Introduction to the Endocrine System

The endocrine system, along with the nervous system, functions in the regulation of body activities. The nervous system acts through electrical impulses and neurotransmitters to cause muscle contraction and glandular secretion. The effect is of short duration, measured in seconds, and localized. The endocrine system acts through chemical messengers called hormones that influence growth, development, and metabolic activities. The action of the endocrine system is measured in minutes, hours, or weeks and is more generalized than the action of the nervous system.

There are two major categories of glands in the body - exocrine and endocrine.

Exocrine Glands

Exocrine glands have ducts that carry their secretory product to a surface. These glands include the sweat, sebaceous, and mammary glands and, the glands that secrete digestive enzymes.

Endocrine Glands

The endocrine glands do not have ducts to carry their product to a surface. They are called ductless glands. The word endocrine is derived from the Greek terms "endo," meaning within, and "krine," meaning to separate or secrete. The secretory products of endocrine glands are called
hormones and are secreted directly into the blood and then carried throughout the body where they influence only those cells that have receptor sites for that hormone.

**Characteristics of Hormones**

**Chemical Nature of Hormones**

Chemically, hormones may be classified as either proteins or steroids. All of the hormones in the human body, except the sex hormones and those from the adrenal cortex, are proteins or protein derivatives.

**Mechanism of Hormone Action**

Hormones are carried by the blood throughout the entire body, yet they affect only certain cells. The specific cells that respond to a given hormone have receptor sites for that hormone. This is sort of a lock-and-key mechanism. If the key fits the lock, then the door will open. If a hormone fits the receptor site, then there will be an effect. If a hormone and a receptor site do not match, then there is no reaction. All the cells that have receptor sites for a given hormone make up the target tissue for that hormone. In some cases, the target tissue is localized in a single gland or organ. In other cases, the target tissue is diffuse and scattered throughout the body so that many areas are affected. Hormones bring about their characteristic effects on target cells by modifying cellular activity.

Protein hormones react with receptors on the surface of the cell, and the sequence of events that results in hormone action is relatively rapid. Steroid hormones typically react with receptor sites inside a cell. Because this method of action actually involves synthesis of proteins, it is relatively slow.

**Control of Hormone Action**

Hormones are very potent substances, which means that very small amounts of a hormone may have profound effects on metabolic processes. Because of their potency, hormone secretion must be regulated within very narrow limits in order to maintain homeostasis in the body.

Many hormones are controlled by some form of a negative feedback mechanism. In this type of system, a gland is sensitive to the concentration of a substance that it regulates. A negative feedback system causes a reversal of increases and decreases in body conditions in order to maintain a state of stability or homeostasis. Some endocrine glands secrete hormones in response to other hormones. The hormones that cause secretion of other hormones are called tropic hormones. A hormone from gland A causes gland B to secrete its hormone. A third method of regulating hormone secretion is by direct nervous stimulation. A nerve stimulus causes gland A to secrete its hormone.

**Endocrine Glands & Their Hormones**

The endocrine system is made up of the endocrine glands that secrete hormones. Although there are eight major endocrine glands scattered throughout the body, they are still considered to be one system because they have similar functions, similar mechanisms of influence, and many important interrelationships.

Some glands also have non-endocrine regions that have functions other than hormone secretion. For example, the pancreas has a major exocrine portion that secretes digestive enzymes and an endocrine portion that secretes hormones. The ovaries and testes secrete hormones and also
produce the ova and sperm. Some organs, such as the stomach, intestines, and heart, produce hormones, but their primary function is not hormone secretion.

**Pituitary & Pineal Glands**

**Pituitary Gland**

The pituitary gland or hypophysis is a small gland about 1 centimeter in diameter or the size of a pea. It is nearly surrounded by bone as it rests in the sella turcica, a depression in the sphenoid bone. The gland is connected to the hypothalamus of the brain by a slender stalk called the infundibulum.

**Hormones of the Anterior Lobe (Adenohypophysis)**

Growth hormone is a protein that stimulates the growth of bones, muscles, and other organs by promoting protein synthesis. This hormone drastically affects the appearance of an individual because it influences height. If there is too little growth hormone in a child, that person may become a pituitary dwarf of normal proportions but small stature. An excess of the hormone in a child results in an exaggerated bone growth, and the individual becomes exceptionally tall or a giant.

