Endocrine system

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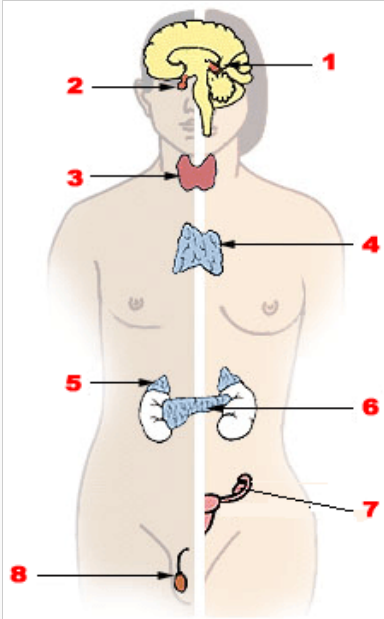
In physiology, the **endocrine system** is a system of glands, each of which secretes a type of hormone into the bloodstream to regulate the body. The endocrine system is an information signal system like the nervous system. Hormones regulate many functions of an organism, including mood, growth and development, tissue function, and metabolism. The field of study that deals with disorders of endocrine glands is endocrinology, a branch of internal medicine.

The endocrine system is made up of a series of ductless glands that produce chemicals called hormones. A number of glands that signal each other in sequence is usually referred to as an axis, for example, the hypothalamic-pituitary-adrenal axis. Typical endocrine glands are the pituitary, thyroid, and adrenal glands. Features of endocrine glands are, in general, their ductless nature, their vascularity, and usually the presence of intracellular vacuoles or granules storing their hormones. In contrast, exocrine glands, such as salivary glands, sweat glands, and glands within the gastrointestinal tract, tend to be much less vascular and have ducts or a hollow lumen.

In addition to the specialised endocrine organs mentioned above, many other organs that are part of other body systems, such as the kidney, liver, heart and gonads, have secondary endocrine functions. For example the kidney secretes endocrine hormones such as erythropoietin and renin.



Major endocrine glands. (Male on the left, female on the right.) ***1.*** *Pineal gland* ***2.*** *Pituitary gland* ***3.*** *Thyroid gland* ***5.*** *Adrenal gland* ***6.*** *Pancreas* ***7.*** *Ovary* ***8.*** *Testis*. Note: the Thymus (labelled 4.) is not an endocrine gland.

Contents

Endocrine organs and secreted hormones

Central nervous system

Hypothalamus

Secreted hormone	Abbreviation	Produced by	Effect
Thyrotropin-releasing hormone (Prolactin-releasing hormone)	TRH, TRF, or PRH	Parvocellular neurosecretory neurons	Stimulate thyroid-stimulating hormone (TSH) release from anterior pituitary (primarily) Stimulate prolactin release from anterior pituitary
Dopamine (Prolactin-inhibiting hormone)	DA or PIH	Dopamine neurons of the arcuate nucleus	Inhibit prolactin release from anterior pituitary
Growth hormone-releasing hormone	GHRH	Neuroendocrine neurons of the Arcuate nucleus	Stimulate Growth hormone (GH) release from anterior pituitary
Somatostatin (growth hormone-inhibiting hormone)	SS, GHIH, or SRIF	Neuroendocrine cells of the Periventricular nucleus	Inhibit Growth hormone (GH) release from anterior pituitary Inhibit thyroid-stimulating hormone (TSH) release from anterior pituitary
Gonadotropin-releasing hormone	GnRH or LHRH	Neuroendocrine cells of the Preoptic area	Stimulate follicle-stimulating hormone (FSH) release from anterior pituitary Stimulate luteinizing hormone (LH) release from anterior pituitary
Corticotropin-releasing hormone	CRH or CRF	Parvocellular neurosecretory neurons	Stimulate adrenocorticotropic hormone (ACTH) release from anterior pituitary
Oxytocin		Magnocellular neurosecretory cells	Uterine contraction Lactation (letdown reflex)
Vasopressin (antidiuretic hormone)	ADH or AVP	Parvocellular neurosecretory neurons	Increases water permeability in the distal convoluted tubule and collecting duct of nephrons, thus promoting water reabsorption and increasing blood volume

Pineal body (epiphysis)

Secreted hormone	From cells	Effect

Melatonin (Primarily)	Pinealocytes	Antioxidant Monitors the circadian rhythm including inducement of drowsiness
Dimethyltryptamine		Speculated role in mystical and dream experiences

