Endocrine System

The endocrine system is a system of ductless glands that secrete hormones directly into the circulatory system to be carried long distances to other target organs that regulate vital body and organ functions.

All the physiological activities are regulated by two major systems in the body:

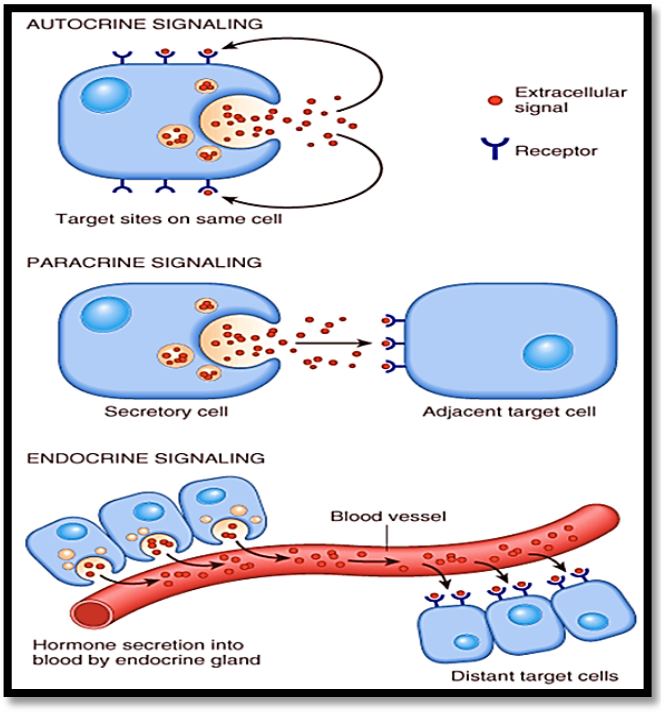
1- Nervous system.

2- Endocrine system.

These two systems interact with one another and regulate the body's functions.

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. Paracrine is secreted by cells into the extracellular fluid and affects 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.



Comparison of Hormonal and Nervous Coordination

The table below lists a few major differences between these two different kinds of control and regulating mechanisms.

Table: difference between hormonal and nervous control

Property	Hormonal control	Nervous control
1. Nature of signal	All hormones are chemical signal.	Nerve impulses are electrical signals. Also, chemical signaling takes place at synapses
2. Transmitted of signals	Indirect; Signals transmitted through the blood.	Direct relations; Signals are transmitted through nerve cells.
3. Speed of signal	Slow; Up to months.	Rapid; Between 0.7- 120 meters per second.
4. Effect in the body	General effect- The hormones can influence cells in many different parts of the body.	Localized effect - Affects only the particular muscle or the gland
5. Effect on growth	Can affect growth	Cannot affect growth
6. Duration of effect	Permanent response. Short term and long lasting	Only short lived. Temporary and reversible.

Similarity between Endocrine and Nerve Systems:

1- Both of them regulated by negative feedback control mechanisms
2- Coordinate and regulate the activities of other cells, tissue, organs and systems
3- Maintain homeostasis
4- Depend on the release of chemicals that bind to specific receptors on target cells.
5- Share various chemical messages ex: norepinephrine and epinephrine are called hormones when released into the bloodstream and neurotransmitters when released across the synapses.

Endocrine glands

Endocrine glands are the glands which synthesize and release the classical hormones directly into the blood without any duct, so they called ductless glands.

Hormones secreted by major endocrine glands

Hypothalamus	1. Thyrotropin-releasing hormone (TRH) 2. Growth hormone -releasing hormone (GRH) 3. Growth hormone inhibitory hormone (somatostatin) (GHRH) 4. Corticotropin-releasing hormone (CRH) 5. Gonadotropin-releasing hormone (GnRH) 6. Dopamine or prolactin- inhibiting factor
Anterior pituitary	1. Growth hormone (GH) 2. Thyroid stimulating hormone (TSH) 3. Endorphins 4. Adrenocorticotropic hormone (ACTH) 5. Follicle stimulating hormone (FSH) 6. Luteinizing hormone (LH) 7. Prolactin
Posterior pituitary	1. Antidiuretic hormone (ADH) 2. Oxytocin
Thyroid gland	1. Thyroxin (T_4) 2. Tri-iodothyronine (T_3) 3. Calcitonin
Parathyroid gland	Parathormone
Pancreas - islets of Langerhans	1. Insulin 2. Glucagon 3. Somatostatin 4. Pancreatic polypeptide
Adrenal cortex *(adrenocortical hormones or corticosteroids)*	
Mineralocorticoids	1. Aldosterone 2. 11 deoxycorticosterone
Glucocorticoids	1. Cortisol 2. Corticosterone
Sex hormones	1. Androgens 2. Estrogen 3. Progesterone
Adrenal medulla	
Catecholamine	1. Adrenaline (Epinephrine) 2. Noradrenaline (Norepinephrine) 3. Dopamine

Hormones

Hormones are type of chemical signal molecules, released by a cell or special endocrine gland in one part of the body that sends out messages affecting cells in other parts of the body, transported by the circulatory system to target distant organs to regulate physiology of the body, maintaining homeostasis and regulating reproduction and development.

