

I. Unit 9: The Endocrine System A. The Endocrine System

- 1. Second-messenger system of the body
- 2. Uses chemical messengers (hormones) that are released into the blood
- 3. Hormones control several major processes
  - a) Reproduction
  - b) Growth and development
  - c) Mobilization of body defenses
  - d) Maintenance of much of homeostasis
  - e) Regulation of metabolism

 B. Hormone Overview

- 1. Hormones are produced by specialized cells
- 2. Cells secrete hormones into extracellular fluids
- 3. Blood transfers hormones to target sites
- 4. These hormones regulate the activity of other cells

 C. The Chemistry of Hormones

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

 D. Mechanisms of Hormone Action

- 1. Hormones affect only certain tissues or organs (target cells or
- 2. Target cells must have specific protein receptors
- 3. Hormone-binding alters cellular activity

 E. Effects Caused by Hormones

- 1. Changes in plasma membrane permeability or electrical state

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- 2. Synthesis of proteins, such as enzymes
- 3. Activation or inactivation of enzymes
- 4. Stimulation of mitosis
- 5. Promotion of secretory activity
- F. The Chemistry of Hormones
  - 1. Two mechanisms in which hormones act
    - a) Direct gene activation
    - b) Second-messenger system
  - 2. Direct Gene Activation (Steroid Hormone Action)
    - a) Diffuse through the plasma membrane of target cells
    - b) Enter the nucleus
    - c) Bind to a specific protein within the nucleus
    - d) Bind to specific sites on the cell's DNA
    - e) Activate genes that result in synthesis of new proteins
  - 3. Second-Messenger System (Nonsteroid Hormone Action)
    - a) Hormone binds to a membrane receptor
    - b) Hormone does not enter the cell
    - c) Sets off a series of reactions that activates an enzyme
    - d) Catalyzes a reaction that produces a second-messenger molecule
    - e) Oversees additional intracellular changes to promote a
- G. Major Endocrine Glands and Hormones
  - 1. Control of Hormone Release
    - a) Hormone levels in the blood are mostly maintained by
    - b) A stimulus or low hormone levels in the blood triggers the release of more hormone
    - c) Hormone release stops once an appropriate level in the blood
  - 2. Hormonal Stimuli of Endocrine Glands
    - a) Most common stimuli

- b) Endocrine glands are activated by other hormones
  - (1) Examples:
    - (a) Anterior pituitary hormones
- 3. Humoral Stimuli of Endocrine Glands
  - a) Changing blood levels of certain ions stimulate hormone release
  - b) Humoral indicates various body fluids such as blood and bile
  - c) Examples:
    - (1) Parathyroid hormone
    - (2) Calcitonin
    - (3) Insulin
- 4. Neural Stimuli of Endocrine Glands
  - a) Nerve impulses stimulate hormone release
  - b) Most are under the control of the sympathetic nervous system
  - c) Examples include the release of norepinephrine and epinephrine by the adrenal medulla
- 5. Major Endocrine Organs
  - a) Pituitary gland
  - b) Thyroid gland
  - c) Parathyroid glands
  - d) Adrenal glands
  - e) Pineal gland
  - f) Thymus gland
  - g) Pancreas
  - h) Gonads (Ovaries and Testes)
  - i) Hypothalamus
- H. Location of Major Endocrine Organs
  - 1. Pituitary Gland
    - a) Size of a pea
    - b) Hangs by a stalk from the hypothalamus in the brain

- c) Protected by the sphenoid bone
- d) Has two functional lobes
  - (1) Anterior pituitary - glandular tissue
  - (2) Posterior pituitary - nervous tissue
  - (3) Often called the “master endocrine gland”
- e) Hormones of the Anterior Pituitary
  - (1) Six anterior pituitary hormones
  - (2) Two affect non-endocrine targets
    - (a) Growth hormone
    - (b) Prolactin
  - (3) Four stimulate other endocrine glands (tropic hormones)
    - (a) Thyroid-stimulating hormone (thyrotropic hormone)
    - (b) Adrenocorticotrophic hormone
    - (c) Two gonadotropic hormones
  - (4) Characteristics of all anterior pituitary hormones
    - (a) Proteins (or peptides)
    - (b) Act through second-messenger systems
    - (c) Regulated by hormonal stimuli, mostly negative feedback
- f) Hormones of the Anterior Pituitary
  - (1) Growth hormone
    - (a) General metabolic hormone
    - (b) Major effects are directed to growth of skeletal muscles and long bones
    - (c) Plays a role in determining final body size
    - (d) Causes amino acids to be built into proteins
    - (e) Causes fats to be broken down for a source of energy
    - (f) Growth hormone (GH) disorders
      - (i) Pituitary dwarfism results from hyopsecretion of GH during childhood