Pituitary Gland (hypophysis)

Anterior pituitary lobe (adenohypophysis)

Secreted hormone	Abbreviation	From cells	Effect
Growth hormone (somatotropin)	GH	Somatotrophs	Stimulates growth and cell reproduction Stimulates Insulin-like growth factor 1 release from liver
Thyroid-stimulating hormone (thyrotropin)	TSH	Thyrotrophs	Stimulates thyroxine (T4) and triiodothyronine (T3) synthesis and release from thyroid gland Stimulates iodine absorption by thyroid gland
Adrenocorticotropic hormone (corticotropin)	ACTH	Corticotrophs	Stimulates corticosteroid (glucocorticoid and mineralcorticoid) and androgen synthesis and release from adrenocortical cells
Follicle-stimulating hormone	FSH	Gonadotrophs	In females: Stimulates maturation of ovarian follicles in ovary In males: Stimulates maturation of seminiferous tubules In males: Stimulates spermatogenesis In males: Stimulates production of androgen-binding protein from Sertoli cells of the testes
Luteinizing hormone	LH	Gonadotrophs	In females: Stimulates ovulation In females: Stimulates formation of corpus luteum In males: Stimulates testosterone synthesis from Leydig cells (interstitial cells)
Prolactin	PRL	Lactotrophs	Stimulates milk synthesis and release from mammary glands Mediates sexual gratification

Posterior pituitary lobe (neurohypophysis)

Secreted hormone	Abbreviation	From cells	Effect
Oxytocin		Magnocellular neurosecretory cells	Uterine contraction Lactation (letdown reflex)
Vasopressin (antidiuretic hormone)	ADH or AVP	Parvocellular neurosecretory neurons	Increases water permeability in the distal convoluted tubule and collecting duct of nephrons, thus promoting water reabsorption and increasing blood volume

Oxytocin and anti-diuretic hormone are not secreted in the posterior lobe, merely stored.

Intermediate pituitary lobe (pars intermedia)

Secreted hormone	Abbreviation	From cells	Effect
Melanocyte-stimulating hormone	MSH	Melanotropes	Stimulates melanin synthesis and release from skin/hair melanocytes

Thyroid

Secreted hormone	Abbreviation	From cells	Effect
Triiodothyronine	T3	Thyroid epithelial cell	(More potent form of thyroid hormone) Stimulates body oxygen and energy consumption, thereby increasing the basal metabolic rate Stimulates RNA polymerase I and II, thereby promoting protein synthesis
Thyroxine (tetraiodothyronine)	T4	Thyroid epithelial cell*s*	(Less active form of thyroid hormone) (Acts as a prohormone to triiodothyronine) Stimulates body oxygen and energy consumption, thereby increasing the basal metabolic rate Stimulates RNA polymerase I and II, thereby promoting protein synthesis
Calcitonin		Parafollicular cell*s*	Stimulates osteoblasts and thus bone construction Inhibits Ca^{2+} release from bone, thereby reducing blood Ca^{2+}

Alimentary system

Stomach

Secreted hormone	Abbreviation	From cells	Effect
Gastrin (Primarily)		G cells	Secretion of gastric acid by parietal cells
Ghrelin		P/D1 cells	Stimulate appetite, secretion of growth hormone from anterior pituitary gland
Neuropeptide Y	NPY		increased food intake and decreased physical activity
Somatostatin		D cells	Suppress release of gastrin, cholecystokinin (CCK), secretin, motilin, vasoactive intestinal peptide (VIP), gastric inhibitory polypeptide (GIP), enteroglucagon Lowers rate of gastric emptying Reduces smooth muscle contractions and blood flow within the intestine.[1]
Histamine		ECL cells	stimulate gastric acid secretion
Endothelin		X cells	Smooth muscle contraction of stomach[2]

Duodenum

Secreted hormone	From cells	Effect
Secretin	S cells	Secretion of bicarbonate from liver, pancreas and duodenal Brunner's glands Enhances effects of cholecystokinin Stops production of gastric juice
Cholecystokinin	I cells	Release of digestive enzymes from pancreas Release of bile from gallbladder hunger suppressant

Liver

Secreted hormone	Abbreviation	From cells	Effect
Insulin-like growth factor (or somatomedin) (Primarily)	IGF	Hepatocytes	insulin-like effects regulate cell growth and development
Angiotensinogen and angiotensin		Hepatocytes	vasoconstriction release of aldosterone from adrenal cortex dipsogen.
Thrombopoietin		Hepatocytes	stimulates megakaryocytes to produce platelets[3]

