Chapter 10
The Endocrine System

PowerPoint® Lecture Slides
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10-1 Homeostasis is preserved through intercellular communication
The Endocrine System

- The Endocrine System
  - Regulates long-term processes:
    - Growth
    - Development
    - Reproduction
  - Uses chemical messengers to relay information and instructions between cells
The Endocrine System

- Endocrine Communication
  - Endocrine cells release chemicals (hormones) into the bloodstream
  - Alters metabolic activities of many tissues and organs simultaneously
The Endocrine System

• Target Cells
  – Are specific cells that possess receptors needed to bind and “read” hormonal messages

• Hormones
  – Stimulate synthesis of enzymes or structural proteins
  – Increase or decrease rate of synthesis
  – Turn existing enzyme or membrane channel “on” or “off”
The endocrine system regulates physiological processes through the binding of hormones to receptors.
The Endocrine System

**HYPOTHALAMUS**
Production of ADH, oxytocin, and regulatory hormones

**PITUITARY GLAND**
Anterior pituitary: ACTH, TSH, GH, PRL, FSH, LH, and MSH
Posterior pituitary: Release of oxytocin and ADH

**PIEANAL GLAND**
Melatonin

**PARATHYROID GLANDS**
(on posterior surface of thyroid gland)
Parathyroid hormone (PTH)

**THYMUS**
(Undergoes atrophy during adulthood)
Thymosins *(Chapter 14)*

**THYROID GLAND**
Thyroxine (T₄)
Triiodothyronine (T₃)
Calcitonin (CT)

**HEART**
Atrial natriuretic peptide (ANP)

Figure 10-1
The Endocrine System

**SUPRARENAL GLANDS**
Each suprarenal gland is subdivided into:
Suprarenal medulla:
Epinephrine (E)
Norepinephrine (NE)
Suprarenal cortex:
Cortisol, corticosterone, aldosterone, androgens

**KIDNEY**
Erythropoietin (EPO)
Calcitriol (*Chapters 11 and 18*)

**ADIPOSE TISSUE**
Leptin

**DIGESTIVE TRACT**
Numerous hormones (*detailed in Chapter 16*)

**PANCREATIC ISLETS**
Insulin, glucagon

**GONADS**
Testes (male):
Androgens (especially testosterone), inhibin
Ovaries (female):
Estrogens, progestins, inhibin

Figure 10-1
The Structure of Hormones

• Hormones can be divided into three groups
  – Amino acid derivatives
  – Peptide hormones
  – Lipid derivatives

• Circulate freely or bound to transport proteins
Mechanisms of Hormone Action

• Hormone Receptor
  – Is a protein molecule to which a particular molecule binds strongly
  – Responds to several different hormones
  – Different tissues have different combinations of receptors
  – Presence or absence of specific receptor determines hormonal sensitivity
Target Cells and Hormones

Figure 10-2
Mechanisms of Hormone Action

• Hormones and Plasma Membrane Receptors
  – Catecholamines and peptide hormones:
    • Are not lipid soluble
    • Are unable to penetrate plasma membrane
    • Bind to receptor proteins at the outer surface of the plasma membrane (extracellular receptors)
Mechanisms of Hormone Action

• Hormones and Plasma Membrane Receptors
  – Bind to receptors in plasma membrane
  – Cannot have direct effect on activities inside target cell
  – Use intracellular intermediary to exert effects:
    • First messenger:
      – leads to second messenger
      – may act as enzyme activator, inhibitor, or cofactor
      – results in change in rates of metabolic reactions
Mechanisms of Hormone Action

• Important Second Messengers
  – Cyclic-AMP (cAMP):
    • Derivative of ATP
  – Cyclic-GMP (cGMP):
    • Derivative of GTP
  – Calcium ions
Mechanisms of Hormone Action

