Hormones and Endocrine System

Chapter 42
Chemical Signals

- Chemical signals that act between individuals are termed pheromones.
  - Work at a distance between individuals, organs, or locally between adjacent cells.
    - Studies have shown that a woman’s axillary extract can alter another woman’s menstrual cycle by a few days.
Chemical Signals

- Pheromone released into the air by female attracts a male.
- Insulin produced by pancreas affects liver metabolism.
- Prostaglandin affects metabolism of nearby cells.
- Releasing hormones produced by hypothalamus affect anterior pituitary.
- Neurotransmitters affect membrane potential of nearby neurons.

a. Signal acts at a distance between individuals.
b. Signal acts at a distance between body parts.
c. Signal acts locally between adjacent cells.
Action of Hormones

- Hormones are chemical signals produced by one or more cells that regulate metabolic function of other cells in the body.
  - Steroid Hormones
    - Can cross cell membranes.
  - Peptide Hormones
    - Most bind to receptor in plasma membrane. (First Messenger)
      - Produces cAMP
        - Second Messenger
Figure 45.3  Mechanisms of chemical signaling: a review

(a) Receptor in plasma membrane

(b) Receptor in cell nucleus

Copyright © Pearson Education, Inc., publishing as Benjamin Cummings.
Action of Steroid Hormone

a. Action of steroid hormone
Action of Peptide Hormone

b. Action of peptide hormone

Mader: Biology 8th Ed.
Human Endocrine System

- **Endocrine glands** are ductless glands that secrete hormones directly into the bloodstream.
  - Most are **peptide** hormones.
    - Only gonads and adrenal cortex produce steroid hormones.
  - Hormone effects controlled two ways:
    - **Negative feedback** opposes release.
    - **Antagonistic hormones** oppose each other’s actions.
Figure 45.8  Feedback control loops regulating the secretion of thyroid hormones $T_3$ and $T_4$. 

- Hypothalamus 
- TRH 
- Anterior pituitary 
- TSH 
- Thyroid 
- $T_3$ 
- $T_4$
Figure 45.1  An example of how feedback regulation maintains homeostasis