Pancreas

Secreted hormone	From cells	Effect
Insulin (Primarily)	β Islet cells	Intake of glucose, glycogenesis and glycolysis in liver and muscle from blood intake of lipids and synthesis of triglycerides in adipocytes Other anabolic effects
Glucagon (Also Primarily)	α Islet cells	glycogenolysis and gluconeogenesis in liver increases blood glucose level
Somatostatin	δ Islet cells	Inhibit release of insulin[4] Inhibit release of glucagon[4] Suppress the exocrine secretory action of pancreas.
Pancreatic polypeptide	PP cells	Self regulate the pancreas secretion activities and effect the hepatic glycogen levels.

Kidney

Secreted hormone	From cells	Effect
Renin (Primarily)	Juxtaglomerular cells	Activates the renin-angiotensin system by producing angiotensin I of angiotensinogen
Erythropoietin (EPO)	Extraglomerular mesangial cells	Stimulate erythrocyte production
Calcitriol (1,25-dihydroxyvitamin D_3)		Active form of vitamin D_3 Increase absorption of calcium and phosphate from gastrointestinal tract and kidneys inhibit release of PTH
Thrombopoietin		stimulates megakaryocytes to produce platelets[3]

Adrenal glands

Adrenal cortex

Secreted hormone	From cells	Effect
Glucocorticoids (chiefly cortisol)	zona fasciculata and zona reticularis cells	Stimulates gluconeogenesis Stimulates fat breakdown in adipose tissue Inhibits protein synthesis Inhibits glucose uptake in muscle and adipose tissue Inhibits immunological responses (immunosuppressive) Inhibits inflammatory responses (anti-inflammatory)
Mineralocorticoids (chiefly aldosterone)	Zona glomerulosa cells	Stimulates active sodium reabsorption in kidneys Stimulates passive water reabsorption in kidneys, thus increasing blood volume and blood pressure Stimulates potassium and H^+ secretion into nephron of kidney and subsequent excretion
Androgens (including DHEA and testosterone)	Zona fasciculata and Zona reticularis cells	In males: Relatively small effect compared to androgens from testes In females: masculinizing effects (ie. excessive facial hair)

Adrenal medulla

Secreted hormone	From cells	Effect
Adrenaline (epinephrine) (Primarily)	Chromaffin cells	Fight-or-flight response: ▪ Boost the supply of oxygen and glucose to the brain and muscles (by increasing heart rate and stroke volume, vasodilation, increasing catalysis of glycogen in liver, breakdown of lipids in fat cells) ▪ Dilate the pupils ▪ Suppress non-emergency bodily processes (e.g., digestion) ▪ Suppress immune system
Noradrenaline (norepinephrine)	Chromaffin cells	Fight-or-flight response: ▪ Boost the supply of oxygen and glucose to the brain and muscles (by increasing heart rate and stroke volume, vasoconstriction and increased blood pressure, breakdown of lipids in fat cells) ▪ Increase skeletal muscle readiness.
Dopamine	Chromaffin cells	Increase heart rate and blood pressure
Enkephalin	Chromaffin cells	Regulate pain

Reproductive

Testes

Secreted hormone	From cells	Effect
Androgens (chiefly testosterone)	Leydig cells	Anabolic: growth of muscle mass and strength, increased bone density, growth and strength, Virilizing: maturation of sex organs, formation of scrotum, deepening of voice, growth of beard and axillary hair.
Estradiol	Sertoli cells	Prevent apoptosis of germ cells[5]
Inhibin	Sertoli cells	Inhibit production of FSH

