinephrine.

(Outcome 13.3.4) b. Protein hormones are composed of long chains of amino acids that are linked and folded into specific molecular structures.

(Outcome 13.3.4) c. Examples of protein hormones are glycoproteins, peptide hormones, prostaglandins.

(Outcome 13.3.4) d. Hormones called glycoproteins are produced by anterior pituitary gland.

(Outcome 13.3.4) e. Peptide hormones are short chains of amino acids.

(Outcome 13.3.4) f. Peptide hormones come from posterior pituitary gland.

(Outcome 13.3.4) g. Prostaglandins are paracrine substances and are produced in a wide variety of cells, including those of the liver, kidneys, heart, lungs, thymus, pancreas, brain, and reproductive organs.

C. Actions of Hormones

1. Introduction

(Outcome 13.3.5) a. Hormones exert their effects by altering metabolic processes.

(Outcome 13.3.5) b. The more receptors the hormone binds on its target cell, the greater the response.

(Outcome 13.3.5) c. Up-regulation is an increase in the number of receptors on a target cell, which often occurs as a response to a prolonged decrease in the level of a hormone.

2. Steroid Hormones and Thyroid Hormones

(Outcome 13.3.5) a. Steroid and thyroid hormones are insoluble in water but are soluble in the lipids that make up the bulk of cell membranes.

(Outcome 13.3.5) b. Steroid and thyroid hormones can diffuse into cells relatively easily and are able to enter any cell in the body, although only target cells will respond.

(Outcome 13.3.5) c. Once steroid and thyroid hormones are inside a cell, they combine with specific protein receptors.

(Outcome 13.3.5) d. The binding of a these hormones to the receptor usually protein.

(Outcome 13.3.5) e. Activated genes code for a mRNA and the latter translated into a protein.

(Outcome 13.3.5) f. The new proteins may be ,
and they bring about cellular changes.

3. Nonsteroid Hormones

(Outcome 13.3.5) a. A nonsteroid hormone usually binds with receptors located target cell membrane.

(Outcome 13.3.5) b. When a nonsteroid hormone binds to a membrane receptor, this causes the receptor's activity site to interact with other membrane proteins.

(Outcome 13.3.5) c. Receptor binding may alter .

(Outcome 13.3.5) d. A first messenger is the hormone that triggers this first step in what becomes a cascade of biochemical activity.

(Outcome 13.3.5) e. Second messengers are the biochemicals in the cell that induce the changes leading to the hormone effect.

(Outcome 13.3.5) f. Many hormones use cyclic adenosine monophosphate as a second messenger.

(Outcome 13.3.5) g. G proteins are activated by resulting hormone-receptor complex activates a protein.

(Outcome 13.3.5) h. Adenylate cyclase is activated by G protein.

(Outcome 13.3.5) i. Adenylate cyclase functions to two phosphates from ATP and reconnects the exposed oxygen, forming cyclic AMP.

(Outcome 13.3.5) j. Cyclic AMP activates another set of enzymes called protein kinases that transfer phosphate groups from ATP molecules to protein substrate molecules, a process called phosphorylation.

(Outcome 13.3.5) k. Protein kinases function to various cellular processes, bringing about the effect of that particular hormone.

(Outcome 13.3.5) l. Phosphorylated substrates may be converted from to active forms.

(Outcome 13.3.5) m. Activated proteins then alter various cellular processes, bringing about the effect of that particular hormone.

(Outcome 13.3.5) n. Cellular responses to second messenger activation include altering membrane permeabilities, activating enzymes, promoting synthesis of certain proteins, stimulating or inhibiting specific metabolic pathways, promoting cellular movements, and initiating secretion of hormones and other substances.

(Outcome 13.3.5) o. Hormones whose actions require cyclic AMP include G protein, protein kinases.

(Outcome 13.3.5) p. An example of another second messenger is protein kinases.

(Outcome 13.3.5) q. In another mechanism, a hormone binding its receptor increases calcium ion concentration in the cell.

(Outcome 13.3.5) r. Calcium ions bind to the protein calmodulin, altering its molecular structure in a way that activates the molecule.

(Outcome 13.3.5) s. Activated calmodulin functions to interact with enzymes, altering their activities and thus eliciting diverse response.