- (ii) Gigantism results from hypersecretion of GH
- (iii) Acromegaly results from hypersecretion of GH during adulthood
- (iv) Dwarfism
- (2) Prolactin (PRL)
  - (a) Stimulates and maintains milk production following childbirth
  - (b) Function in males is unknown
- (3) Adrenocorticotrophic hormone (ACTH)
  - (a) Regulates endocrine activity of the adrenal cortex
- (4) Thyroid-stimulating hormone (TSH)
  - (a) Influences growth and activity of the thyroid gland
- (5) Gonadotropic hormones
  - (a) Regulate hormonal activity of the gonads
  - (b) Follicle-stimulating hormone (FSH)
    - (i) Stimulates follicle development in ovaries
    - (ii) Stimulates sperm development in testes
  - (c) Luteinizing hormone (LH)
    - (i) Triggers ovulation of an egg in females
    - (ii) Stimulates testosterone production in males
- g) Pituitary–Hypothalamus Relationship
  - (1) Hormonal release is regulated by releasing and inhibiting hormones produced by the hypothalamus
  - (2) Hypothalamus produces two hormones
    - (a) These hormones are transported to neurosecretory cells of the posterior pituitary
      - (i) Oxytocin
      - (ii) Antidiuretic hormone
  - (3) The posterior pituitary is not strictly an endocrine gland, but does release hormones
- h) Hormones of the Posterior Pituitary

- h) **Hormones of the Posterior Pituitary**
  - (1) **Oxytocin**
    - (a) **Stimulates contractions of the uterus during labor, sexual relations, and breastfeeding**
    - (b) **Causes milk ejection in a nursing woman**
  - (2) **Antidiuretic hormone (ADH)**
    - (a) **Inhibits urine production by promoting water reabsorption by the kidneys**
    - (b) **In large amounts, causes vasoconstriction leading to increased blood pressure**
    - (c) **Also known as vasopressin**
- 2. **Thyroid Gland**
  - a) **Found at the base of the throat**
  - b) **Consists of two lobes and a connecting isthmus**
  - c) **Produces two hormones**
    - (1) **Thyroid hormone**
      - (a) **Major metabolic hormone**
        - (i) **Composed of two active iodine-containing hormones**
          - (a) **Thyroxine (T4) - secreted by thyroid follicles**
          - (b) **Triiodothyronine (T3) - conversion of T4 at target tissues**
    - (2) **Calcitonin**
      - (a) **Decreases blood calcium levels by causing its deposition**
      - (b) **Antagonistic to parathyroid hormone**
      - (c) **Produced by parafollicular cells**
      - (d) **Parafollicular cells are found between the follicles**
- d) **Thyroid hormone disorders**
  - (1) **Goiters**
    - (a) **Thyroid gland enlarges due to lack of iodine**
    - (b) **Salt is iodized to prevent goiters**

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

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



- e) **Hormones of the Adrenal Medulla**
  - (1) **Produces two similar hormones (catecholamines)**
    - (a) **Epinephrine (adrenaline)**
    - (b) **Norepinephrine (noradrenaline)**
  - (2) **These hormones prepare the body to deal with short-term stress (“fight or flight”) by**
    - (a) **Increasing heart rate, blood pressure, blood glucose levels**
    - (b) **Dilating small passageways of lungs**
- 5. **Pancreatic Islets**
  - a) **The pancreas is a mixed gland and has both endocrine and exocrine functions**
  - b) **The pancreatic islets produce hormones**
    - (1) **Insulin - allows glucose to cross plasma membranes into cells from beta cells**
    - (2) **Glucagon - allows glucose to enter the blood from alpha cells**
    - (3) **These hormones are antagonists that maintain blood sugar homeostasis**
- 6. **Pineal Gland**
  - a) **Found on the third ventricle of the brain**
  - b) **Secretes melatonin**
    - (1) **Helps establish the body’s wake and sleep cycles**
    - (2) **Believed to coordinate the hormones of fertility in humans**
- 7. **Thymus Gland**
  - a) **Located posterior to the sternum**
  - b) **Largest in infants and children**
  - c) **Produces thymosin**
    - (1) **Matures some types of white blood cells**
    - (2) **Important in developing the immune system**
- 8. **Gonads**
  - a) **Ovaries**

- a) Ovaries
  - (1) Produce eggs
  - (2) Produce two groups of steroid hormone
    - (a) Estrogens
    - (b) Progesterone
- b) Testes
  - (1) Produce sperm
  - (2) Produce androgens, such as testosterone
- c) Hormones of the Ovaries
  - (1) Estrogens
    - (a) Stimulate the development of secondary female characteristics
    - (b) Mature female reproductive organs
    - (c) With progesterone, estrogens also
      - (i) Promote breast development
      - (ii) Regulate menstrual cycle
  - (2) Progesterone
    - (a) Acts with estrogen to bring about the menstrual cycle
    - (b) Helps in the implantation of an embryo in the uterus
    - (c) Helps prepare breasts for lactation
- d) Hormones of the Testes
  - (1) Produce several androgens
  - (2) Testosterone is the most important androgen
    - (a) Responsible for adult male secondary sex characteristics
    - (b) Promotes growth and maturation of male reproductive system
    - (c) Required for sperm cell production
- 9. Other Hormone-Producing Tissues and Organs
  - a) Parts of the small intestine
  - b) Parts of the stomach
  - c) Kidneys

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- d) Heart
- e) Many other areas have scattered endocrine cells
- 10. Endocrine Function of the Placenta
  - a) Produces hormones that maintain the pregnancy
  - b) Some hormones play a part in the delivery of the baby
    - (1) Produces human chorionic gonadotropin (hCG) in addition to estrogen, progesterone, and other hormones
- I. Developmental Aspects of the Endocrine System
  - 1. Most endocrine organs operate smoothly until old age
  - 2. Menopause is brought about by lack of efficiency of the ovaries
  - 3. Problems associated with reduced estrogen are common
  - 4. Growth hormone production declines with age
  - 5. Many endocrine glands decrease output with age