

# The Endocrine System

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The *endocrine system* comprises a set of glands [Figure 11 - 1]

These glands are distributed around the body, with no direct anatomical inter-connections.

The glands of the endocrine system are:

- the pituitary gland,
- the thyroid gland,
- four parathyroid glands,
- two adrenal glands,
- the islets of Langerhans in the pancreas,
- the pineal gland,
- two ovaries in the female,
- two testes in the male.

(The ovaries and testes are considered as part of the reproductive system).

The glands of the endocrine system are also known as *ductless glands* as their secretions, known as hormones, pass directly into the bloodstream, rather than passing along ducts direct to specific organs.

A *hormone* is a 'chemical messenger', and when circulated around the body has no effect on most cells and organs. However, as little as a few molecules of a hormone can have a profound effect in specific *target cells*.

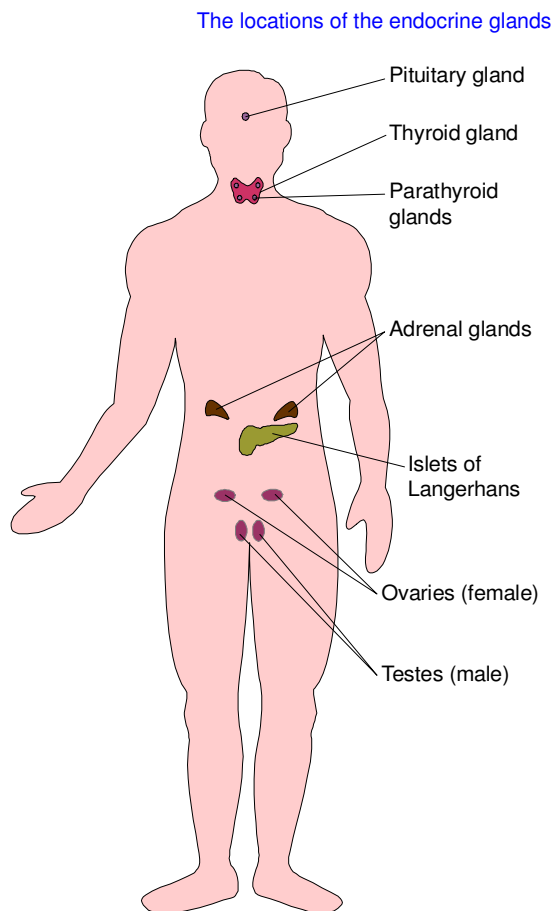
In many cases, hormonal control over a function of the body operates as a balance between two contra-acting hormones.

The cells of the glands synthesise hormones from raw materials and pass them into the extra-cellular spaces from where they pass into capillaries, and thus into the blood.

Some hormone secretions, for example from the pituitary gland and adrenal glands, follow a *circadian rhythm* in that they vary according to the time of day and to sleep/wake patterns.

Adjustment of this rhythm, as is necessary during travel across world time zones, may take several days.

Figure 11 - 1 the endocrine glands



## Pituitary Gland

The *pituitary gland* operates in close conjunction with the hypothalamus, and is situated beneath it, at the front of the brain.

Although the daily output from the pituitary gland totals less than 1µg, it regulates the functions of the majority of the other glands.



The pituitary gland is divided into two lobes, the anterior and the posterior. Between the two lobes is a third area, but its function is unknown.

### Anterior Lobe

The *anterior lobe* secretes seven hormones in response to *control hormones*, or *release hormones*, from the hypothalamus. [Table 11 - 1]

As the blood supply to the pituitary gland passes first via the hypothalamus, the release hormones reach the pituitary directly.

### Posterior Lobe

The *posterior lobe* does not actually secrete, but acts as a storage mechanism for two hormones secreted by the hypothalamus, and passed to it along nerve fibres. [Table 11 - 1]

**Table 11 - 1** hormones from the pituitary gland

The hormones secreted by the pituitary gland, and their main functions

Hormone	Functions
<i>Hormones from the anterior lobe</i>	
Growth hormone	Stimulates growth of bone and muscle, and varies the metabolism of fat and proteins
Prolactin	Promotes milk production in females after childbirth (secreted during sleep)
Thyroid stimulating hormone	Stimulates production of thyroid hormones (secreted to a circadian rhythm)
Adrenocorticotrophic hormone	Stimulates production of adrenal cortex steroids (secreted to a circadian rhythm)
Luteinising hormone	Stimulates development of reproductive glands and their hormone production
Follicle stimulating hormone	Stimulates ovulation in females, and sperm production in males
Melanocyte stimulating hormone	Function not clear - maybe affects skin pigmentation
<i>Hormones from the posterior lobe</i>	
Antidiuretic hormone	Increases water re-absorption in kidney tubules and raises blood pressure
Oxytocin	Stimulates childbirth and milk production in females

### Thyroid Gland

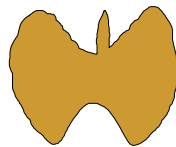
The *thyroid gland* is situated in the neck, in front of the larynx, just below the thyroid cartilage.