(Outcome 13.3.5) t. Cells are highly sensitive to changes in concentration of nonsteroid hormones because of such rapid amplification.

D. Prostaglandins

(Outcome 13.3.5) 1. Prostaglandins are paracrine substances, acting locally, that are in small amounts, but potent.

(Outcome 13.3.5) 2. Some prostaglandins regulate cellular responses to hormones.

(Outcome 13.3.5) 3. The variety of effects prostaglandins can produce include some prostaglandins relax smooth muscle in the airways of the lungs and in the blood vessels, dilating these passageways.

**IV. Control of Hormone Secretion**

A. Introduction

(Outcome 13.4.6, 13.4.7) 1. Hormones with short half-lives of ten minutes would start out at 100% of its blood concentration, and if secretion were to stop, it would drop to 50% in ten minutes, 25% in another ten minutes, 12.5% in another ten minutes, and so on.

(Outcome 13.4.6, 13.4.7) 2. Hormones are continually excreted in urine and broken down by enzymes in the liver.

(Outcome 13.4.6, 13.4.7) 3. Increasing or decreasing blood levels of hormones requires increased or decreased secretion.

B. Control Sources

(Outcome13.4.6, 13.4.7 ) 1. Control of hormone secretion is essential to maintaining the internal environment.

(Outcome 13.4.6, 13.4.7) 2. The hypothalamus controls the anterior pituitary gland's release of hormones.

(Outcome 13.4.6, 13.4.7) 3. Tropic hormones stimulate some glands.

(Outcome 13.4.6, 13.4.7) 4. An example of an endocrine organ directly stimulated by the nervous system is adrenal medulla.

(Outcome 13.4.6, 13.4.7) 5. Some endocrine glands respond to changes in the composition of the internal environment.

(Outcome 13.4.6, 13.4.7) 6. As a result of relatively stable, hormone levels remain relatively stable.

**V. – X. Pituitary Gland —Other Endocrine Glands**

A. Introduction

(Outcome 13.5.8) 1. The pituitary gland is located at the base of the brain.

(Outcome 13.5.8) 2. The infundibulum is the pituitary stalk.

(Outcome 13.5.8) 3. The two portions of the pituitary are anterior lobe and a posterior lobe.

(Outcome 13.5.8) 4. The anterior lobe secretes the following hormones: growth hormone (GH), thyroid-stimulating hormone (TSH), adrenocorticotropic hormone (ACTH), follicle-stimulating hormone (FSH), luteinizing hormone (LH), and prolactin (PRL).

(Outcome 13.5.8) 5. The posterior pituitary secretes the following hormones: antidiuretic hormone (ADH) and oxytocin (OT). The cell bodies of these neurons are in the hypothalamus.

(Outcome 13.5.10) 6. The brain controls most of the pituitary gland's activities.

(Outcome 13.5.10) 7. The posterior pituitary receives impulses from axons.

(Outcome 13.5.10) 8. Other endocrine glands from the hypothalamus controls the anterior pituitary.

(Outcome 13.5.10) 9. The hypophyseal portal veins are that pass downward along the pituitary stalk and give rise to a second capillary bed in the anterior lobe.

B. Anterior Pituitary Hormones

(Outcome 13.5.8) 1. Somatotropes secrete GH.

(Outcome 13.5.8) 2. Mammotropes secrete PRL.

(Outcome 13.5.8) 3. Thyrotropes secrete TSH.

(Outcome 13.5.8) 4. Corticotropes secrete ACTH.

(Outcome 13.5.8) 5. Gonadotropes secrete FSH and LH.

(Outcome 13.5.8) 6. Actions of growth hormone are stimulates cells to enlarge and more rapidly divide. It enhances the movement of amino acids through cell membranes and increases the rate of protein synthesis. GH also decreases the rate at which cells use carbohydrates and increases the rate at which they use fats.

(Outcome 13.5.10) 7. The secretion of GH is controlled by two biochemicals from the hypothalamus.

(Outcome 13.5.9) 8. Actions of prolactin are promotes milk production. No normal physiological role for this hormone in human males has been fi rmly established. Abnormally elevated levels of the hormone can disrupt sexual function in both sexes.

(Outcome 13.5.10) 9. The secretion of PRL is under inhibitory control by dopamine from the hypothalamus.

