Chapter 11: The Endocrine System

- Exocrine glands will produce a substance that will transports through a duct outside of the gland
- Endocrine glands will produce a substance (hormone) that will be secreted into bodily fluids to travel to a specific or target cell or gland
- Characteristics of the Endocrine System
  - Coordinates and integrates with the nervous system to maintain homeostasis
  - Utilizes hormones secreted from endocrine glands to target precisely a specific structure. The process and communication of the endocrine system may be slower than that of the nervous system but the target is precise and the effects are longer-lasting even with a small amount of hormonal secretion.

REFER TO FIGURE 11.1

- Hormones are chemicals that the endocrine system produces and uses to communicate with target cells or organs.
  - Types of hormones

REFER TO TABLE 11.2

- Steroid hormones are lipid soluble structures that can diffuse through the cell membrane
  - The receptors of the steroid hormones are located in the target cell’s nucleus
  - The hormone and the receptor will bind to form the hormone-receptor complex in order to stimulate a change in the target.

REFER TO FIGURE 11.3

- Nonsteroid hormones are amino acid-based hormones (any hormone that contains a component of proteins) so these hormones can not diffuse through the cell membrane.
  - The nonsteroid hormone is described as the “first messenger” because it can not enter the target cell.
  - The receptor of the nonsteroid hormone is located on the cell membrane.
  - The hormone and receptor will bind to form the hormone-receptor complex in order to trigger a cascade of biological activities.
  - The complex will activate a protein called G protein which in turn will activate and membrane enzyme called adenylate cyclase.
  - Adenylate cyclase will transform ATP into cAMP—the second messenger.
  - cAMP will activate the enzymes, protein kinases to manipulate and activate other inactive proteins in the cell and cause them to be altered.
  - The altered proteins will activate various cellular changes and processes to occur; and thus, bring on the effects of the hormone.

REFER TO FIGURE 11.4

- Prostaglandins are “local hormones” that will be produced before its secretion into the gland that produced it or into the surrounding tissues in which the substance was released into.
  - Effects of steroid/nonsteroid hormones
    - Cell membrane permeability
    - Synthesis
    - Enzymatic activity
    - Stimulation of mitosis
  - Effects prostaglandins
    - Relaxation of muscles
    - Contraction of muscles
    - Stimulation of the secretion of other hormones
    - Influence blood pressure
    - Inflammation
• Regulation of hormonal secretions is through:

**REFER TO FIGURE 11.5**
1. Hypothalamus can stimulate hormones of the pituitary gland via releasing hormones from the hypothalamus
2. Nervous system can trigger a nerve impulse to the gland or organ to activate the release of a hormone.
3. Glands responses to changes in the internal fluid composition can induce the release of hormones to correct the fluctuations occurring in the body.

• Negative feedback system: For the endocrine system, an endocrine gland monitors the concentration of a substance. When the regulated substance skews away from a certain level (optimal range), the action of the gland (in negative feedback) will be in OPPOSITION of the direction of the substance until the concentration of the substance returns to optimal range.

**REFER TO FIGURE 11.6**
• Positive feedback system: For the endocrine system, an endocrine gland will have a direction relationship with the regulated substance. When the regulated substance skews away from the optimal range, the action of the gland (in positive feedback) will be in a DIRECT relationship (follows in the same direction) to the regulated substance until the goal of the regulated substance is achieved.

• Major endocrine glands
  o Pituitary gland

**REFER TO FIGURES 11.7, 11.8, 11.9**
- Location: Attached to the base of the brain
- Parts of the pituitary gland
  - Anterior lobe or anterior pituitary is densely packed with dense connective tissue and epithelial tissues and hinders thin-walled blood vessels from this part of the pituitary gland.
  - Hormones: All of these hormones follow negative feedback mechanism

**REFER TO TABLE 11.3**
- Growth hormone (GH)—stimulates the size and division rate of somatic cells
- Prolactin (PRL)—encourages milk production after childbirth
- Thyroid-stimulating hormone (TSH)—controls the hormonal secretions from the thyroid gland
- Adrenocorticotropic hormone (ACTH)—controls the hormonal secretions from the cortex of the adrenal gland
- Gonadotropins—male and female hormones that supplement the hormones produced by the male and female gonads
  - Follicle-stimulating hormone (FSH)—for females: aids in the development of the egg-containing follicles and stimulates the secretion of estrogen; for males: stimulates sperm cell production
  - Luteinizing hormone (LH)—encourages the secretion of the sex hormones in both male and female. For females, plays a vital role in the release of the mature egg
- Melanocyte-stimulating hormone (MSH)—stimulates the melanocytes to affect skin tone and absorb harmful rays

- Regulation of hormonal secretions of the anterior pituitary is through the hypothalamus. The hypothalamus has specialized cells called the neurosecretory cells that release hormones called “releasing hormones” to control the secretions of the anterior lobe. The specific releasing hormone from the hypothalamus is carried through the bloodstream and
enters the hypophyseal portal veins to arrive in the anterior lobe. It will then be able to direct specific anterior lobe hormone to be produced and released into the body via blood to reach its target.

- Posterior lobe or posterior pituitary consists of nerve fibers and glandular epithelial cells.
  - Hormones
    - Antidiurectic hormone (ADH)—promotes conservation of water by the kidneys and affects blood pressure (Follows negative feedback mechanism)
    - Oxytocin (OT)—encourages contraction of the muscles of the uterus especially during childbirth and encourages milk letdown after childbirth (Follows positive feedback mechanism)
  - Regulation of hormonal secretions of the posterior pituitary is through innervations of the hypothalamus. Nerve fibers and impulses from the hypothalamus are conducted through a specialized neurosecretory cells that have long axons extending into the posterior lobe. The releasing hormones from the hypothalamus go directly into the posterior lobe to activate the specific posterior lobe hormone. The specific posterior lobe hormone then travel into the blood to reach its target.

