Endocrine System

- The glands of the body may be divided into those with an internal secretion (endocrine glands) and those with an external secretion (exocrine glands). Examples of exocrine glands are the sweat, lacrimal and mammary glands which pass their secretion along ducts to the external surface of the body, and the glands of the mouth, stomach and intestines whose secretions are passed along ducts into the alimentary tract. On the other hand, the endocrine (ductless) glands do not possess any ducts or openings to the exterior.
- The endocrine and nervous systems are the major control systems of the body.
- The endocrine system regulates functions by releasing hormones, whereas the nervous system regulates functions by releasing neurotransmitters.
- There is some overlap between hormones and neurotransmitters; for example, epinephrine acts as both.
- Endocrine glands lack the ducts that are present in exocrine glands.
- The endocrine glands secrete their products, which are biologically active molecules called **hormones**, directly into the blood. The blood carries the hormones to target cells that contain specific receptor proteins for the hormones, and which therefore can respond in a specific fashion to them.
- Some specialized neurons, particularly in the hypothalamus, secrete chemical messengers into the blood rather than into a narrow synaptic cleft. In these cases, the chemical that the neurons secrete is sometimes called a **neurohormone**. In addition, a number of chemicals—norepinephrine, for example—are secreted both as a neurotransmitter and a hormone.
- Although the effects of hormones are many and varied, their actions are involved in
  (1) regulating ion and water balance;
  (2) responding to adverse conditions, such as infection, trauma, and emotional stress;
  (3) sequentially integrating features of growth and development;
  (4) contributing to basic processes of reproduction, including gamete production, fertilization, nourishment of the embryo and fetus, delivery, and nourishment of the newborn;
  (5) digesting, using, and storing nutrients.
- Feedback mechanisms regulate the endocrine system, just as in many other physiologic systems. The mechanism is usually negative feedback, although a few positive feedback mechanisms are known. Both types of feedback control occur because the endocrine cell, in addition to synthesizing and secreting its own hormone product, has the ability to sense the biologic consequences of secretion of that hormone. This enables the endocrine cell to adjust its rate of hormone secretion to produce the desired level of effect, ensuring the maintenance of homeostasis.

Hormone Classes:

There are four chemical classes

(1) amine-derived hormone: Structurally they are the simplest hormones, consisting of one or two modified amino acids for example norepinephrine and thyroxine, are derived from tyrosine. They include the hormones secreted by the adrenal medulla, thyroid, and pineal glands.

(2) Polypeptides and proteins: Polypeptide hormones generally contain less than 100 amino acids; an example is antidiuretic hormone. Protein hormones are polypeptides with more than 100 amino acids; growth hormone is an example.

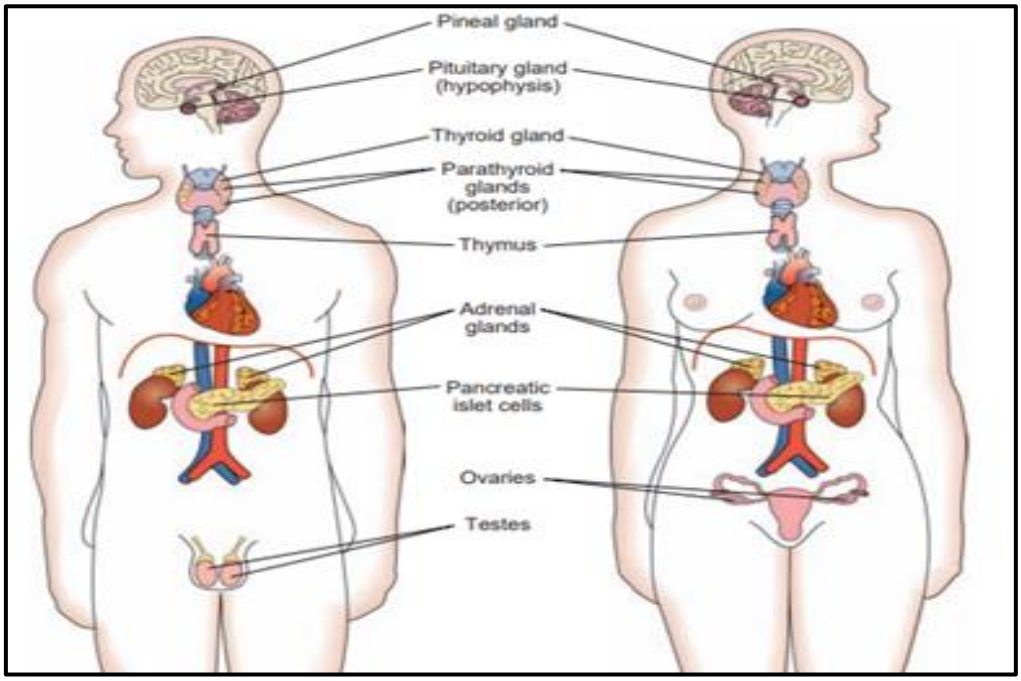
(3) Glycoproteins. These molecules consist of a long polypeptide (containing more than 100 amino acids) bound to one or more carbohydrate groups. Examples are follicle-stimulating hormone (FSH) and luteinizing hormone (LH).