Nature of Hormones

1- Hormones are secreted from their source directly into the blood.
2- Blood carries the hormone to the target cells which respond to it.
3- Hormones regulate the physiological processes.
4- They are produced in very small quantities and are biologically very active; usually measured in micrograms or milligrams per day.
5- Their excess and deficiency, both, cause serious disorders.

Classification of hormones

Based on chemical nature the hormones are classified into three types:

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.
2. ***Steroids*** secreted by the adrenal cortex (cortisol and aldosterone), the ovaries (estrogen and progesterone), the testes (testosterone), and the placenta (estrogen and progesterone).
3. ***Derivatives of the amino acid tyrosine***, secreted by the thyroid (thyroxine and triiodothyronine) and the adrenal medullae (epinephrine and norepinephrine).

Hormone Secretors

In humans there are many tissues and organs that produce hormones. These can be listed under two categories:

(a) Exclusively endocrine: Pituitary, thyroid, parathyroid, thymus and the adrenal glands

(b) Partially endocrine: The pancreas, gastric and duodenal epithelium, the gonads (testis in males and ovary in females) and placenta in females.

Differences between endocrine and exocrine glands

	Endocrine glands	**Exocrine glands**
1.	Secrete hormones	Produce enzyme
2.	These are ductless gland released hormones into interstitial space surround cell and nearest capillary then to blood.	Glands may have ducts (tubes) to carry substances outside the body (sweat to skin) or into body cavity (pancreatic juice to intestine).
3.	They pour secretion directly into the blood.	The secretion is poured directly at the site of action or reaches the target.
4.	They control long term of target organ.	They control short term activity.
5.	Thyroid, pituitary and adrenal glands	Salivary, sweat and gastric gland

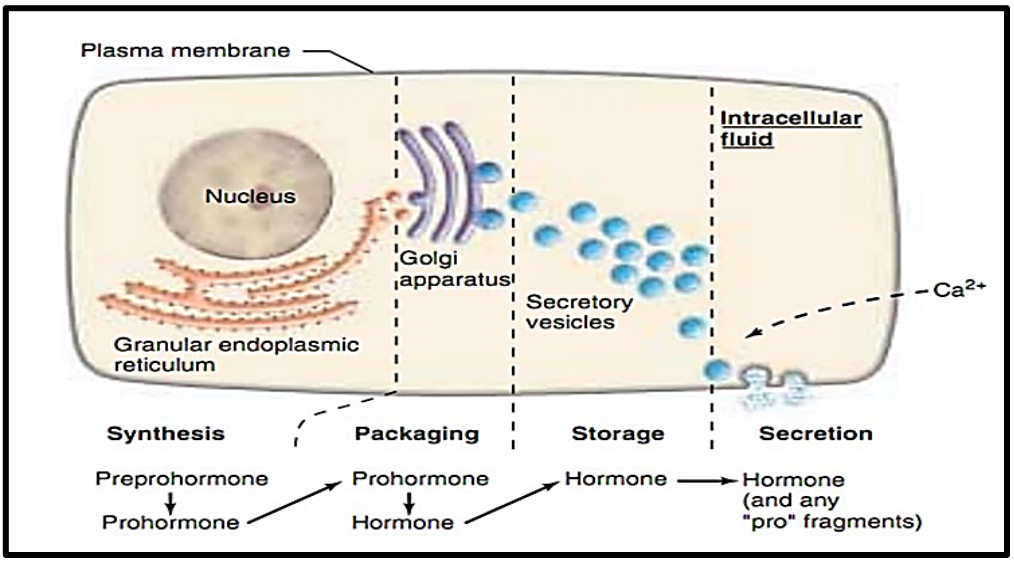
Synthesis and storage of hormones

Most of the hormones in the body are polypeptides and proteins. These hormones range in size from small peptides with as few as three amino acids (TRH) to proteins with almost 200 amino acids (growth hormone and prolactin). In general, polypeptides with 100 or more amino acids are called proteins, and those with fewer than 100 amino acids are referred to as peptides.

