

# LECTURE TOPICS OUTLINE

# ENDOCRINE SYSTEM

*Please bring these typed notes to lecture.*

## I. GENERAL CHARACTERISTICS OF THE ENDOCRINE SYSTEM

- A. The endocrine system is made up of the cells, tissues, and organs that secrete hormones into body fluids.
- B. "Local hormones" include paracrine secretions that are released to interstitial fluid and affect only nearby cells, and autocrine secretions that influence the cell secreting the hormone.
- C. Endocrine glands and their hormones regulate a number of metabolic processes within cells, as well as reproduction, development, and growth.

## II. HORMONE ACTION

- A. A hormone is a biochemical secreted by one cell that affects a specific target cell with appropriate cell surface receptors. Compare to the Nervous system.
- B. Chemistry of Hormones
  1. Hormones are steroids, amines, peptides, proteins, or glycoproteins; they can influence target cells even if they are present only in minute concentrations.
  2. Prostaglandins are paracrine substances that are lipids; they occur in a wide variety of cells.
- C. Action of Hormones
  1. Hormones exert their effects by altering metabolic processes in target cells.
  2. To do so, hormones must bind to their specific receptors, an action that triggers a series of changes in the target cell.
  3. **Steroid Hormones**
    - a. Steroid hormones are lipid-soluble and can pass through cell membranes.
    - b. Receptors for steroid hormones are located in the target cell's nucleus.
    - c. The hormone-receptor complex binds with the DNA and activates specific genes that, in turn, direct the synthesis of specific proteins.
  4. **Nonsteroid Hormones**
    - a. Nonsteroid hormones are water-soluble and do not enter the cell.
    - b. Surface receptors combine with the nonsteroid hormones, and the hormone-receptor complex (as first messenger) triggers a cascade of biological activity.
    - c. The hormone-receptor complex generally activates a G protein, which then activates adenylate cyclase that is bound to the inner cell membrane.
    - d. Adenylate cyclase removes two phosphates from ATP to produce cyclic AMP (the second messenger), which in turn activates protein kinases that phosphorylate proteins.
    - e. The activated proteins induce changes in the cell.
    - f. Not all nonsteroid hormones use cAMP; others use diacylglycerol (DAG) or cyclic GMP.
  5. Cellular response to a steroid hormone is directly proportional to the number of hormone-receptor complexes that form.
  6. The cellular response to a nonsteroid hormone through a second messenger is greatly amplified.

## II. HORMONE ACTION (CONT.)

#### D. Prostaglandins

1. Some prostaglandins regulate cellular responses to hormones by controlling the production of cAMP.
2. Prostaglandins produce a variety of effects: some relax smooth muscle, others contract smooth muscle, some stimulate secretion of other hormones, and others influence blood pressure and inflammation.

### III. CONTROL OF HORMONAL SECRETIONS

A. Hormone levels are very precisely regulated.

B. Control Sources

1. Release of **tropic hormones** from the hypothalamus controls secretions of the anterior pituitary.
2. Other glands respond directly to changes in the internal fluid composition.
3. The nervous system influences certain endocrine glands directly.

C. Negative Feedback Systems

1. Commonly, negative feedback mechanisms operate to control hormonal releases.
2. In a negative feedback system, a gland is sensitive to the concentration of the substance it regulates.
3. When the concentration of the regulated substance reaches a certain level (high or low), it inhibits the gland from secreting more hormone until the concentration returns to normal.

### IV. PITUITARY GLAND

A. The pituitary gland is attached to the base of the brain and has an anterior lobe (adenohypophysis) and a posterior lobe (neurohypophysis).

B. The anterior lobe secretes six hormones, and the posterior pituitary stores two hormones secreted by neurosecretory cells.

C. The hypothalamus controls the activity of the pituitary gland.

1. **Releasing hormones** from the hypothalamus control the secretions of the anterior pituitary.
  - a. The **releasing hormones** are carried in the bloodstream directly to the anterior pituitary by hypophyseal portal veins.
2. The posterior pituitary releases hormones into the bloodstream *in response to nerve impulses from the hypothalamus*.

