

The Endocrine System consists of **endocrine glands** that secrete specific chemicals called **hormones** into the blood/tissue fluid.

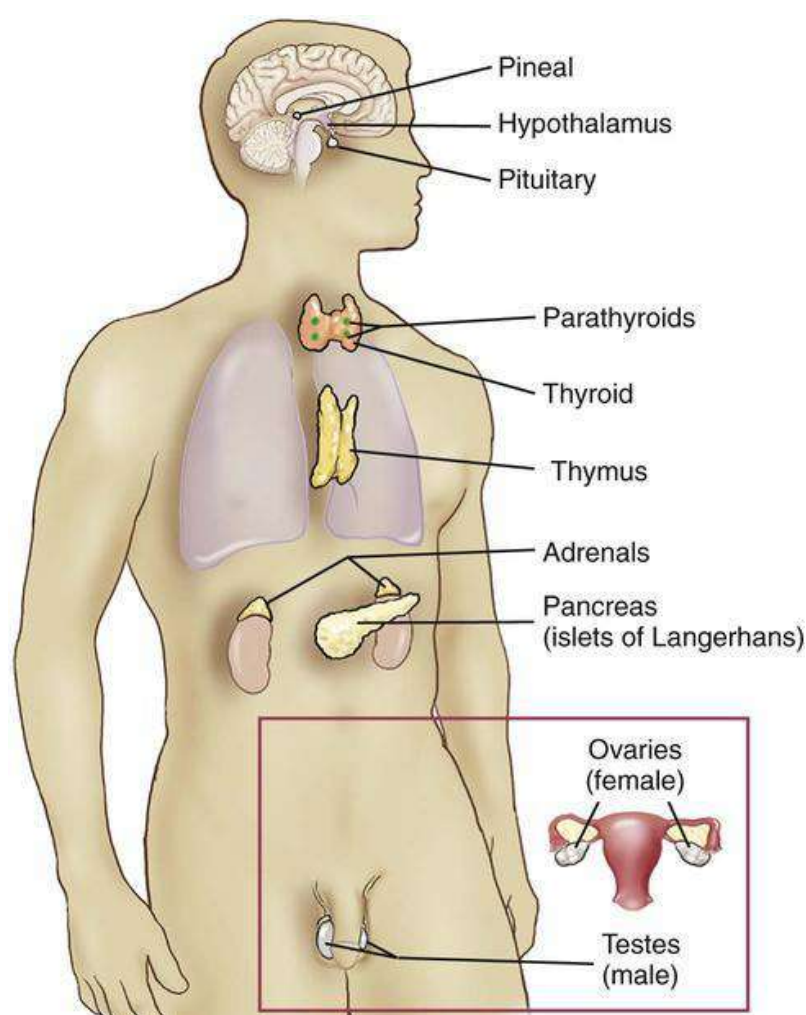
The Endocrine System is one of the body's communication systems and uses these **hormones** as messengers to help to regulate cellular activity by providing a constant internal environment, i.e. homeostasis.

A hormone is a chemical substance that is generated in one organ and carried by the blood to a target organ where it excites activity.

The Endocrine System works very closely with the nervous system to help control the body.

Endocrine glands are ductless and secrete their hormones directly into the bloodstream.

The Endocrine Glands in the body are: (Hypothalamus); Pituitary; Pineal; Thyroid; Parathyroids; Adrenals; Pancreas - Islets of Langerhans; Thymus; Ovaries; Testes.



The Hypothalamus and Pituitary Gland act as a unit to regulate activity of each other:

- Pituitary has 2 lobes - anterior lobe and posterior lobe
- The Pituitary is attached to the Hypothalamus of the brain by a stalk
- This stalk brings blood from the hypothalamus rich in O_2 , nutrients, releasing and inhibiting hormones (RH; IH) to the anterior lobe to influence its secretions: 'Pituitary Portal System'
- The stalk brings nerves from the hypothalamus to the posterior lobe
- The Pituitary is often referred to as the '**Master Gland**' because it produces several hormones or releasing factors that influence the secretion of hormones of other endocrine glands.

