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Parul
Junior Lecturer, Shri Baba Mastnath Public Sr. Sec. School, Rohtak.

Correspondence
Parul
Junior Lecturer, Shri Baba Mastnath Public Sr. Sec. School, Rohtak.

Human endocrine system: A secreting organ or structure

Parul

Abstract
The endocrine system and the changes of adolescence are two portions of the Core Knowledge study of the human body. We have combined the two as one mini-unit within the general topic of The Human Body, and have chosen to introduce the Endocrine System prior to Adolescent Changes in an attempt to make the latter information more valid and understandable for students.

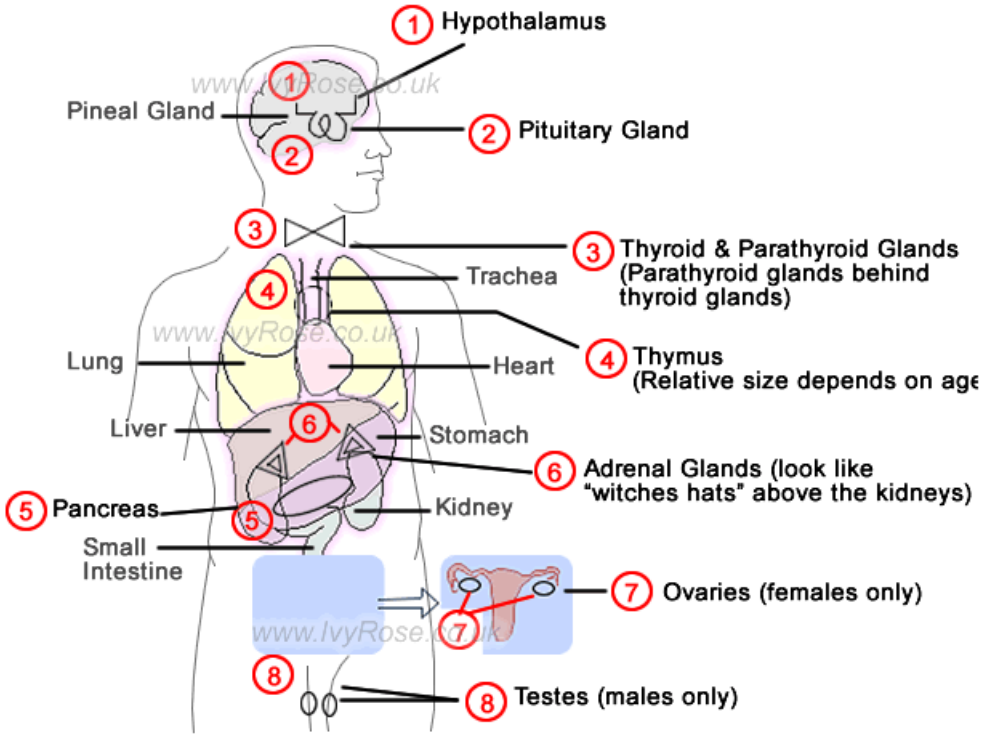
Keywords: endocrine system, secreting organ, adolescence

Introduction
Simply put, endocrinology is the study of endocrine glands. Endocrine glands are a group of glands in the body which secrete hormones. The purpose of the secreted hormones is to cause a specific response in other cells of the body which are located far away. As shown in the picture, the hormones are secreted out of the cells of an endocrine gland into the blood stream giving them access to all other cells of the body.
A great example of how hormones work is shown in our 5 minute video animation showing how a parathyroid gland grows into a tumor that secretes parathyroid hormone which then circulates through the blood stream to cause lots of problems throughout the body. Remember, the definition of a hormone is a molecule that is secreted by one cell which has an effect on another cell some distance away.

Types of Glands
Exocrine Gland
Exocrine glands are glands that produce and secrete substances onto an epithelial surface by way of a duct. Examples of exocrine glands include sweat, salivary, mammary, ceruminous, lacrimal, sebaceous, and mucous. Exocrine glands are one of two types of glands in the human body, the other being endocrine glands, which secrete their products directly into the bloodstream. The liver and pancreas are both exocrine and endocrine glands; they are exocrine glands because they secrete products—bile and pancreatic juice—into the gastrointestinal tract through a series of ducts, and endocrine because they secrete other substances directly into the bloodstream.

