

## Lecture 14 – Animal hormones

### Endocrine Vs Nervous System

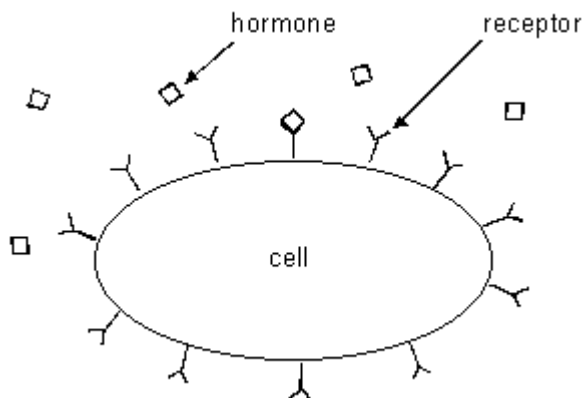
The endocrine system acts with [nervous system](#) to coordinate the body's activities.

Both systems enable cells to communicate with others by using chemical messengers.

The endocrine system uses chemical messengers called *hormones* that are transported by the circulatory system (blood). They act on target cells that may be anywhere in the body.

The endocrine system is slower than the nervous system because hormones must travel through the circulatory system to reach their target.

Target cells have *receptors* that are specific to the signaling molecules. The binding of hormones to the receptors on or within the target cell produces a response by the target cell.



The chemical messengers used by the nervous system are [neurotransmitters](#). Neurotransmitters travel across a narrow space (the [synaptic cleft](#)) and bind to receptors on the target cell.

The nervous system conducts signals much quicker than the endocrine system.

### Endocrine Vs Exocrine glands

Endocrine glands do not have ducts. Exocrine glands have ducts that carry their secretions to specific locations.

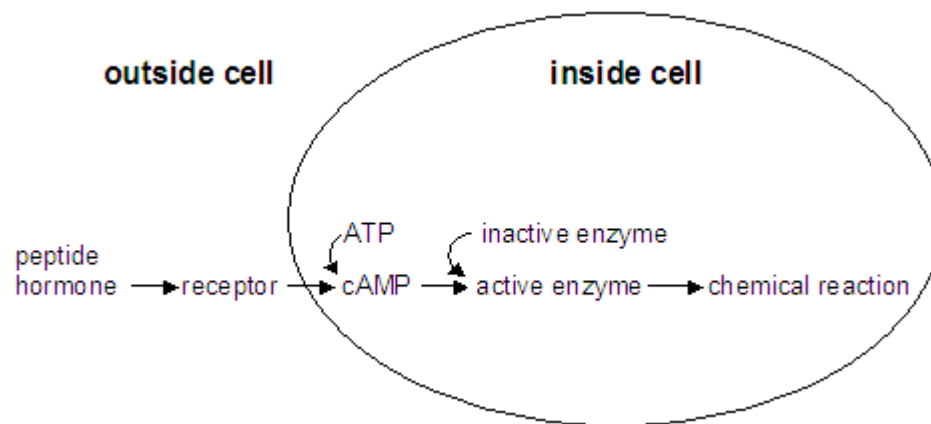
### Two Kinds of Hormones

## Peptide Hormones

Peptide hormones are composed of amino acids.

A peptide hormone binds to a cell-surface receptor, it does not enter the cell.

The resulting complex activates an enzyme that catalyzes the synthesis of cyclic AMP from ATP. Cyclic AMP activates other enzymes that are inactive.

