Basic concepts of Endocrinology

Dr. Madhu Gupta
Assistant Professor
Department of Zoology
University of Lucknow
Lucknow

Basic concepts of Endocrinology

Endocrinology is the science of structure and functions of body's endocrine glands, regulation of their functions, diagnosis and treatment of endocrine pathologies.

The Endocrine system is the collection of cells and tissues (ductless/ endocrine glands) of the body that secrete hormones that the body uses for wide range of functions including growth, development, respiration, homeostasis, reproduction etc.

Chemical messengers are signaling molecules that serve to transmit a message either locally (neurotransmitters, autocrines, paracrines) or to distantly located cells/ tissues (hormones).

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

Autocrines are secreted by cells into the extracellular fluid and affect the function of the same cells that produced them by binding to cell surface receptors.

Paracrines are secreted by cells into the extracellular fluid and affect neighbouring cells of a different type.

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.

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

Pheromones {pherein, to bring} are specialized ectohormones that act on other organisms of the same species to elicit a physiological or behavioural response.

Exocrines secretions are released into the external environment through ducts.

Neurohormones are secreted by neurons into the circulating blood and influence the function of cells at another location in the body.

Target cells/ tissues possess receptors for different chemical messengers; respond to them through signal transduction and/or transmission.

Cell surface receptors are present on the plasma membrane of the cells; having an extracellular domain which binds chemical messengers, a trans-membrane domain and a cytosolic or intracellular domain.

Intracellular receptors are found in the cytosol or nucleoplasm; having a DNA binding domain (DBD), a hormone binding domain and domains for transcription activation functions.

Transcription factors are regulatory proteins that bind to DNA and alter gene expression.

Feedback regulation is a process whereby the end product of a metabolic pathway act as a modulator (positive or negative) and influences its own production by altering the activity of one or more enzymes involve in the pathway.

Endocrine disorders are caused by imbalances in hormone secretion or hormone action or non-responsiveness of target tissues.

Syndrome is a group of signs and symptoms that occur together and characterize a particular abnormality or condition.

What makes a chemical a hormone?

- Hormones are secreted by a cell or group of cells.
- Hormones are secreted into the blood.
- Hormones are transported to a distant target.
- Hormones exert their effect at very low concentrations.

Classification of hormones

Chemically and functionally, hormones can be divided into two broad classes: those that are soluble in lipids, and those that are soluble in water.

Lipid-Soluble Hormones

1. **Steroid hormones** are derived from cholesterol.
2. **Two thyroid hormones (T3 and T4**) are synthesized by attaching iodine to the amino acid tyrosine. The presence of two benzene rings within a T3 or T4 molecule makes these molecules very lipid-soluble.
3. **The gas nitric oxide (NO)** is both a hormone and a neurotransmitter. Its synthesis is catalysed by the enzyme nitric oxide synthase.

Receptors for all lipid-soluble hormones are localized within cytoplasm or nucleus. Though some (e.g., estrogen) have cell surface receptors also.

Water-Soluble Hormones

4. **Amine hormones** are synthesized by decarboxylating and otherwise modifying certain amino acids. They are called amines because they retain an amino group (—NH_3). The catecholamines— epinephrine, norepinephrine, and dopamine—are synthesized by modifying the amino acid tyrosine. Histamine is synthesized from the amino acid histidine by mast cells and platelets. Serotonin and melatonin are derived from tryptophan.

5. **Peptide hormones and protein hormones** are amino acid polymers. The smaller peptide hormones consist of chains of 3 to 49 amino acids; the larger protein hormones include 50 to 200 amino acids. Examples of peptide hormones are antidiuretic hormone and oxytocin; protein hormones include human growth hormone and insulin. Several of the protein hormones, such as thyroid-stimulating hormone, have attached carbohydrate groups and thus are glycoprotein hormones.
6. **The eicosanoid hormones** are derived from arachidonic acid, a 20-carbon fatty acid. The two major types of eicosanoids are prostaglandins and leukotrienes. The eicosanoids are important local hormones, and they may act as circulating hormones as well.

Receptors for all water-soluble hormones are trans-membrane located on the plasma membrane.