The gland has two lobes, one on each side, connected across the front. The lobes are identical in function.

The thyroid gland is made up from two types of cell:

**Follicular cells.** These secrete thyroid hormones, and form follicles which store the hormones.

**C-cells.** These are found as clusters between the follicles, and they secrete the hormone calcitonin.



#### Hormones of the Thyroid Gland

The *thyroid hormones*, *thyroxine* and *triiodothyronine*, are produced in the follicles. They operate together to increase the metabolic rate throughout the body. They are also essential for correct skeletal growth, and nervous system development, during childhood.

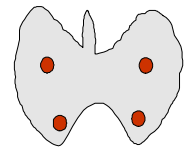
*Calcitonin*, produced in the C-cells, reduces the Calcium level in the blood, by increasing storage in the bone cells, and excretion via the kidneys.

### Parathyroid Glands

The four *parathyroid glands* are situated in the posterior of the thyroid gland - two in each lobe.

The parathyroid glands secrete the hormone *parathryn*. This increases the level of Calcium in the blood, by increasing absorption in the intestines, and by removing stored calcium from bone cells.

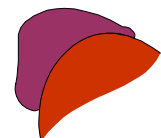
Parathryn and calcitonin operate together to maintain the correct level of Calcium in the blood.



### Adrenal Glands

The two *adrenal glands* rest on the superior tips of the kidneys.

Each adrenal gland has two sections: an inner part - the medulla, and an outer part - the cortex. Although in close physical association, the two parts function separately.



#### Adrenal Medulla

The cells of the *adrenal medulla* are similar in nature to those of the sympathetic nervous system.

The adrenal medulla secretes two hormones: *adrenaline* (also known as *epinephrine*) and *noradrenaline* (also known as *norepinephrine*).

These hormones have an effect similar to general sympathetic nervous stimulation; they increase the blood supply to the heart, thus increasing heart output, they dilate the respiratory passages, and increase the general metabolic rate.

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## Adrenal Cortex

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The *adrenal cortex* secretes three types of steroid hormone:

**Glucocorticoids.** (mainly *hydrocortisone*) These regulate carbohydrate metabolism, and blood levels. They act as anti-inflammatory agents, and limit the effects of physical and mental stress.

Secretion follows a circadian rhythm.

**Mineralocorticoids.** (mainly *aldosterone*) These control Sodium and Potassium retention and excretion in the kidneys.

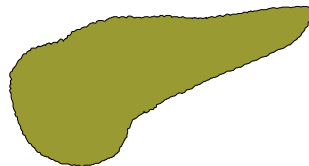
**Gonadocorticoids.** (mainly *androgens*) These have slight effects on the reproductive organs.

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## Islets of Langerhans

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The *islets of Langerhans* are clusters of cells, distributed throughout the pancreas which is located behind the stomach.



There are two main types of cells in the islets of Langerhans:

**$\alpha$ -cells.** These secrete *glucagon* which causes the release of glucose from glycogen stored in the liver, and the release of nutrient from adipose tissue.

**$\beta$ -cells.** These secrete *insulin* which facilitates the use of glucose by muscles. It also stimulates the storage of excess glucose as glycogen, and the storage of other excess nutrients in adipose tissue. Glucagon and insulin operate together to maintain the correct level of glucose in the blood.

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## Other Hormonal Activity

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### The Digestive System

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The hormonal activity concerned with the digestive system is considered as part of the digestive system.

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### Pineal Gland

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The *pineal gland* is also known as the *pineal body*. It is located deep inside the cerebrum in the brain.

It secretes *melatonin*. This is only secreted in darkness and operates to synchronise the brain to the 24 hour day and night pattern. Melatonin operates together with serotonin to regulate sleep patterns and the level of alertness.

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## Thymus Gland

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The main function of the *thymus gland* is in the production of lymphocytes, but it also produces a series of hormones which regulate lymphocyte production.