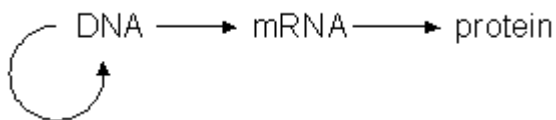


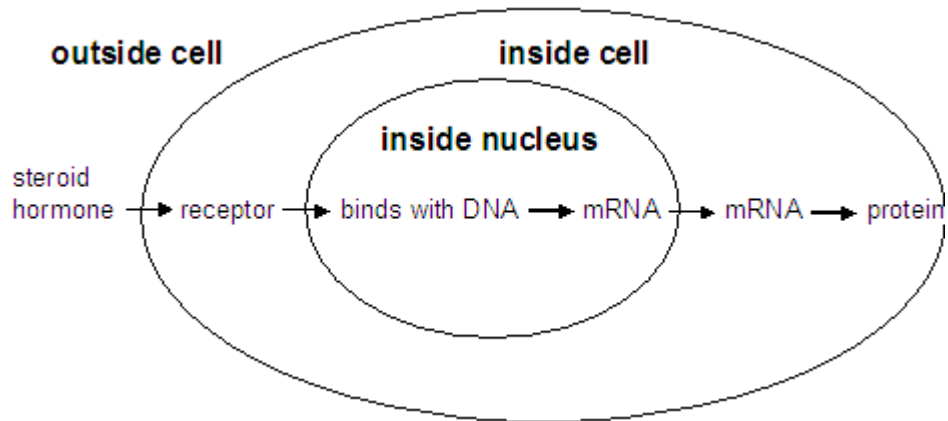
Cyclic AMP is a second messenger; the hormone is the first messenger. Other second messengers have been discovered.

## Steroid Hormones

Steroid hormones enter the cell and bind to receptors in the cytoplasm.

The hormone-receptor complex enters the nucleus where it binds with chromatin and activates specific genes. Genes (DNA) contain information to produce protein as diagrammed below. When genes are active, protein is produced.





Steroid hormones act more slowly than peptide hormones because of the time required to produce new proteins as opposed to activating proteins that are already present.

