CHAPTER 13 – ENDOCRINE SYSTEM

OBJECTIVES

On completion of this chapter, you will be able to:

- Describe the primary glands of the endocrine system.
- State the vital function of the endocrine system.
- Identify and state the functions of the various hormones secreted by the endocrine glands.
- Analyze, build, spell, and pronounce medical words.
- Comprehend the drugs highlighted in this chapter.
- Describe diagnostic and laboratory tests related to the endocrine system.
- Identify and define selected abbreviations.
- Describe each of the conditions presented in the Pathology Spotlights.
- Review the Pathology Checkpoint
- Complete the Study and Review section and the Chart Note Analysis.

OUTLINE

I. Anatomy and Physiology Overview

The endocrine system is made up of glands and the hormones they secrete (Table 13–1, pp. 408–409). The primary glands of the endocrine system are the:

- Pituitary
- Pineal
- Thyroid
- Parathyroid
- Islets of Langerhans
- Adrenals
- Ovaries in women
- Testes in males

Some other organs such as the brain, heart, lungs, liver, skin, thymus, and the gastrointestinal mucosa as well as the placenta during pregnancy produce and release hormones.

The vital function of the endocrine system involves the production and regulation of chemical substances called hormones. A hormone is a chemical transmitter that is released in small amounts and transported via the bloodstream to a target organ or other cells. The endocrine and nervous system work together to help maintain homeostasis and are linked together by the hypothalamus, a collection of specialized cells that are located in the lower central part of the brain. The purpose of the hypothalamus is to synthesize and secrete releasing hormones. It also controls the anterior pituitary and controls the secretion of the hormones epinephrine and norepinephrine.

A. Pituitary Gland (Hypophysis) (Fig. 13–1, p. 406) – a small gray gland located at the base of the brain. The pituitary gland is known as the
master gland of the body because of its regulatory effect on the other endocrine glands. It resides in a shallow depression in the sphenoid bone called the sella turcica. It is divided into an anterior and posterior lobe.

1. **Anterior Lobe (Fig. 13–2, p. 410)** – also known as the adenohypophysis, secretes several hormones that are essential for the growth and development of bones, muscles, other organs, sex glands, the thyroid gland, and the adrenal cortex.
   a. **Growth Hormone (GH)** – also known as somatotropin hormone (STH); essential for growth and development of bone, muscles, and other organs. It also enhances protein synthesis, decreases the use of glucose, and promotes fat destruction.
      i. Hyposecretion can result in dwarfism and Simmonds’ disease.
      ii. Hypersecretion may result in gigantism (early years) and acromegaly (adults).
   b. **Adrenocorticotropic (ACTH)** – essential for growth and development of the middle and inner zones of the adrenal cortex, which secretes the glucocorticoids cortisol and corticosterone.
   c. **Thyroid-Stimulating Hormone (TSH)** – essential for growth and development of the thyroid gland. Stimulates production of thyroxine and triiodothyronine and influences the body’s metabolic processes.
   d. **Follicle-Stimulating Hormone (FSH)** – gonadotrophic hormone that is essential in stimulating the growth of ovarian follicles in females and sperm production in males.
   e. **Luteinizing Hormone (LH)** – gonadotrophic hormone essential in the maturation process of the ovarian follicles and stimulation of the corpus luteum in females and testosterone production in males.
   f. **Prolactin (PRL)** – also known as lactogenic hormone (LTH). It is a gonadotropic hormone that stimulates the growth and development of the mammary glands.
   g. **Melanocyte-Stimulating Hormone (MSH)** – regulates skin pigmentation and promotes deposit of melanin in the skin after exposure to sunlight.

2. **The Posterior Lobe (Fig. 13–2, p. 410)** – also known as the neuropophysis; secretes two known hormones that are synthesized in the hypothalamus:
   a. **Antidiuretic Hormone (ADH)** – also known as vasopressin (VP). Stimulates the reabsorption of water by the renal tubules and has a pressor effect that elevates blood pressure. Hyposecretion results in diabetes insipidus (DI).
b. **Oxytocin** – acts on the mammary glands to stimulate the release of milk during suckling and stimulates the uterus to contract during labor, delivery, and parturition.

