Introduction to Endocrinology ***Dr. Aqeel Al Jothery (lect.1)***

The multiple activities of the cells, tissues, and organs of the body are coordinated by the interplay of several types of chemical messenger systems:

1. ***Neurotransmitters*** are released by axon terminals of neurons into the synaptic junctions and act locally to control nerve cell functions.

2. ***Endocrine hormones*** are released by glands or specialized cells into the circulating blood and influence the function of target cells at another location in the body.

3. ***Neuroendocrine hormones*** are secreted by neurons into the circulating blood and influence the function of target cells at another location in the body.

4. ***Paracrines*** are secreted by cells into the extracellular fluid and affect neighboring target cells of a different type.

5. ***Autocrines*** are secreted by cells into the extracellular fluid and affect the function of the same cells that produced them.

6. ***Cytokines*** are peptides secreted by cells into the extracellular fluid and can function as autocrines, paracrines, or endocrine hormones. Examples of cytokines include the *interleukins* and other *lymphokines* that are secreted by helper cells and act on other cells of the immune system.

Cytokine hormones (e.g., *leptin*) produced by adipocytes are sometimes called *adipokines*

The endocrine hormones:

1-Carried by the circulatory system to cells throughout the body, including the nervous system, and binding with receptors and initiate many cell reaction.

2- Endocrine hormones affect mainly specific target tissues because these tissues have abundant receptors for the hormone. For example, adrenocorticotropic hormone (ACTH) from the anterior pituitary gland specifically stimulates the adrenal cortex, causing it to secrete adrenocortical hormones.

3- Other hormones affect many different types of cells of the body; for example, growth hormone (from the anterior pituitary gland) causes growth in most parts of the body endocrine hormones affect many different types of cells of the body; for example, growth hormone (from the anterior pituitary gland) causes growth in most parts of the body.

Figure 74-1 shows the anatomical loci of the major endocrine glands and endocrine tissues of the body, except for the placenta, which is an additional source of the sex hormones and Table 74-1 provides an

overview of the different hormone systems and their most important actions.

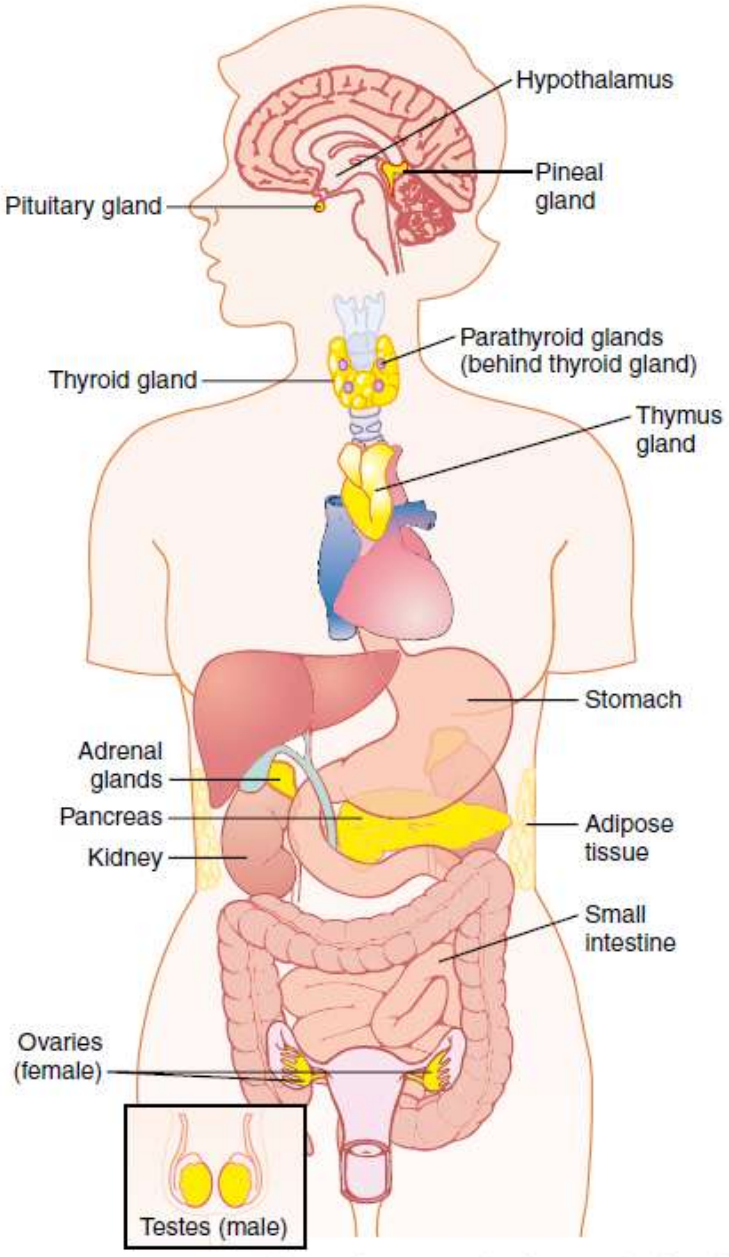

Figure 74-1 Anatomical loci of the principal endocrine glands and tissues of the body.