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## Kidneys

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The *kidneys*, as well as performing their function within the urinary system, produce hormones. The main kidney hormone is *erythropoietin* which stimulates the production of erythrocytes.

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## Heart

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The tissues of the atria secrete minute quantities of the hormone *atriopeptin*.

This assists in the control of blood volume and of blood salt levels, by affecting excretion via the kidneys.

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## Local Hormones

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### Histamine

*Histamine* is produced by mast cells in connective tissue. It is found throughout the body, and is generated as part of the immune response.

It causes dilation of blood vessels and increased permeability of capillaries. It constricts the air passages, towards closing them against the possibility of inhaled allergens.

### Prostaglandins

Although *prostaglandins* are not considered as hormones, they are included here as they are substances of a similar nature to hormones. However, they are produced in tissue cells, close to their point of action, rather than in specific glands.

They have wide and varied effects, and are believed to act as part of the body's defence mechanism.

### Serotonin

Serotonin is synthesised in specialised cells in the intestines and the central nervous system. It is found mainly in the intestines, but also in the brain and in platelets in the blood.

Serotonin causes blood vessel constriction and is believed to contribute to blood clotting mechanisms. It is also a neurotransmitter and may have a role in conditions such as schizophrenia and depression.

### Adrenal Gland Problems

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#### Addison's disease

An under-activity of the adrenal cortex is known as *Addison's disease*. This causes anaemia, weakness and fatigue.

The pituitary gland reacts by producing larger amounts of adrenocorticotrophic hormone, which results in a slightly darkened pigmentation to the skin.

#### Adrenogenital syndrome

*Adrenogenital syndrome* results from a tumour in the adrenal cortex which over-produces androgens. These cause male physical characteristics to develop in the female.

#### Cushing's syndrome

*Cushing's syndrome* results from an over-production of glucocorticoids.

The face and torso take on excessive fat although the limbs do not. The muscles weaken and the risk of diabetes is increased by an elevated blood pressure.

The condition is sometimes caused by a tumour in the adrenal cortex, or by a tumour in the pituitary gland which then produces excessive adrenocorticotrophic hormone.

### Diabetes Mellitus

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*Diabetes mellitus* is a disorder whereby the body fails to metabolise sugar from foods.

The underlying causes are unknown, although hereditary factors may be involved.

#### Type 1 diabetes mellitus

*Type 1 diabetes* (also known as *insulin dependent diabetes*) is caused by a significant or total failure of insulin production in the  $\beta$ -cells in the islets of Langerhans in the pancreas. This failure, once occurred, will be permanent, requiring regular insulin treatment to control the condition.

The onset tends to be rapid, occurring mainly in young people, and leading to *hyperglycaemia* - high blood glucose.

The body attempts to remove the excessive glucose via the urinary system, giving a very high output of sugary urine. This directly causes a persistent thirst, encouraging the intake of large amounts of fluids.

At the same time, the body's inability to take energy from glucose leads to fatigue and weight loss, and a general fall in the level of health.

With the inability to metabolise glucose, the body derives its energy directly from fats, with resulting bi-products of *ketones* (substances similar in nature to alcohols). These appear on the breath, and raise the general level of acidity - disrupting all the body's systems.

#### Type 2 diabetes mellitus

*Type 2 diabetes* (also known as *non-insulin dependent diabetes*) is caused by an increased resistance of insulin's target cells to insulin. Insulin production remains almost normal, and may even be raised in early stages of the condition.

The onset tends to occur above the age of 50 years, and is almost imperceptible, to the point of often going unnoticed until discovered during routine testing.

Once developed, the condition is permanent, but may often be controlled by a planned diet.

#### Gestational diabetes mellitus

*Gestational diabetes* occurs during pregnancy. It usually passes after childbirth, although it may increase the risk of a subsequent development of type 2 diabetes.

#### Secondary diabetes mellitus

Diabetes may result from a variety of other diseases such as Cushing's syndrome and chronic pancreatitis.

Over-use of some medications, such as diuretics, may also result in diabetes mellitus, by abnormally reducing the body's Potassium level.

#### Diabetic emergencies

A person with diabetes, particularly type 1 diabetes, must maintain a balance between insulin and glucose. Failure to maintain this balance may lead to an emergency situation.

**Hyperglycaemic emergencies.** These are rare. They generally occur if an insulin injection has been missed or considerable amounts of sugar, or sugar providing foods, have been ingested.