1. If calcium level rises above set point

2. Thyroid gland releases calcitonin

3. Blood calcium level falls

4. If calcium level falls below set point

5. Parathyroid glands release parathyroid hormone (PTH)

6. Blood calcium level rises

Homeostasis: Blood calcium level

Copyright © Pearson Education, Inc., publishing as Benjamin Cummings.
Figure 45.5  Human endocrine glands surveyed in this chapter
<table>
<thead>
<tr>
<th>Gland</th>
<th>Hormone</th>
<th>Chemical Class</th>
<th>Representative Actions</th>
<th>Regulated By</th>
</tr>
</thead>
<tbody>
<tr>
<td>Hypothalamus</td>
<td>Hormones released by the posterior pituitary and hormones that regulate the anterior pituitary (see below)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Pituitary gland</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Posterior pituitary</td>
<td>Oxytocin</td>
<td>Peptide</td>
<td>Stimulates contraction of uterus and mammary gland cells</td>
<td>Nervous system</td>
</tr>
<tr>
<td>(releases hormones made by hypothalamus)</td>
<td>Antidiuretic hormone (ADH)</td>
<td>Peptide</td>
<td>Promotes retention of water by kidneys</td>
<td>Water/salt balance</td>
</tr>
<tr>
<td>Anterior pituitary</td>
<td>Growth hormone (GH)</td>
<td>Protein</td>
<td>Stimulates growth (especially bones) and metabolic functions</td>
<td>Hypothalamic hormones</td>
</tr>
<tr>
<td></td>
<td>Prolactin (PRL)</td>
<td>Protein</td>
<td>Stimulates milk production and secretion</td>
<td>Hypothalamic hormones</td>
</tr>
<tr>
<td></td>
<td>Follicle-stimulating hormone (FSH)</td>
<td>Glycoprotein</td>
<td>Stimulates production of ova and sperm</td>
<td>Hypothalamic hormones</td>
</tr>
<tr>
<td></td>
<td>Luteinizing hormone (LH)</td>
<td>Glycoprotein</td>
<td>Stimulates ovaries and testes</td>
<td>Hypothalamic hormones</td>
</tr>
<tr>
<td></td>
<td>Thyroid-stimulating hormone (TSH)</td>
<td>Glycoprotein</td>
<td>Stimulates thyroid gland</td>
<td>Thyroxine in blood; hypothalamic hormones</td>
</tr>
<tr>
<td></td>
<td>Adrenocorticotropic hormone (ACTH)</td>
<td>Peptide</td>
<td>Stimulates adrenal cortex to secrete glucocorticoids</td>
<td>Glucocorticoids; hypothalamic hormones</td>
</tr>
<tr>
<td>Thyroid gland</td>
<td>Triiodothyronine (T₃) and thyroxine (T₄)</td>
<td>Amine</td>
<td>Stimulate and maintain metabolic processes</td>
<td>TSH</td>
</tr>
<tr>
<td></td>
<td>Calcitonin</td>
<td>Peptide</td>
<td>Lowers blood calcium level</td>
<td>Calcium in blood</td>
</tr>
<tr>
<td>Parathyroid glands</td>
<td>Parathyroid hormone (PTH)</td>
<td>Peptide</td>
<td>Raises blood calcium level</td>
<td>Calcium in blood</td>
</tr>
<tr>
<td>Gland</td>
<td>Hormone</td>
<td>Chemical Class</td>
<td>Representative Actions</td>
<td>Regulated By</td>
</tr>
<tr>
<td>---------------</td>
<td>------------------</td>
<td>----------------</td>
<td>----------------------------------------------------------------------------------------</td>
<td>----------------------</td>
</tr>
<tr>
<td>Pancreas</td>
<td>Insulin</td>
<td>Protein</td>
<td>Lowers blood glucose level</td>
<td>Glucose in blood</td>
</tr>
<tr>
<td></td>
<td>Glucagon</td>
<td>Protein</td>
<td>Raises blood glucose level</td>
<td>Glucose in blood</td>
</tr>
<tr>
<td>Adrenal glands</td>
<td>Epinephrine and</td>
<td>Amine</td>
<td>Raise blood glucose level; increase metabolic activities; constrict certain blood vessels</td>
<td>Nervous system</td>
</tr>
<tr>
<td>Adrenal medulla</td>
<td>norepinephrine</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Adrenal cortex</td>
<td>Glucocorticoids</td>
<td>Steroid</td>
<td>Raise blood glucose level</td>
<td>ACTH</td>
</tr>
<tr>
<td></td>
<td>Mineralocorticoids</td>
<td>Steroid</td>
<td>Promote reabsorption of Na⁺ and excretion of K⁺ in kidneys</td>
<td>K⁺ in blood</td>
</tr>
<tr>
<td>Gonads</td>
<td>Androgens</td>
<td>Steroid</td>
<td>Support sperm formation; promote development and maintenance of male secondary sex characteristics</td>
<td>FSH and LH</td>
</tr>
<tr>
<td>Testes</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Ovaries</td>
<td>Estrogens</td>
<td>Steroid</td>
<td>Stimulate uterine lining growth; promote development and maintenance of female secondary sex characteristics</td>
<td>FSH and LH</td>
</tr>
<tr>
<td></td>
<td>Progesterone</td>
<td>Steroid</td>
<td>Promotes uterine lining growth</td>
<td>FSH and LH</td>
</tr>
<tr>
<td>Pineal gland</td>
<td>Melatonin</td>
<td>Amine</td>
<td>Involved in biological rhythms</td>
<td>Light/dark cycles</td>
</tr>
<tr>
<td>Thymus</td>
<td>Thymosin</td>
<td>Peptide</td>
<td>Stimulates T lymphocytes</td>
<td>Not known</td>
</tr>
</tbody>
</table>
Hypothalamus and Pituitary Gland

- Hypothalamus regulates internal environment through autonomic system.
  - Also controls glandular secretions of pituitary gland.

  ✷ Posterior Pituitary
    - Antidiuretic Hormone (ADH)
      - Controlled by negative feedback.
    - Oxytocin
      - Controlled by positive feedback.
Hypothalamus and Pituitary Gland

- **Anterior Pituitary**
  
  - Hypothalamus controls anterior pituitary by producing hypothalamic-releasing hormones and hypothalamic-inhibiting hormones.
Anterior Pituitary Hormones

• Affect Other Glands
  - Thyroid-Stimulating Hormone (TSH)
  - Adrenocorticotropic Hormone (ACTH)
  - Gonadotropic Hormones

• Do Not Affect Other Glands
  - Prolactin (PRL)
  - Melanocyte-Stimulating Hormone (MSH)
  - Growth Hormone (GH)
Figure 45.6a  Hormones of the hypothalamus and pituitary glands

Neurosecretory cells of the hypothalamus

Posterior pituitary

Hormone
ADH
Oxytocin

Target
Kidney tubules
Mammary glands, uterine muscles

(a) The posterior pituitary
Figure 45.6b  Hormones of the hypothalamus and pituitary glands

(b) The anterior pituitary

Copyright © Pearson Education, Inc., publishing as Benjamin Cummings.
Effect of Growth Hormone
Thyroid Glands