(4) Lipid/phospholipid-derived hormone: Steroids are lipid-soluble, hydrophobic molecules synthesized from cholesterol. Examples include aldosterone, cortisol, and androgen, which are secreted by the cortex (outer zone) of the adrenal glands; testosterone, secreted by the testes; and estrogen and progesterone, secreted by the ovaries. Steroid hormones are synthesized and secreted on demand.

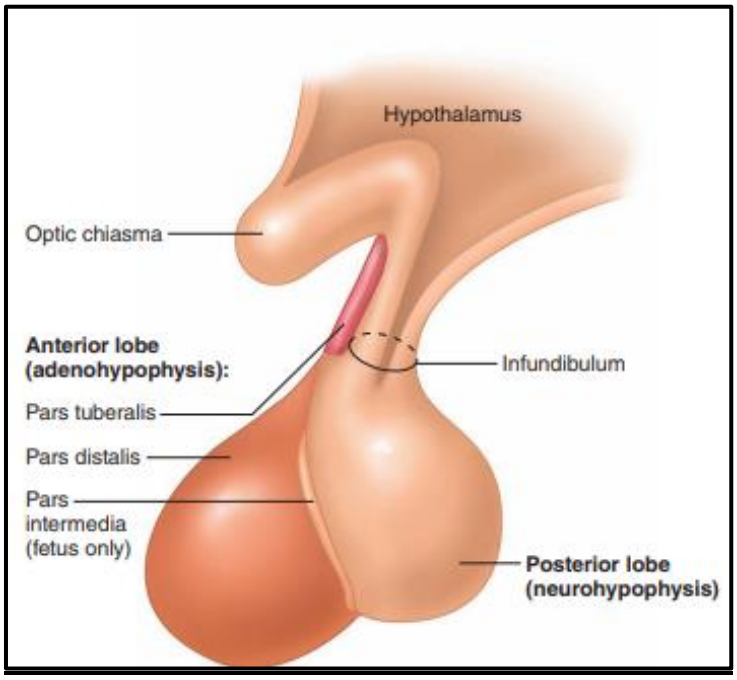
- In terms of their actions in target cells, hormone molecules can be divided into:
    1. Polar (water-soluble) which cannot pass through plasma membranes but bind to cell surface receptors then exert their effects through second-messenger systems.
    2. Nonpolar, (insoluble in water). Since the nonpolar hormones are soluble in lipids, they are often referred to as lipophilic hormones. Lipophilic hormones can diffuse and gain entry into their target cells and activate nuclear receptors to regulate gene transcription. These lipophilic hormones include the steroid hormone and thyroid hormones.

- Hormone Release: Hormone release may be initiated by
    1. neuronal stimulation.
    2. by the action of releasing hormones
    3. or as a direct response to fluctuating plasma levels.