D. Anterior Pituitary Hormones

1. The anterior pituitary consists mostly of epithelial tissue arranged around blood vessels and enclosed in a capsule of collagenous connective tissue.
2. **Growth hormone (GH)** stimulates body cells to grow and reproduce.
  - a. **Growth hormone-releasing hormone** from the hypothalamus increases the amount of **GH** released, while **somatostatin** inhibits its release.
  - b. Nutritional status affects the release of **GH**; more is released when nutrients are insufficient.
3. **Prolactin (PRL)** promotes milk production.
  - a. **Prolactin-releasing hormone** from the hypothalamus increases the amount of **PRL** released, while **prolactin release-inhibiting hormone** inhibits release of **PRL**.
4. **Thyroid-stimulating hormone (TSH)** controls the secretion of hormones from the thyroid gland.
  - a. It also stimulates the growth of the thyroid gland under certain conditions.
  - b. **Thyrotropin-releasing hormone** from the hypothalamus regulates the release of **TSH**.
  - c. Cold and emotional stress also influence the amount of **TSH** released.
5. **Adrenocorticotropic hormone (ACTH)** controls the secretion of hormones from the adrenal cortex.
  - a. It is regulated by **corticotropin-releasing hormone** from the hypothalamus, and stress can also increase its release.
6. **Follicle-stimulating hormone (FSH)** is responsible for growth of egg-cell-containing follicles in the ovary and stimulates production of sperm in the male at puberty.
  - a. Release of **FSH** is regulated by **gonadotropin-releasing hormone** from the hypothalamus at puberty.
7. **Luteinizing hormone (LH)** promotes the secretion of sex hormones in both males and females and is essential for triggering ovulation.
  - a. Release of **LH**: regulated by **gonadotropin-releasing hormone** (hypothalamus) at puberty.

#### IV. PITUITARY GLAND CONT.

##### E. Posterior Pituitary Hormones

1. The posterior lobe consists of nerve fibers and neuroglial cells that support nerve fibers arising in the hypothalamus.
2. Neurons in the hypothalamus produce **antidiuretic hormone** and **oxytocin**, which are stored in the posterior pituitary.
3. **Antidiuretic hormone (ADH)** produces its effect by causing the kidneys to conserve water.
  - a. The hypothalamus regulates the secretion of **ADH** based on osmotic pressure of body fluids.
4. **Oxytocin** plays a role in childbirth by contracting muscles in the uterine wall, and in milk-letdown by forcing milk into ducts from the milk glands.
  - a. Stretching of the uterus in the latter stages of pregnancy stimulates release of **oxytocin**.
  - b. Suckling of an infant at the breast stimulates release of **oxytocin** after childbirth.

#### V. THYROID GLAND

A. The thyroid gland is located below the larynx and requires iodine.

##### B. Structure of the Gland

1. The thyroid consists of secretory parts called follicles filled with hormone-storing colloid.
2. Extrafollicular cells that secrete a different hormone lie outside the follicles.

##### C. Thyroid Hormones

1. The follicular cells produce two iodine-containing hormones, **thyroxine (T<sub>4</sub>)** tetraiodothyronine) and triiodothyronine (**T<sub>3</sub>**), that together regulate energy metabolism.
  - a. These two hormones increase the rate at which cells release energy from carbohydrates, enhance protein synthesis, and stimulate the breakdown and mobilization of lipids.
  - b. These hormones are essential for normal growth and development.
2. The extrafollicular cells secrete **calcitonin**, which lowers blood levels of calcium and phosphate ions when they are too high.
  - a. **Calcitonin** increases the rate at which calcium is stored in bones.
  - b. **Calcitonin** secretion is regulated by negative feedback involving blood concentrations of calcium.

#### VI. PARATHYROID GLANDS

A. The four, tiny parathyroids are located on the posterior of the thyroid.

##### B. Structure of the Glands

1. Parathyroid glands consist of tightly packed secretory cells covered by a thin capsule of connective tissue.

##### C. Parathyroid Hormone

1. **Parathyroid hormone (PTH)** increases blood calcium ion concentration and decreases phosphate ion concentration.
  2. **PTH** stimulates bone resorption by osteoclasts, which releases calcium into the blood.
  3. **PTH** also influences vitamin D metabolism, which results in an increased absorption of calcium in the intestines.
  4. A negative feedback mechanism involving blood calcium levels regulates release of **PTH**.
- D. **Calcitonin** and **PTH** exert opposite effects in regulating calcium ion levels in the blood within precise limits.

#### VII. ADRENAL GLANDS

A. The adrenal glands sit atop the kidneys enclosed in a layer of fat.

##### B. Structure of the Glands

1. The pyramid-shaped glands consist of an inner adrenal medulla and an outer adrenal cortex.
2. The adrenal medulla is made up of modified postganglionic neurons that are connected to the sympathetic nervous system.
3. The adrenal cortex makes up the bulk of the adrenal glands and consists of epithelial cells in three layers: an outer zona glomerulosa, a middle zona fasciculata, and an inner zona reticularis.