**Thyroid-stimulating hormone, or thyrotropin,** causes the glandular cells of the thyroid to secrete thyroid hormone. When there is a hypersecretion of thyroid-stimulating hormone, the thyroid gland enlarges and secretes too much thyroid hormone.

**Adrenocorticotropic hormone** reacts with receptor sites in the cortex of the adrenal gland to stimulate the secretion of cortical hormones, particularly cortisol.

**Gonadotropic hormones** react with receptor sites in the gonads, or ovaries and testes, to regulate the development, growth, and function of these organs.

**Prolactin** hormone promotes the development of glandular tissue in the female breast during pregnancy and stimulates milk production after the birth of the infant.

**Hormones of the Posterior Lobe (Neurohypophysis)**

**Antidiuretic hormone** promotes the reabsorption of water by the kidney tubules, with the result that less water is lost as urine. This mechanism conserves water for the body. Insufficient amounts of antidiuretic hormone cause excessive water loss in the urine.

**Oxytocin** causes contraction of the smooth muscle in the wall of the uterus. It also stimulates the ejection of milk from the lactating breast.

**Pineal Gland**

The pineal gland, also called pineal body or epiphysis cerebri, is a small cone-shaped structure that extends posteriorly from the third ventricle of the brain. The pineal gland consists of portions of neurons, neuroglial cells, and specialized secretory cells called pinealocytes. The pinealocytes synthesize the hormone melatonin and secrete it directly into the cerebrospinal fluid, which takes it into the blood. Melatonin affects reproductive development and daily physiologic cycles.
Thyroid & Parathyroid Glands

Thyroid Gland

The thyroid gland is a very vascular organ that is located in the neck. It consists of two lobes, one on each side of the trachea, just below the larynx or voice box. The two lobes are connected by a narrow band of tissue called the isthmus. Internally, the gland consists of follicles, which produce thyroxine and triiodothyronine hormones. These hormones contain iodine.

About 95 percent of the active thyroid hormone is thyroxine, and most of the remaining 5 percent is triiodothyronine. Both of these require iodine for their synthesis. Thyroid hormone secretion is regulated by a negative feedback mechanism that involves the amount of circulating hormone, hypothalamus, and adenohypophysis.

If there is an iodine deficiency, the thyroid cannot make sufficient hormone. This stimulates the anterior pituitary to secrete thyroid-stimulating hormone, which causes the thyroid gland to increase in size in a vain attempt to produce more hormones. But it cannot produce more hormones because it does not have the necessary raw material, iodine. This type of thyroid enlargement is called simple goiter or iodine deficiency goiter.

Calcitonin is secreted by the parafollicular cells of the thyroid gland. This hormone opposes the action of the parathyroid glands by reducing the calcium level in the blood. If blood calcium becomes too high, calcitonin is secreted until calcium ion levels decrease to normal.

Parathyroid Gland

Four small masses of epithelial tissue are embedded in the connective tissue capsule on the posterior surface of the thyroid glands. These are parathyroid glands, and they secrete parathyroid hormone or parathormone. Parathyroid hormone is the most important regulator of blood calcium levels. The hormone is secreted in response to low blood calcium levels, and its effect is to increase those levels.

Hypoparathyroidism, or insufficient secretion of parathyroid hormone, leads to increased nerve excitability. The low blood calcium levels trigger spontaneous and continuous nerve impulses, which then stimulate muscle contraction.

Adrenal Gland

The adrenal, or suprarenal, gland is paired with one gland located near the upper portion of each kidney. Each gland is divided into an outer cortex and an inner medulla. The cortex and medulla of the adrenal gland, like the anterior and posterior lobes of the pituitary, develop from different embryonic tissues and secrete different hormones. The adrenal cortex is essential to life, but the medulla may be removed with no life-threatening effects.

The hypothalamus of the brain influences both portions of the adrenal gland but by different mechanisms. The adrenal cortex is regulated by negative feedback involving the hypothalamus and adrenocorticotropic hormone; the medulla is
regulated by nerve impulses from the hypothalamus.

**Hormones of the Adrenal Cortex**

The adrenal cortex consists of three different regions, with each region producing a different group or type of hormones. Chemically, all the cortical hormones are steroid.

