The Endocrine System – Important Concepts

THE ENDOCRINE SYSTEM: the glands of the body and the hormones produced by those glands.

HORMONES are chemical messengers that send messages throughout the body to control the activities of cells.

TARGET CELLS – are controlled by hormones

Two Types of Hormones:

Endocrine hormone – sent directly through the bloodstream or fluid around cells.

Exocrine hormone – sent through (ducts or tubes) rather than through the bloodstream, to specific locations. Sweat glands, mucous glands, salivary glands and other digestive glands are exocrine glands. The exocrine part of the pancreas delivers digestive enzymes to the small intestine.

Hormonelike substances which don't travel through bloodstream -

Neuropeptides are secreted by the nervous system.

a. Enkephalins inhibit pain messages.
b. Endorphins regulate emotion, influence pain and affect reproduction.

Prostaglandins are secreted by most cells. They constrict blood vessels and affect blood pressure and temperature. Others cause blood vessels to dilate, sometimes causing headaches.

Endocrine System and Nervous System

The endocrine system works alongside of the nervous system to form the control systems of the body. The nervous system provides a very fast and narrowly targeted system to turn on specific glands and muscles throughout the body.

The endocrine system is much slower acting, but has widespread, long lasting, and powerful effects. Hormones are distributed by glands through the bloodstream to the entire body, affecting any cell with a receptor for a particular hormone. Most hormones affect cells in several organs or throughout the entire body, leading to many diverse and powerful responses.

- Controlled directly by stimulation from the nervous system & by chemical receptors in the blood and hormones produced by other glands.

- Help to maintain the body's homeostasis. Cellular metabolism, reproduction, sexual development, sugar and mineral homeostasis, heart rate, and digestion

Hypothalamus

- a part of the brain located superior and anterior to the brain stem and inferior to the thalamus.

- is responsible for the direct control of the endocrine system through the pituitary gland. The hypothalamus contains special cells called neurosecretory cells—neurons that secrete hormones:

Thyrotropin-releasing hormone (TRH)
Growth hormone-releasing hormone (GHRH)
Growth hormone-inhibiting hormone (GHIH)
Gonadotropin-releasing hormone (GnRH)
Corticotropin-releasing hormone (CRH)
Oxytocin
Antidiuretic hormone (ADH)

These affect the function of the anterior pituitary gland.

TRH stimulates the anterior pituitary gland to release thyroid-stimulating hormone. GHRH and GHIH work to regulate the release of growth hormone—GHRH stimulates growth hormone release, GHIH inhibits its release. GnRH stimulates the release of follicle stimulating hormone and luteinizing hormone while CRH stimulates the release of adrenocorticotropic hormone.

The last two hormones—oxytocin and antidiuretic hormone—are produced by the hypothalamus and transported to the posterior pituitary, where they are stored and later released.

Pituitary Gland

- also known as the hypophysis, is a small pea-sized lump of tissue connected to the inferior portion of the hypothalamus of the brain. Many blood vessels surround the pituitary gland to carry the hormones it releases throughout the body. Situated in a small depression in the sphenoid bone called the sella turcica, the pituitary gland is actually made of 2 completely separate structures: the posterior and anterior pituitary glands.

Oxytocin triggers uterine contractions during childbirth and the release of milk during breastfeeding.

Antidiuretic hormone (ADH) prevents water loss in the body by increasing the re-uptake of water in the kidneys and reducing blood flow to sweat glands.

Anterior Pituitary: The anterior pituitary gland is the true glandular part of the pituitary gland. The function of the anterior pituitary gland is controlled by the releasing and inhibiting hormones of the hypothalamus. The anterior pituitary produces 6 important hormones:

Thyroid stimulating hormone (TSH), as its name suggests, is a tropic hormone responsible for the stimulation of the thyroid gland.

Adrenocorticotropic hormone (ACTH) stimulates the adrenal cortex, the outer part of the adrenal gland, to produce its hormones.

Follicle stimulating hormone (FSH) stimulates the follicle cells of the gonads to produce gametes—ova in females and sperm in males.

Luteinizing hormone (LH) stimulates the gonads to produce the sex hormones—estrogens in females and testosterone in males.

Human growth hormone (HGH) affects many target cells throughout the body by stimulating their growth, repair, and reproduction.

Prolactin (PRL) has many effects on the body, chief of which is that it stimulates the mammary glands of the breast to produce milk.

Pineal Gland
- a small, pinecone-shaped mass of glandular tissue found just under the thalamus of the brain.

- produces the hormone melatonin that helps to regulate the human sleep-wake cycle known as the circadian rhythm. Melatonin production causes humans to feel drowsy at nighttime when the pineal gland is active.

Thyroid Gland
- a butterfly-shaped gland located at the base of the neck and wrapped around the sides of the trachea.

- produces 3 major hormones:

- Calcitonin: released when calcium ion levels in the blood rise above a certain set point. Reduces the concentration of calcium ions in the blood by aiding the absorption of calcium into the matrix of bones.

- The hormones T3 and T4 work together to regulate the body's metabolic rate. Increased levels of T3 and T4 lead to increased cellular activity and energy usage in the body. This is known as hyperthyroidism.

More commonly, the thyroid does not produce enough hormone, and metabolism is reduced. This leads to fatigue and weight gain.

Parathyroid Glands
- 4 small masses of glandular tissue found in back of the thyroid gland. They produce parathyroid hormone (PTH), which is involved in calcium ion homeostasis.