B. **Pineal Gland (Body)** (Fig. 13–1, p. 406) – small pine cone-shaped gland located near the posterior end of the corpus callosum. It secretes the following:

1. **Melatonin** – a hormone that may be released at night to regulate the release of gonadotropin.
2. **Serotonin** – hormone that is a neurotransmitter, vasoconstrictor, and smooth muscle stimulant and acts to inhibit gastric secretion.

C. **Thyroid Gland** (Figs. 13 – 1 and Fig. 13–3, pp. 406, 412) – large bilobed gland located in the neck. It plays a vital role in metabolism and regulates the body’s metabolic processes. The thyroid gland secretes:

1. **Thyroxine (T4)** – essential for maintenance and regulation of the *basal metabolic rate* (BMR). It contains four iodine atoms. Thyroxine influences growth and development and the metabolism of fats, proteins, carbohydrates, water, vitamins, and minerals.
2. **Triiodothyronine (T3)** – effective thyroid hormone that contains three iodine atoms. It influences the basal metabolic rate.
3. **Calcitonin** – also known as *thyrocalcitonin*, it is a thyroid hormone that influences bone and calcium metabolism and maintains plasma calcium homeostasis.
4. **Hyposcretion** of T4 and T3 can result in:
   - Cretinism (infancy) and myxedema (adulthood).
   - Hashimoto’s disease (a chronic thyroid disease).
5. **Hypersecretion** of T4 and T3 can result in:
   - Hyperthyroidism or thyrotoxicosis.
   - Graves’ Disease, exophthalmic goiter, toxic goiter, or Basedow’s disease (enlargement of the thyroid gland caused by a lack of iodine in the diet) (Fig. 13–18, p. 435).

D. **Parathyroid Glands** (Figs. 13–1 and 13–4, pp. 406, 413) – small, yellowish-brown bodies that occur as two pairs and located on the dorsal and lower aspect of the thyroid gland. The hormone secreted is:

1. **Parathyroid Hormone or Parathormone (PTH)** – essential for the maintenance of a normal serum calcium level. It also aids in the metabolism of phosphorus.
   a. **Hyposcretion of PTH** (Fig 13–5, p. 413) – can result in hypoparathyroidism, which can result in tetany (intermittent cramp or tonic muscle contractions).
   b. **Hypersecretion of PTH** – can result in hyperparathyroidism, which may result in osteoporosis, kidney stones, and hypercalcemia.
E. Pancreas (Islets of Langerhans) (Figs. 13–1 and 13–6, pp. 406, 414) – small clusters of cells located within the pancreas. There are three types of cells:

1. Alpha Cells (Fig. 13–7, p. 414) – secrete the hormone glucagon, which facilitates the breakdown of glycogen to glucose, thereby elevating blood sugar.

2. Beta Cells (Fig. 13–7, p. 414) – secrete the hormone insulin, which is essential for the maintenance of normal blood sugar. Insulin promotes the use of glucose in cells, thereby lowering the blood glucose level, and plays a vital role in carbohydrate, protein, and fat metabolism.
   b. Hypersecretion – results in hyperinsulinism.

3. Delta Cells – secrete the hormone somatostatin, which suppresses the release of glucagon and insulin.

F. Adrenal Glands (Suprarenals) (Figs. 13–1 and 13–8, pp. 406, 415) – two small, triangular-shaped glands on top of each kidney. Each gland consists of an outer portion or cortex and an inner portion, the medulla.