Table 1: Endocrine glands, their secretions and functions

Cell/Tissue/ Gland	Hormone	Chemical Structure	Main Functions	Target cell/ Tissue
Pineal gland	Melatonin	Amine	Circadian rhythms; immune function; antioxidant	Brain, other tissues
Hypothalamus	Thyrotropin-releasing hormone (TRH)	Peptide	Stimulates secretion of TSH and prolactin	Anterior pituitary
	Corticotropin-releasing hormone (CRH)	Peptide	Causes release of ACTH	Anterior pituitary
	Growth hormone–releasing hormone (GHRH)	Peptide	Causes release of growth hormone	Anterior pituitary
	Growth hormone inhibitory hormone (GHIH) (somatostatin)	Peptide	Inhibits release of growth hormone	Anterior pituitary
	Gonadotropin-releasing hormone (GnRH)	Peptide	Causes release of LH and FSH	Anterior pituitary
	Dopamine or prolactin-inhibiting factor (PIF)	Amine	Inhibits release of prolactin	Anterior pituitary
Anterior pituitary	Growth hormone	Peptide	Stimulates protein synthesis and overall growth of most cells and tissues	Liver, Many tissues
	Thyroid-stimulating hormone (TSH)	Peptide	Stimulates synthesis and secretion of thyroid hormones (thyroxine and triiodothyronine)	Thyroid gland
	Adrenocorticotropic hormone (ACTH)	Peptide	Stimulates synthesis and secretion of adrenocortical hormones (cortisol, androgens,	Adrenal cortex

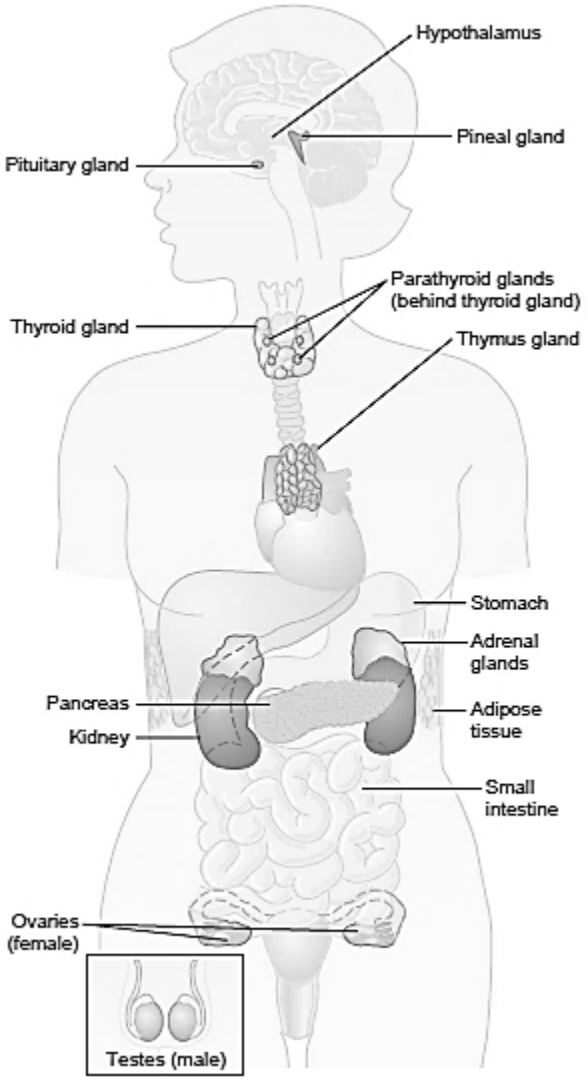
			and aldosterone)	
	Prolactin	Peptide	Promotes development of the female breasts and secretion of milk	Breast
	Follicle-stimulating hormone (FSH)	Peptide	Causes growth of follicles in the ovaries and sperm maturation in Sertoli cells of testes	Gonads
	Luteinizing hormone (LH)	Peptide	Stimulates testosterone synthesis in Leydig cells of testes; stimulates ovulation, formation of corpus luteum, and estrogen and progesterone synthesis in ovaries	Gonads
Posterior pituitary	Antidiuretic hormone (ADH) (also called vasopressin)	Peptide	Increases water reabsorption by the kidneys and causes vasoconstriction and increased blood pressure	Kidney
	Oxytocin	Peptide	Stimulates milk ejection from breasts and uterine contractions	Breast and uterus
Thyroid	Thyroxine (T4) and triiodothyronine (T3)	Amine	Increases the rates of chemical reactions in most cells, thus increasing body metabolic rate	Many tissues
	Calcitonin	Peptide	Promotes deposition of calcium in the bones and decreases extracellular fluid calcium ion concentration	Bone
Parathyroid	Parathyroid hormone (PTH)	Peptide	Controls serum calcium ion concentration by	Bone, kidney