- Major Endocrine Glands:
    1. Pituitary gland.
    2. Pineal gland
    3. Thyroid gland
    4. Thymus
    5. adrenal gland
    6. Pancreas
    7. Ovary
    8. Testis



PITUITARY GLAND



- Hypothalamus is a part of the brain whereas pituitary is an endocrine gland. Together they form the core of the neuroendocrine system which controls many physiological processes leading to homeostasis.
- The pituitary gland, or hypophysis, is located on the inferior aspect of the brain in the region of the diencephalon. Roughly the size of a pea—about 1.3 cm in diameter— it is attached to the hypothalamus by a stalklike structure called the infundibulum
- The pituitary gland is structurally and functionally divided into an anterior lobe, or adenohypophysis, and a posterior lobe called the neurohypophysis.
- The posterior pituitary stores and releases hormones that are actually produced by the hypothalamus, whereas the anterior pituitary produces and secretes its own hormones. The anterior pituitary, however, is regulated by hormones secreted by the hypothalamus, as well as by feedback from the target gland hormones.
- Because axons do not enter the anterior pituitary, hypothalamic control of the anterior pituitary is achieved through hormonal rather than neural regulation. Releasing and inhibiting hormones, produced by neurons in the hypothalamus, are transported to axon endings in the basal portion of the hypothalamus then by vascular link between the hypothalamus and the anterior pituitary called the hypothalamo-hypophyseal portal system.
- These hormones regulate the secretions of the anterior pituitary: Thyrotropin-releasing hormone (TRH) stimulates the secretion of TSH, and corticotropin-releasing hormone (CRH) stimulates the secretion of ACTH from the anterior pituitary. A single releasing hormone, gonadotropin-releasing hormone, or GnRH, stimulates the secretion of both gonadotropic hormones (FSH and LH) from the anterior pituitary. The anterior pituitary secretion of growth hormone is under the control of two polypeptide hormones from the hypothalamus. The secretion of growth hormone–releasing hormone (GHRH) by the hypothalamus stimulates the anterior pituitary to secrete growth hormone, whereas somatostatin from the hypothalamus inhibits growth hormone secretion. A prolactin inhibiting hormone, identified as the neuro-transmitter dopamine, inhibits the secretion of prolactin from the anterior pituitary. This is the most physiologically important regulator of prolactin secretion, although several factors (including oxytocin and TRH) have been shown to promote prolactin secretion when dopamine release declines.

- At one time the anterior pituitary was called the “master gland” because it secretes hormones that regulate some other endocrine gland
- The hormones secreted by the anterior pituitary are called trophic hormones. The term trophic means “feed.” Although the anterior pituitary hormones are not food for their target organs, this term is used because high concentrations of the anterior pituitary hormones cause their target organs to hypertrophy, while low levels cause their target organs to atrophy.

1. Growth hormone (GH, or somatotropin): GH promotes the movement of amino acids into cells and the incorporation of these amino acids into proteins, thus promoting overall tissue and organ growth. Some of growth hormone’s actions, including growth of cartilage and bones and protein synthesis in muscles, result from a group of molecules (the somatomedins) produced by the liver under growth hormone stimulation.