   a. Glucocorticoids
      i. Cortisol (hydrocortisone) – the principal steroid hormone secreted by the cortex. Hyposecretion can result in Addison’s disease and hypersecretion can result in Cushing’s disease. Cortisol works to:
         • Regulate carbohydrates, proteins, and fat metabolism.
         • Stimulate output of glucose from the liver.
         • Increase the blood sugar level.
         • Regulate other physiologic body processes.
         • Promote the transport of amino acids into extracellular tissue, thereby making them available for energy.
         • Influence the effectiveness of catecholamines such as dopamine, epinephrine, and norepinephrine.
         • Have an anti-inflammatory effect.
         • Help the body cope during times of stress.
      ii. Corticosterone – a steroid hormone secreted by the adrenal cortex, it is essential for normal use of carbohydrates, the absorption of glucose, and the formation of glycogen in the liver and tissues.
   b. Mineralocorticoids – aldosterone is secreted by the adrenal cortex. It regulates electrolyte and water balance by promoting sodium and chloride retention and potassium
secretion. Hyposecretion results in a reduced plasma volume, and hypersecretion results in primary aldosteronism.

c. **Androgens** – hormones that promote the development of male characteristics. The two main androgen hormones are testosterone and androsterone. They are responsible for development of secondary male sex characteristics.

2. **Adrenal Medulla** – synthesizes, secretes, and stores catecholamines, specifically the following:

a. **Dopamine** – dilates systemic arteries, elevated blood pressure, increases cardiac output, and increases urinary output.

b. **Epinephrine** – *Adrenalin or adrenaline*, acts as a vasoconstrictor, vasopressor, cardiac stimulant, antispasmodic, and sympathomimetic. Its main function is to assist in the regulation of the sympathetic branch of the autonomic nervous system. Influences and functions of the hormone include:

   - Elevates the systolic blood pressure.
   - Increases the heart rate and cardiac output.
   - Increases glycogenolysis (conversion of glycogen into glucose), thereby hastening the release of glucose from the liver. This action elevates the blood sugar level and provides the body with a spurt of energy (*fight-or-flight syndrome*).
   - Dilates the bronchial tubes and relaxes air passageways.
   - Dilates the pupils so that a person can see more clearly.

c. **Norepinephrine** (*Noradrenalin*) – acts as a vasoconstrictor, vasopressor, and neurotransmitter. It elevates systolic and diastolic blood pressure, increases the heart rate and cardiac output, and increases glycogenolysis.

G. **Ovaries** (Fig. 13–1, p. 406) – the hormones produced by the ovaries are essential for promoting growth, development, and the maintenance of secondary female sex organs and characteristics. They also prepare the uterus for pregnancy, promote development of the mammary glands and play a vital role in a woman’s emotional well-being and sexual drive. The hormones produced are:

1. **Estrogens** (*estradiol, estrone, and estriol*) – the female sex hormone secreted by the graafian follicles of the ovaries.

2. **Progesterone** – the steroid hormone secreted by the corpus luteum.
**H. Testes (Fig. 13–1, p. 406)** – produce **testosterone**, which is essential for normal growth and development of the male accessory sex organs. Testosterone plays a role in the erection process of the penis and, thus, is necessary for the sexual act, copulation.

**I. Placenta** – the spongy structure that joins the mother and child. It produces chorionic gonadotropin hormone, estrogen, and progesterone.

**J. Gastrointestinal Mucosa** – secretes the following hormones:
1. **Gastrin** – secreted by the mucosa of the pyloric area of the stomach, which stimulates gastric acid secretion. It also affects the gallbladder, pancreas, and small intestine secretory activities.
2. **Secretin** – secreted by the mucosa of the duodenum and jejunum and stimulates pancreatic juices, bile, and intestinal secretion.
3. **Pancreozymin-cholecystokinin** – secreted by the mucosa of the duodenum and stimulates the pancreas.
4. **Enterogastrone** – secreted by the mucosa of the duodenum and regulates gastric secretions.

**K. Thymus (Fig. 13–9, p. 417)** – a bilobed body located in the mediastinal cavity in front of and above the heart. It is composed of lymphoid tissue and is a part of the lymphatic system. This ductless glandlike body secretes:
1. **Thymosin** – promotes the maturation process of T lymphocytes (thymus dependent).
2. **Thymopoietin** – hormone that influences production of lymphocyte precursors and aids in their process of becoming T lymphocytes.