Table 74-1 Endocrine Glands, Hormones, and Their Functions and Structure

Gland/Tissue	Hormones	Major Functions	Chemical Structure
Hypothalamus (Chapter 75)	Thyrotropin-releasing hormone (TRH)	Stimulates secretion of thyroid-stimulating hormone (TSH) and prolactin	Peptide
	Corticotropin-releasing hormone (CRH)	Causes release of adrenocorticotropic hormone (ACTH)	Peptide
	Growth hormone–releasing hormone (GHRH)	Causes release of growth hormone	Peptide
	Growth hormone inhibitory hormone (GHIH) (somatostatin)	Inhibits release of growth hormone	Peptide
	Gonadotropin-releasing hormone (GnRH)	Causes release of luteinizing hormone (LH) and follicle-stimulating hormone (FSH)	
	Dopamine or prolactin-inhibiting factor (PIF)	Inhibits release of prolactin	Amine
Anterior pituitary (Chapter 75)	Growth hormone	Stimulates protein synthesis and overall growth of most cells and tissues	Peptide
	TSH	Stimulates synthesis and secretion of thyroid hormones (thyroxine and triiodothyronine)	Peptide
	ACTH	Stimulates synthesis and secretion of adrenocortical hormones (cortisol, androgens, and aldosterone)	Peptide
	Prolactin	Promotes development of the female breasts and secretion of milk	Peptide
	FSH	Causes growth of follicles in the ovaries and sperm maturation in Sertoli cells of testes	Peptide
	LH	Stimulates testosterone synthesis in Leydig cells of testes; stimulates ovulation, formation of corpus luteum, and estrogen and progesterone synthesis in ovaries	Peptide
Posterior pituitary (Chapter 75)	Antidiuretic hormone (ADH) (also called *vasopressin*)	Increases water reabsorption by the kidneys and causes vasoconstriction and increased blood pressure	Peptide
	Oxytocin	Stimulates milk ejection from breasts and uterine contractions	Peptide
Thyroid (Chapter 76)	Thyroxine (T_4) and triiodothyronine (T_3)	Increases the rates of chemical reactions in most cells, thus increasing body metabolic rate	Amine
	Calcitonin	Promotes deposition of calcium in the bones and decreases extracellular fluid calcium ion concentration	Peptide
Adrenal cortex (Chapter 77)	Cortisol	Has multiple metabolic functions for controlling metabolism of proteins, carbohydrates, and fats; also has anti-inflammatory effects	Steroid
	Aldosterone	Increases renal sodium reabsorption, potassium secretion, and hydrogen ion secretion	Steroid
Adrenal medulla (Chapter 60)	Norepinephrine, epinephrine	Same effects as sympathetic stimulation	Amine
Pancreas (Chapter 78)	Insulin (β cells)	Promotes glucose entry in many cells, and in this way controls carbohydrate metabolism	Peptide

Gland/Tissue	Hormones	Major Functions	Chemical Structure
	Glucagon (α cells)	Increases synthesis and release of glucose from the liver into the body fluids	Peptide
Parathyroid (Chapter 79)	Parathyroid hormone (PTH)	Controls serum calcium ion concentration by increasing calcium absorption by the gut and kidneys and releasing calcium from bones	Peptide
Testes (Chapter 80)	Testosterone	Promotes development of male reproductive system and male secondary sexual characteristics	Steroid
Ovaries (Chapter 81)	Estrogens	Promotes growth and development of female reproductive system, female breasts, and female secondary sexual characteristics	Steroid
	Progesterone	Stimulates secretion of "uterine milk" by the uterine endometrial glands and promotes development of secretory apparatus of breasts	Steroid
Placenta (Chapter 82)	Human chorionic gonadotropin (HCG)	Promotes growth of corpus luteum and secretion of estrogens and progesterone by corpus luteum	Peptide
	Human somatomammotropin	Probably helps promote development of some fetal tissues as well as the mother's breasts	Peptide
	Estrogens	See actions of estrogens from ovaries	Steroid
	Progesterone	See actions of progesterone from ovaries	Steroid
Kidney (Chapter 26)	Renin	Catalyzes conversion of angiotensinogen to angiotensin I (acts as an enzyme)	Peptide
	1,25-Dihydroxycholecalciferol	Increases intestinal absorption of calcium and bone mineralization	Steroid
	Erythropoietin	Increases erythrocyte production	Peptide
Heart (Chapter 22)	Atrial natriuretic peptide (ANP)	Increases sodium excretion by kidneys, reduces blood pressure	Peptide
Stomach (Chapter 64)	Gastrin	Stimulates HCl secretion by parietal cells	Peptide
Small intestine (Chapter 64)	Secretin	Stimulates pancreatic acinar cells to release bicarbonate and water	Peptide
	Cholecystokinin (CCK)	Stimulates gallbladder contraction and release of pancreatic enzymes	Peptide
Adipocytes (Chapter 71)	Leptin	Inhibits appetite, stimulates thermogenesis	Peptide

Chemical Structure and Synthesis of Hormones:

There are three classes of chemical structure of hormones:

1-Proteins and polypeptides, including hormones secreted by the anterior and posterior pituitary gland, the pancreas (insulin and glucagon), the parathyroid gland (parathyroid hormone), and many others (see Table 74-1).

