

Unit 9: The Endocrine System

I. The Endocrine System

- A. Second-messenger system of the body
- B. Uses chemical messengers (hormones) that are released into the blood
- C. Hormones control several major processes
 - 1. Reproduction
 - 2. Growth and development
 - 3. Mobilization of body defenses
 - 4. Maintenance of much of homeostasis
 - 5. Regulation of metabolism

II. Hormone Overview

- A. Hormones are produced by specialized cells
- B. Cells secrete hormones into extracellular fluids
- C. Blood transfers hormones to target sites
- D. These hormones regulate the activity of other cells

III. The Chemistry of Hormones

- A. Hormones are classified chemically as
 - 1. Amino acid-based, which includes
 - a. Proteins
 - b. Peptides
 - c. Amines
 - 2. Steroids—made from cholesterol
 - 3. Prostaglandins—made from highly active lipids

IV. Mechanisms of Hormone Action

- A. Hormones affect only certain tissues or organs (target cells or target organs)
- B. Target cells must have specific protein receptors
- C. Hormone-binding alters cellular activity

V. Effects Caused by Hormones

- A. Changes in plasma membrane permeability or electrical state
- B. Synthesis of proteins, such as enzymes
- C. Activation or inactivation of enzymes
- D. Stimulation of mitosis
- E. Promotion of secretory activity

VI. The Chemistry of Hormones

A. Two mechanisms in which hormones act

1. Direct gene activation
2. Second-messenger system

B. Direct Gene Activation

(Steroid Hormone Action)

1. Diffuse through the plasma membrane of target cells
2. Enter the nucleus
3. Bind to a specific protein within the nucleus
4. Bind to specific sites on the cell's DNA
5. Activate genes that result in synthesis of new proteins

C. Second-Messenger System

(Nonsteroid Hormone Action)

1. Hormone binds to a membrane receptor
2. Hormone does not enter the cell
3. Sets off a series of reactions that activates an enzyme
4. Catalyzes a reaction that produces a second-messenger molecule
5. Oversees additional intracellular changes to promote a specific response

VII. Major Endocrine Glands and Hormones

A. Control of Hormone Release

1. Hormone levels in the blood are mostly maintained by negative feedback
2. A stimulus or low hormone levels in the blood triggers the release of more hormone
3. Hormone release stops once an appropriate level in the blood is reached

B. Hormonal Stimuli of Endocrine Glands

1. Most common stimuli
2. Endocrine glands are activated by other hormones
 - a. Examples:
 - (1) Anterior pituitary hormones

C. Humoral Stimuli of Endocrine Glands

1. Changing blood levels of certain ions stimulate hormone release
2. Humoral indicates various body fluids such as blood

and bile

3. Examples:

- a. Parathyroid hormone
- b. Calcitonin
- c. Insulin

D. Neural Stimuli of Endocrine Glands

1. Nerve impulses stimulate hormone release
2. Most are under the control of the sympathetic nervous system
3. Examples include the release of norepinephrine and epinephrine by the adrenal medulla

E. Major Endocrine Organs

1. Pituitary gland
2. Thyroid gland
3. Parathyroid glands
4. Adrenal glands
5. Pineal gland
6. Thymus gland
7. Pancreas
8. Gonads (Ovaries and Testes)
9. Hypothalamus

VIII. Location of Major Endocrine Organs

A. Pituitary Gland

1. Size of a pea
2. Hangs by a stalk from the hypothalamus in the brain
3. Protected by the sphenoid bone
4. Has two functional lobes
 - a. Anterior pituitary—glandular tissue
 - b. Posterior pituitary—nervous tissue
 - c. Often called the “master endocrine gland”
5. Hormones of the Anterior Pituitary
 - a. Six anterior pituitary hormones
 - b. Two affect non-endocrine targets
 - (1) Growth hormone
 - (2) Prolactin
 - c. Four stimulate other endocrine glands (tropic hormones)