- Thyroid gland
  **REFER TO FIGURE 11.10**
  - Location: below the larynx
  - Hormones

  **REFER TO FIGURE 11.4**
  - Thyroxine (T4) and Triiodothyronine (T3) secreted by the follicular cells of the thyroid—regulates metabolism and release of energy. In the optimal range, T3 and T4 will promote normal growth and development. T3 and T4 are stored in the colloid of the follicle of the thyroid.
  - Calcitonin secreted by the extrafollicular cells of the thyroid gland—stores calcium in the bones when calcium levels are too high in the blood. Encourages the osteoblasts and osteocytes to make more bone matrix and bone deposition.

- Parathyroid gland
  **REFER TO FIGURE 11.11**
  - Location: posterior side of the thyroid gland. Parathyroid gland consists of four lobes (two superior lobes and two inferior lobes)
  - Hormone:
    - Parathyroid hormone (PTH)—releases calcium from bones when calcium levels are low in the blood. Activates the osteoclasts to break down bone. Antagonist hormone to calcitonin.

- Adrenal gland
  **REFER TO FIGURE 11.12**
  - Location: Superior to the kidneys
  - Parts of the adrenal gland
    - Adrenal Medulla—interior portion of the adrenal gland and is innervated to the sympathetic division of the autonomic nervous system
    - Adrenal Cortex – outer layer of the adrenal gland
  - Hormones

**REFER TO TABLE 11.6**
• From the adrenal medulla
  o Epinephrine and Norepinephrine—these are hormones. Please note: There are neurotransmitters with the same names, but in this chapter we are discussing the hormones. These hormones are stimulated by the nervous system and are active during the sympathetic division of the autonomic system (“fight or flight”). The hormones provide the short-term responses to stress.

**REFER TO TABLE 11.5**

• From the adrenal cortex—the hormones are organized in zones.
  o Outer zone of the cortex: Aldosterone is a mineralcorticoid that regulates mineral and electrolyte concentrations, especially sodium in the blood. Please note: water generally follows the solute sodium due to osmosis. Provides long-term response to stress.
  o Middle zone of the cortex: Cortisol and cortisone are glucocorticoids that regulate the metabolism of glucose in response to stress. Provides long-term responses to stress. Cortisol is released to target cells to stimulate glucose formation (main source of energy to make ATP), inhibits protein synthesis, and promotes fatty acid release. Please note: parts of protein and lipids can be converted into new organic structures to produce ATP.

**REFER TO FIGURE 11.4**

  o Inner zone of the cortex: Adrenal sex hormones—supplemental hormones to the hormones released by the gonads.

**Pancreas**

**REFER TO FIGURES 11.15, 11.17**

- Location: Posterior to the stomach and serves as both an exocrine gland with digestive functions and as an exocrine gland
- Exocrine component: Acinar cells that make pancreatic juice—discussed in the Digestive System
- Endocrine component:
  • Islets of Langerhans
    o Hormones
      ▪ Glucagon secreted by the alpha cells that will increase glucose in the blood by directing the liver to break down glycogen
      ▪ Insulin secreted by the beta cells that will decrease glucose in the blood and will direct the liver to store the excess glucose in the form of glycogen
      ▪ These two hormones work in opposition to keep glucose level in the blood at optimal range

**REFER TO FIGURE 11.17**

• Minor endocrine glands
  o Pineal gland
    ▪ Location: upper portion of the thalamus
    ▪ Hormone: Melatonin regulates circadian rhythm by light (day) and dark (night) cues
  o Thymus gland
    ▪ Location: between the lungs
    ▪ Hormone: Thymosin encourages the maturation of specific white blood cells that play an active part in the immune system
  o Reproductive glands
    ▪ Location: pelvic girdle
    ▪ Hormones:
• Male: Testosterone produced in the gonad—testes that aids in the production of sperm cells and contributes to the male secondary sexual characteristics
• Female: Estrogen and progesterone produced in the ovaries and in the placenta during pregnancy that regulate the female reproductive cycle. Estrogen also contributes to the female secondary sexual characteristics

  o Digestive glands
    ▪ Location: in the accessory organs and glands of the digestive system
    ▪ Multiple hormones that aid in the digestion of the foods consumed—discussed more specific in the digestive system chapter
  o Heart
    ▪ Location: behind the sternum and in the mediastinum
    ▪ Hormone: Atrial natriuretic peptide helps to regulate blood pressure
  o Kidneys
    ▪ Location: posterior to the stomach and liver
    ▪ Hormone: Erythropoietin stimulates blood cell production

• Stress and Health
  o Types of stress
    ▪ Physical stress—regards to the survival of tissues
    ▪ Psychological stress—abstract feelings that lead to anxiety or fear
  o Responses to stress
    ▪ Main objective is to maintain homeostasis
    ▪ The nervous system and endocrine system collaborate to achieve homeostasis
      • Sympathetic system innervates to the medulla of the adrenal gland to stimulate hormones to provide short-term responses to stress
      • ACTH from the anterior lobe stimulates the cortex of the adrenal gland to stimulate the hormones to provide long-term responses to stress
  REFER TO FIGURE 11.18
  o Health
    ▪ Indirect relationship between age and hormonal output—with increasing age, there is a reduction or deficiency in hormonal production and release