Chapter 17

The Endocrine System

The Endocrine System: An Overview
- A system of ductless glands
  - Secrete messenger molecules called hormones
  - Hormones travel to distant body cells and signal characteristic physiological responses
  - Interacts closely with the nervous system
  - Controls and integrates the functions of other organ systems in the body, slow process
  - Maintains homeostasis, controls growth, metabolism, stress defenses, blood chemistry, etc.

Endocrine Organs
- Scattered throughout the body and small
  - **Pure endocrine organs**
    - Pituitary, pineal, thyroid, parathyroid, and adrenal glands
  - **Endocrine organs that belong to other organ systems but contain endocrine cells**
    - Pancreas, thymus, gonads, and the hypothalamus
    - Richly vascularized with blood and lymph vessels
    - Mostly epithelial origin
Location of the Major Endocrine Glands

Hormones

- **Classes of hormones**
  - Amino acid-based hormones – protein based
  - Steroids – lipid based derived from cholesterol

- **Basic hormone action**
  - Circulate throughout the body in blood vessels
  - Influences only specific tissues – target cells that have receptor for hormone
  - A hormone can have different effects on different target cells
  - Effects depend on the preprogrammed response of the target cells – hormones are merely molecular “triggers”

Control of Hormones Secretion

- Secretion triggered by three major types of stimuli.
  - **Humoral** – simplest of endocrine control mechanisms
    - Secretion in direct response to changing ion or nutrient levels in the blood
  - **Neural** – secretion of endocrine glands controlled by neural stimuli
    - Example: sympathetic nerve fibers stimulate cells in the adrenal medulla, induces release of epinephrine and norepinephrine
  - **Hormonal** – stimuli received from other glands
    - Certain hormones signal secretion of other hormones
Types of Endocrine Gland Stimuli

- **Humoral stimulus**: Capillary blood contains low concentration of Ca²⁺, which stimulates
- **Neural stimulus**: Parasympathetic fibers stimulate adrenal medulla cells
- **Hormonal stimulus**: The hypothalamus secretes hormones that stimulate other endocrine glands

Control of Hormones Secretion
- **Always controlled by feedback loops**
  - Blood concentration declines below a minimum
    - More hormone is secreted
  - Blood concentration exceeds maximum
    - Hormone production is halted

Major Endocrine Organs
- Pituitary
- Thyroid
- Parathyroid
- Adrenal (suprarenal)
- Pineal (not discussed)
- Pancreas
- Thymus-T-cell maturation (not discussed)
- Gonads
The Pituitary Gland (Hypophysis)

- Secretes nine major hormones
- Found in hypophyseal fossa, depression found in sella turcica of sphenoid bone
- Attached to the hypothalamus by the infundibulum
- **Two basic divisions** of the pituitary gland
  - Adenohypophysis (anterior)
  - Neurohypophysis (posterior)

The Pituitary Gland

- [Diagram of the pituitary gland showing various areas like hypophyseal fossa, sella turcica, etc.]

The Anterior Lobe

- Has five different types of endocrine cells to make the following hormones:
  1. **Growth Hormone (GH)** (a.k.a. somatotropic hormone/somatotropin)
  2. Prolactin
  3. **Thyroid stimulating hormone (TSH)**
  4. **Adrenocorticotropic hormone (ACTH)**
  5. Melanocyte-stimulating hormone (MSH)
  6. **Follicle-stimulating hormone (FSH)**
  7. **Luteinizing Hormone (LH)**
When appropriately stimulated, hypothalamic neurons secrete releasing and inhibiting hormones into the primary capillary plexus. Hypothalamic hormones travel through the portal veins to the anterior pituitary where they stimulate or inhibit release of hormones from the anterior lobe. Anterior pituitary hormones are secreted into the secondary capillary plexus.