## VII. ADRENAL GLANDS (P. 490) CONT.

### C. Hormones of the Adrenal Medulla

1. The chromaffin cells of the adrenal medulla produce and store **epinephrine** and **norepinephrine**.
2. The effects of these hormones resemble those of the sympathetic division neurotransmitters of the same name, except that they last up to 10 times longer when released into the bloodstream.
3. Release of medullary hormones is regulated by nervous impulses from the central nervous system.

### D. Hormones of the Adrenal Cortex

1. The cells of the adrenal cortex produce over 30 different steroids, some of which are vital to survival, the most important of which are **aldosterone**, **cortisol**, and the **sex hormones**.
2. **Aldosterone**
  - a. **Aldosterone**, from the **zona glomerulosa**, causes the kidneys to conserve sodium ions and thus water, and to excrete potassium ions.
  - b. **Aldosterone** is secreted in response to decreasing blood volume and blood pressure as a result of changes in the renin-angiotensin system.
  - c. The result of **aldosterone** secretion is maintenance of blood volume and blood pressure within normal limits.
3. **Cortisol**
  - a. **Cortisol** (**zona fasciculata**) influences the metabolism of glucose, protein, and fat in response to conditions that stress the body and require a greater supply of energy in the bloodstream.
  - b. A negative feedback mechanism involving **CRH** from the hypothalamus and **ACTH** from the anterior pituitary controls the release of **cortisol**.
4. **Sex Hormones**
  - a. **Sex hormones**, produced in the **zona reticularis**, are mostly of the male type (**adrenal androgens**), but can be converted to female hormones (**estrogens**) in the skin, liver, and adipose tissues.
  - b. These hormones supplement those released by the gonads and may (in the case of female **estrogens**) influence the female sex drive.

## VIII. PANCREAS

A. The pancreas secretes hormones as an endocrine gland, and digestive juices as an accessory organ to the digestive tract.

### B. Structure of the Gland

1. The pancreas is an elongated organ posterior to the stomach.
2. Its endocrine portions are the islets of Langerhans that include three cell types--alpha cells (secrete **glucagon**), beta cells (secrete **insulin**), and delta cells (secrete **somatostatin**).

### C. Hormones of the Islets of Langerhans

1. **Glucagon** increases the blood levels of glucose by stimulating the breakdown of glycogen and the conversion of noncarbohydrates into glucose.
  - a. The release of **glucagon** is controlled by a negative feedback system involving low blood glucose levels.
2. **Insulin** decreases the blood levels of glucose by stimulating the liver to form glycogen, increasing protein synthesis, and stimulating adipose cells to store fat.
  - a. The release of **insulin** is controlled by a negative feedback system involving high blood glucose levels.
3. **Somatostatin** helps regulate glucose metabolism by inhibiting the secretion of glucagon and insulin.
  - a. Its source of control has not been determined.

## IX. OTHER ENDOCRINE GLANDS

### A. Pineal Gland

1. The pineal gland, near the upper portion of the thalamus, secretes **melatonin**, which is involved in the regulation of circadian rhythms of the body.

### B. Thymus Gland

1. The thymus gland, lying between the lungs under the sternum, secretes **thymosins** that affect production and differentiation of T lymphocytes that are important in immunity.

### C. Reproductive Glands

1. The ovaries produce **estrogen** and **progesterone**.
2. The placenta produces **estrogen**, **progesterone**, and a **gonadotropin**.
3. The testes produce **testosterone**.

### D. Digestive Glands

1. The digestive glands secrete hormones associated with the processes of digestion. (recall **gastrin**)

### E. Other Hormone-Producing Organs

1. The kidneys also produce **erythropoietin**.

## X. STRESS AND ITS EFFECTS

### A. Factors that serve as stressors to the body produce stress and threaten homeostasis.

### B. Types of Stress

1. Stress may be physical, psychological, or some combination of the two.
2. Physical stress threatens the survival of tissues, such as extreme cold, prolonged exercise, or infections.
3. Psychological stress results from real or perceived dangers, and includes feelings of anger, depression, fear, and grief; sometimes, pleasant stimuli cause stress.

### C. Response to Stress

1. Responses to stress are designed to maintain homeostasis.
2. The hypothalamus controls the general stress syndrome, which involves increased sympathetic activity and increased secretion of **cortisol**, **glucagon**, **growth hormone**, and **antidiuretic hormone**.