Endocrine Glands
Endocrine glands are glands of the endocrine system that secrete their products, *hormones*, directly into the blood rather than through a duct. The major glands of the endocrine system include the pineal gland, pituitary gland, pancreas, ovaries, testes, thyroid gland, parathyroid gland, hypothalamus and adrenal glands. The hypothalamus and pituitary gland are neuroendocrine organs. Local chemical messengers, not generally considered part of the endocrine system, include autocrines, which act on the cells that secrete them, and paracrines, which act on a different cell type nearby.
The ability of a target cell to respond to a hormone depends on the presence of receptors, within the cell or on its plasma membrane, to which the hormone can bind.
Hormone receptors are dynamic structures. Changes in number and sensitivity of hormone receptors may occur in response to high or low levels of stimulating hormones.
Blood levels of hormones reflect a balance between secretion and degradation/excretion. The liver and kidneys are the major organs that degrade hormones; breakdown products are excreted in urine and feces. Hormone half-life and duration of activity are limited and vary from hormone to hormone.

Location of Glands



The secretory organs that make up the human endocrine system, such as the anterior pituitary gland, the adrenal glands, and the pancreas, synthesize and secrete specific hormones. In addition, many endocrine glands, such as the thyroid gland, ovaries, and testes, are discrete, readily recognizable organs with defined borders and endocrine functions. Other glands are embedded within structures; for example, the islets of Langerhans are embedded within the pancreas and may be seen clearly only under the microscope.

Glands and hormones of the human endocrine system

Gland or Tissue	Principal Hormone	Function
Testis	Testosterone	stimulates development of male sex organs and secondary sex characteristics, including facial hair growth and increased muscle mass
Ovary	Estrogens (Estradiol, Estrone, Estriol)	stimulate development of female sex organs and secondary sex characteristics, maturation of ovarian follicles, formation and maintenance of bone tissue, and contraction of the uterine muscles
	Inhibin (Folliculostin)	inhibits secretion of follicle-stimulating hormone from the pituitary gland
	Progesterone	stimulates secretion of substances from the lining of the uterus (endometrium) in preparation for egg implantation in the uterine wall
		induces relaxation of pubic ligaments during childbirth to facilitate infant delivery
Thyroid Gland	Thyroxine	stimulates cellular metabolism, lipid production, carbohydrate utilization, and central and autonomic nervous system activation
	Triiodothyronine	stimulates cellular metabolism, lipid production, carbohydrate utilization, and central and autonomic nervous system activation
Adrenal Gland, Medulla	Epinephrine (Adrenaline)	stimulates "fight or flight" response, increases heart rate, dilates blood vessels in skeletal muscles and liver, increases oxygen delivery to muscle and brain tissues, increases blood glucose concentrations, and suppresses digestion
	Norepinephrine (Noradrenaline)	stimulates "fight or flight" response, increases heart rate, constricts blood vessels, increases blood glucose concentrations, and suppresses digestion
Adrenal Gland, Cortex	Cortisol	activates physiological stress responses to maintain blood glucose concentrations, augments constriction of blood vessels to maintain blood pressure, and stimulates anti-inflammatory pathways
	Aldosterone	regulates balance of salt and water in the body
	Androgens	contribute to growth and development of the male reproductive system and serve as precursors to testosterone and estrogen
Pituitary Gland, Anterior Lobe	corticotropin (adrenocorticotropin, ACTH)	stimulates growth and secretion of cells of the adrenal cortex; increases skin pigmentation
	growth hormone (GH; somatotropin)	stimulates growth of essentially all tissues in the body
	thyrotropin (thyroid-stimulating hormone)	stimulates secretion of thyroid hormone and growth of thyroid cells
	follicle-stimulating hormone (FSH)	stimulates maturation of egg follicles in females and development of

