**ENDOCRINE SYSTEM Dr. Nadia Hameed**

The **endocrine system** includes glands that outpour their hormones directly to the blood. Hormones help to maintain the body’s homeostasis, cellular metabolism, reproduction, sexual development, sugar and mineral homeostasis, heart rate, and digestion.

**Hormones are characterized by:**

1. **Specificity**: they can only affect target cells that have the **appropriate receptors.**

2. One hormone may act on more than one target organs and many hormones may be produced by a single gland.

3. **Tropic or trophic** hormones. A tropic hormone is a hormone that is able to trigger the release of another hormone in another gland, eg **gonadotropic or (phic) hormones (FSH & LH)** from pituitary gland act on ovaries release estrogen and progesterone hormones.

Hormones are classified into 2 categories depending on their solubility:

1. **Water-soluble hormones**: Water-soluble hormones include the peptide and amino-acid hormones such as **insulin, epinephrine, Human Growth Hor., and oxytocin**. They are unable to pass through the phospholipid bilayer of the cell membrane so their specific receptor present on the cell membrane.
2. **Lipid-soluble hormones**: Lipid-soluble hormones include the steroid hormones such as **testosterone, estrogens, glucocorticoids**, and **mineralocorticoids.** these hormones are able to pass through the phospholipid bilayer of the plasma membrane and bind directly to receptors inside the cell **nucleus**.

**Endocrine System vs. Nervous System Function:**The endocrine system generally is much slower acting system, has very widespread targets (all body tissue), and powerful effects.

The nervous system provides a very fast acting system but narrowly targeted system

**Anatomically endocrine system can be divided to:**

1. Glands of Head and neck: hypothalamus, pituitary, pineal, thyroid and parathyroid
2. Glands of Upper trunk: thymus, pancrease and suprarenal glands
3. Glands of Lower trunk: ovaries in females and testeses in males

**Glands of Head and neck**

1. **Hypothalamus**:

The hypothalamus is a part of the brain located superior and anterior to the brain stem and inferior to the thalamus. It controls the endocrine system by its regulatory effect on pituitary gland.

It releases the following hormones:

1. Thyrotropin-releasing hormone (TRH(
2. Growth hormone-releasing hormone (GHRH(
3. Growth hormone-inhibiting hormone (GHIH(
4. Gonadotropin-releasing hormone (GnRH(
5. Corticotropin-releasing hormone (CRH(
6. Oxytocin
7. Antidiuretic hormone (ADH)

The 1st five hormones act on the anterior pituitary gland.The last two hormones (oxytocin and antidiuretic hormone ADH) are synthesized in the hypothalamus, stored and released from the posterior pituitary glands

1. **Pituitary Gland**

The 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 throughout the body. It was 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**.

* **Posterior Pituitary:** The posterior pituitary gland is actually not glandular tissue at all; it is a small **extension of axons of some of neurosecretory** cells of the hypothalamus. These neurosecretory cells create 2 hormones in the hypothalamus that are stored and released by the posterior pituitary:

1. Oxytocin triggers uterine contractions during childbirth and the release of milk during breastfeeding.
2. Antidiuretic hormone (ADH) prevents water loss in the body by increasing the re-uptake of water in the kidneys.

* **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:

1. Thyroid stimulating hormone (TSH), as its name suggests, is a tropic hormone responsible for the stimulation of the thyroid gland.
2. Adrenocorticotropic hormone (ACTH) stimulates the adrenal cortex, the outer part of the adrenal gland, to produce its hormones.
3. Follicular stimulating hormone (FSH) stimulates the follicle cells of the gonads to produce gametes—ova in females and sperm in males.
4. Luteinizing hormone (LH) stimulates the gonads to produce the sex hormones—estrogens in females and testosterone in males.

FSH and LH called gonadotropic hormones.

1. Human growth hormone (HGH) affects many target cells throughout the body by stimulating their growth, repair, and reproduction.
2. Prolactin (PRL) stimulates the mammary glands of the breast to produce milk.
3. **Pineal Gland**

The pineal gland is a small mass of glandular tissue found **just posterior to the thalamus of the brain.** The pineal gland produces the hormone **melatonin** that helps to regulate the human sleep-wake cycle known as the **circadian rhythm**. The activity of the pineal gland is inhibited by stimulation from the photoreceptors of the retina.

**Glands of Upper trunk**

1. **Thyroid gland:**The thyroid gland is a butterfly-shaped gland located at the base of the neck around the lateral sides of the trachea. The thyroid gland produces 3 major hormones:
2. Calcitonin: released when calcium ion levels in the blood rise above a certain set point. It reduces the calcium ions in the blood by aiding the absorption of calcium into the matrix of bones.
3. Triiodothyronine (T3) c) Thyroxine (T4)

Both regulate the body’s metabolic rate

1. **Parathyroid Glands**

The parathyroid glands are 4 small masses of glandular tissue found on the posterior side of the thyroid gland. The parathyroid glands produce the hormone **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 to increase its level by:

1. stimulates the osteoclasts to break down the calcium containing bone matrix
2. triggers the kidneys to return calcium ions filtered out of the blood back to the bloodstream
3. **Thymus**

The thymus is a soft, triangular-shaped organ found in **the chest posterior to the sternum.** The thymus produces hormones called **thymosin** that help to train and develop T-lymphocytes during fetal development and childhood.