Anterior Pituitary	Function	Target
Growth Hormone (GH)	Stimulate growth of skeletal muscle, organs + connective tissue e.g. bone	Many tissues
Thyroid Stimulating Hormone (TSH)	Stimulates growth & activity of the thyroid gland	Thyroid
Adrenocorticotropin (ACTH)	Stimulates & controls the growth and hormonal output of the adrenal cortex	Adrenal Cortex
Prolactin	Stimulates lactation Release is stimulated by suckling	Breast
Follicle Stimulating Hormone or	FSH: stimulates the development and ripening of ovarian / graafian follicle that secretes oestrogen (female) Stimulates testes to produce sperm (male)	Ovaries/testes
Luteinising Hormone	LH: stimulates final maturation of ovarian follicle and ovulation Promotes formation of Corpus luteum that secretes Progesterone (female) Stimulates testes to produce testosterone (male)	
Melanocyte Stimulating Hormone (MSH)	Stimulates the production of melanin in the basal cell layer of the epidermis	Skin

Posterior Pituitary		
Oxytocin	Promotes uterine contraction and expression of milk	Uterus & Breast
Vasopressin/antidiuretic Hormone (ADH)	Contraction of smooth muscle (blood vessels) = increase BP Increase permeability of kidneys to water = more water absorbed	Blood vessels Kidney tubules

- 'Pituitary Portal System' The anterior secretions of the pituitary are dependent on stimulation from the hypothalamus and are involved in 'Negative feedback mechanism'.
- 'Negative Feedback Mechanism': If a hormone blood level is low - stimulation of the hypothalamus to produce its stimulating hormone - stimulate pituitary to release hormone - increase blood hormone level - signal hypothalamus to release its inhibiting hormone - goes to pituitary - amount of hormone released is decreased.

The Pineal Gland

- Pea-sized mass of nerve tissue deep in the brain
- It secretes the hormone melatonin (made from serotonin)
- More melatonin is released in the darkness and can promote sleepiness
- It functions to co-ordinate circadian rhythms / day & night rhythms / biological clock
- Overproduction of melatonin during winter months can cause Seasonal Affective Disorder (SAD) as daylight hours are shortened. It is also thought to be associated with Jet Lag

The Thyroid Gland

- A 2-lobed gland in the neck in front of the larynx and trachea. 2 parathyroid glands lie on the posterior of each
- It is controlled by the pituitary gland
- The gland contains hormones and colloid (thick sticky semifluid protein)
- It has 3 major secretions: T3 (tri-iodothyronine), T4 (Thyroxine) and Calcitonin
- C-Cells (parafollicular cells) produce the hormone *Calcitonin* which reduces Calcium levels in the blood. It inhibits calcium reabsorption from bones and renal tubules. An increase in calcium blood levels = increase in calcitonin levels.
- Iodine is essential for formation of T3 and T4 and has to be ingested.
- After formation, T3 and T4 combine with colloid = 'Thyroglobulin'
- Function of T3 and T4 are: Physical growth / Mental development / metabolic rate control / Peristalsis / Nervous function.

The Parathyroid Gland

- 4 of them - 2 on either side of thyroid. Posterior to the thyroid.
- They secrete Parathormone (PTH)
- A drop in blood calcium levels = increase in PTH secretion
- PTH promotes calcium reabsorption from bones and in the small intestine and renal tubules
- PTH and calcitonin from the thyroid help maintain blood calcium levels which is very important for muscle contraction, blood clotting and nerve impulse transmission.

The Thymus Gland

- Is found behind the sternum, between the lungs
- It has 2 lobes made of epithelial cells and lymphocytes
- Thymosin and thymic factor are the hormones secreted by epithelial cells
- It stimulates the maturation of the thymus and t-lymphocytes
- Required for development and activity of t-lymphocytes

The Islets of Langerhans (Pancreas)

- The ductless parts of the pancreas secrete the 2 hormones: Glucagon and Insulin
- Both of these are vital for the control of blood glucose levels
- Glucagon secretion = increases blood glucose levels
- Insulin secretion = decreases blood glucose levels
- GHRH from the hypothalamus can inhibit insulin and glucagon secretion

GLUCAGON	INSULIN
Increases blood glucose	Decreases blood glucose
Converts Glycogen to Glucose (especially in liver & muscles)	Converts Glucose to Glycogen (especially in liver & muscles)

The Adrenal Glands

- There are 2 of them - each lie on top of a kidney
- They have a structure of an outer cortex and an inner medulla

The **Adrenal Cortex** produces Glucocorticoids, Mineralocorticoids and Androgens from cholesterol.