			increasing calcium absorption by the gut and kidneys and releasing calcium from bones	
Thymus gland	Thymosin, thymopoietin	Peptide	Lymphocyte development	Lymphocytes
Liver	Angiotensinogen	Peptide	Aldosterone secretion; increases blood pressure	Adrenal cortex, blood vessels
	Insulin-like growth factors	Peptide	Growth	Many tissues
Adrenal cortex	Cortisol	Steroid	Has multiple metabolic functions for controlling metabolism of proteins, carbohydrates, and fats; also has anti-inflammatory effects	Many tissues
	Aldosterone	Steroid	Increases renal sodium reabsorption, potassium secretion, and hydrogen ion secretion	Kidney
Adrenal medulla	Norepinephrine, epinephrine	Amine	Same effects as sympathetic stimulation	Many tissues
Pancreas	Insulin (β cells)	Peptide	Promotes glucose entry in many cells, and in this way controls carbohydrate metabolism	Many tissues
	Glucagon (α cells)	Peptide	Increases synthesis and release of glucose from the liver into the body fluids	Many tissues
Testes	Testosterone	Steroid	Promotes development of male reproductive system and male secondary sexual	Many tissues

			characteristics	
Ovaries	Estrogens	Steroid	Promotes growth and development of female reproductive system, female breasts, and female secondary sexual characteristics	Many tissues
	Progesterone	Steroid	Stimulates secretion of “uterine milk” by the uterine endometrial glands and promotes development of secretory apparatus of breasts	Many tissues
Placenta	Human chorionic gonadotropin (HCG)	Peptide	Promotes growth of corpus luteum and secretion of estrogens and progesterone by corpus luteum	Corpus luteum
	Human somatomammotropin	Peptide	Probably helps promote development of some fetal tissues as well as the mother’s breasts	Many tissues
	Estrogens	Steroid	See actions of estrogens from ovaries	Many tissues
	Progesterone	Steroid	See actions of progesterone from ovaries	Many tissues
Kidney	Renin	Peptide	Catalyzes conversion of angiotensinogen to angiotensin I (acts as an enzyme)	Many tissues
	1,25-Dihydroxycholecalciferol	Steroid	Increases intestinal absorption of calcium and bone mineralization	Intestine
	Erythropoietin	Peptide	Increases erythrocyte production	Bone marrow
Heart	Atrial natriuretic peptide (ANP)	Peptide	Increases sodium excretion by kidneys, reduces blood pressure	Kidneys

Stomach	Gastrin	Peptide	Stimulates HCl secretion by parietal cells	GI tract
Small intestine	Secretin	Peptide	Stimulates pancreatic acinar cells to release bicarbonate and water	GI tract and pancreas
	Cholecystokinin (CCK)	Peptide	Stimulates gallbladder contraction and release of pancreatic enzymes	GI tract and pancreas
Adipocytes	Leptin	Peptide	Inhibits appetite, stimulates thermogenesis	Hypothalamus, other tissues

Location of various endocrine glands and tissues



References:

- Guyton, Arthur C. Textbook of medical physiology, 11th Edition. Elsevier, Inc.
- Tortora, G J and Derrickson, B. Principles of Anatomy & Physiology, 13th Edition. John Wiley & Sons, Inc.
- Silverthorn, D U. Human physiology: an integrated approach, 6th Edition. Pearson Education, Inc.