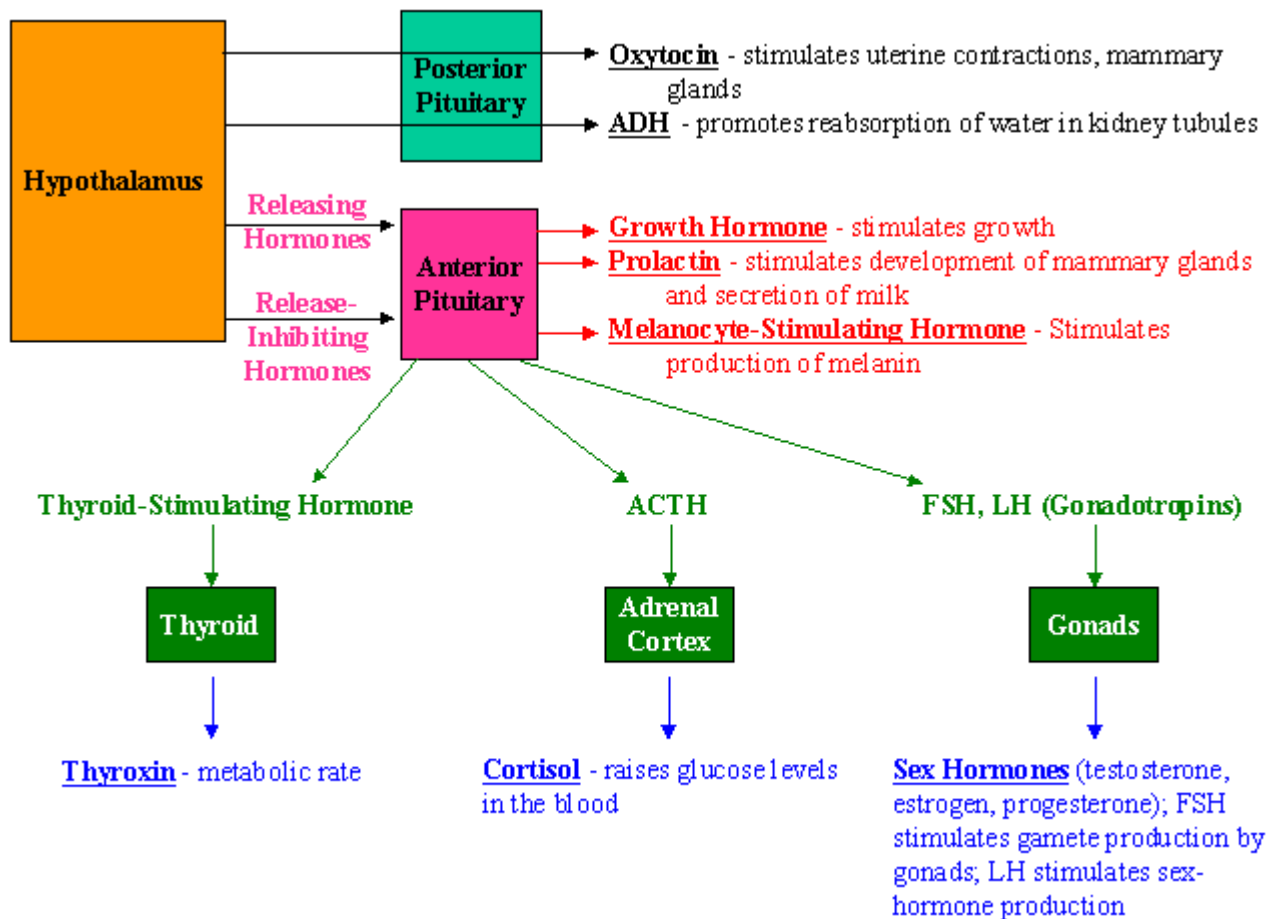
### **Hypothalamus**

The [hypothalamus](#) is part of the brain. It maintains homeostasis (constant internal conditions) by regulating the internal environment (examples: heart rate, body temperature, water balance, and the secretions of the pituitary gland).

### **Pituitary Gland**

The pituitary contains two lobes. Hormones released by the posterior lobe are synthesized by neurons in the hypothalamus. Unlike the posterior lobe, the anterior lobe produces the hormones that it releases.

Refer to the diagram below as you read about the hypothalamus, pituitary, and each of the glands they control.



## Posterior pituitary

The posterior pituitary contains axons of neurons that extend from the hypothalamus. Hormones are stored in and released from axon endings in the posterior lobe of the pituitary.

### **Oxytocin**

Oxytocin stimulates uterine contractions of labor that are needed to move the child out through the birth canal.

The hormone stimulates the release of milk from the mammary glands by causing surrounding cells to contract. After birth, stimulation of the breast by the infant feeding stimulates the posterior pituitary to produce oxytocin.