• Hormones and Plasma Membrane Receptors
  – G Protein:
    • Enzyme complex coupled to membrane receptor
    • Involved in link between first messenger and second messenger
    • Binds GTP
    • Activated when hormone binds to receptor at membrane surface and changes concentration of second messenger cyclic-AMP (cAMP) within cell:
      – increased cAMP level accelerates metabolic activity within cell
Nonsteroidal Hormones

Figure 10-3a

(a) Mechanisms of action for nonsteroidal hormones
Mechanisms of Hormone Action

• Hormones and Intracellular Receptors
  – Alter rate of DNA transcription in nucleus:
    • Change patterns of protein synthesis
  – Directly affect metabolic activity and structure of target cell
  – Includes steroids and thyroid hormones
Steroids and Thyroid Hormones

Figure 10-3b

(b) Mechanisms of action for steroid and thyroid hormones
Endocrine reflexes can be triggered by

- **Humoral stimuli:**
  - Changes in composition of extracellular fluid

- **Hormonal stimuli:**
  - Arrival or removal of specific hormone

- **Neural stimuli:**
  - Arrival of neurotransmitters at neuroglandular junctions
Hypothalamic Control over Endocrine Function

Figure 10-4
10-3 The bilobed pituitary gland is an endocrine organ that releases nine peptide hormones.
The Pituitary Gland

• Also called hypophysis

• Lies within sella turcica

• Hangs inferior to hypothalamus
  – Connected by infundibulum
Pituitary Gland

Figure 10-5

(a) Subdivisions of the pituitary gland

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The Hypophyseal Portal System

Figure 10-6
Pituitary Gland

• Two Classes of Hypothalamic Regulatory Hormones

  – Releasing hormones (RH):
    • Stimulate synthesis and secretion of one or more hormones at anterior lobe

  – Inhibiting hormones (IH):
    • Prevent synthesis and secretion of hormones from the anterior lobe

• Rate of secretion is controlled by negative feedback
Pituitary Gland

- Anterior lobe (also called *adenohypophysis*)
  - Hormones “turn on” endocrine glands or support other organs
Feedback Control of Endocrine Secretion

Figure 10-7a
Feedback Control of Endocrine Secretion

Figure 10-7b

(b) Pattern variations

- Stimulation
- Inhibition

Anterior pituitary

- PRL
  - Stimulates mammary glands

Liver

- Epithelia, adipose tissue, liver
- Somatomedins
  - Skeletal muscle, cartilage, and many other tissues

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Figure 10-8
Pituitary Gland

• Posterior lobe (also called **neurohypophysis**)
  – Contains unmyelinated axons of hypothalamic neurons
  – **Supraoptic** and **paraventricular nuclei** manufacture:
    • Antidiuretic hormone (ADH)
    • Oxytocin (OXT)
<table>
<thead>
<tr>
<th>REGION</th>
<th>HORMONE</th>
<th>TARGET</th>
<th>HORMONAL EFFECTS</th>
</tr>
</thead>
<tbody>
<tr>
<td>Anterior pituitary</td>
<td>Thyroid-stimulating hormone (TSH)</td>
<td>Thyroid gland</td>
<td>Secretion of thyroid hormones</td>
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<tr>
<td></td>
<td>Adrenocorticotropic hormone (ACTH)</td>
<td>Suprarenal cortex</td>
<td>Glucocorticoid secretion (cortisol, corticosterone)</td>
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<td></td>
<td><strong>Gonadotropins:</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Follicle-stimulating hormone (FSH)</td>
<td>Follicle cells of ovaries</td>
<td>Estrogen secretion, follicle development</td>
</tr>
<tr>
<td></td>
<td>Luteinizing hormone (LH)</td>
<td>Nurse cells of testes</td>
<td>Sperm maturation</td>
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<tr>
<td></td>
<td>Prolactin (PRL)</td>
<td>Follicle cells of ovaries</td>
<td>Ovulation, formation of corpus luteum, and progesterone secretion</td>
</tr>
<tr>
<td></td>
<td>Growth hormone (GH)</td>
<td>Interstitial cells of testes</td>
<td>Testosterone secretion</td>
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<td></td>
<td></td>
<td>Mammary glands</td>
<td>Production of milk</td>
</tr>
<tr>
<td></td>
<td>Melanocyte-stimulating hormone (MSH)</td>
<td>All cells</td>
<td>Growth, protein synthesis, lipid mobilization and catabolism</td>
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<tr>
<td></td>
<td></td>
<td>Melanocytes of skin</td>
<td>Increased melanin synthesis in epidermis</td>
</tr>
<tr>
<td>Posterior pituitary</td>
<td>Antidiuretic hormone (ADH)</td>
<td>Kidneys</td>
<td>Reabsorption of water, elevation of blood volume and pressure</td>
</tr>
<tr>
<td></td>
<td>Oxytocin</td>
<td>Uterus, mammary glands (females)</td>
<td>Labor contractions, milk ejection</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Sperm duct and prostate gland (males)</td>
<td>Contraction of sperm duct and prostate gland</td>
</tr>
</tbody>
</table>