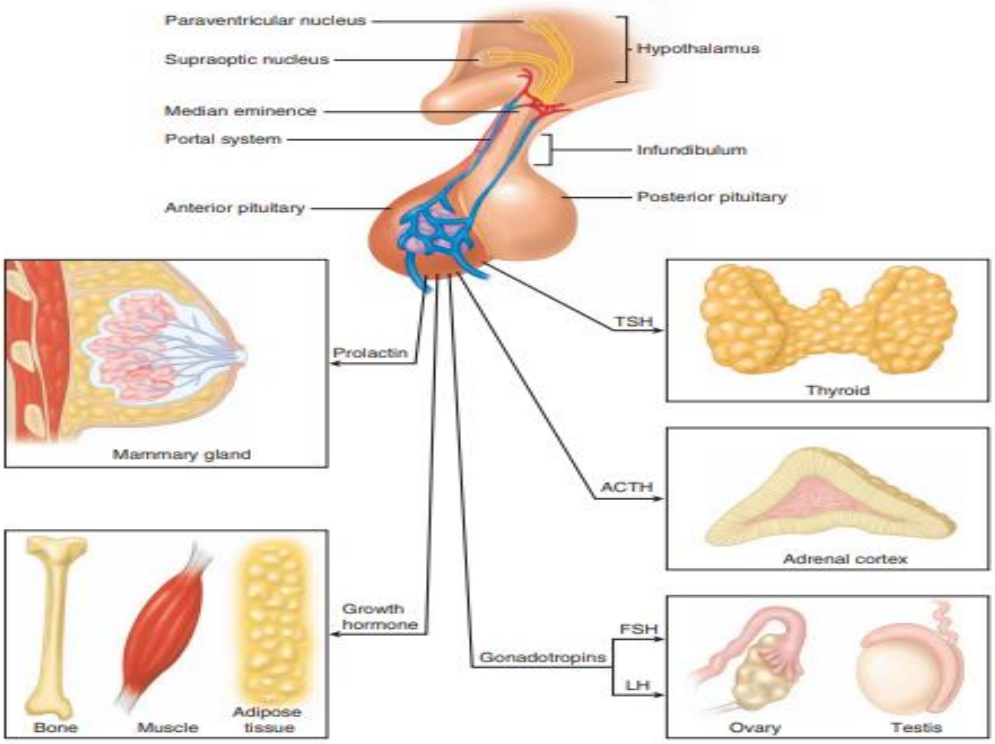
2. Thyroid-stimulating hormone (TSH, or thyrotropin): TSH stimulates the thyroid gland to produce and secrete thyroxine (tetraiodothyronine, or T 4) and triiodothyronine (T 3).

3. Adrenocorticotropic hormone (ACTH, or corticotropin): ACTH stimulates the adrenal cortex to secrete the glucocorticoids, such as cortisol (hydrocortisone).

4. Follicle-stimulating hormone (FSH, or folliculotropin): FSH stimulates the growth of ovarian follicles in females and the production of sperm cells in the testes of males.

5. Luteinizing hormone (LH, or luteotropin): This hormone and FSH are collectively called gonadotropic hormones. In females, LH stimulates ovulation and the conversion of the ovulated ovarian follicle into an endocrine structure called a corpus luteum. In males, LH is sometimes called interstitial cell stimulating hormone, or ICSH; it stimulates the secretion of male sex hormones (mainly testosterone) from the interstitial cells (Leydig cells) in the testes.

6. Prolactin (PRL): This hormone is secreted in both males and females. Its best known function is the stimulation of milk production by the mammary glands of women after the birth of a baby. Prolactin plays a supporting role in the regulation of the male reproductive system by the gonadotropins (FSH and LH) and acts on the kidneys to help regulate water and electrolyte balance.



The posterior pituitary stores and releases two hormones, both of which are produced in the hypothalamus.

The ADH and oxytocin hormones produced in the hypothalamus are transported along axons of the hypothalamo hypophyseal tract to the posterior pituitary, where they are stored and later released in response to appropriate stimulation. The posterior pituitary is thus more a storage organ than a true gland.

The release of ADH and oxytocin from the posterior pituitary is controlled by neuroendocrine reflexes. In nursing mothers, for example, the mechanical stimulus of suckling acts, via sensory nerve impulses to the hypothalamus, to stimulate the reflex secretion of oxytocin. The secretion of ADH is stimulated by osmo receptor neurons in the hypothalamus in response to a rise in the plasma osmolality. An increased osmolality (and osmotic pressure) produces a greater release of ADH by exocytosis. This is similar to the way axon terminals release neurotransmitter. Conversely, ADH secretion can be inhibited by sensory input from stretch receptors in the left atrium of the heart, which are stimulated when there is a rise in blood volume.

1. Antidiuretic hormone (ADH): The "antidiuretic" effect of this hormone is stimulation of water retention by the kidneys, so that less water is excreted in the urine. Because of this, the hormone will be termed antidiuretic hormone (ADH).

2. Oxytocin: In females, oxytocin stimulates contractions of the uterus during labor and for this reason is needed for parturition (childbirth). Oxytocin also stimulates contractions of the mammary gland alveoli and ducts, which result in the milk-ejection reflex in a lactating woman. In men, a rise in oxytocin secretion at the time of ejaculation has been measured, but the physiological significance of this hormone in males remains to be demonstrated.