They tend to be indicated in a similar manner to the original onset of diabetes, with a gradual lapse into unconsciousness.

**Hypoglycaemic emergencies.** These tend to occur if too much insulin has been injected, a meal has been missed, unusually strenuous exercise has been taken, or through a combination of these factors.

As the body's glucose level falls, hypoglycaemia takes hold and is usually indicated by pale skin with profuse sweating, a rapid, full pulse, uncoordinated or confused behaviour - giving an appearance of drunkenness, an aggressive uncooperative manner, and a falling level of consciousness, maybe with convulsions.

### ***Complications***

Long term diabetes mellitus may give rise to other problems such as atherosclerosis, especially in peripheral areas. This in turn can result in poor tissue structure, a deterioration of eyesight, and peripheral neuropathy - with the lower areas of the body most likely to be affected.

### ***Diabetes insipidus***

*Diabetes insipidus*, although similar in some of its initial symptoms, is totally different to diabetes mellitus. It is a condition where the kidney tubules fail to re-absorb water, and thus excessive water is removed from the circulation.

The cause is either a lack of antidiuretic hormone from the hypothalamus, or a defect in the renal tubules preventing the action of antidiuretic hormone.

The base cause may be genetic, or it may be a follow on from trauma or other diseases.

### ***Jet Lag***

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Although the condition of *jet lag* is largely caused by the physical and psychological aspects of long distance air travel, passage across time zones upsets the normal circadian rhythm of the body.

Whilst the body adjusts its hormonal secretion patterns to local day and night timing, there may be disruption to sleep patterns, with fatigue and other associated problems.

### ***Parathyroid Problems***

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Problems with the parathyroid glands are typically only caused by tumours.

The effects of parathyroid over- or under-secretion are to upset the balances of Calcium and Phosphorus in the body, producing a large variety of knock-on conditions, from osteoporosis, through kidney problems and muscular tetanus, to personality changes.

### ***Pituitary Problems***

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Problems with the pituitary gland are relatively rare. The main ones are concerned with the production of growth hormone. This may be disrupted by the presence of small benign tumours.

An over-secretion of growth hormone leads to the excessive growth and physical development of *giantism* or *gigantism*. When this occurs after the skeleton has reached its normal limit of development, it is known as *acromegaly*, and appears as over-large hands and feet, together with coarse facial features. Internal organs may also grow beyond normal sizes.

An under-secretion of growth hormone leads to reduced physical growth, known as *dwarfism*.

### ***Seasonal Affective Disorder Syndrome***

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*Seasonal affective disorder syndrome (SADS)* is the term used for a condition in which depression, excessive sleep, and an overall reduction in body and mind functions occur with the onset of winter.

The start of spring brings relief.

Although the overall cause is not known, with psychological factors likely to be involved, the condition is believed to be associated with the shorter daylight hours of winter. These increase the time during which the pineal gland produces melatonin.

### ***Thyroid Problems***

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#### ***Hyperthyroidism***

*Hyperthyroidism* is a condition whereby the thyroid gland secretes excessive thyroxine.

This has the effect of accelerating functions throughout the body.

Both mental and physical processes are affected, giving rise to a large variety of signs and symptoms. These will typically include nervousness and irritability, elevated heart rate and blood pressure, weight loss and weakness. Oxygen use is raised, even when at rest.

The condition often leads to a build-up of fat, fluid and fibrous tissue behind the eyes, making them bulge outwards.

#### ***Hypothyroidism***

*Hypothyroidism* is a condition whereby the thyroid gland fails to secrete sufficient thyroxine.

This has the effect of slowing down functions throughout the body.

Both mental and physical processes are affected, giving rise to a large variety of signs and symptoms. These will typically include fatigue and weakness, weight gain, depression, brittle hair and nails, constipation, and intolerance of cold.

*Hashimoto's disease*, an inflammation of the thyroid gland through formation of unnatural antibodies to thyroid tissue, is a common cause of hypothyroidism. Other causes include failure of the pituitary gland to secrete sufficient thyroid stimulating hormone, congenital defects, and infections.

### ***Goitre***

A *goitre* is a swelling of the thyroid gland - appearing as a lump in the neck.

A common cause is a lack of dietary iodine, inhibiting thyroxine production; the pituitary gland secretes an elevated level of thyroid stimulating hormone, and the thyroid expands in size in an attempt to produce sufficient thyroxine.

Goitre is also associated with hyperthyroidism.