- (1) Thyroid-stimulating hormone (thyrotropic hormone)
- (2) Adrenocorticotrophic hormone
- (3) Two gonadotropic hormones
- d. Characteristics of all anterior pituitary hormones
 - (1) Proteins (or peptides)
 - (2) Act through second-messenger systems
 - (3) Regulated by hormonal stimuli, mostly negative feedback
- 6. Hormones of the Anterior Pituitary
 - a. Growth hormone
 - (1) General metabolic hormone
 - (2) Major effects are directed to growth of skeletal muscles and long bones
 - (3) Plays a role in determining final body size
 - (4) Causes amino acids to be built into proteins
 - (5) Causes fats to be broken down for a source of energy
 - (6) Growth hormone (GH) disorders
 - (a) Pituitary dwarfism results from hyposecretion of GH during childhood
 - (b) Gigantism results from hypersecretion of GH during childhood
 - (c) Acromegaly results from hypersecretion of GH during adulthood
 - (d) Dwarfism
 - b. Prolactin (PRL)
 - (1) Stimulates and maintains milk production following childbirth
 - (2) Function in males is unknown
 - c. Adrenocorticotrophic hormone (ACTH)
 - (1) Regulates endocrine activity of the adrenal cortex
 - d. Thyroid-stimulating hormone (TSH)
 - (1) Influences growth and activity of the thyroid gland
 - e. Gonadotropic hormones
 - (1) Regulate hormonal activity of the gonads
 - (2) Follicle-stimulating hormone (FSH)
 - (a) Stimulates follicle development in ovaries
 - (b) Stimulates sperm development in testes

(3) Luteinizing hormone (LH)

(a) Triggers ovulation of an egg in females

(b) Stimulates testosterone production in males

7. Pituitary-Hypothalamus Relationship

a. Hormonal release is regulated by releasing and inhibiting hormones produced by the hypothalamus

b. Hypothalamus produces two hormones

(1) These hormones are transported to neurosecretory cells of the posterior pituitary

(a) Oxytocin

(b) Antidiuretic hormone

c. The posterior pituitary is not strictly an endocrine gland, but does release hormones

8. Hormones of the Posterior Pituitary

a. Oxytocin

(1) Stimulates contractions of the uterus during labor, sexual relations, and breastfeeding

(2) Causes milk ejection in a nursing woman

b. Antidiuretic hormone (ADH)

(1) Inhibits urine production by promoting water reabsorption by the kidneys

(2) In large amounts, causes vasoconstriction leading to increased blood pressure

(3) Also known as vasopressin

B. Thyroid Gland

1. Found at the base of the throat

2. Consists of two lobes and a connecting isthmus

3. Produces two hormones

a. Thyroid hormone

(1) Major metabolic hormone

(a) Composed of two active iodine-containing hormones

i. Thyroxine (T₄)—secreted by thyroid follicles

ii. Triiodothyronine (T₃)—conversion of T₄ at target tissues

b. Calcitonin

(1) Decreases blood calcium levels by causing its deposition on bone

- (2) Antagonistic to parathyroid hormone
- (3) Produced by parafollicular cells
- (4) Parafollicular cells are found between the follicles

4. Thyroid hormone disorders
 - a. Goiters
 - (1) Thyroid gland enlarges due to lack of iodine
 - (2) Salt is iodized to prevent goiters
 - b. Cretinism
 - (1) Caused by hyposecretion of thyroxine
 - (2) Results in dwarfism during childhood
 - c. Myxedema
 - (1) Caused by hypothyroidism in adults
 - (2) Results in physical and mental sluggishness
 - d. Graves' disease
 - (1) Caused by hyperthyroidism
 - (2) Results in increased metabolism, heat intolerance, rapid heartbeat, weight loss, and exophthalmos
- c. Parathyroid Glands
 1. Tiny masses on the posterior of the thyroid
 2. Secrete parathyroid hormone (PTH)
 - a. Stimulate osteoclasts to remove calcium from bone
 - b. Stimulate the kidneys and intestine to absorb more calcium
 - c. Raise calcium levels in the blood
- d. Adrenal Glands
 1. Sit on top of the kidneys
 2. Two regions
 - a. Adrenal cortex—outer glandular region has three layers
 - (1) Mineralocorticoids secreting area
 - (2) Glucocorticoids secreting area
 - (3) Sex hormones secreting area
 - b. Adrenal medulla—inner neural tissue region
 3. Hormones of the Adrenal Cortex
 - a. Mineralocorticoids (mainly aldosterone)
 - (1) Produced in outer adrenal cortex
 - (2) Regulate mineral content in blood