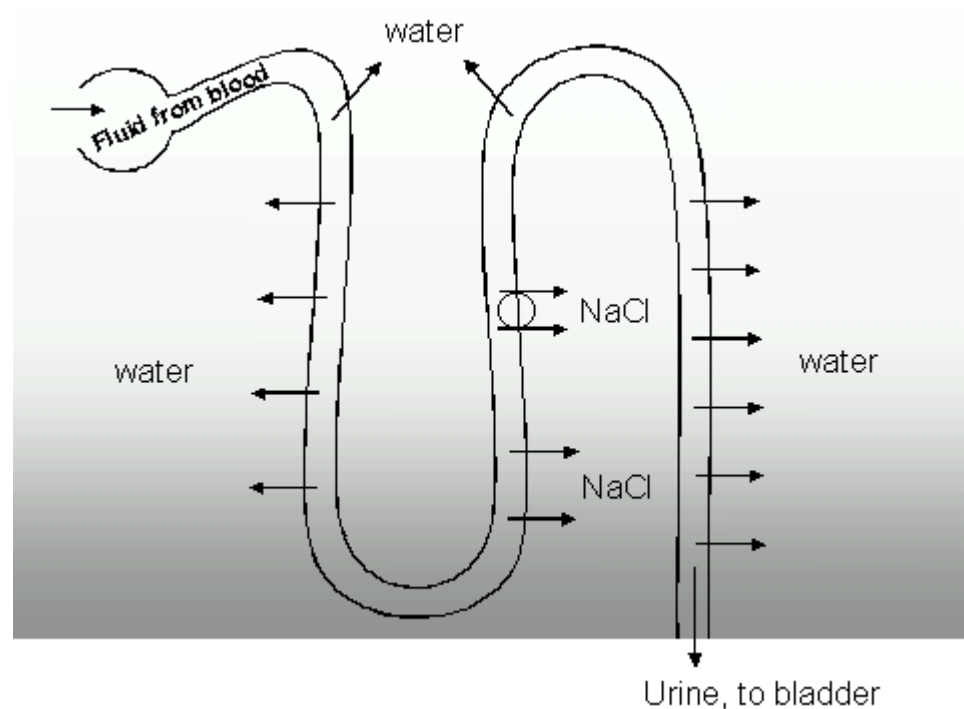
### **Antidiuretic Hormone (ADH)**

Antidiuretic hormone increases the permeability of the distal convoluted tubule and collecting duct of the kidney nephron resulting in less water in the urine. The urine becomes more concentrated as water is conserved.

The secretion of ADH is controlled by a negative feedback mechanism as follows:

concentrated blood (too little water) → hypothalamus → ADH → kidney → reabsorbs water, makes blood more dilute

Below: Within the kidney, fluid and dissolved substances are filtered from the blood and pass through tubules where some of the water and dissolved substances are reabsorbed. The remaining liquid and wastes form urine. Details of this process are discussed in the [chapter on the excretory system](#).



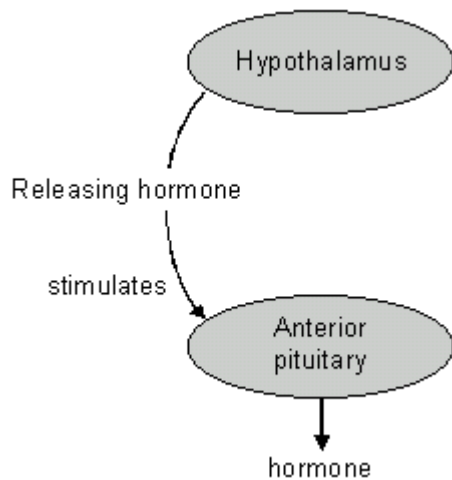
The presence of too much blood in the circulatory system stimulates the heart to produce a hormone called *atrial natriuretic factor* (ANF). This hormone inhibits the release of ADH by the posterior pituitary causing the kidneys to excrete excess water.

Alcohol inhibits the release of ADH, causing the kidneys to produce dilute urine.

### Control of the Anterior Pituitary

The hypothalamus produces hormones that travel in blood vessels to the anterior pituitary, stimulating it to produce other hormones.

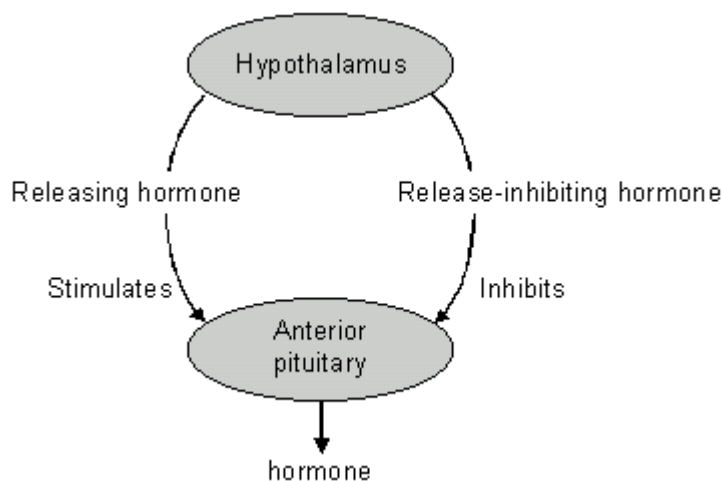
The hormones produced by the hypothalamus are called *hypothalamic-releasing hormones*.