Mineralocorticoids are secreted by the outermost region of the adrenal cortex. The principal mineralocorticoid is aldosterone, which acts to conserve sodium ions and water in the body. Glucocorticoids are secreted by the middle region of the adrenal cortex. The principal glucocorticoid is cortisol, which increases blood glucose levels.

The third group of steroids secreted by the adrenal cortex is the gonadocorticoids, or sex hormones. These are secreted by the innermost region. Male hormones, androgens, and female hormones, estrogens, are secreted in minimal amounts in both sexes by the adrenal cortex, but their effect is usually masked by the hormones from the testes and ovaries. In females, the masculinization effect of androgen secretion may become evident after menopause, when estrogen levels from the ovaries decrease.

**Hormones of the Adrenal Medulla**

The adrenal medulla develops from neural tissue and secretes two hormones, epinephrine and norepinephrine. These two hormones are secreted in response to stimulation by sympathetic nerve, particularly during stressful situations. A lack of hormones from the adrenal medulla produces no significant effects. Hypersecretion, usually from a tumor, causes prolonged or continual sympathetic

**Pancreas—Islets of Langerhans**

The pancreas is a long, soft organ that lies transversely along the posterior abdominal wall, posterior to the stomach, and extends from the region of the duodenum to the spleen. This gland has an exocrine portion that secretes digestive enzymes that are carried through a duct to the duodenum. The endocrine portion consists of the pancreatic islets, which secrete glucagons and insulin.

Alpha cells in the pancreatic islets secrete the hormone glucagons in response to a low concentration of glucose in the blood. Beta cells in the pancreatic islets secrete the hormone insulin in response to a high concentration of glucose in the blood.

**Gonads**

The gonads, the primary reproductive organs, are the testes in the male and the ovaries in the female. These organs are responsible for producing the sperm and ova, but they also secrete hormones and are considered to be endocrine glands.

**Testes**

Male sex hormones, as a group, are called androgens. The principal androgen is testosterone, which is secreted by the testes. A small amount is also produced by the adrenal cortex.
Production of testosterone begins during fetal development, continues for a short time after birth, nearly ceases during childhood, and then resumes at puberty. This steroid hormone is responsible for:

- The growth and development of the male reproductive structures
- Increased skeletal and muscular growth
- Enlargement of the larynx accompanied by voice changes
- Growth and distribution of body hair
- Increased male sexual drive

Testosterone secretion is regulated by a negative feedback system that involves releasing hormones from the hypothalamus and gonadotropins from the anterior pituitary.

Other Endocrine Glands

In addition to the major endocrine glands, other organs have some hormonal activity as part of their function. These include the thymus, stomach, small intestines, heart, and **placenta**.

**Thymosin**, produced by the thymus gland, plays an important role in the development of the body's immune system.

The lining of the stomach, the gastric mucosa, produces a hormone, called **gastrin**, in response to the presence of food in the stomach. This hormone stimulates the production of hydrochloric acid and the enzyme pepsin, which are used in the digestion of food.

The mucosa of the small intestine secretes the hormones **secretin** and **cholecystokinin**. Secreting stimulates the pancreas to produce a bicarbonate-rich fluid that neutralizes the stomach acid. Cholecystokinin stimulates contraction of the gallbladder, which releases bile. It also stimulates the pancreas to secrete digestive enzyme.

The heart also acts as an endocrine organ in addition to its major role of pumping blood. Special cells in the wall of the upper chambers of the heart, called atria, produce a hormone called **atrial natriuretic** hormone, or **atriopeptin**.

The placenta develops in the pregnant female as a source of nourishment and gas exchange for the developing fetus. It also serves as a temporary endocrine gland. One of the hormones it secretes is **human chorionic gonadotropin**, which signals the mother's ovaries to secrete hormones to maintain the uterine lining so that it does not degenerate and slough off in menstruation.
Review: Introduction to the Endocrine System

Here is what we have learned from *Introduction to the Endocrine System*:

- Chemical messengers from the endocrine system help regulate body activities. Their effect is of longer duration and is more generalized than that of the nervous system.
- Neurons are the nerve cells that transmit impulses. Supporting cells are neuroglia.
- Endocrine glands secrete hormones directly into the blood, which transports the hormones through the body.
- Cells in a target tissue have receptor sites for specific hormones.
- Many hormones are regulated by a negative feedback mechanism; some are controlled by other hormones; and others are affected by direct nerve stimulation.
- Even though the endocrine glands are scattered throughout the body, they are still considered to be one system because they have similar functions, similar mechanisms of influence, and many important interrelationships.
- Major glands include: pituitary gland, thyroid gland, parathyroid gland, adrenal (suprarenal) gland, pancreas, gonads (testes and ovaries), pineal gland, and other endocrine glands.