Ovarian follicle / Corpus luteum

Secreted hormone	From cells	Effect
Progesterone	Granulosa cells, theca cells	Support pregnancy[6]: ▪ Convert endometrium to secretory stage ▪ Make cervical mucus permeable to sperm. ▪ Inhibit immune response, e.g., towards the human embryo ▪ Decrease uterine smooth muscle contractility[6] ▪ Inhibit lactation ▪ Inhibit onset of labor. Other: ▪ Raise epidermal growth factor-1 levels ▪ Increase core temperature during ovulation[7] ▪ Reduce spasm and relax smooth muscle (widen bronchi and regulate mucus) Anti-inflammatory ▪ Reduce gall-bladder activity[8] ▪ Normalize blood clotting and vascular tone, zinc and copper levels, cell oxygen levels, and use of fat stores for energy ▪ Assist in thyroid function and bone growth by osteoblasts ▪ Increase resilience in bone, teeth, gums, joint, tendon, ligament, and skin ▪ Promote healing by regulating collagen ▪ Provide nerve function and healing by regulating myelin ▪ Prevent endometrial cancer by regulating effects of estrogen
Androstenedione	Theca cells	Substrate for estrogen
Estrogens (mainly	Granulosa cells	Structural: ▪ Promote formation of female secondary sex characteristics ▪ Accelerate height growth ▪ Accelerate metabolism (burn fat) ▪ Reduce muscle mass ▪ Stimulate endometrial growth ▪ Increase uterine growth ▪ Maintain blood vessels and skin ▪ Reduce bone resorption, increase bone formation Protein synthesis: ▪ Increase hepatic production of binding proteins Coagulation: ▪ Increase circulating level of factors 2, 7, 9, 10, antithrombin III, plasminogen ▪ Increase platelet adhesiveness ▪ Increase HDL, triglyceride, height growth ▪ Decrease LDL, fat deposition

estradiol)	Granulosa cells	Fluid balance: ▪ Regulate salt (sodium) and water retention ▪ Increase growth hormone ▪ Increase cortisol, SHBG Gastrointestinal tract: ▪ Reduce bowel motility ▪ Increase cholesterol in bile Melanin: ▪ Increase pheomelanin, reduce eumelanin Cancer: ▪ Support hormone-sensitive breast cancers [9] (Suppression of production in the body of estrogen is a treatment for these cancers.) Lung function: ▪ Promote lung function by supporting alveoli.[10]
Inhibin	Granulosa cells	Inhibit production of FSH from anterior pituitary

Placenta (when pregnant)

Secreted hormone	Abbreviation	From cells	Effect
Progesterone (Primarily)			Support pregnancy[6]: ▪ Inhibit immune response, towards the fetus. ▪ Decrease uterine smooth muscle contractility[6] ▪ Inhibit lactation ▪ Inhibit onset of labor. ▪ Support fetal production of adrenal mineralo- and glucosteroids. Other effects on mother similar to ovarian follicle-progesterone
Estrogens (mainly Estriol) (Also Primarily)			Effects on mother similar to ovarian follicle estrogen
Human chorionic gonadotropin	HCG	Syncytiotrophoblast	promote maintenance of corpus luteum during beginning of pregnancy Inhibit immune response, towards the human embryo.
Human placental lactogen	HPL	Syncytiotrophoblast	increase production of insulin and IGF-1 increase insulin resistance and carbohydrate intolerance
Inhibin		Fetal Trophoblasts	suppress FSH

Uterus (when pregnant)

Secreted hormone	Abbreviation	From cells	Effect
Prolactin	PRL	Decidual cells	milk production in mammary glands
Relaxin		Decidual cells	Unclear in humans and animals

Calcium regulation

Parathyroid

Secreted hormone	Abbreviation	From cells	Effect
Parathyroid hormone	PTH	Parathyroid chief cell	Calcium: ▪ Stimulates Ca^{2+} release from bone, thereby increasing blood Ca^{2+} ▪ Stimulates osteoclasts, thus breaking down bone ▪ Stimulates Ca^{2+} reabsorption in kidney ▪ Stimulates activated vitamin D production in kidney Phosphate: ▪ Stimulates $PO_4^{=}$ release from bones, thereby increasing blood $PO_4^{=}$ ▪ Inhibits $PO_4^{=}$ reabsorption in kidney, so more $PO_4^{=}$ is excreted ▪ Overall, small net drop in serum $PO_4^{=}$

Skin

Secreted hormone	From cells	Effect
Calcidiol (25-hydroxyvitamin D_3)		Inactive form of vitamin D_3

Miscellaneous

Heart

Secreted hormone	Abbreviation	From cells	Effect
Atrial-natriuretic peptide	ANP	Cardiac myocytes	Reduce blood pressure by: reducing systemic vascular resistance, reducing blood water, sodium and fats
Brain natriuretic peptide	BNP	Cardiac myocytes	(To a lesser degree than ANP) reduce blood pressure by: reducing systemic vascular resistance, reducing blood water, sodium and fats