**II. Life Span Considerations**

**A. The Child** – most structures and glands of the endocrine system develop during the first 3 months of pregnancy. Excessively high or insufficient production of growth hormone (GH) by the anterior lobe of the pituitary gland can cause abnormal growth patterns. Conditions common to the endocrine system of the child are as follows.
1. **Excessive GH Production** – can result in **gigantism**.
2. **Insufficient GH Production** – can result in **dwarfism**.
3. **Diabetes Mellitus** – most common endocrine system disorder of childhood. The classic symptoms are:
   - Polyuria (frequent urination)
   - Polydipsia (excessive thirst)
   - Polyphagia (extreme hunger)

**B. The Older Adult** – hormonal changes vary with each individual. Tissue receptors decrease, thus diminishing the body’s response to hormones. **Type 2 diabetes mellitus** in the older adult occurs because the amount of insulin produced by the body is sufficient, but the number of receptors is
reduced. This results in the inability of glucose to enter the cells. Risk factors associated with the development of diabetes in the older adult are:

- Age-related decreased insulin production
- Age-related insulin resistance
- Heredity
- Decreased physical activity
- Multiple diseases
- Polypharmacy or the use of many drugs together
- Obesity
- New stressors in life

III. Building Your Medical Vocabulary
A. Medical Words and Definitions – this section provides the foundation for learning medical terminology. Medical words can be made up of four types of word parts:
   1. Prefix (P)
   2. Root (R)
   3. Combining Forms (CF)
   4. Suffixes (S)

By connecting various word parts in an organized sequence, thousands of words can be built and learned. In the text, the word list is alphabetized so one can see the variety of meanings created when common prefixes and suffixes are repeatedly applied to certain word roots and/or combining forms. Words shown in pink are additional words related to the content of this chapter that have not been divided into word parts. Definitions identified with an asterisk icon (*) indicate terms that are covered in the Pathology Spotlights section of the chapter.

IV. Drug Highlights
A. Thyroid Hormones – increase metabolic rate, cardiac output, oxygen consumption, body temperature, respiratory rate, blood volume, and carbohydrate, fat, and protein metabolism, and influences growth and development at the cellular level. They are used as a supplement or replacement therapy in hypothyroidism, myxedema, and cretinism.

B. Antithyroid Hormones – inhibit the synthesis of thyroid hormones by decreasing iodine use in manufacture of thyroglobin and iodothyronine. They are used in the treatment of hyperthyroidism.

C. Insulin – stimulates carbohydrate metabolism by increasing the movement of glucose and other monosaccharides into cells. It also influences fat and carbohydrate metabolism in the liver and adipose cells. It decreases blood sugar, phosphate, and potassium, and increases blood pyruvate and lactate. Used in the treatment of Type 1 diabetes mellitus, Type 2 DM when other treatment regimens are not effective, and to treat ketoacidosis.

D. Insulin Preparations – insulin is available in rapid-acting (½ hour), intermediate-acting (1-1½ hours), long-acting (3-5 hours), and an inhaled type (rapid action).
E. **Oral Hypoglycemic Agents** – stimulates insulin secretion from pancreatic cells in noninsulin-dependent diabetes with some pancreatic function.

F. **Hypoglycemic Agents** – cause an increase in blood glucose of diabetic patients with severe hypoglycemia.

V. **Diagnostic and Lab Tests**

A. **Catecholamines** – test performed on urine to determine the amount of epinephrine and norepinephrine present. These adrenal hormones increase in times of stress.

B. **Corticotropin, Corticotrophin-releasing Factor (CRF)** – test performed on blood plasma to determine the amount of corticotrophin present. Increased levels may indicate stress, adrenal cortical hypo function, and/or pituitary tumors. Decreased levels may indicate adrenal neoplasms and/or Cushing’s syndrome.