(Outcome 13.5.9) 10. Actions of thyroid-stimulating hormone are controls secretion of certain hormones from the thyroid gland. TSH can also stimulate growth of the gland, and abnormally high TSH levels may lead to an enlarged thyroid gland, or goiter.

(Outcome 13.5.10) 11. The secretion of TSH is controlled by producing thyrotropin-releasing hormone (TRH).

(Outcome 13.5.9) 12. The actions of adrenocorticotropic hormone are controls the manufacture and secretion of certain hormones from the outer layer (cortex) of the adrenal gland.

(Outcome 13.5.10) 13. The secretion of ACTH is controlled by corticotropin-releasing hormone (CRH).

(Outcome 13.5.8) 14. Gonadotropins are both follicle-stimulating hormone and luteinizing hormone are glycoproteins.

(Outcome 13.5.9) 15. The actions of follicle-stimulating hormone are stimulates the production of sperm cells in the testes.

(Outcome 13.5.9) 16. The actions of luteinizing hormone are promotes secretion of sex hormones in both males and females and is essential for release of egg cells from the ovaries.

(Outcome 13.5.10) 17. The secretion of FSH and LH is controlled by sex hormones in both males and females and is essential for release of egg cells from the ovaries.

C. Posterior Pituitary Hormones

(Outcome 13.5.8) 1. The posterior pituitary consists of neuroglia (pituicytes) and the axons of hypothalamic neurons.

(Outcome 13.5.8) 2. Specialized neurons in the hypothalamus produce two hormones called antidiuretic hormone (also known as vasopressin) and oxytocin.

(Outcome 13.5.10) 3. The hormones produced in the hypothalamus travel down axons through the pituitary stalk to the posterior pituitary and are stored in vesicles (secretory granules) near the ends of the axons.

(Outcome 13.5.9) 4. The actions of antidiuretic hormone are produces its antidiuretic effect by reducing the volume of water that the kidneys excrete.

(Outcome 13.5.10) 5. The secretion of ADH is controlled by reducing the volume of water that the kidney.

(Outcome 13.5.9) 6. The actions of oxytocin are can contract smooth muscle in the uterine wall, playing a role in the later stages of childbirth. The uterus becomes more sensitive to oxytocin's effects during pregnancy. Stretching of uterine and vaginal tissues late in pregnancy, as the fetus grows, initiates sensory impulses to the hypothalamus, which then signals the posterior pituitary to release oxytocin, which, in turn, stimulates the uterine contractions of labor.

(Outcome 13.5.10) 7. The secretion of oxytocin is controlled by .

D. Thyroid Gland- Introduction

(Outcome 13.6.8) 1. The thyroid gland consists of two large lateral lobes connected by a broad isthmus.

(Outcome 13.6.8) 2. The thyroid gland is located below the larynx (voicebox) on either side and anterior to the trachea.

E. Structure of the Gland

(Outcome 13.6.8) 1. Follicles are made up of many secretory parts.

(Outcome 13.6.8) 2. Colloid is a clear viscous substance.

(Outcome 13.6.8) 3. Thyroglobulin is consists primarily of a glycoprotein.

(Outcome 13.6.8) 4. Extrafollicular cells are located outside the follicles.

(Outcome 13.6.8) 5. The follicular cells produce and secrete hormones that are either stored in the colloid or released into nearby capillaries.

F. Thyroid Hormones

(Outcome 13.6.8) 1. The three hormones produced by the thyroid gland are thyroxine, triiodothyronine, and calcitonin.

(Outcome 13.6.9) 2. The actions of thyroxine and triiodothyronine are increase the rate at which cells release energy from carbohydrates, enhance the rate of protein synthesis, and stimulate breakdown and mobilization of lipids. These hormones are the major factors determining how many calories the body must consume at rest to maintain life, which is measured as the basal metabolic rate (BMR). The two hormones are essential for normal growth and development and for maturation of the

nervous system. TSH from the anterior pituitary gland controls the levels of thyroid hormones.

(Outcome 13.6.10) 3. The secretion of $T_3$ and $T_4$ are controlled by TSH from the anterior pituitary gland.

(Outcome 13.6.10) 4. Follicular cells require iodine salts (iodides) to produce $T_3$ and $T_4$.