- **Glucocorticoids:** Cortisone/Hydrocortisone. Stimulated by ACTH or by stress. They regulate carbohydrate, protein and fat metabolism / promote sodium and water absorption in kidneys / have anti-inflammatory properties.

- **Mineralocorticoids:** Aldosterone is the major one. It is very important for electrolyte balance within the body and stimulates reabsorption of sodium and water in the kidney tubules. Decrease in blood sodium = increased release of aldosterone = increased blood sodium.
- **Androgens:** Sex hormones produced in very small amounts here.

The **Adrenal Medulla** is made of nervous tissue closely related to the nervous system. It is stimulated by Sympathetic Nervous supply in a big way to release catecholamines - Adrenaline and Noradrenaline.

Adrenaline is very important in stress - 'fight or flight' response.

- Constricts skin and intestinal blood vessels
- Dilates bronchioles (more O₂)
- Dilates muscle blood vessels (O₂ and nutrient delivery/waste removal)
- Increases metabolic rate (energy)
- Dilates pupils (Alert! Vision)
- Converts glycogen to glucose (energy)

Noradrenaline also works when stress occurs to increase blood pressure. But it is mainly involved in what we call 'Rest & Digest' to promote recovery.

- Vasoconstriction of small blood vessels = increased BP
- Increased rate and depth of breathing
- Relaxation of smooth muscle in intestinal wall

The Ovaries

Found in the lower abdomen of females, below the kidneys. There are 2 ovaries each attached to the upper part of the uterus by ligaments. Affected by FSH and LH from the Pituitary.

Main Functions:

1. Production of ova at ovulation
2. Production of sex hormones Oestrogen and Progesterone. These influence the secondary sex characteristics in females and affect the process of reproduction.

The Testes

Found in the groin of males. There are 2, each held in a sac called the scrotum. Main functions:

1. Secretion of the hormone testosterone which controls the development of secondary sex characteristics in the male at puberty (affected by LH).
2. The production of sperm (affected by FSH).

Life Changes

Puberty: Internal organs of reproduction of boys and girls reach maturity and start to function. There is a surge of hormones released into the blood stream.

In girls:

- The ovaries are stimulated by FSH and LH. This results in the production of Oestrogen and Progesterone.
- The adrenals are stimulated to produce androgens.

Overall results are development and maturation of breasts, vulva and vagina. There is increased subcutaneous fat giving the curved female shape. Ovulation and the menstrual cycle begin. There is growth of pubic and axillary hair. It is the androgens that are responsible for **hair growth in target areas**. If there is an imbalance at this stage and too much androgens are produced, then excess hair may develop. Once the correct balance of oestrogens and androgens is restored after puberty, excess hair should balance and disappear.

In boys the testes are stimulated by FSH and LH. This results in the production of Testosterone. Results are growth of muscle and bone; voice breaks and larynx enlarges; growth of pubic, facial and axillary, abdominal and chest hair; sexual organs develop; semen and sperm is produced.

The Menstrual Cycle

Regular sequence of events in females. Lasts approx. 28 days.

1. Menstrual Stage: Days 1 - 7. If pregnancy does not occur after 8 - 24 hours, the CL shrinks and the endometrium is shed. This is **menstruation**. Over a period of 5 days, the uterus walls contract to allow the shedding of the endometrium.
2. Proliferative Stage: Days 7 - 14. Ovum develops within ovarian follicle due to release of FSH from anterior pituitary. Oestrogen is released by the ovaries to promote growth of new blood vessels and mucous cells in the endometrium. The ovum bursts from the follicle when mature and travels along the fallopian tubes. This is **ovulation** and is said to occur normally at day 14.
3. Secretory Stage: Days 14 - 28. LH (luteinising hormone) is released from the anterior pituitary. A temporary endocrine gland called the Corpus Luteum develops from the ruptured ovarian follicle. Corpus Luteum secretes Progesterone. This along with oestrogen causes the endometrium to thicken in preparation for pregnancy. If fertilisation does occur, the egg is attached to the endometrium and the CL continues to secrete progesterone. It continues to do so until the 4th month. After this, the placenta secretes progesterone to maintain pregnancy.