C. **Fasting Blood Sugar (FBS)** – test performed on blood to determine the level of sugar in the bloodstream. Increased levels may indicate diabetes mellitus, diabetes acidosis, and other conditions. Decreased levels may indicate hypoglycemia, hyperinsulinism, and other conditions. Also referred to as fasting blood glucose (FBG).

D. **Glucose Tolerance Test (GTT)** – blood sugar test performed at specified intervals after the patient has been given a certain amount of glucose. Blood samples are drawn, and the blood glucose level of each sample is determined.

E. **17-Hydroxycorticosteroids (17-OHCS)** – test performed on urine to identify adrenocorticosteroid hormones. Used to determine adrenal cortical function.

F. **17-Ketosteroids (17-KS)** – test performed on urine to determine the amount of 17-KS (the end product of androgens secreted from the adrenal glands and testes) present. Used to diagnose adrenal tumors.

G. **Protein-bound Iodine (PBI)** – test performed on serum to indicate the amount of iodine that is attached to serum protein. Used to indicate thyroid function.

H. **Radioactive Iodine Uptake (RAIU)** – test to measure the ability of the thyroid to concentrate ingested iodine. Increased level can indicate hyperthyroidism, cirrhosis, and/or thyroiditis. Decreased level can indicate hypothyroidism.

I. **Radioimmunoassay (RIA)** – standard assay method used to measure minute quantities of specific antibodies and/or antigens. Can be used for clinical laboratory measurements of hormones, therapeutic drug monitoring, and substance abuse screening.

J. **Thyroid Scan** – test to detect tumors of the thyroid gland. Patient is given radioactive iodine 131, which localizes in the thyroid gland, and then the gland is visualized with a scanner device.

K. **Thyroxine (T4)** – test performed on blood serum to determine the amount of thyroxine present. Increased levels can indicate hyperthyroidism. Decreased levels can indicate hypothyroidism.
L. **Triiodothyronine Uptake (T3U)** – test performed on blood serum to determine the amount of triiodothyronine present. Increased levels can indicate thyrotoxicosis, toxic adenoma, and/or Hashimoto’s struma (goiter). Decreased levels can indicate starvation, severe infection, and severe trauma.

M. **Total Calcium** – test performed on blood serum to determine the amount of calcium present. Increased levels can indicate hyperparathyroidism. Decreased levels can indicate hypoparathyroidism.

N. **Ultrasonography** – use of high-frequency sound waves to visualize the structures being studied. Can be used to visualize the pancreas, thyroid, and any other gland. Used as a screening test or as a diagnostic tool.

VI. **Abbreviations (p. 431)**

VII. **Pathology Spotlights**

A. **Addison’s Disease** – occurs when the cortex of the adrenal gland is damaged and there is a deficiency in the production of the adrenocortical hormones. This condition is most often caused by autoimmunity. For reasons unknown, the immune system views the adrenal cortex as a foreign body. Other causes include infections of the adrenal glands, spread of cancer to the glands, or hemorrhage into the glands. Diagnosis is determined by blood and urine tests that measure the amount of corticosteroid hormone present. Signs and symptoms of the disease include:

- Weight loss
- Anorexia
- Weakness and lethargy
- Increased pigmentation of the skin and mucous membranes
- Hypoglycemia
- Joint and muscle aches
- Persistent fever
- Nausea, vomiting, diarrhea, and abdominal discomfort

B. **Diabetes Mellitus (Table 13–2, p. 433)** – complex disorder of metabolism in which the body does not produce or properly use insulin. Insulin is a hormone that is needed to convert sugar, starch, and other foods into energy needed for daily life. There are three major types of diabetes:

1. **Type 1** – is an autoimmune disease that results from the body’s failure to produce insulin. Individuals with this type of diabetes will take insulin for life. The development of Type 1 diabetes is most often in children and young adults, but can occur at any age.

2. **Type 2** – the most common type of diabetes, Type 2 results from insulin resistance combined with relative insulin deficiency. This type of diabetes used to be rare in children, but with the increase in childhood obesity, health care providers have documented an
increase of incidence in children. To help prevent the onset of Type 2 diabetes:

- Eat a healthy diet.
- Exercise 30 minutes a day at least 5 days a week.
- Maintain a proper body weight for age and body type.