(Outcome 13.6.10) 5. The action of calcitonin is control of blood calcium and phosphate ion concentrations. It helps lower concentrations of calcium and phosphate ions by decreasing the rate at which they leave the bones and enter extracellular fluids by inhibiting the bone-destroying activity of osteoclasts.

(Outcome 13.6.10) 6. The secretion of calcitonin is controlled by high blood calcium ion concentration.

G. Parathyroid Glands- Introduction

(Outcome 13.7.8) 1. Parathyroid glands are located the posterior surface of the thyroid gland.

(Outcome 13.7.8) 2. Usually a person has four parathyroid glands.

H. Structure of the Glands

(Outcome 13.7.8) 1. Each parathyroid gland is covered by a thin capsule of connective tissue.

(Outcome 13.7.8) 2. The body of a parathyroid gland consists of many tightly packed secretory cells closely associated with capillary networks.

I. Parathyroid Hormone

(Outcome 13.7.9) 1. The action of PTH is increases blood calcium ion concentration and decreases blood phosphate ion concentration through actions in the bones, kidneys, and intestines.

(Outcome 13.7.10) 2. The secretion of PTH is controlled by as bone resorption increases, calcium and phosphate ions are released into the blood. At the same time, PTH causes the kidneys to conserve blood calcium ions and to excrete more phosphate ions in the urine.

J. Adrenal Glands- Structure of the Glands

(Outcome 13.8.8) 1. The adrenal glands are shaped like pyramids.

(Outcome 13.8.8) 2. The two parts of an adrenal gland are adrenal medulla and adrenal cortex.

(Outcome 13.8.8) 3. The adrenal medulla consists of irregularly shaped cells grouped around blood vessels.

(Outcome 13.8.8) 4. The adrenal cortex is composed of closely packed masses of epithelial layers that form outer, middle, and inner zones the zona glomerulosa, the zona fasciculata, and the zona reticularis.

(Outcome 13.8.8) 5. The three layers of the adrenal cortex are zona glomerulosa, the zona fasciculata, and the zona reticularis.

K. Hormones of the Adrenal Medulla

(Outcome 13.8.8) 1. The two hormones released by the adrenal medulla are epinephrine, norepinephrine.

(Outcome 13.8.9) 2. The actions of epinephrine and norepinephrine are a type of amine hormone called a catecholamine, and they have similar molecular structures and physiological functions.

(Outcome 13.8.10) 3. The secretion of epinephrine and norepinephrine are controlled by different physiological conditions.

L. Hormones of the Adrenal Cortex

1. Introduction

(Outcome 13.8.8) a. The adrenal cortex produces more than thirty different steroids.

(Outcome 13.8.8) b. The most important adrenal cortical hormones are aldosterone, cortisol, and certain sex hormones.

2. Aldosterone

(Outcome 13.8.8, 13.8.9) a. Aldosterone is secreted by cells and is called a mineralocorticoid because it helps regulate the concentration of mineral electrolytes, such as sodium and potassium ions.

(Outcome 13.8.9) b. The actions of aldosterone are causes the kidney to conserve sodium ions and to excrete potassium ions.

(Outcome 13.8.10) c. The secretion of aldosterone is controlled by renin-angiotensin system.

3. Cortisol

(Outcome 13.8.8, 13.8.9) a. Cortisol is secreted by protein and fat metabolism and is called a glucocorticoid because it affects glucose metabolism.

(Outcome 13.8.9) b. The actions of cortisol are inhibits the synthesis of protein in various tissues, increasing the blood concentration of amino acids.

(Outcome 13.8.10) c. The secretion of cortisol is controlled by feedback loop.

4. Sex Hormones

(Outcome 13.8.8) a. The sex hormones are secreted by cells in the inner zone.

(Outcome 13.8.9) b. The actions of the sex hormones are may contribute to early development of the reproductive organs.

(Outcome 13.8.8) c. Examples of sex hormones are androgens and estrogens.

M. Pancreas-Structure of the Gland

(Outcome 13.9.8) 1. The pancreas is located posterior to the stomach and partly between the parietal peritoneum and the posterior abdominal wall.

(Outcome 13.9.8) 2. The endocrine portion of the pancreas consists of cells grouped around blood vessels.

(Outcome 13.9.8) 3. Three cell types of the pancreatic islets are alpha cells, beta cells, and delta cells.

