Hormones and the Endocrine System

Chapter 45
Intercellular Communication

• **Endocrine Signaling** - secreted molecules diffuse into bloodstream and trigger target cells to respond.
Intercellular Communication

- **Local Regulators** - molecules that act over short distances and reach their target cells by diffusion.
- **Paracrine Signaling** - target cells lie near secreting cell.
- **Autocrine Signaling** - the target cell is the secreting cell itself.
Intercellular Communication

- **Synaptic Signaling**: Neurotransmitters diffuse across synapses and trigger responses in target tissues (neurons, muscles, or glands).
Intercellular Communication

- Neuronendocrine Signaling - neurosecretory cells release hormones that trigger responses in target cells.
Endocrine Tissues and Organs

Major endocrine glands:
- Hypothalamus
- Pineal gland
- Pituitary gland
- Thyroid gland
- Parathyroid glands (behind thyroid)

Organs containing endocrine cells:
- Thymus
- Heart
- Liver
- Stomach
- Kidneys
- Small intestine

- Pancreas
- Ovaries (female)
- Testes (male)
Chemical Classes of Hormones

- Polypeptides
- Steroids
- Amines
Signal Transduction Pathway

- Epinephrine
- G protein-coupled receptor
- GTP
- ATP
- cAMP
- Second messenger
- Inhibition of glycogen synthesis
- Promotion of glycogen breakdown
- Protein kinase A
- DNA
- mRNA for vitellogenin
- Estradiol (estrogen) receptor
- Hormone-receptor complex
- Plasma membrane
- Extracellular fluid
- Nucleus
- Cytoplasm
- Vitellogenin
Warm Up Exercise

• Explain the difference in how lipid and water soluble hormones elicit a response on a target cell and specifically what type of responses are characteristic of lipid soluble hormones?
Simple Endocrine Pathway - endocrine cells respond to stimulus by secreting a hormone that travels in bloodstream to target cells, where it binds to its specific receptors.
Simple Hormone Pathways

- **Simple Neuroendocrine Pathway**: stimulus is received by sensory neuron, which stimulates a neurosecretory cell which releases a neurohormone that diffuses into bloodstream and travels to target cells.
Control of Blood Glucose

- When blood glucose rises above normal, insulin is released, which triggers uptake of glucose from blood into body cells, decreasing blood glucose concentration.

- When blood glucose drops below the normal range, glucagon is released which promotes release of glucose into the blood from energy stores (such as glycogen in the liver) increasing blood glucose concentration.
Body cells take up more glucose.

Liver takes up glucose and stores it as glycogen.

Blood glucose level declines.

Blood glucose level rises.

Liver breaks down glycogen and releases glucose into the blood.

Homeostasis: Blood glucose level (70–110 mg/100 mL)

STIMULUS: Blood glucose level falls (for instance, after skipping a meal).

Alpha cells of pancreas release glucagon into the blood.

STIMULUS: Insulin

Beta cells of pancreas release insulin into the blood.

Insulin
Diabetes

- **Type 1** - insulin-dependent diabetes - an autoimmune disorder - the immune system destroys beta cells of pancreas that produce insulin.

- **Type 2** - non-insulin dependent - failure of target cells to respond normally to insulin, resulting in continually high blood glucose levels.
Warm Up Exercise

- Explain the difference in the regulation of a simple endocrine pathway and a simple neuroendocrine pathway.
Hypothalamus and Pituitary

- **Hypothalamus** receives information from nerves throughout the body and initiates signaling in response to the stimuli.
Hypothalamus and Pituitary

- **Pituitary Gland** - respond to signals from the hypothalamus.
- **Posterior Pituitary** - secrete neurohormones synthesized in the hypothalamus.
- **Anterior Pituitary** - synthesizes and secretes hormones in response to signals from hypothalamus.
- **Tropic Hormones** - regulate the function of other endocrine cells/glands.
Posterior Pituitary