- Thyroid gland composed of large number of follicles filled with triiodothyronine (T$_3$) and thyroxine (T$_4$).
- Effect of Thyroid Hormones
  - Increase metabolic rate.
    - **Simple goiter** - Poor hormone production.
    - **Cretinism** - Poor thyroid development.
    - **Myxedema** - Hypothyroidism.
    - **Exophthalmic goiter** - Hyperthyroidism.
Thyroid Malfunction
Calcitonin

- Blood calcium level is regulated in part by **calcitonin**.
  - Secreted by thyroid gland when blood calcium level rises.
    - Brings about deposit of calcium in the bones.
  - Low blood calcium level stimulates the release of **parathyroid hormone (PTH)**.
Parathyroid Glands

- Parathyroid hormone causes the blood phosphate level to decrease and the blood calcium level to increase.
  - Insufficient parathyroid hormone production leads to tetany.
Figure 45.9  Hormonal control of calcium homeostasis in mammals

**HOMEOSTASIS:** Blood calcium level

- **STIMULUS:** Rising blood Ca^{2+} level
  - Thyroid gland releases calcitonin
    - Stimulates Ca^{2+} deposition in bones
    - Reduces Ca^{2+} uptake in kidneys

- **STIMULUS:** Falling blood Ca^{2+} level
  - Parathyroid glands release parathyroid hormone (PTH)
    - Increases Ca^{2+} uptake in kidneys
    - Increases Ca^{2+} release from bones
    - Active vitamin D increases Ca^{2+} uptake in intestines

Copyright © Pearson Education, Inc., publishing as Benjamin Cummings.
Adrenal Glands

• Sit atop kidneys.
  - Each consists of inner portion, adrenal medulla, and outer portion, adrenal cortex.
    - Adrenal medulla produces epinephrine and norepinephrine.
      ▶ Short-term response to stress.
    - Adrenal cortex produces mineralocorticoids and glucocorticoids.
      ▶ Long-term response to stress.
Adrenal Glands

Stress response: Long Term

- **Glucocorticoids**
  - Protein and fat metabolism instead of glucose breakdown.
  - Reduction of inflammation; immune cells are suppressed.

- **Mineralocorticoids**
  - Sodium ions and water are reabsorbed by kidney.
  - Blood volume and pressure increase.

Stress response: Short Term

- Heartbeat and blood pressure increase.
- Blood glucose level rises.
- Muscles become energized.
Glucocorticoids

- **Cortisol**
  - Raises blood glucose level.
    - Promotes breakdown of muscle proteins to amino acids.
    - Promotes metabolism of fatty acids.
  - Counteracts inflammatory response.
Mineralocorticoids

- **Aldosterone**
  - Promotes renal absorption of sodium and renal excretion of potassium.
  - Renin-angiotensin-aldosterone system raises blood pressure.
    - Angiotensin II constricts arterioles.
    - Aldosterone causes kidneys to reabsorb sodium.
  - Atrial natriuretic hormone (ANH) is antagonistic to aldosterone.
Malfunction of Adrenal Cortex

• Hyposecretion - Addison disease
  - Bronzing of skin.
Malfunction of Adrenal Cortex

- Hypersecretion - Cushing syndrome
Pancreas

- Pancreas made up of exocrine and endocrine tissue.
  - Endocrine tissue, pancreatic islets, produce and secrete insulin and glucagon.
    - **Insulin** secreted during high blood glucose level.
      - Stimulates uptake of glucose by cells.
    - **Glucagon** secreted during low blood glucose level.
      - Stimulates liver to break down glycogen.
Figure 45.10  Glucose homeostasis maintained by insulin and glucagon

**STIMULUS:** Rising blood glucose level (e.g., after eating a carbohydrate-rich meal)

- Beta cells of pancreas stimulated to release insulin into the blood
- Insulin
- Body cells take up more glucose
- Liver takes up glucose and stores it as glycogen
- Blood glucose level declines to a set point; stimulus for insulin release diminishes
- Blood glucose level rises to set point; stimulus for glucagon release diminishes
- Alpha cells of pancreas stimulated to release glucagon into the blood
- Glucagon
- Liver breaks down glycogen and releases glucose to the blood

**Homeostasis:** Blood glucose level

- High
- Low

**STIMULUS:**
- Removal of excess glucose from blood
- Low blood glucose level (e.g., after skipping a meal)
Other Endocrine Glands

- **Gonads**
  - **Testes**
    - Produce testosterone
      - Secondary sex characteristics.
  - **Ovaries**
    - Produce estrogen and progesterone.
      - Reproduction
      - Secondary sex characteristics.
Other Endocrine Glands

- **Pineal Gland**
  - Produces *melatonin*.
  - Involved in Circadian rhythms.

- **Thymus Gland**
  - Secrete *thymosins*.
  - Aid in differentiation of lymphocytes.

- **Prostaglandins**
  - Produced within cells.
  - Not distributed in blood.