Bone Marrow

Secreted hormone	From cells	Effect
Thrombopoietin	liver and kidney cells	stimulates megakaryocytes to produce platelets[3]

Adipose tissue

Secreted hormone	From cells	Effect
Leptin (Primarily)	Adipocytes	decrease of appetite and increase of metabolism.
Estrogens[11] **(mainly Estrone)**	Adipocytes	

Major endocrine systems

The human endocrine system consists of several integrated systems that operate via feedback loops. Several important feedback systems are mediated via the hypothalamus and pituitary.[12]

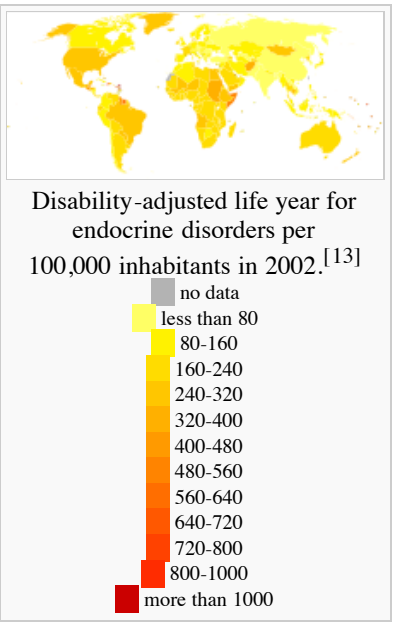
- TRH - TSH - T3/T4
- GnRH - LH/FSH - sex hormones
- CRH - ACTH - cortisol
- Renin - angiotensin - aldosterone

Diseases

Main article: Endocrine diseases

Diseases of the endocrine system are common,[14] including conditions such as diabetes mellitus, thyroid disease, and obesity. Endocrine disease is characterized by disregulated hormone release (a productive pituitary adenoma), inappropriate response to signaling (hypothyroidism), lack of a gland (diabetes mellitus type 1, diminished erythropoiesis in chronic renal failure), or structural enlargement in a critical site such as the testis (toxic multinodular goitre). Hypofunction of endocrine glands can occur as a result of loss of reserve, hyposecretion, agenesis, atrophy, or active destruction. Hyperfunction can occur as a result of hypersecretion, loss of suppression, hyperplastic or neoplastic change, or hyperstimulation.

Endocrinopathies are classified as primary, secondary, or tertiary. Primary endocrine disease inhibits the action of downstream glands. Secondary endocrine disease is indicative of a problem with the pituitary gland. Tertiary endocrine disease is associated with dysfunction of the hypothalamus and its releasing hormones.[*citation needed*]



Disability-adjusted life year for endocrine disorders per 100,000 inhabitants in 2002.[13]

As the thyroid, and hormones have been implicated in signaling distant tissues to proliferate, for example, the estrogen receptor has been shown to be involved in certain breast cancers. Endocrine, paracrine, and autocrine signaling have all been implicated in proliferation, one of the required steps of oncogenesis.[15]

Other types of signaling

The typical mode of cell signaling in the endocrine system is endocrine signaling. However, there are also other modes, i.e., paracrine, autocrine, and neuroendocrine signaling.[16] Purely neurocrine signaling between neurons, on the other hand, belongs completely to the nervous system.

Autocrine

Main article: Autocrine signalling

Autocrine signaling is a form of signaling in which a cell secretes a hormone or chemical messenger (called the autocrine agent) that binds to autocrine receptors on the same cell, leading to changes in the cells.

Paracrine

Main article: Paracrine signalling

Paracrine signaling is a form of cell signaling in which the target cell is near the signal-releasing cell.

Juxtacrine

Main article: Juxtacrine signalling

juxtacrine signaling is a type of intercellular communication that is transmitted via oligosaccharide, lipid, or protein components of a cell membrane, and may affect either the emitting cell or the immediately adjacent cells.

It occurs between adjacent cells that possess broad patches of closely opposed plasma membrane linked by transmembrane channels known as connexons. The gap between the cells can usually be between only 2 and 4 nm.

Unlike other types of cell signaling (such as paracrine and endocrine), juxtacrine signaling requires physical contact between the two cells involved.

Juxtacrine signaling has been observed for some growth factors, cytokine and chemokine cellular signals

See also

- Releasing hormones
- Neuroendocrinology
- Nervous system
- Endocrine disruptor
- Human anatomy#Major organ systems
- Endocrine disease
- Endocrinology

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