Copyright © 2010 Pearson Education, Inc.
10-4 The thyroid gland lies inferior to the larynx and requires iodine for hormone synthesis
The Thyroid Gland

- Lies anterior to thyroid cartilage of larynx
- Consists of two **lobes** connected by narrow **isthmus**
  - Thyroid follicles:
    - Hollow spheres lined by cuboidal epithelium
    - Cells surround follicle cavity that contains viscous colloid
    - Surrounded by network of capillaries that
      - deliver nutrients and regulatory hormones
      - accept secretory products and metabolic wastes
The Thyroid Gland

- **Thyroglobulin (Globular Protein)**
  - Synthesized by follicle cells
  - Secreted into colloid of thyroid follicles
  - Molecules contain the amino acid tyrosine

- **Thyroxine (T<sub>4</sub>)**
  - Also called tetraiodothyronine
  - Contains four iodide ions

- **Triiodothyronine (T<sub>3</sub>)**
  - Contains three iodide ions
The Thyroid Gland

Figure 10-9a

(a) Location of thyroid gland, anterior view
The Thyroid Gland

Figure 10-9b

(b) Thyroid follicles

Thyroid follicle
Cuboidal epithelium of follicle
C cell

Thyroid hormones stored in colloid of follicle

LM × 260
The Thyroid Gland

• Thyroid-Stimulating Hormone (TSH)
  – Absence causes thyroid follicles to become inactive:
    • Neither synthesis nor secretion occurs
  – Binds to membrane receptors
  – Activates key enzymes in thyroid hormone production
The Thyroid Gland

• Thyroid Hormones
  – Enter target cells by transport system
  – Affect most cells in body
  – Bind to receptors in:
    • Cytoplasm
    • Surfaces of mitochondria
    • Nucleus
  – In children, essential to normal development of:
    • Skeletal, muscular, and nervous systems
The Thyroid Gland

• Calorigenic Effect
  – Cell consumes more energy resulting in increased heat generation
  – Is responsible for strong, immediate, and short-lived increase in rate of cellular metabolism
<table>
<thead>
<tr>
<th>GLAND/CELLS</th>
<th>HORMONE(S)</th>
<th>TARGETS</th>
<th>HORMONAL EFFECTS</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>THYROID</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Follicular epithelium</td>
<td>Thyroxine (T&lt;sub&gt;4&lt;/sub&gt;),</td>
<td>Most cells</td>
<td>Increased energy utilization, oxygen consumption, growth,</td>
</tr>
<tr>
<td>C cells</td>
<td>triiodothyronine (T&lt;sub&gt;3&lt;/sub&gt;)</td>
<td>Bone, kidneys</td>
<td>and development</td>
</tr>
<tr>
<td></td>
<td>Calcitonin (CT)</td>
<td></td>
<td>Decreased calcium concentrations in body fluids (see Figure 10-10)</td>
</tr>
<tr>
<td><strong>PARATHYROIDS</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Chief cells</td>
<td>Parathyroid hormone (PTH)</td>
<td>Bone, kidneys</td>
<td>Increased calcium concentrations in body fluids (see Figure 10-10)</td>
</tr>
</tbody>
</table>
The Thyroid Gland