Pregnancy: Progesterone is the pregnancy hormone. It maintains the uterus lining and develops the placenta. It also prepares the breasts for lactation. Oestrogen is also secreted in large amounts. This is accompanied by increase in secretions of androgens to try to maintain a balance. This can also result in excess **hair growth in target areas**, particularly on the upper lip, chin, side of face. It is normally vellus hair, which should disappear after birth of the child.

Menopause: This marks the end of a woman's reproductive life when oestrogen levels decline. Ovulation and the menstrual cycle become irregular until they cease altogether. There is a fall in the levels of oestrogen production that can result in the following symptoms:

- ✧ Hot flushes
- ✧ Palpitations
- ✧ Anxiety
- ✧ Irritability
- ✧ Fatigue
- ✧ Lack of concentration
- ✧ Osteoporosis

Normally, the hormones from the ovaries will have a feedback relationship with the anterior pituitary to control hormone levels in the body. However, in menopause, the ovaries stop working, which means the master gland will be confused about what stimulating hormones to release. This can result in over-stimulation of the adrenal cortex which can lead to excess androgens released. Sometimes, women of menopausal age find they develop excess facial and body hair.

Disorders and Diseases

PITUITARY GLAND

Hypersecretion of growth from the pituitary leads to **gigantism** in children with rapid growth of the body to 7 - 8 feet.

If this occurs in adulthood, there would be abnormal enlargement of the hands, feet, coarsening of the facial features. This is called **acromegaly**.

Hyopsecretion of growth hormone in children lead to stunted growth - condition known as **dwarfism**.
Hyopsecretion of ADH from the posterior lobe of the pituitary can lead to **Diabetes Insipidus**, which causes dehydration, increased thirst and urine output.

PINEAL GLAND

S.A.D. - can be due to hyopsecretion of melatonin, which can affect the mood leading to depression, excessive sleeping and over-eating and also a general slowing down of mind and body. SAD can also be caused due to hypersecretion of melatonin in the winter months when daytime is shorter.

THYROID

Hypersecretion of hormones can lead to **Graves' Disease** which is an autoimmune disease. It causes protruding eyes, increased metabolic rate, weight loss, sweating, restlessness, increased appetite, high temperature, frequent bowel movements and anxiety.

Hypersecretion of thyroxine can cause **goitre**, which is an enlargement of the thyroid gland.

Hyopsecretion leads to impaired mentality, small structure, coarse hair and skin and deposition of fat on the body. In children, this is called **cretinism**.

In adults, hyopsecretion leads to **myxoedema** which is characterised by slowing down of physical and mental activity with lethargy, oedema of face making it look puffy, brittle hair, coarse skin and slow metabolism.

PARATHYROID

Hypersecretion of parathormone with enlargement of the gland can cause very high blood calcium levels as more calcium is re-absorbed from bones. This causes kidney stones, kidney failure, calcification of soft tissue and tumours.

Hyopsecretion of parathormone means there would be less calcium in the blood. This can cause muscle twitching and tetany. Symptoms can be relieved by administration of calcium.

ADRENALS

Cortex Hypersecretion Hypersecretion of Aldosterone can lead to kidney failure, high blood pressure and excessive potassium in the blood causing irregular heartbeat. Hypersecretion of Corticoids leads to **Cushing's Syndrome**. Weight gain, reddening of face and neck, excess growth of facial and body hair, high blood pressure, loss of mineral for bone and mental disturbances.

Hypersecretion of androgens can cause hirsutism and amenorrhoea in females due to increased testosterone levels. In males, it can lead to atrophy and development of breasts due to increased oestrogen levels.

Cortex Hyopsecretion: Lack of corticoids from the cortex can cause **Addison's disease**. Symptoms are loss of appetite, weight loss, brown pigmentation, low blood sugar, low blood pressure, tiredness and muscle weakness. This is treated with hormone therapy.