(Outcome 13.9.8) 4. Alpha cells secrete glucagon.

(Outcome 13.9.8) 5. Beta cells secrete insulin.

(Outcome 13.9.8) 6. Delta cells secrete somatostatin.

N. Hormones of the Pancreatic Islets

(Outcome 13.9.9) 1. The actions of glucagon are stimulates the liver to break down glycogen into glucose (glycogenolysis) and to convert noncarbohydrates, such as amino acids, into glucose (gluconeogenesis). Glucagon also stimulates breakdown of fats into fatty acids and glycerol.

(Outcome 13.9.10) 2. The secretion of glucagon is controlled by a negative feedback system.

(Outcome 13.9.9) 3. The actions of insulin are decreases the concentration of blood glucose, promotes transport of glucose and amino acids into cells, and increases

glycogen and protein synthesis. It also stimulates adipose cells to synthesize and store fat.

(Outcome 13.9.10) 4. The secretion of insulin is controlled by negative feedback system sensitive to the concentration of blood glucose.

(Outcome 13.9.9) 5. The function of somatostatin is help regulate glucose metabolism by inhibiting secretion of glucagon and insulin, but its inhibitory effect in the pancreas is not strong.

O. Other Endocrine Glands

(Outcome 13.10.8) 1. The pineal gland is located deep between the cerebral hemispheres, where it attaches to the upper portion of the thalamus near the roof of the third ventricle.

(Outcome 13.10.8) 2. The pineal gland produces the hormone melatonin.

(Outcome 13.10.9) 3. The functions of melatonin are synthesized from serotonin. Varying patterns of light and dark outside the body control the gland's activities.

(Outcome 13.10.8) 4. The thymus gland is located the mediastinum posterior to the sternum and between the lungs.

(Outcome 13.10.8) 5. The thymus gland secretes a group of hormones called thymosins.

(Outcome 13.10.9) 6. The function of thymosin is affect production and differentiation of certain white blood cells.

(Outcome 13.10.8) 7. Reproductive organs that secrete hormones are testes, ovaries, and placenta.

(Outcome 13.10.8) 8. Examples of hormones produced by reproductive organs are testosterone, estrogens and progesterone.

(Outcome 13.10.8) 9. The hormone produced by the heart is natriuretic peptides.

(Outcome 13.10.8) 10. The hormone produced by the kidneys is erythropoietin.

**XI. Stress and Its Effects**

A. Introduction

(Outcome 13.11.11) 1. A stressor is a factor capable of stimulating such a response.

(Outcome 13.11.11) 2. Stress is the condition it produces in the body.

B. Types of Stress

(Outcome 13.11.11) 1. Examples of physical stress include extreme heat or cold, decreased oxygen concentration, infections, injuries, prolonged heavy exercise, and loud sounds inflict physical stress. Unpleasant or painful sensations often accompany physical stress.

(Outcome 13.11.11) 2. Examples of psychological stress are results from thoughts about real or imagined dangers, personal losses, unpleasant social interactions (or lack of social interactions), or any threatening factors. Feelings of anger, fear, grief, anxiety, depression, and guilt cause psychological stress.

C. Responses to Stress

(Outcome 13.11.12) 1. The general stress syndrome is the hypothalamus controls the response to stress.

(Outcome 13.11.12) 2. Major events of the general stress syndrome are response proceeds through two stages: the immediate "alarm" stage and the long-term "resistance" stage, and works to maintain homeostasis.

**XII. Life-Span Changes**

(Outcome 13.12.13) A. General changes in the glands of the endocrine system are decrease in size and increase in the proportion of each gland that is fibrous in nature. At the cellular level, lipofuscin pigment accumulates as glands age. Hormone levels change with advancing years.

(Outcome 13.12.13) B. Treatments for endocrine disorders include aging supplement deficient hormones, remove part of an overactive gland, or use drugs to block the action of an overabundant hormone.

(Outcome 13.12.13) C. Levels of antidiuretic hormone increase with age and as a result, the kidneys slowed elimination.

(Outcome 13.12.13) D. The decrease of calcitonin levels with age increases the risk of osteoporosis.

(Outcome 13.12.13) E. The most obvious changes in endocrine function involve glucose regulation.