		spermatozoa in males
	luteinizing hormone (LH; interstitial cell stimulating hormone, ICSH)	stimulates rupture of mature egg follicles and production of progesterone and androgens in females and secretion of androgens in males
	prolactin (PRL; luteotropic hormone, LTH; lactogenic hormone; mammotropin)	stimulates and maintains lactation in breast-feeding mothers
Pituitary Gland, Posterior Lobe	oxytocin	stimulates milk ejection during breast-feeding and uterine muscle contraction during childbirth
	vasopressin (antidiuretic hormone, ADH)	regulates fluid volume by increasing or decreasing fluid excretion in response to changes in blood pressure
Pituitary Gland, Intermediate Lobe	melanocyte-stimulating hormones (MSH)*	stimulate melanin synthesis in skin cells to increase skin pigmentation; may also suppress appetite
Hypothalamus	corticotropin-releasing hormone (CRH)	stimulates synthesis and secretion of corticotropin from the anterior pituitary gland
	growth hormone-releasing hormone (GHRH)	stimulates synthesis and secretion of growth hormone from the anterior pituitary gland
	thyrotropin-releasing hormone (TRH)	stimulates and regulates secretion of thyrotropin from the anterior pituitary gland and may modulate neuronal activity in the brain and spinal cord
	gonadotropin-releasing hormone (GnRH)	stimulates synthesis and secretion of follicle-stimulating hormone and luteinizing hormone from the anterior pituitary gland
	prolactin-inhibiting factor (PIF; dopamine)	inhibits secretion of prolactin from the anterior pituitary gland
	somatostatin	inhibits secretion of growth hormone from the anterior pituitary gland, inhibits secretion of insulin and glucagon in the pancreas, and inhibits secretion of gastrointestinal hormones and secretion of acid in the stomach
	gastrointestinal neuropeptides	hormones secreted from the stomach and pancreas that stimulate hypothalamic secretion of neuropeptides, such as neuropeptide Y, gastrin-releasing peptide, and somatostatin, that regulate appetite, fat storage, and metabolism
Pancreatic Islets of Langerhans	glucagon	maintains blood glucose concentrations by stimulating release of glucose from the liver and production of glucose from amino acids and glycerol
	insulin	stimulates glucose uptake and storage in adipose, muscle, and liver tissues
	somatostatin	inhibits glucagon and insulin secretion from the pancreas and inhibits secretion of gastrointestinal hormones and secretion of acid in the stomach
	pancreatic polypeptide	inhibits contraction of the gallbladder and secretion of exocrine substances from the pancreas
Parathyroid Gland	parathyroid hormone (parathormone)	increases serum calcium concentrations by stimulating release of calcium from bone tissue, reabsorption of calcium in the kidneys, and production of vitamin D in the kidneys; inhibits reabsorption of phosphate in the kidneys
	calcitonin	decreases serum calcium concentrations by promoting uptake of calcium into bone tissue and excretion of calcium in the urine
Skin, Liver, Kidneys	calciferols (vitamin D)	maintain serum calcium concentrations by increasing absorption of calcium and phosphate in the intestines and reabsorption of calcium and phosphate in the kidneys; mobilizes calcium from bone in response to parathyroid hormone activity
Stomach	gastrin	stimulates secretion of acid and pepsin in the stomach and contraction of the pyloric region of the stomach near the small intestine to increase motility during digestion
Duodenum	cholecystokinin (CCK; pancreozymin)	stimulates release of bile from the gallbladder into the intestine and stimulates secretion of pancreatic juices into the intestine; may induce satiety
	secretin	stimulates secretion of water and bicarbonate from the pancreas into the duodenum; inhibits secretion of gastrin in the stomach, delaying gastric emptying
	gastric-inhibitory polypeptide (GIP)	inhibits secretion of acid into the stomach; stimulates secretion of insulin from the pancreas
	vasoactive intestinal peptide (VIP)	stimulates dilation of blood vessels and secretion of water and electrolytes from the intestine; modulates immune functions
Pineal Gland	melatonin	regulates circadian rhythm (primarily in response to light and dark cycles) and release of gonadotropin-releasing hormone from the hypothalamus and gonadotropins from the pituitary gland
Kidneys	renin	regulates blood pressure and blood flow by catalyzing conversion of angiotensinogen to angiotensin I in the kidneys
Multiple Tissues	insulin-like growth factors (somatomedins)	stimulate growth by mediating secretion of growth hormone from the pituitary gland
	prostaglandins	regulate many physiological processes, including dilation and constriction of blood vessels, aggregation of platelets, and inflammation

Hormones can be chemically classified into four groups:

- **Amino acid-derived:** Hormones that are modified amino acids.
- **Polypeptide and proteins:** Hormones that are chains of amino acids of less than or more than about 100 amino acids, respectively. Some protein hormones are actually glycoproteins, containing glucose or other carbohydrate groups.

- **Steroids:** Hormones that are lipids synthesized from cholesterol. Steroids are characterized by four interlocking carbohydrate rings.
- **Eicosanoids:** Are lipids synthesized from the fatty acid chains of phospholipids found in plasma membrane.

Hormones circulating in the blood diffuse into the interstitial fluids surrounding the cell. Cells with specific receptors for a hormone respond with an action that is appropriate for the cell. Because of the specificity of hormone and target cell, the effects produced by a single hormone may vary among different kinds of target cells.