Disorders and Diseases of the Endocrine System

**Hypopituitarism**

Hypopituitarism is a rare disorder in which your pituitary gland either fails to produce one or more of its hormones or doesn't produce enough of them.

Hypopituitarism is often progressive. Although the signs and symptoms can occur suddenly, they more often develop gradually. They are sometimes subtle and may be overlooked for months or even years.

Signs and symptoms of hypopituitarism vary, depending on which pituitary hormones are deficient and how severe the deficiency is. They may include:

- Fatigue
- Weight loss
- Decreased sex drive
- Sensitivity to cold or difficulty staying warm
- Decreased appetite
- Facial puffiness
- Anemia
- Infertility
- Hot flashes, irregular or no periods, loss of pubic hair, and inability to produce milk for breast-feeding in women
- Decreased facial or body hair in men
- Short stature in children

**Acromegaly**

Acromegaly (ak-roh-MEG-uh-lee) is a rare hormonal disorder that develops when your pituitary gland produces too much growth hormone, nearly always as a result of a noncancerous (benign) tumor. The excess hormone causes swelling, skin thickening, tissue growth and bone enlargement, especially in face, hands and feet.

Typical signs and symptoms of acromegaly include:

- Enlarged hands and feet
- Larger and broader facial features
- Protrusion of the lower jaw so the lower teeth extend beyond the upper teeth (underbite)
- Thickened, oily skin
- Excessive sweating and body odor
- Small skin outgrowths (skin tags)
- Fatigue and muscle weakness
- A deepened, husky voice due to enlarged vocal cords and sinuses
- Severe snoring and frequent brief interruptions in nighttime breathing (sleep apnea) due to tissue swelling that blocks your upper airway
- Impaired vision
- Headaches
- Enlarged tongue
- Back pain
- Pain and limited mobility in joints
- Menstrual cycle irregularities in women
- Reduced sex drive and, in men, trouble achieving or maintaining an erection (erectile dysfunction)
- Enlarged liver, heart, kidneys, spleen and other organs
- Increased chest size (barrel chest)

Acromegaly usually develops slowly, and even your family members may not initially notice the gradual physical changes that have occurred. Timely diagnosis is important, though, so that you can receive proper care. Acromegaly can lead to serious complications if it's not treated.

**Diabetes insipidus**

Diabetes insipidus (die-uh-BEE-te in-SIP-uh-dus) is an uncommon disorder characterized by intense thirst and the excretion of large amounts of urine (polyuria). In most cases, it's the result of your body not properly producing, storing or releasing a key hormone, but diabetes insipidus (DI) can also occur when your kidneys are unable to respond properly to that hormone. Rarely, diabetes insipidus can occur during pregnancy (gestational diabetes insipidus).

The most common signs and symptoms of diabetes insipidus are:

- Extreme thirst
- Excretion of an excessive amount of diluted urine

Depending on the severity of the condition, urine output can range from 2.6 quarts (about 2.5 liters) a day if one has mild diabetes insipidus to 16 quarts (about 15 liters) a day if the condition is severe and if one is taking in a lot of fluids. In comparison, the average urine output for a healthy adult is in the range of 1.6 to 2.6 quarts (about 1.5 to 2.5 liters) a day.

Infants and young children who have diabetes insipidus may have the following signs and symptoms:

- Unexplained fussiness or inconsolable crying
- Unusually wet diapers
- Fever, vomiting or diarrhea
- Dry skin with cool extremities
- Delayed growth

- Weight loss

Complications of diabetes insipidus include:

**Dehydration**

Except for dipsogenic DI, which causes a person to retain too much water, diabetes insipidus can cause the body to retain too little water to function properly, and one can become dehydrated. Dehydration can cause:

- Dry mouth
- Muscle weakness
- Low blood pressure (hypotension)
- Elevated blood sodium (hyponatremia)
- Sunken appearance to your eyes
- Fever
- Headache
- Rapid heart rate
- Weight loss

**Electrolyte imbalance**

Diabetes insipidus can also cause an electrolyte imbalance. Electrolytes are minerals in the blood — such as sodium, potassium and calcium — that maintain the balance of fluids in the body. Electrolyte imbalance can cause symptoms, such as:

- Headache
- Fatigue
- Irritability
- Muscle pains

**Water intoxication**

Excessive fluid intake in dipsogenic diabetes insipidus can lead to water intoxication, a condition that lowers sodium concentration in the blood, which can damage the brain.