- PTH is released from the parathyroid glands when calcium ion levels in the blood drop below a set point. It stimulates the osteoclasts to break down the calcium containing bone matrix to release free calcium ions into the bloodstream. PTH also triggers the kidneys to return calcium ions filtered out of the blood back to the bloodstream so that it is conserved.

Adrenal Glands

- a pair of roughly triangular glands found immediately superior to the kidneys. The adrenal glands are each made of 2 distinct layers

- the outer adrenal cortex. The adrenal cortex produces many cortical hormones in 3 classes

1. Glucocorticoids: the breakdown of proteins and lipids to produce glucose, reducing inflammation and immune response.

2. Mineralocorticoids that help to regulate the concentration of mineral ions in the body.

3. Androgens, regulate the growth and activity of cells that are receptive to male hormones - leading to the appearance of male secondary sex characteristics.

The inner adrenal medulla: produces epinephrine and norepinephrine. Increase the flow of blood to the brain and muscles to improve the "fight-or-flight" response to stress. Increases heart rate, breathing rate, and blood pressure. Decreases flow of blood to and function of organs that are not involved in responding to emergencies.

Pancreas: a large gland located in the abdominal cavity just below and behind the stomach.

- The endocrine cells of the pancreas make up just about 1% of the total mass of the pancreas, called islets of Langerhans containing 2 types of cells—alpha and beta cells.

- The alpha cells produce glucagon, responsible for raising blood glucose levels. Glucagon triggers muscle and liver cells to break down glycogen to release glucose into the bloodstream.

- The beta cells produce the hormone insulin, which lowers blood glucose levels after a meal by permitting the cells to absorb glucose.

Gonads: ovaries in females and testes in males

- produce the sex hormones of the body. These determine the secondary sex characteristics of adult females and adult males.

- Testes: poduce the androgen testosterone in males after the start of puberty. Testosterone affects muscles, bones, sex organs, and hair follicles, causes growth and increase in strength of the bones and muscles. Also affects development of the sex organs and body hair of males, including pubic, chest, and facial hair. In men who have inherited genes for baldness testosterone triggers the onset of androgenic alopecia, commonly known as male pattern baldness.

- Ovaries: The ovaries are a pair of almond-shaped glands located in the pelvic body cavity near the uterus in females.

- produce the female sex hormones progesterone and estrogens. Progesterone is most active in females during ovulation and pregnancy where it maintains appropriate conditions in the human body to support a developing fetus.

The release of estrogen during puberty triggers the development of female secondary sex characteristics such as uterine development, breast development, and the growth of pubic hair and increased body size during puberty.

Thymus: a soft, triangular-shaped organ found in the chest behind the sternum. From fetal development through childhood the thymus produces thymosins, which aid growth of T-lymphocytes. The thymus becomes inactive during puberty and is slowly replaced by adipose tissue.

Digestive System: The hormones cholecystokinin (CCK), secretin, and gastrin are all produced by the organs of the gastrointestinal tract.

- help to regulate the secretion of pancreatic juice, bile, and gastric juice in response to the presence of food in the stomach. CCK is also instrumental in the sensation of satiety or "fullness" after eating a meal.

Adipose (fat) tissue produces the hormone leptin that is involved in the management of appetite and energy usage by the body. Leptin is produced at levels relative to the amount of adipose tissue in the body, allowing the brain to monitor the body's energy storage condition. When the body contains a sufficient level of adipose for energy storage, the level of leptin in the blood tells the brain that the body is not starving and may work normally.

If the level of adipose or leptin decreases below a certain threshold, the body enters starvation mode and attempts to conserve energy through increased hunger and food intake and decreased energy usage.

Placenta: In pregnant women, the placenta produces several hormones that help to maintain pregnancy. Progesterone is produced to relax the uterus, protect the fetus from the mother's immune system, and prevent premature delivery of the fetus. Human chorionic gonadotropin (HCG) assists progesterone by signaling the ovaries to maintain the production of estrogen and progesterone throughout pregnancy.

HORMONE PROPERTIES

Once hormones have been produced by glands, they are distributed through the body via the bloodstream. As hormones travel through the body, they pass through cells or along the plasma membranes of cells until they encounter a receptor for that particular hormone. Hormones can only affect target cells that have the appropriate receptors. This property of hormones is known as specificity. Hormone specificity explains how each hormone can have specific effects in widespread parts of the body.

Tropic hormones: trigger the release of another hormone in another gland. Tropic hormones provide a pathway of control for hormone production as well as a way for glands to be controlled in distant regions of the body. Many of the hormones produced by the pituitary gland, such as TSH, ACTH, and FSH are tropic hormones.

Hormonal Regulation

The levels of hormones in the body can be regulated by several factors. The nervous system can control hormone levels through the action of the hypothalamus and its releasing and inhibiting hormones. For example, TRH produced by the hypothalamus stimulates the anterior pituitary to produce TSH (thyroid stimulating hormone). Tropic hormones provide another level of control for the release of hormones. For example, TSH is a tropic hormone that stimulates the thyroid gland to produce T3 and T4. Nutrition can also control the levels of hormones in the body.

The thyroid hormones T3 and T4 require 3 or 4 iodine atoms, respectively, to be produced. People lacking iodine in their diet, will fail to produce sufficient levels of thyroid hormones to maintain a healthy metabolic rate.

This can lead to fatigue and weight gain.

Finally, the number of receptors present in cells can be varied by cells in response to hormones. Cells that are exposed to high levels of hormones for extended periods of time can begin to *reduce the number of receptors that they produce, leading to reduced hormonal control of the cell.*