The anterior pituitary produces at least six different hormones. Each one is produced in response to a specific hypothalamic-releasing hormone.

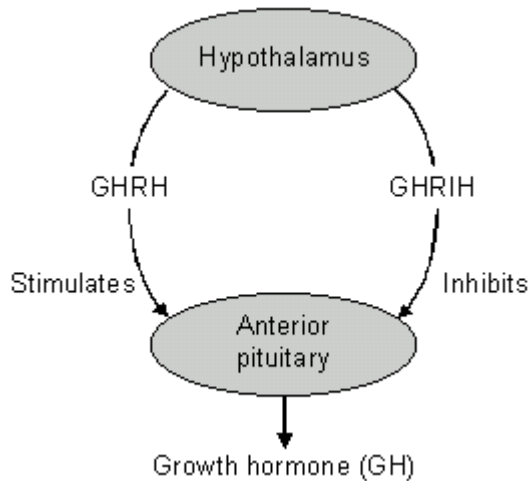
The blood vessel that carries hypothalamic-releasing hormones from the hypothalamus to the pituitary is called a *portal vein* because it connects two capillary beds. One capillary bed is in the hypothalamus and the other is in the anterior pituitary.

Release-inhibiting hormones produced by the hypothalamus inhibit the pituitary from secreting its hormones.

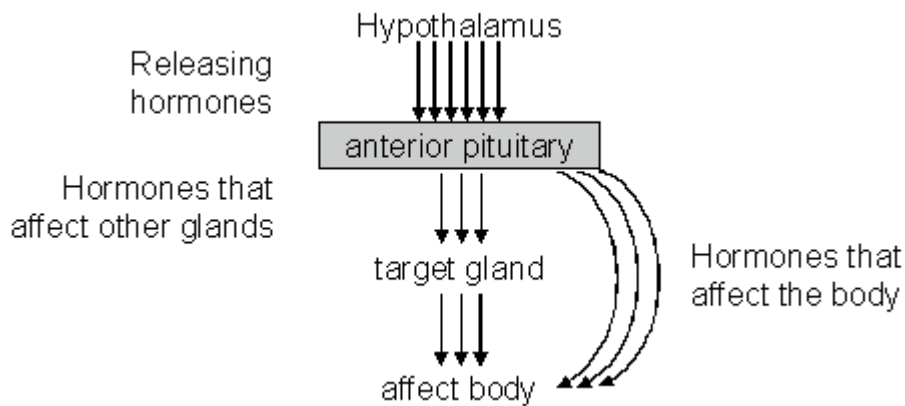


### **Example**

The pituitary is stimulated to release growth hormone (GH) by growth hormone releasing hormone (GHRH) produced in the hypothalamus. It is inhibited from releasing growth hormone by growth hormone release-inhibiting hormone(GHRIH), also produced by the hypothalamus.



Six different hormones produced by the anterior lobe will be studied here. Three of these have direct effects on the body, the other three control other glands.



## Anterior Pituitary Hormones that Directly Affect the Body

### ***Growth Hormone (GH or Somatotrophic Hormone)***

Growth hormone stimulates body cells to grow. If too little hormone is produced, pituitary dwarfism results. The secretion of too much hormone results in a pituitary giant.

Acromegaly is a genetic disease in which growth hormone is produced throughout a persons lifetime.

### ***Prolactin***

Prolactin is produced in quantity after childbirth.

It stimulates the development of the mammary glands and the production of milk.

It is also involved in the metabolism of fats and carbohydrates.

### **Melanocyte-Stimulating Hormone (MSH)**

This hormone causes skin color changes in some fishes, amphibians, and reptiles.

In humans, it stimulates the melanocytes to synthesize melanin.

### **Anterior pituitary hormones that regulate other glands**

The pituitary also controls other glands and is often referred to as the "master gland".