- Stores hormones from neurosecretory cells (in hypothalamus) and releases them in response to nerve impulses transmitted by the hypothalamus.
Anterior Pituitary

• Hormones synthesized by the anterior pituitary are controlled by releasing and inhibiting hormones secreted from the hypothalamus.
Hormone Cascade Pathway

Stimulus: Cold
- Sensory neuron
- Hypothalamus
  - Neurosecretory cell
  - Releasing hormone
  - Blood vessel
- Anterior pituitary
  - Tropic hormone
- Endocrine cell
  - Hormone
- Target cells
- Response: Increased cellular metabolism

Example:
- Hypothalamus secretes thyrotropin-releasing hormone (TRH).
- Anterior pituitary secretes thyroid-stimulating hormone (TSH, also known as thyrotropin).
- Thyroid gland secretes thyroid hormone ($T_3$ and $T_4$).
Thyroid Disorders

• **Hypothyroidism** - too little thyroid function.

• **Hyperthyroidism** - excessive secretion of thyroid hormone.
  - **Graves Disease** - autoimmune disorder - body produces antibodies that bind to receptor for TSH leading to sustained thyroid hormone production.

• **Goiter** - enlargement of the thyroid gland. Due to lack of iodine in the diet.
Goiter and Graves

Graves’ ophthalmopathy

Bulging, reddened eyes
Tropic and Nontropic Hormones

- Tropic
  - TSH (Thyroid Stimulating Hormone)
  - FSH (Follicle-Stimulating Hormone)
  - LH (Luteinizing Hormone)
  - ACTH (Adrenocorticotropic Hormone)
  - Growth Hormone (GH)
    - Can be tropic and nontropic
Warm Up Exercise

• Explain some differences in the anterior and posterior pituitary.

• Describe the role of the hypothalamus.
Parathyroid Hormones: Control of Blood Calcium

- **Parathyroid Glands** - four small structures on the posterior side of the thyroid - play a role in Ca$^{2+}$ regulation.
  - Hormone: PTH - parathyroid hormone
Adrenal Hormones: Response to Stress

- **Adrenal Glands**- made up of two glands: the adrenal cortex (outside) and adrenal medulla (inside). Both respond to stressful stimuli.
  - **Catecholamines**- synthesized by the adrenal medulla. (response to nervous input)
    - Ex: epinephrine and norepinephrine- which trigger “fight or flight” or acute stress response.
  - **Corticosteroids**- synthesized by the adrenal cortex. (response to endocrine signals)
    - Two classes: glucocorticoids (cortisol) and mineralocorticoids (aldosterone).
(a) Short-term stress response and the adrenal medulla

- Spinal cord (cross section)
- Nerve signals
- Nerve cell
- Adrenal medulla secretes epinephrine and norepinephrine.

(b) Long-term stress response and the adrenal cortex

- Hypothalamus
- Released hormone
- Anterior pituitary
- Blood vessel
- Adrenal cortex secretes mineralocorticoids and glucocorticoids.

Effects of epinephrine and norepinephrine:
- Glycogen broken down to glucose; increased blood glucose
- Increased blood pressure
- Increased breathing rate
- Increased metabolic rate
- Change in blood flow patterns, leading to increased alertness and decreased digestive, excretory, and reproductive system activity

Effects of mineralocorticoids:
- Retention of sodium ions and water by kidneys

Effects of glucocorticoids:
- Proteins and fats broken down and converted to glucose, leading to increased blood glucose
- Increased blood volume and blood pressure
- Partial suppression of immune system

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Sex Hormones

• Androgens
  • **Testosterone** - determines male development at birth and the development of secondary sex characteristics during puberty.

• Estrogens
  • **Estradiol** - maintenance of female reproductive system and secondary sex characteristics.

• Progestins
  • **Progesterone** - preparing and maintaining tissues of the uterus required to support the growth and development of an embryo.
Pineal Gland

- **Pineal Gland** - primary source of the hormone melatonin.
  - **Melatonin** - secreted at night in response to light and dark; helps induce sleep.