Protein and peptide hormones are synthesized on the rough endoplasmic reticulum of the different endocrine cells. They are usually synthesized first as larger proteins that are not biologically active called ***preprohormones*** and are cleaved to form smaller ***prohormones*** in the endoplasmic reticulum.

These prohormones are then transferred to the Golgi apparatus for packaging into secretory vesicles. Enzymes in the vesicles cleave the prohormones to produce smaller, biologically active hormones. The vesicles are stored within the cytoplasm and serve as reservoir to hormones. ***Polypeptide and protein hormones are stored in secretory vesicles until needed.***

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. The peptide hormones are water soluble, allowing them to enter the circulatory system easily, where they are carried to their target tissues.



Hormonal action

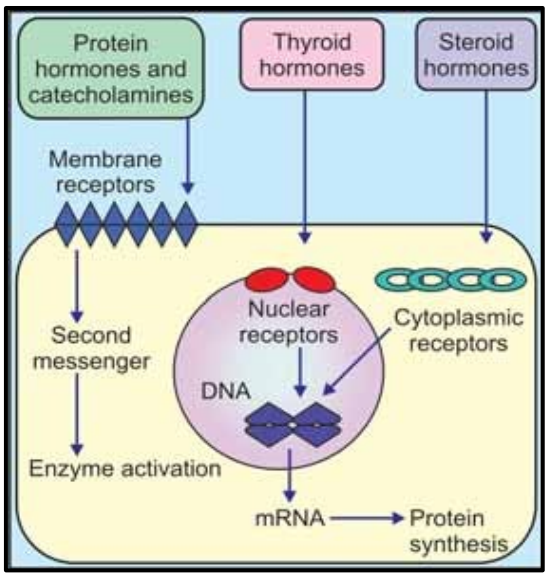
Hormone does not act directly on the cellular structures. First it combines with receptors present on the target cells and forms a hormone- receptor complex. This hormone-receptor complex induces various changes or reactions in the target cells.

Hormone receptors

The hormone receptors are the large proteins present in the target cells. Each receptor is specific for one single hormone, (each receptor can combine with only one hormone).

Hormone receptors are situated either in cell membrane or cytoplasm or nucleus of the cells as follows:

1. ***In or on the cell membrane***: The membrane receptors are specific mostly for the protein, peptide, and catecholamine hormones.
2. ***Cytoplasm***: Receptors of steroid hormones are situated in cytoplasm of the cells.
3. ***Nucleus***: Receptors of thyroid hormones are in the nucleus of the target cell.



Mechanism of hormonal function

On the target cell, the hormone–receptor complex acts by any one of the following mechanisms:

1. By altering the permeability of the cell membrane

The neurotransmitter substances in a synapse or neuromuscular junction act by changing the permeability of postsynaptic membrane.

2. By Activating the Intracellular Enzyme

The protein and catecholamines hormones act by activating intracellular enzymes. The hormone, which acts on a target cell, is called ***first messenger***. These hormones, in combination with receptor forms hormone-receptor complex; which activates the enzymes of the cell and causes the formation of the ***second messenger***; which produces the effects of the hormone inside the cells; like adenosine mono- phosphate (cyclic AMP or cAMP).

3. By Acting on Genes

Thyroid and steroid hormones act by activating the genes of the target cells.

Hormone secretion after a stimulus and duration of action of different hormones

Some hormones, such as norepinephrine and epinephrine, are secreted within seconds after the gland is stimulated and may develop full action within few seconds to minutes. The actions of other hormones, such as thyroxin or growth hormone, may require months for full effect. Thus, each of the different hormones has its own characteristic onset and duration of action to perform its specific control function.

Transport of hormones in the blood

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.

Steroid and thyroid hormones, in contrast, circulate in the blood while being mainly bound to plasma proteins. Usually less than 10% of steroid or thyroid hormones in the plasma exist free in solution. More than 99% of the thyroxin in the blood is bound to plasma proteins. However, protein-bound hormones cannot easily diffuse across the capillaries and reach to their target cells and are therefore biologically inactive until they dissociate from plasma proteins.

Measurement of Hormone Concentrations in the Blood

Most hormones are present in the blood in extremely minute quantities. Therefore, it was difficult to measure these concentrations by the usual chemical means. Therefore, the method used is called ***radioimmunoassay***. More recently, additional methods, such as ***enzyme-linked immunosorbent assays (ELIZA),*** have been developed for accurate measurements of hormones.