Features of Polypeptide and Protein Hormones:

A-ranged in size from small peptides (3 amino acids, thyrotropin-releasing hormone) to proteins with almost (200 amino acids, growth hormone and prolactin)

B- Synthesized on the rough end of the endoplasmic reticulum of the different endocrine cells as larger proteins (non-active, preprohormones) and are cleaved to form smaller prohormones in the endoplasmic reticulum. Then transferred to the Golgi apparatus for packaging into secretory vesicles

C-Secretion of the hormones occurs when the secretory vesicles fuse with the cell membrane and the granular contents are extruded into the interstitial fluid or directly into the blood stream by exocytosis.

2. **Steroids** secreted by the adrenal cortex (cortisol and aldosterone), the ovaries (estrogen and progesterone), the testes (testosterone), and the placenta (estrogen and progesterone).

Features of Steroid Hormones

A- Synthesized from cholesterol.

B-consisted of three cyclohexyl rings and one cyclopentyl ring combined into a single structure.

C-They are lipid soluble and once they are synthesized, they simply Diffuse across the cell membrane and enter the interstitial fluid and then the blood

3. **Derivatives of the amino acid tyrosine**, secreted by the thyroid (thyroxine and triiodothyronine) and the adrenal medullae (epinephrine and norepinephrine). There are no known polysaccharides or nucleic acid hormones.

Features of Amine Hormones

A-Derived from tyrosine

B-formed by the actions of enzymes in the cytoplasmic compartments of the glandular cells.

C-The thyroid hormones are synthesized and stored in the thyroid gland and incorporated into macromolecules of the protein thyroglobulin which is stored in large follicles within the thyroid gland

D-Hormone secretion occurs when the amines are split from thyroglobulin, and the free hormones are then released into the blood stream

Hormone Secretion

1-Secretion of hormones can happen within seconds after the gland is stimulated and they may develop full action within another few seconds to minutes. While others may require months for full effect.

2- Their concentrations in the blood range from as little as 1 picogram (which is one millionth of one millionth of a gram) in each milliliter of blood up to at most a few micrograms (a few millionths of a gram) per milliliter of blood.

Feedback Control of Hormone Secretion

1- Negative Feedback (Prevents Overactivity): All hormones appear to be closely controlled by negative feedback mechanisms that ensure a proper level of hormone activity at the target tissue. The hormone (or one of its products) has a negative feedback effect to prevent oversecretion of the hormone or overactivity at the target tissue.

2- Positive feedback (Surges of Hormones): the biological action of the hormone causes additional secretion of the hormone.

Transport of hormones

1- Water-soluble hormones (peptides and catecholamines) are dissolved in the plasma and transported from their sites of synthesis to target tissues, where they diffuse out of the capillaries, into the interstitial fluid, and ultimately to target cells.
2- Steroid and thyroid hormones, in contrast, circulate in the blood mainly bound to plasma proteins. However, protein-bound hormones cannot easily diffuse across the capillaries and gain access to their target cells and are therefore biologically inactive until they dissociate from plasma proteins.

“Clearance” of Hormones from the Blood

Two factors can increase or decrease the concentration of a hormone in the blood. One of these is the rate of hormone secretion into the blood. The second is the rate of removal of the hormone from the blood, which is called the metabolic clearance rate. This is usually expressed in terms of the number of milliliters of plasma cleared of the hormone per minute. To

calculate this clearance rate, one measures (1) the rate of disappearance of the hormone from the plasma (e.g., nanograms per minute) and (2) the plasma concentration of the hormone (e.g., nanograms per milliliter of plasma). Then, the metabolic clearance rate is calculated by the following formula:

Metabolic clearance rate = Rate of disappearance of hormone from the plasma /Concentration of hormone

Hormones are “cleared” from the plasma in several ways, including (1) metabolic destruction by the tissues,(2) binding with the tissues, (3) excretion by the liver into the bile, and (4) excretion by the kidneys into the urine. For certain hormones, a decreased metabolic clearance rate may cause an excessively high concentration of the hormone in the circulating body fluids. For instance, this occurs for several of the steroid hormones when the liver is diseased because these hormones are conjugate mainly in the liver and then “cleared” into the bile.