**Hyperthyroidism**

Hyperthyroidism (overactive thyroid) is a condition in which the thyroid gland produces too much of the hormone thyroxine. Hyperthyroidism can significantly accelerate the body's metabolism, causing sudden weight loss, a rapid or irregular heartbeat, sweating, and nervousness or irritability.

Hyperthyroidism can mimic other health problems, which may make it difficult for a
doctor to diagnose. It can also cause a wide variety of signs and symptoms, including:

- Sudden weight loss, even when your appetite and diet remain normal or even increase
- Rapid heartbeat (tachycardia) — commonly more than 100 beats a minute — irregular heartbeat (arrhythmia) or pounding of your heart (palpitations)
- Increased appetite
- Nervousness, anxiety and irritability
- Tremor — usually a fine trembling in your hands and fingers
- Sweating
- Changes in menstrual patterns
- Increased sensitivity to heat
- Changes in bowel patterns, especially more frequent bowel movements
- An enlarged thyroid gland (goiter), which may appear as a swelling at the base of your neck
- Fatigue, muscle weakness
- Difficulty sleeping

Older adults are more likely to have either no signs or symptoms or subtle ones, such as an increased heart rate, heat intolerance and a tendency to become tired during ordinary activities. Medications called beta blockers, which are used to treat high blood pressure and other conditions, can mask many of the signs of hyperthyroidism.

**Hypothyroidism**

Hypothyroidism (underactive thyroid) is a condition in which the thyroid gland doesn't produce enough of certain important hormones.

At first, one may barely notice the symptoms of hypothyroidism, such as fatigue and sluggishness, or may simply attribute them to getting older. But as the metabolism continues to slow, one may develop more obvious signs and symptoms. Hypothyroidism signs and symptom may include:

- Fatigue
- Sluggishness
- Increased sensitivity to cold
- Constipation
- Pale, dry skin
- A puffy face
- Hoarse voice
- An elevated blood cholesterol level
- Unexplained weight gain
- Muscle aches, tenderness and stiffness
- Pain, stiffness or swelling in your joints
- Muscle weakness
- Heavier than normal menstrual periods
- Brittle fingernails and hair
- Depression

When hypothyroidism isn't treated, signs and symptoms can gradually become more severe. Constant stimulation of your thyroid to release more hormones may lead to an enlarged thyroid (goiter). In addition, person with hypothyroidism may become more forgetful, thought processes may slow, or the person may feel depressed.

**Diabetes mellitus**

The term "diabetes mellitus" refers to a group of diseases that affect how the body uses blood glucose, commonly called blood sugar. Glucose is vital to the health because it's an important source of energy for the cells that make up the muscles and tissues. It's the brain's main source of fuel.

Chronic diabetes conditions include type 1 diabetes and type 2 diabetes. Potentially reversible diabetes conditions include prediabetes — when the blood sugar levels are higher than normal, but not high enough to be classified as diabetes — and gestational diabetes, which occurs during pregnancy.

Diabetes symptoms vary depending on how high the blood sugar is elevated. Some people, especially those with prediabetes or type 2 diabetes, may not experience symptoms initially. In type 1 diabetes, however, symptoms tend to come on quickly and be more severe. Some of the signs and symptoms of type 1 and type 2 diabetes include:

- Increased thirst
- Frequent urination
- Extreme hunger
- Unexplained weight loss
- Presence of ketones in the urine (ketones are a byproduct of the breakdown of muscle and fat that happens when there's not enough insulin)
- Fatigue
• Blurred vision
• Slow-healing sores
• Mild high blood pressure
• Frequent infections, such as gum or skin infections and vaginal or bladder infections

Although type 1 diabetes can develop at any age, it typically appears during childhood or adolescence. Type 2 diabetes, the most common type, can develop at any age and is often preventable.