• C (Clear) Cells of the Thyroid Gland
  – Produce calcitonin (CT):
    • Helps regulate concentrations of Ca$^{2+}$ in body fluids
The four parathyroid glands, embedded in the posterior surface of the thyroid gland, secrete parathyroid hormone to elevate blood calcium levels.
Parathyroid Glands

- Embedded in posterior surface of thyroid gland
- Parathyroid hormone (PTH)
  - Produced by chief cells
  - In response to low concentrations of Ca$^{2+}$
Figure 10-11
Parathyroid Glands

• Four Effects of PTH
  – It stimulates osteoclasts:
    • Accelerates mineral turnover and releases Ca\(^{2+}\) from bone
  – It inhibits osteoblasts:
    • Reduces rate of calcium deposition in bone
  – It enhances reabsorption of Ca\(^{2+}\) at kidneys, reducing urinary loss
  – It stimulates formation and secretion of calcitriol at kidneys:
    • Effects complement or enhance PTH
    • Enhances Ca\(^{2+}\), PO\(_4\)\(^{3-}\) absorption by digestive tract
# TABLE 10-2  Hormones of the Thyroid Gland and Parathyroid Glands

<table>
<thead>
<tr>
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<tr>
<td><strong>THYROID</strong></td>
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</tr>
<tr>
<td>Follicular</td>
<td>Thyroxine ($T_4$), triiodothyronine ($T_3$)</td>
<td>Most cells</td>
<td>Increased energy utilization, oxygen consumption, growth, and development</td>
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<tr>
<td>epithelium</td>
<td>Calcitonin (CT)</td>
<td>Bone, kidneys</td>
<td>Decreased calcium concentrations in body fluids (see Figure 10-10)</td>
</tr>
<tr>
<td>C cells</td>
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<tr>
<td><strong>PARATHYROIDS</strong></td>
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<tr>
<td>Chief cells</td>
<td>Parathyroid hormone (PTH)</td>
<td>Bone, kidneys</td>
<td>Increased calcium concentrations in body fluids (see Figure 10-10)</td>
</tr>
</tbody>
</table>
10-6 The suprarenal glands, consisting of a cortex and a medulla, cap each kidney and secrete several hormones
Suprarenal (Adrenal) Glands

• Lie along superior border of each kidney
• Subdivided into
  – Superficial suprarenal cortex:
    • Stores lipids, especially cholesterol and fatty acids
    • Manufactures steroid hormones: adrenocortical steroids (corticosteroids)
  – Inner suprarenal medulla:
    • Secretory activities controlled by sympathetic division of ANS
    • Produces epinephrine (adrenaline) and norepinephrine
    • Metabolic changes persist for several minutes
Suprarenal Glands

- **Mineralocorticoids**
  - For example, *aldosterone*:
    - Stimulates conservation of sodium ions and elimination of potassium ions
    - Increases sensitivity of salt receptors in taste buds
  - Secretion responds to:
    - Drop in blood Na\(^+\), blood volume, or blood pressure
    - Rise in blood K\(^+\) concentration
Suprarenal Glands

• **Glucocorticoids**
  
  – For example, **cortisol** (hydrocortisone) with **corticosterone**:
    
    • Liver converts cortisol to **cortisone**
  
  – Secretion regulated by negative feedback

  – Has inhibitory effect on production of
    
    • Corticotropin-releasing hormone (CRH) in hypothalamus
    • ACTH in adenohypophysis
Suprarenal Glands