The hypothalamus
- Controls secretion of anterior lobe hormones
- Exerts control by secreting
  - **Releasing hormones**—prompt anterior lobe to release hormones
  - **Inhibiting hormones**—turn off secretion of anterior lobe hormones

### Table 17.1

<table>
<thead>
<tr>
<th>Hormone (Cell Type)</th>
<th>Target Organ and Effects</th>
<th>Effects of Hyposecretion</th>
<th>Effects of Hypersecretion</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>ANTERIOR LOBE HORMONES</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Growth hormone (GH)</td>
<td>Liver, muscle, bone, cartilage, and other tissues stimulate growth and development; increases blood glucose</td>
<td>[ \text{Deficiency in children: growth failure, puberty delay} ]</td>
<td>[ \text{Excess in adults: acromegaly} ]</td>
</tr>
<tr>
<td>Thyroid-stimulating hormone (TSH)</td>
<td>Thyroid gland stimulates thyroid gland to release thyroid hormones</td>
<td>[ \text{Deficiency: myxedema} ]</td>
<td>[ \text{Excess: hyperthyroidism, goiter} ]</td>
</tr>
<tr>
<td>Adrenocorticotropic hormone (ACTH)</td>
<td>Adrenal crest releases aldosterone (mineralocorticoids) and cortisol (glucocorticoids)</td>
<td>[ \text{Deficiency: Addison's disease} ]</td>
<td>[ \text{Excess: Cushing's disease} ]</td>
</tr>
</tbody>
</table>
Table 17.1 - Pituitary Hormones: Summary of Target Organs and Effects (continued)

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<th>Hormone (Cell Type)</th>
<th>Target Organ and Effects</th>
<th>Effects of Hypo- and Hypersecretion</th>
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<tr>
<td>Oxytocin (MRN)</td>
<td>Breast secretory tissues, premature lactation</td>
<td></td>
</tr>
<tr>
<td>Vasopressin (ADH)</td>
<td>Kidneys and arterioles to regulate fluid volume and blood pressure</td>
<td></td>
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</table>

The Posterior Lobe

- Structurally part of the brain
- Does not make hormones, merely stores and releases hormones produced by hypothalamus
- Secretes two hormones
  - Antidiuretic hormone (ADH; a.k.a. vasopressin)- targets kidneys and arterioles to regulate fluid volume and blood pressure
  - Oxytocin - uterine contraction and milk secretion

Relationship Between the Posterior Pituitary and Hypothalamus

- Hypothalamic neurons synthesize oxytocin and ADH.
- Oxytocin and ADH are transported along the hypothalamic hypophyseal tract to the posterior lobe.
- Oxytocin and ADH are stored in axon terminals in the posterior pituitary.
- Oxytocin and ADH are released into the blood stream for release into the systemic circulation.
The Thyroid Gland

- Located in the anterior neck-inferior to larynx
- Two lateral lobes connected by isthmus
- Largest pure endocrine gland
- Composed of follicular and parafollicular cells. Produces two hormones
  - **Thyroid hormone (TH)**- controls metabolic rate
  - **Calcitonin**- depresses blood calcium levels (via osteoclasts and kidney function).
The Thyroid Gland

Hormonal stimulus

1. Stimulates the thyroid gland to produce thyroid hormones.
2. Stimulates the gonad to produce hormones.
3. Stimulates the adrenal cortex.

Disorders of Thyroid

- Hypothyroidism: Person always cold, gains weight but doesn't feel hungry.
- Hyperthyroidism: Person is “hot”, loses weight, very hungry, anxious. Must ablate thyroid (radioactive iodine).
- Goiter
The Parathyroid Gland

- Lie on the posterior surface of the thyroid gland
- Could be embedded in thyroid and numbers and, sometimes location, vary
- Contain two types of endocrine cells
  - Chief cells – produce parathyroid hormone (PTH)
    - Increases blood concentration of Ca²⁺
  - Oxyphil cells – function unknown
The Pancreas