- (3) Regulate water and electrolyte balance
 - (4) Target organ is the kidney
 - (5) Production stimulated by renin and aldosterone
 - (6) Production inhibited by atrial natriuretic peptide (ANP)
- b. **Glucocorticoids** (including cortisone and cortisol)
- (1) Produced in the middle layer of the adrenal cortex
 - (2) Promote normal cell metabolism
 - (3) Help resist long-term stressors
 - (4) Released in response to increased blood levels of ACTH
- c. **Sex hormones**
- (1) Produced in the inner layer of the adrenal cortex
 - (2) Small amounts are made throughout life
 - (3) Mostly androgens (male sex hormones) are made but some estrogens (female sex hormones) are also formed
4. **Adrenal cortex disorders**
- a. **Addison's disease**
- (1) Results from hyposecretion of all adrenal cortex hormones
 - (2) Bronze skin tone, muscles are weak, burnout, susceptibility to infection
- b. **Hyperaldosteronism**
- (1) May result from an ACTH-releasing tumor
 - (2) Excess water and sodium are retained leading to high blood pressure and edema
- c. **Cushing's syndrome**
- (1) Results from a tumor in the middle cortical area of the adrenal cortex
 - (2) "Moon face," "buffalo hump" on the upper back, high blood pressure, hyperglycemia, weakening of bones, depression
- d. **Masculinization**
- (1) Results from hypersecretion of sex hormones
 - (2) Beard and male distribution of hair growth
5. **Hormones of the Adrenal Medulla**
- a. Produces two similar hormones (catecholamines)

- (1) Epinephrine (adrenaline)
 - (2) Norepinephrine (noradrenaline)
- b. These hormones prepare the body to deal with short-term stress ("fight or flight") by
 - (1) Increasing heart rate, blood pressure, blood glucose levels
 - (2) Dilating small passageways of lungs
- E. Pancreatic Islets
 - 1. The pancreas is a mixed gland and has both endocrine and exocrine functions
 - 2. The pancreatic islets produce hormones
 - a. Insulin—allows glucose to cross plasma membranes into cells from beta cells
 - b. Glucagon—allows glucose to enter the blood from alpha cells
 - c. These hormones are antagonists that maintain blood sugar homeostasis
- F. Pineal Gland
 - 1. Found on the third ventricle of the brain
 - 2. Secretes melatonin
 - a. Helps establish the body's wake and sleep cycles
 - b. Believed to coordinate the hormones of fertility in humans
- G. Thymus Gland
 - 1. Located posterior to the sternum
 - 2. Largest in infants and children
 - 3. Produces thymosin
 - a. Matures some types of white blood cells
 - b. Important in developing the immune system
- H. Gonads
 - 1. Ovaries
 - a. Produce eggs
 - b. Produce two groups of steroid hormone
 - (1) Estrogens
 - (2) Progesterone
 - 2. Testes
 - a. Produce sperm
 - b. Produce androgens, such as testosterone

3. Hormones of the Ovaries
 - a. Estrogens
 - (1) Stimulate the development of secondary female characteristics
 - (2) Mature female reproductive organs
 - (3) With progesterone, estrogens also
 - (a) Promote breast development
 - (b) Regulate menstrual cycle
 - b. Progesterone
 - (1) Acts with estrogen to bring about the menstrual cycle
 - (2) Helps in the implantation of an embryo in the uterus
 - (3) Helps prepare breasts for lactation
4. Hormones of the Testes
 - a. Produce several androgens
 - b. Testosterone is the most important androgen
 - (1) Responsible for adult male secondary sex characteristics
 - (2) Promotes growth and maturation of male reproductive system
 - (3) Required for sperm cell production
- I. Other Hormone-Producing Tissues and Organs
 1. Parts of the small intestine
 2. Parts of the stomach
 3. Kidneys
 4. Heart
 5. Many other areas have scattered endocrine cells
- J. Endocrine Function of the Placenta
 1. Produces hormones that maintain the pregnancy
 2. Some hormones play a part in the delivery of the baby
 - a. Produces human chorionic gonadotropin (hCG) in addition to estrogen, progesterone, and other hormones
- IX. Developmental Aspects of the Endocrine System
 - A. Most endocrine organs operate smoothly until old age
 - B. Menopause is brought about by lack of efficiency of the

ovaries

- c. Problems associated with reduced estrogen are common
- d. Growth hormone production declines with age
- e. Many endocrine glands decrease output with age