Untreated diabetes mellitus or complications can result in various multisystem effects to include:

a. **Hyperglycemia** – can lead to **ketoacidosis** (accumulation of ketones and acids in the body due to faulty metabolism of carbohydrates and the improper burning of fats) and the development of a coma when the blood sugar is too high or an insufficient amount of insulin has been received.

b. **Hypoglycemia** – occurs when too much insulin has been taken. Insulin shock is a severe form of hypoglycemia and requires immediate doses of glucose.

c. **Other Complications** – (Fig. 13–17, p. 434)

3. **Gestational Diabetes** – pregnancy-induced form of diabetes that usually goes away after the woman’s child is born.

4. **Prediabetes** – occurs when a person’s blood glucose levels are higher than normal but not high enough for a diagnosis of Type 2 diabetes.

C. **Hypothyroidism** (Fig. 13–18, p. 435) – condition in which the thyroid gland does not produce adequate amounts of thyroid hormone.

1. **Symptoms include** fatigue, decreased concentration, intolerance to cold environments, constipation, loss of appetite, muscle cramping and stiffness, and weight gain. Some nail changes.

2. **Untreated hypothyroidism** individuals notice hair loss, dry skin, or can lead to a number of health problems which include a **goiter** – enlargement of the thyroid gland. One of the most common causes of a goiter is **Hashimoto’s thyroiditis**, an autoimmune inflammation of the thyroid.

3. **Another type of goiter** is an endemic goiter, which develops in certain geographic regions where the iodine content in food and water is deficient.

4. **Myxedema** (Fig. 13–19, p. 435) – is the most severe form of hypothyroidism. It is characterized by pronounced edema of the face and a somnolent look. The hair is stiff and dull, and without treatment, coma and death can occur.

5. **Congenital hypothyroidism (CHT)** – is a condition that affects infants from birth (congenital) and results from a partial or complete loss of thyroid function. If untreated, congenital hypothyroidism can result in mental retardation and abnormal growth. In 80 to 85 % of cases, the thyroid is either absent, abnormally located, or severely reduced in size. In 15 to 20 % of cases, there is a normal sized or enlarged thyroid, but the hormone secretion is decreased or absent.
6. **Treatment** of hypothyroidism involves the replacement of thyroxine with daily regulated doses of levothyroxine sodium (Levothroid, Synthroid). The medication should be taken before breakfast, and the patient is advised to avoid foods and over-the-counter medications that contain iodine.

D. **Hyperthyroidism** – condition caused by elevated levels of thyroid hormone.
   1. **Symptoms** can include nervousness, palpitations, tremors, sweating, increased activity in the intestinal tract, changes in menstruation, and weight loss as well as intolerance to heat, anxiety, restlessness, irregular heartbeat, and changes in fingernails and hair.
   2. The most **common etiologies** are:
      a. **Graves’ Disease** – an autoimmune disease in which antibodies produced by the immune system stimulate the thyroid to produce too much thyroxine. People with Graves’ ophthalmopathy develop eye problems, including bulging, red or swollen eyes, sensitivity to light, and blurring or double vision.
      b. **Toxic Multinodular Goiter**
      c. **Thyroiditis** – inflammation of the thyroid gland.
      d. **Tumors of the Thyroid Gland**
   3. Some of the most serious **complications** involve the heart including a rapid heart rate, atrial fibrillation, and congestive heart failure. Untreated hypothyroidism can also lead to osteoporosis.
   4. Hyperthyroidism is **treated** with antithyroid medications, radioactive iodine, or surgery. If the thyroid is destroyed or removed, replacement thyroid hormones must be taken for life. If the parathyroid glands are also removed, the patient needs medication to keep the blood calcium levels normal.

VIII. Pathology Checkpoint

IX. Study and Review (pp. 437–443)

X. Practical Application: SOAP: Chart Note Analysis