- Produces androgens under stimulation by ACTH
Suprarenal Glands

Figure 10-12
Suprarenal Glands

• Suprarenal Medulla
  – Contains two types of secretory cells:
    • One produces epinephrine (adrenaline):
      – 75% to 80% of medullary secretions
    • The other produces norepinephrine (noradrenaline):
      – 20% to 25% of medullary secretions
<table>
<thead>
<tr>
<th>REGION</th>
<th>HORMONE</th>
<th>TARGET</th>
<th>EFFECTS</th>
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</thead>
<tbody>
<tr>
<td>Suprarenal cortex</td>
<td>Mineralocorticoids, primarily aldosterone</td>
<td>Kidneys</td>
<td>Increases reabsorption of sodium ions and water by the kidneys; accelerates urinary loss of potassium ions</td>
</tr>
<tr>
<td></td>
<td>Glucocorticoids: cortisol</td>
<td></td>
<td>Release of amino acids from skeletal muscles and lipids from adipose tissues; promotes liver formation of glycogen and glucose; promotes peripheral use of lipids; anti-inflammatory effects</td>
</tr>
<tr>
<td></td>
<td>(hydrocortisone), corticosterone, cortisone</td>
<td>Most cells</td>
<td>Uncertain significance under normal conditions</td>
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<td></td>
<td>Androgens</td>
<td></td>
<td></td>
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<tr>
<td>Suprarenal medulla</td>
<td>Epinephrine (E, adrenaline),</td>
<td>Most cells</td>
<td>Increases cardiac activity, blood pressure, glycogen breakdown, and blood glucose levels; release of lipids by adipose tissue (see Table 8-5, p. 295)</td>
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<tr>
<td></td>
<td>norepinephrine (NE, noradrenaline)</td>
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</tbody>
</table>
10-7 The pineal gland, attached to the third ventricle, secretes amelatonin
Pineal Gland

• Lies in posterior portion of roof of third ventricle

• Contains pinealocytes
  – Synthesize hormone melatonin
Pineal Gland

• Functions of Melatonin
  – Inhibiting reproductive functions
  – Protecting against damage by free radicals
  – Setting circadian rhythms
The endocrine pancreas produces insulin and glucagon, hormones that regulate blood glucose levels.
Pancreas

- Lies between
  - Inferior border of stomach
  - And proximal portion of small intestine
- Contains exocrine and endocrine cells
Pancreas

• Endocrine Pancreas
  – Consists of cells that form clusters known as **pancreatic islets**, or islets of Langerhans:
    • Alpha cells produce glucagon
    • Beta cells produce insulin
Pancreas

Figure 10-13

(a) Pancreas, anterior view
Pancreas

• Blood Glucose Levels
  – When levels rise:
    • Beta cells secrete insulin, stimulating transport of glucose across plasma membranes
  – When levels decline:
    • Alpha cells release glucagon, stimulating glucose release by liver
Figure 10-14
10-9 Many organs have secondary endocrine functions
Endocrine Tissues of Other Systems

- Intestines (digestive system)
- Kidneys (urinary system)
- Heart (cardiovascular system)
- Thymus (lymphoid system and immunity)
- Gonads (reproductive system)
Endocrine Tissues of Other Systems

• Intestines
  – Produce hormones important to coordination of digestive activities

• Kidneys
  – Produce the hormones calcitriol and erythropoietin
  – Produce the enzyme renin
Endocrine Tissues of Other Systems

• Heart
  – Produces **natriuretic peptides** (*ANP* and *BNP*):
    • When blood volume becomes excessive
    • Action opposes angiotensin II
    • Resulting in reduction in blood volume and blood pressure

• Thymus
  – Produces **thymosins** (blend of thymic hormones):
    • That help develop and maintain normal immune defenses
Endocrine Tissues of Other Systems

• Testes (Gonads)
  – Produce androgens in interstitial cells:
    • Testosterone is the most important male hormone
  – Secrete inhibin in nurse (sustentacular) cells:
    • Support differentiation and physical maturation of sperm
Endocrine Tissues of Other Systems