Three kinds of pituitary hormones that regulate other glands are discussed below. The glands that they regulate will be discussed in the following section.

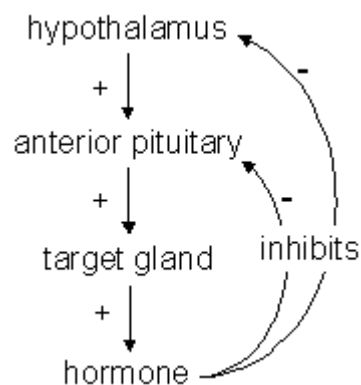
Thyroid Stimulating Hormone (TSH) → thyroid → thyroxin

Adrenocorticotrophic Hormone (ACTH) → adrenal cortex → cortisol

Gonadotropic Hormones (FSH and LH) → ovaries and testes → sex hormones; controls gamete production

### **Negative Feedback Inhibition**

Hormone secretions by glands that are under the control of the hypothalamus are controlled by *negative feedback*. When the hormone levels are high, they inhibit the hypothalamus and anterior pituitary, resulting in a decline in their levels.



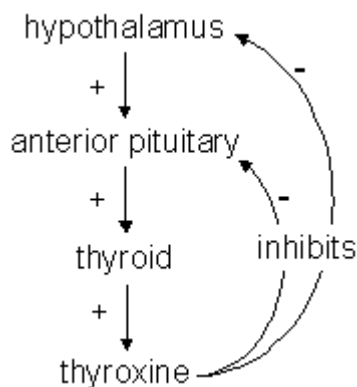


## Thyroid gland

The thyroid produces *thyroxin* (also called T<sub>4</sub> because it contains 4 iodine atoms) and *triiodothyronine* (also called T<sub>3</sub> because it contains 3 iodine atoms).

Both T<sub>4</sub> and T<sub>3</sub> have similar effects on target cells. In most target tissues, T<sub>4</sub> is converted to T<sub>3</sub>. They influence metabolic rate, growth, and development.

Thyroxin production is regulated by a negative feedback mechanism in which it inhibits the hypothalamus from stimulating the thyroid.



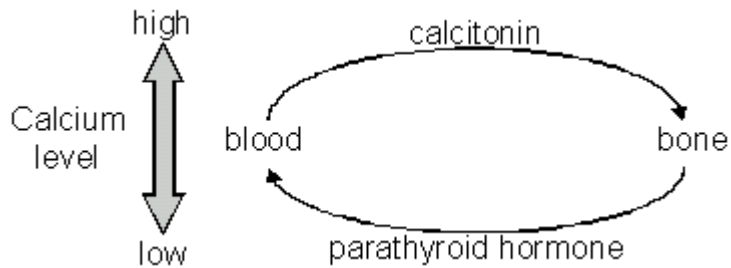
**Hypothyroidism** occurs when the thyroids produce too little hormone. In adults, it results in lethargy and weight gain. In infants, it causes cretinism, which is characterized by dwarfism, mental retardation, and lack of sexual maturity. Administering thyroid hormones treats these affects.

Too much T<sub>3</sub> and T<sub>4</sub> (hyperthyroidism) increases heart rate and blood pressure, and causes weight loss.

Iodine is needed to manufacture thyroid hormones. A deficiency in iodine prevents the synthesis of thyroid hormones which, in turn, results in an excess of thyroid stimulating hormone being produced by the anterior pituitary. A **goiter** results when constant stimulation of the thyroid causes it to enlarge.

## **Calcitonin**

The thyroid gland also secretes *calcitonin*, which stimulates calcium deposition in the bones. This is the opposite of the action of parathyroid hormone (see below).



Calcitonin production *is not* regulated by the anterior pituitary. Its secretion is stimulated by high calcium levels in the blood.

### **Parathyroid glands**

The parathyroid glands are 4 small glands embedded in posterior surface of the thyroid gland.

They secrete *parathyroid hormone (PTH)*, which increases blood levels of  $\text{Ca}^{++}$ .