- Located in the posterior abdominal wall
- Contains both endocrine and exocrine cells
  - **Exocrine** cells – acinar cells – secrete digestive enzymes into small intestine
  - **Endocrine** cells – pancreatic islets (islets of Langerhans)
    - About one million islets – scattered throughout the pancreas

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The Pancreas

- **Main endocrine cell types**
  - **Alpha cells** (A cells) – secrete **glucagon**
    - Signals liver to release glucose from glycogen
    - Raises blood sugar
  - **Beta cells** (B cells) – secrete **insulin**
    - Signals most body cells to take up glucose from the blood
    - Lowers blood sugar
Diabetes Mellitus

- Caused by:
  - Insufficient secretion of insulin
  - Resistance of body cells to the effects of insulin
- Type I diabetes – develops suddenly, usually before age 15
  - T cell-mediated autoimmune response destroys beta cells

Type II diabetes – adult onset
- Usually occurs after age 40
- Cells have lowered sensitivity to insulin
- Controlled by dietary changes and regular exercise

The Adrenal Glands

- Located on the superior surface of the kidneys
- Nerve supply is almost exclusively sympathetic fibers
- Two endocrine glands in one
  - Adrenal medulla – a knot of nervous tissue
  - Adrenal cortex – bulk of the adrenal gland
    - Cortex is composed of three layers
      - Zona glomerulosa
      - Zona fasciculata
      - Zona reticularis
The Adrenal Medulla
- *Chromaffin cells* – modified postganglionic sympathetic neurons
  - Secrete catecholamines (amino acids - norepinephrine and epinephrine).
  - Active in "fight, flight, and fright" response

The Adrenal Cortex
- Secretes a variety of hormones - all are steroids and are grouped into two main classes:
  - **Mineralocorticoids**
    - Aldosterone is secreted by the zona glomerulosa
  - **Glucocorticoids**
    - Cortisol – secreted by zona fasciculata and zona reticularis
    - Helps the body deal with stressful situations
  - **(Androgenic)**
    - Dehydroepiandrosterone (DHEA) – converted to testosterone and estrogen. May help with stress or elevating immune system, mood modifier.

The Adrenal Gland–Gross and Microscopic

![Diagram of the adrenal gland](image)
Stress and the Adrenal Gland

Figure 17.8

Short-term stress

1. Increased heart rate
2. Increased blood pressure
3. Liver converts glycogen to glucose and releases glucose to blood
4. Dilation of bronchioles
5. Changes in blood flow patterns leading to decreased digestive system activity and reduced urine output
6. Increased metabolic rate

Long-term stress response

1. Retention of sodium and water by kidneys
2. Increased blood volume and blood pressure
3. Proteins and fats converted to glucose or broken down for energy
4. Increased blood glucose
5. Suppression of immune system

The Gonads

Main sources of sex hormones – testes and ovaries

Male – interstitial cells secrete androgens
- Primarily testosterone
  - Promotes the formation of sperm
  - Maintains secondary sex characteristics

Female – ovaries
- Androgens secreted by the theca folliculi, converted to estrogen by follicular granulosa cells
- Estrogen – maintains secondary sex characteristics and signals uterine mucosa to repair itself after menstrual period
- Also secrete progesterone – produced by the follicular granulosa cells and the corpus luteum and prepares the uterus for pregnancy
- Corpus luteum also secretes estrogen and progesterone.
Hormonal stimulus

The hypothalamus secretes hormones that...

...stimulate the anterior pituitary gland to secrete hormones...

...stimulate other endocrine glands to secrete hormones.

Other Endocrine Structures

Endocrine cells occur within:

- **The GI tract** – enteroendocrine cells, scattered within the epithelial lining of the alimentary canal. Assist with digestion, blood chemistry, etc.
- **The placenta** – sustains the fetus and secretes several steroid and protein hormones (Human chorionic gonadotropin- HCG, pregnancy tests)
- **The kidneys** – cells of the juxtaglomerular apparatus secrete renin (signals adrenal cortex to release aldosterone)