• Ovaries (Gonads)
  – Produce estrogens:
    • Principle estrogen is estradiol
  – After ovulation, follicle cells:
    • Reorganize into corpus luteum
    • Release estrogens and progestins, especially progesterone
<table>
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<tr>
<th>STRUCTURE/Cells</th>
<th>HORMONE</th>
<th>PRIMARY TARGET</th>
<th>EFFECTS</th>
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<td><strong>TESTES</strong></td>
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<tr>
<td>Interstitial cells</td>
<td>Androgens</td>
<td>Most cells</td>
<td>Support functional maturation of sperm, protein synthesis in skeletal</td>
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<td></td>
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<td>muscles, male secondary sex characteristics, and associated behaviors</td>
</tr>
<tr>
<td>Nurse cells</td>
<td>Inhibin</td>
<td>Anterior pituitary</td>
<td>Inhibits secretion of FSH</td>
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<td><strong>OVARIES</strong></td>
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<td>Follicular cells</td>
<td>Estrogens</td>
<td>Most cells</td>
<td>Support follicle maturation, female secondary sex characteristics, and</td>
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<td>associated behaviors</td>
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<td></td>
<td>Inhibin</td>
<td>Anterior pituitary</td>
<td>Inhibits secretion of FSH</td>
</tr>
<tr>
<td></td>
<td>Progestins</td>
<td>Uterus, mammary glands</td>
<td>Prepare uterus for implantation; prepare mammary glands for</td>
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<tr>
<td>Corpus luteum</td>
<td></td>
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<td>secretory functions</td>
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</tbody>
</table>
Endocrine Tissues of Other Systems

• Adipose Tissue Secretions
  – Leptin:
    • Feedback control for appetite
    • Controls normal levels of GnRH, gonadotropin synthesis
  – Resistin:
    • Reduces insulin sensitivity
10-10 Hormones interact to produce coordinated physiological responses
Hormone Interactions

- Antagonistic (opposing) effects
- Synergistic (additive) effects
- Permissive effects: one hormone is necessary for another to produce effect
- Integrative effects: hormones produce different and complementary results
Hormones and Growth

• Growth Hormone (GH)
  – In children:
    • Supports muscular and skeletal development
  – In adults:
    • Maintains normal blood glucose concentrations
    • Mobilizes lipid reserves
Hormones and Growth

• Thyroid Hormones
  – If absent during fetal development or for first year:
    • Nervous system fails to develop normally
    • Mental retardation results
  – If T$_4$ concentrations decline before puberty:
    • Normal skeletal development will not continue
Hormones and Growth

- **Insulin**
  - Allows passage of glucose and amino acids across plasma membranes

- **Parathyroid Hormone (PTH) and calcitriol**
  - Promote absorption of calcium salts for deposition in bone
  - Inadequate levels cause weak and flexible bones
Hormones and Growth

• Reproductive Hormones
  – Androgens in males, estrogens in females
  – Stimulate cell growth and differentiation in target tissues
  – Produce gender-related differences in:
    • Skeletal proportions
    • Secondary sex characteristics
Hormones and Stress

• General Adaptation Syndrome (GAS)
  – Also called stress response
  – How body responds to stress-causing factors
  – Is divided into three phases:
    1. Alarm phase
    2. Resistance phase
    3. Exhaustion phase
Hormones and Stress

ALARM PHASE (Fight or flight)

Immediate short-term response to crises

1. Increased mental alertness
2. Increased energy use by all cells
3. Mobilization of glycogen and lipid reserves
4. Changes in circulation
5. Reduction in digestive activity and urine production
6. Increased sweat gland secretion
7. Increases in heart and respiratory rates

Figure 10-15
Hormones and Stress

**RESISTANCE PHASE**

- Brain
  - Sympathetic stimulation
- Suprarenal cortex
- Kidney
  - Renin
  - Angiotensin II

**Long-term metabolic adjustments**

1. **Mobilization of remaining energy reserves:** Lipids are released by adipose tissue; amino acids are released by skeletal muscle