Hormones activate target cells by one of two methods, depending upon the chemical nature of the hormone.

Lipid-soluble hormones (steroid hormones and hormones of the thyroid gland) diffuse through the cell membranes of target cells. The lipid-soluble hormone then binds to a receptor protein that, in turn, activates a DNA segment that turns on specific genes. The proteins produced as result of the transcription of the genes and subsequent translation of mRNA act as enzymes that regulate specific physiological cell activity.

Water-soluble hormones (polypeptide, protein, and most amino acid hormones) bind to a receptor protein on the plasma membrane of the cell.

Cyclic AMP (CAMP) is produced when the receptor protein activates another membrane-bound protein called a G protein. The G protein activates adenylate cyclase, the enzyme that catalyzes the production of CAMP from ATP. Cyclic AMP then triggers an enzyme that generates specific cellular changes.

Inositol triphosphate (IP3) is produced from membrane phospholipids. IP3, in turn, triggers the release of CA2+ from the endoplasmic reticulum, which then activates enzymes that generate cellular changes.

Endocrine glands release hormones in response to one or more of the following stimuli:

- Hormones from other endocrine glands.
- Chemical characteristics of the blood (other than hormones).
- Neural stimulation.

Most hormone production is managed by a negative feedback system. The nervous system and certain endocrine tissues monitor various internal conditions of the body. If action is required to maintain homeostasis, hormones are released, either directly by an endocrine gland or indirectly through the action of the hypothalamus of the brain, which stimulates other endocrine glands to release hormones. The hormones activate target cells, which initiate physiological changes that adjust the body conditions. When normal conditions have been recovered, the corrective action - the production of hormones - is discontinued. Thus, in negative feedback, when the original (abnormal) condition has been repaired, or negated, corrective actions decrease or discontinue. For example, the amount of glucose in the blood controls the secretion of insulin and glucagons via negative feedback.

The production of some hormones is controlled by positive feedback. In such a system, hormones cause a condition to intensify, rather than decrease. As the condition intensifies, hormone production increases. Such positive feedback is uncommon, but does occur during childbirth, where hormone levels build with increasingly intense labor contractions. Also in lactation, hormone levels increase in response to nursing, which causes an increase in milk production. The hormone produced by the hypothalamus causing the milk let down and uterine contraction is oxytocin.

Glossary

Adrenal Gland: endocrine gland that is located on top of each kidney

Amino Acid-derived: hormones that are modified amino acids

Antagonistic Hormones: hormones that act to return body conditions to within acceptable limits from opposite extremes.

Calcitonin: hormone produced by the thyroid; contributes to the regulation of blood calcium levels.

Eicosanoids: lipids that are synthesized from the fatty acid chains of phospholipids found in plasma membrane.

Endocrine Glands: glands that have no duct and release their secretions directly into the intercellular fluid or into the blood.

Endocrine System: a control system of ductless glands that secrete chemical messengers called hormones.

Estrogen: hormone in females; stimulates the development of the uterus and vagina.

Exocrine Glands: glands that release their cellular secretions through a duct which empties to the outside or into the lumen (empty internal space) of an organ.

Hormone: a specific chemical substance produced by certain cells that control, or help to control, cellular processes elsewhere in an organism.

Insulin: hormone that acts to lower blood sugar levels by allowing the sugar to flow into cells.

Iodine: chemical in the body; Thyroid hormone can not be produced with out it.

Lipid-soluble Hormones: diffuse through the cell membranes of target cells.

Parathyroid: four masses of tissue, two embedded posterior in each lateral mass of the thyroid gland.

Pancreas: organ involved with the digestion system and the circulatory system; helps to maintain blood sugar levels.

Pineal Gland: small endocrine gland in the brain located near the center of the brain, between the two hemispheres, tucked in a groove where the two rounded thalamic bodies join.

Pituitary Gland: endocrine gland that is attached to the hypothalamus of the lower forebrain.

Polypeptide and Proteins: hormones that are chains of amino acids of less than or more than about 100 amino acids.

Steroids: hormones that are lipids that are synthesized from cholesterol; characterized by four interlocking carbohydrate rings.

Testosterone: hormone more prominent in males; belongs to the family of androgens, which are steroid hormones producing masculinizing effects.

Thyroid Gland: endocrine gland that consists of two lateral masses that are attached to the trachea.

Thyroxine: serves to stimulate oxidative metabolism in cells; increases the oxygen consumption and heat production of most body tissues.

Water-soluble Hormones: bind to a receptor protein on the plasma membrane of the cell.

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