Slide 1

The Endocrine System

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Slide 2

The Endocrine System

- Second-messenger system of the body
- Uses chemical messengers (hormones) that are released into the blood
- Hormones control several major processes
  - Reproduction
  - Growth and development
  - Mobilization of body defenses
  - Maintenance of much of homeostasis
  - Regulation of metabolism

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Hormone Overview

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

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**The Chemistry of Hormones**
- Hormones are classified chemically as:
  - Amino acid-based, which includes: Proteins, Peptides, Amines
  - Steroids—made from cholesterol
  - Prostaglandins—made from highly active lipids

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**Mechanisms of Hormone Action**
- Hormones affect only certain tissues or organs (target cells or target organs)
- Target cells must have specific protein receptors
- Hormone-binding alters cellular activity

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**Effects Caused by Hormones**
- Changes in plasma membrane permeability or electrical state
- Synthesis of proteins, such as enzymes
- Activation or inactivation of enzymes
- Stimulation of mitosis
- Promotion of secretory activity
The Chemistry of Hormones

- Two mechanisms in which hormones act
  - Direct gene activation
  - Second-messenger system

Direct Gene Activation
(Steroid Hormone Action)

- Diffuse through the plasma membrane of target cells
- Enter the nucleus
- Bind to a specific protein within the nucleus
- Bind to specific sites on the cell’s DNA
- Activate genes that result in synthesis of new proteins

Steroid Hormone

Figure 9.1a

Steroid hormone
Receptor protein
Hormone-receptor complex
DNA
mRNA
New protein
Plasma membrane of target cell

Figure 9.1a
Second-Messenger System (Nonsteroid Hormone Action)

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

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Figure 9.1b

Nonsteroid hormone (first messenger)

Enzyme

Second messenger

Cytoplasm

Effect on cellular function, such as glycogen breakdown

Plasma membrane of target cell

ATP

cAMP

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Figure 9.1b, step 1

Nonsteroid hormone (first messenger)

Receptor protein

Plasma membrane of target cell

Cytoplasm

Effect on cellular function, such as glycogen breakdown

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Figure 9.1b, step 2

Cytoplasm
Nonsteroid hormone (first messenger)
Enzyme
Receptor protein
Plasma membrane of target cell

Figure 9.1b, step 3

Cytoplasm
Nonsteroid hormone (first messenger)
Enzyme
Receptor protein
Second messenger
ATP
cAMP

Figure 9.1b, step 4

Cytoplasm
Nonsteroid hormone (first messenger)
Enzyme
Receptor protein
Second messenger
ATP
cAMP
Effect on cellular function, such as glycogen breakdown.
**Table 9.1 (1 of 4)**

<table>
<thead>
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<th>Major Endocrine Glands and Hormones</th>
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<tbody>
<tr>
<td><strong>Gland</strong></td>
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<tr>
<td>Adrenal</td>
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<td></td>
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<tr>
<td>Thyroid gland</td>
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**Table 9.1 (2 of 4)**

<table>
<thead>
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<tr>
<td><strong>Gland</strong></td>
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<td>Pituitary</td>
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**Table 9.1 (3 of 4)**

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<td><strong>Gland</strong></td>
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<td>Pineal gland</td>
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</table>
Control of Hormone Release
- Hormone levels in the blood are mostly maintained by negative feedback
- A stimulus or low hormone levels in the blood triggers the release of more hormone
- Hormone release stops once an appropriate level in the blood is reached

Hormonal Stimuli of Endocrine Glands
- Most common stimuli
- Endocrine glands are activated by other hormones
- Examples:
  - Anterior pituitary hormones
Humoral Stimuli of Endocrine Glands

- Changing blood levels of certain ions stimulate hormone release
- Humoral indicates various body fluids such as blood and bile
- Examples:
  - Parathyroid hormone
  - Calcitonin
  - Insulin
Neural Stimuli of Endocrine Glands

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

Figure 9.2c

Major Endocrine Organs

- Pituitary gland
- Thyroid gland
- Parathyroid glands
- Adrenal glands
- Pinea gland
- Thymus gland
- Pancreas
- Gonads (Ovaries and Testes)
- Hypothalamus
Location of Major Endocrine Organs

Figure 9.3

Pituitary Gland

- Size of a pea
- Hangs by a stalk from the hypothalamus in the brain
- Protected by the sphenoid bone
- Has two functional lobes
  - Anterior pituitary—glandular tissue
  - Posterior pituitary—nervous tissue
- Often called the “master endocrine gland”

Hormones of the Anterior Pituitary

- Six anterior pituitary hormones
  - Two affect non-endocrine targets
    - Growth hormone
    - Prolactin
  - Four stimulate other endocrine glands (tropic hormones)
    - Thyroid-stimulating hormone (thyrotropic hormone)
    - Adrenocorticotropic hormone
    - Two gonadotropic hormones
Hormones of the Anterior Pituitary

- Characteristics of all anterior pituitary hormones
  - Proteins (or peptides)
  - Act through second-messenger systems
  - Regulated by hormonal stimuli, mostly negative feedback

Hormones of the Anterior Pituitary

- Growth hormone
  - General metabolic hormone
  - Major effects are directed to growth of skeletal muscles and long bones
  - Plays a role in determining final body size
  - Causes amino acids to be built into proteins
  - Causes fats to be broken down for a source of energy
Hormones of the Anterior Pituitary

- Growth hormone (GH) disorders
  - Pituitary dwarfism results from hyposecretion of GH during childhood
  - Gigantism results from hypersecretion of GH during childhood
  - Acromegaly results from hypersecretion of GH during adulthood

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Hormones of the Anterior Pituitary

Gigantism

Figure 9.5a

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Hormones of the Anterior Pituitary

Dwarfism

Figure 9.5b
Hormones of the Anterior Pituitary

- **Prolactin (PRL)**
  - Stimulates and maintains milk production following childbirth
  - Function in males is unknown
- **Adrenocorticotropic hormone (ACTH)**
  - Regulates endocrine activity of the adrenal cortex
- **Thyroid-stimulating hormone (TSH)**
  - Influences growth and activity of the thyroid gland

Hormones of the Anterior Pituitary

- **Gonadotropic hormones**
  - Regulate hormonal activity of the gonads
  - **Follicle-stimulating hormone (FSH)**
    - Stimulates follicle development in ovaries
    - Stimulates sperm development in testes
  - **Luteinizing hormone (LH)**
    - Triggers ovulation of an egg in females
    - Stimulates testosterone production in males

Pituitary–Hypothalamus Relationship

- Hormonal release is regulated by releasing and inhibiting hormones produced by the hypothalamus
- Hypothalamus produces two hormones
  - These hormones are transported to neurosecretory cells of the posterior pituitary
    - Oxytocin
    - Antidiuretic hormone
- The posterior pituitary is not strictly an endocrine gland, but does release hormones
Hormones of the Posterior Pituitary

- Oxytocin
  - Stimulates contractions of the uterus during labor, sexual relations, and breastfeeding
  - Causes milk ejection in a nursing woman

Hormones of the Posterior Pituitary

- Antidiuretic hormone (ADH)
  - Inhibits urine production by promoting water reabsorption by the kidneys
  - In large amounts, causes vasoconstriction leading to increased blood pressure
  - Also known as vasopressin

Figure 9.6