Bone tissue acts as a storage reservoir for calcium and PTH stimulates the removal of calcium from the bone to increase levels in the blood.

It increases the kidney's reabsorption of  $\text{Ca}^{++}$  so that less is lost in urine.

It activates vitamin D which enhances  $\text{Ca}^{++}$  absorption from food in the gut.

Secretion is regulated by the  $\text{Ca}^{++}$  level in the blood, (not hypothalamic or pituitary hormones).

### **Adrenal Cortex**

The outer layer of an adrenal gland is the adrenal cortex.

It produces three kinds of steroid hormones. These are *glucocorticoids*, *mineralocorticoids*, and small amounts of sex hormones. The major glucocorticoid is *cortisol* and the major mineralocorticoid is *aldosterone*.

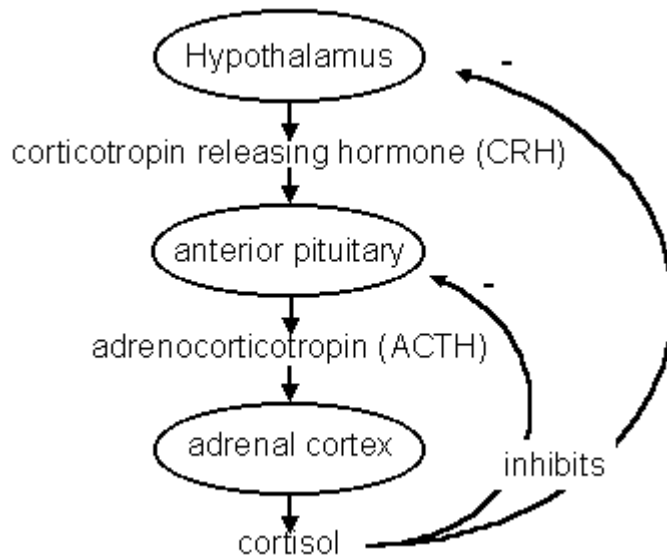
#### ***Cortisol (A Glucocorticoid)***

Glucocorticoids are produced in response to stress.

Cortisol raises the level of glucose in the blood by stimulating the liver to produce glucose from stored non-[carbohydrate](#) sources such as [proteins](#) and [lipids](#) and to release it into the blood.

Cortisol reduces swelling by inhibiting the immune system. Swelling of tissues due to injury or infection is discussed in the [chapter on the immune system](#). The drug prednisone, derived from cortisol, is used to treat inflammation.

Negative feedback control of cortisol level is diagrammed below.



### ***Aldosterone (A Mineralocorticoid)***

Aldosterone secretion is not under the control of the anterior pituitary.

It acts primarily on the kidney to promote absorption of sodium and excretion of potassium.

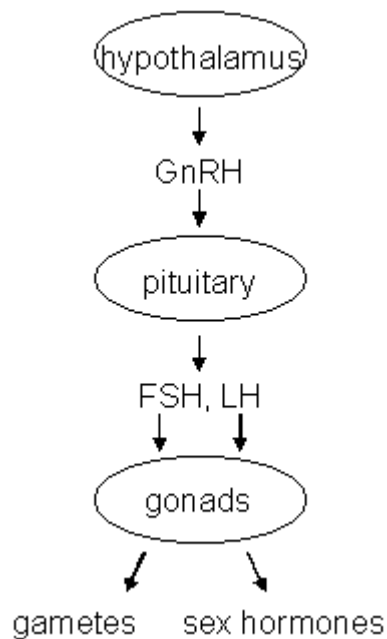
Increased sodium levels contributes to the retention of water and thus increased blood volume. In the absence of aldosterone, sodium is excreted and the lower sodium levels result in decreased blood volume and lower blood pressure.