2. **Conservation of glucose:** Peripheral tissue (except neural) breaks down lipids to obtain energy

3. **Elevation of blood glucose concentrations:** Liver synthesizes glucose from other carbohydrates, amino acids, and lipids

4. **Conservation of salts and water, loss of K⁺ and H⁺**

**Figure 10-15**
### Hormones and Stress

#### Figure 10-15

<table>
<thead>
<tr>
<th>EXHAUSTION PHASE</th>
<th>Collapse of vital systems</th>
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</thead>
<tbody>
<tr>
<td>Causes may include:</td>
<td></td>
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<tr>
<td>• Exhaustion of lipid reserves</td>
<td>• Inability to produce glucocorticoids</td>
</tr>
<tr>
<td>• Cumulative structural or functional damage to vital organs</td>
<td>• Failure of electrolyte balance</td>
</tr>
</tbody>
</table>
Hormone Interactions

• Hormones and Behavior
  – Can alter intellectual capabilities, memory, learning, and emotional states
  – Affect behavior when endocrine glands are over-secreting or under-secreting

• Aging
  – Causes few functional changes
  – Decline in concentration of:
    • Growth hormone
    • Reproductive hormones
10-11 Extensive integration occurs between the endocrine system and other body systems
The Endocrine System in Perspective

Functional Relationships Between the Endocrine System and Other Systems
The Integumentary System protects superficial endocrine organs; epidermis synthesizes vitamin D₃.

The Endocrine System’s sex hormones stimulate sebaceous glands, influence hair growth, fat distribution, and apocrine sweat glands; PRL stimulates development of mammary glands; suprarenal hormones alter dermal blood flow, stimulate release of lipids from adipocytes; MSH stimulates melanocytes.
The Skeletal System protects endocrine organs, especially in the brain, chest, and pelvic cavity.

The Endocrine System regulates skeletal growth: PTH and calcitonin mobilize calcium; sex hormones speed growth and close epiphyseal cartilages at puberty, and help maintain bone mass in adults.
The Muscular System provides protection for some endocrine organs.

The Endocrine System adjusts muscle metabolism, energy production, and growth; regulates calcium and phosphate levels in body fluids; speeds skeletal muscle growth.
The Nervous System's hormones control secretions by the pituitary, other endocrine organs, and suprarenal medullae; secretes ADH and oxytocin.

The Endocrine System's hormones affect neural metabolism; help regulate fluid and electrolyte balance; reproductive hormones influence CNS development and behaviors.
The Cardiovascular System’s vessels distribute hormones throughout the body; heart secretes ANP.

The Endocrine System’s hormone EPO regulates production of RBCs; several hormones elevate blood pressure; Epinephrine elevates heart rate and contraction force.
The Lymphoid System

The Lymphoid System’s lymphocytes defend against infection and, with other WBCs, assist in repair after Injury

The Endocrine System’s hormones have anti-inflammatory effects (glucocorticoids), stimulate development of lymphocytes (thymosins), and affect immune function
The Respiratory System

The Respiratory System provides oxygen and eliminates carbon Dioxide generated by endocrine Cells

The Endocrine System’s hormones Epinephrine and NE stimulate respiration and dilate respiratory passageways
The Digestive System provides nutrients to endocrine cells; Pancreas secretes insulin and glucagon; liver produces angiotensinogen

The Endocrine System’s hormones Epinephrine and NE constrict sphincters and depress activity along digestive tract; digestive tract hormones coordinate secretions along tract
The Urinary System’s kidney cells (1) release renin and EPO when local blood pressure declines and (2) produce calcitriol.

The Endocrine System’s hormones (aldosterone, ADH, and ANP) adjust fluid and electrolyte reabsorption in kidneys.
The Reproductive System

The Reproductive System’s steroid sex hormones and inhibin suppress secretion in hypothalamus and pituitary.

The Endocrine System’s hypothalamic and pituitary hormones regulate sexual development and function; oxytocin stimulates contractions of the uterus and mammary glands.