1. **Pancreas**

The **pancreas** is a large gland located in the abdominal cavity **just inferior and posterior to the stomach**. The pancreas is considered to be **a heterocrine** gland as it contains both **endocrine and exocrine tissue**. The endocrine cells about 1% of the total mass of the pancreas (**islets of Langerhans**). Within these islets are 2 types of cells—**alpha and beta cells**.

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

**The beta** cells produce the hormone **insulin**, which is responsible for lowering blood glucose levels after a meal triggering glucose enntry from the blood into cells, where it converted to glycogen molecules for storage.

1. **Adrenal Glands**

The adrenal glands are a pair of roughly triangular glands found immediately superior to the kidneys.

The adrenal glands are each made of 2 distinct layers, each with their own unique functions:

1. Outer adrenal cortex 2. inner adrenal medulla

**Adrenal cortex:** The adrenal cortex produces many cortical hormones in 3 classes: glucocorticoids, mineralocorticoids, and androgens.

1. Glucocorticoids have many diverse functions, including the breakdown of proteins and lipids to produce glucose. Glucocorticoids also function to reduce inflammation and immune response.
2. Mineralocorticoids, as their name suggests, are a group of hormones that help to regulate the concentration of mineral ions in the body.
3. Androgens, such as testosterone, are produced at low levels in the adrenal cortex to regulate the growth and activity of cells that are receptive to male hormones. In adult males, the amount of androgens produced by the testes is many times greater than the amount produced by the adrenal cortex, leading to the appearance of male secondary sex characteristics.

**Adrenal medulla:** The adrenal medulla produces the hormones **epinephrine and norepinephrine (adrenalin and nor adrenalin)** under stimulation by the sympathetic division of the autonomic nervous system. Both of these hormones help to increase the flow of blood to the brain and muscles to improve the “fight-or-flight” response to stress. These hormones also work to increase heart rate, breathing rate, and blood pressure.

**Glands of Lower trunk**

**Gonads**

The gonads—**ovaries in females and testes in males**—are responsible for producing the sex hormones of the body. These sex hormones determine the secondary sex characteristics of adult females and adult males.

1. **Testes:**

The testes are found in the scrotum of males that produce testosterone in males after the start of puberty. During puberty, testosterone controls the growth and development of the sex organs and body hair of males, including pubic, chest, and facial hair.

1. **Ovaries**

The ovaries are a pair of glands located in the pelvic body cavity lateral and superior to the uterus in females. The ovaries produce the female sex hormones progesterone and estrogens

. **Progesterone:** is most active in the **second** part of cycle ie **after ovulation** and **during pregnanc**.

**Estrogens**: are a group of related hormones that function as the primary female sex hormones. It is the hormone of the first part of female cycle. 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.

In addition to the glands of the endocrine system, many other non-glandular organs and tissues in the body produce hormones as well.

* ***Heart*:** The cardiac muscle tissue of the [**heart**](http://www.innerbody.com/image/card01.html) is capable of producing the hormone atrial natriuretic peptide (ANP) in response to [**high blood pressure**](http://www.innerbody.com/diseases-conditions/hypertension) levels. ANP reduce blood pressure by vasodilatation decrease blood volume by water and salt loss out of the blood by the kidneys.
* ***Kidneys*:** The [**kidneys**](http://www.innerbody.com/image_urinov/dige05-new.html) produce the hormone erythropoietin (EPO) in response to low levels of oxygen in the blood (hypoxia). EPO stimulates bone marrow for production of red blood cells.
* ***Digestive System*:** The hormones cholecystokinin (CCK) regulates the secretion of pancreatic juice, bile, and gastric juice in response to the presence of food in the stomach. CCK is also responsible for sensation of satiety or “fullness” after eating a meal.
* ***Adipose***: subcutaneous adipose tissue produces the following hormones:
  1. **Leptin** hormone that is involved in the management of appetite and energy usage by the body.
  2. **estrogens** hormone in both men and women. In obese people the large volume of adipose tissue may lead to abnormal estrogen levels.
* ***Placenta***: In pregnant women, the placenta produces several hormones that help to maintain pregnancy.

**1.**  **Progesterone** is produced to relax the uterus and prevent premature delivery of the fetus.

**2.**  **Human chorionic gonadotropin (HCG)** signaling the ovaries to maintain the production of estrogen and progesterone throughout pregnancy.