The presence of too much blood in the circulatory system stimulates the heart to produce *atrial natriuretic factor*. This hormone inhibits the release of aldosterone by the adrenal cortex and ADH by the posterior pituitary causing the kidneys to excrete excess water. The loss of water and sodium contribute to lowering the blood volume.



larynx), growth of facial hair, and muscle development. Some secondary sex characteristics in females are development of the breasts and broadening of the pelvis. Both sexes show increased activity of sweat glands and sebaceous glands (oil glands in the skin), and growth of pubic and axillary (armpit) hair.

FSH controls gamete (egg or sperm) production.



## **Pancreas**

The pancreas is a digestive gland that secretes digestive enzymes into the duodenum through the pancreatic duct.

The *islets of Langerhans* are groups of cells within the pancreas that secrete *insulin* and *glucagon*. The islets are endocrine glands because they are ductless; the circulatory system carries their hormones to target cells.

### ***Insulin***

Insulin promotes the removal of glucose from the blood for storage as glycogen (muscle, liver), fats (fat cells), and protein.

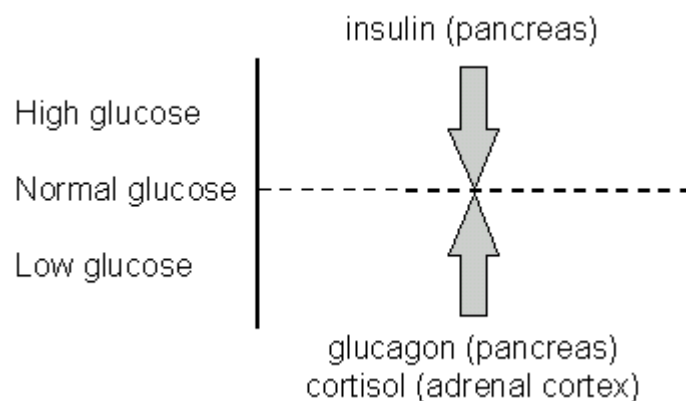
It promotes the buildup of fats and proteins and inhibits their use as an energy source.

## **Glucagon**

Glucagon is produced in the islets of Langerhans but by different cells than those that produce insulin.

The effects of glucagon are opposite those of insulin. It raises the level of glucose in the blood.

It is normally secreted between meals to maintain the concentration of glucose in the blood.



## **Diabetes Mellitus**

Diabetes mellitus is a disease in which glucose is not sufficiently metabolized. This results in high glucose levels in blood and glucose in the urine.

Cells can starve because glucose is not being metabolized.

### **Type I**

Type I diabetes is also called "juvenile-onset diabetes" or "insulin-dependent diabetes" because the symptoms usually appear during childhood and insulin injections are necessary to treat it.

It usually occurs after a viral infection triggers an immune response that results in the body destroying its own insulin-producing cells.

Because the disease is caused by a lack of insulin, it can be treated with insulin injections.

### **Type II**

Type II diabetes is more common than type I.

Type II diabetes is caused by a deficiency in insulin production or by changes in insulin receptors on the target cells. In either case, blood glucose level may be high because cells do not receive the message to metabolize glucose.

This form of diabetes usually becomes noticeable in middle age.

It is treated with a low fat, low sugar diet, regular exercise, weight control. Another treatment is oral medications that make the cells more sensitive to the effects of insulin or that stimulate more insulin production.

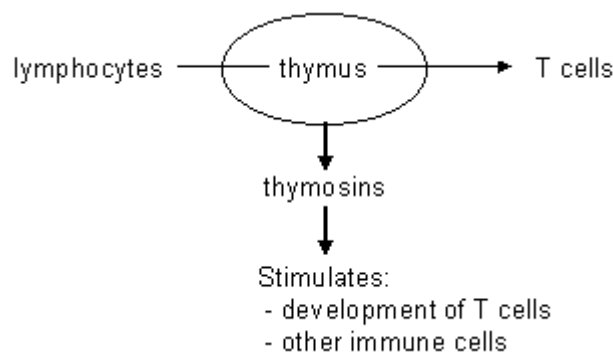
## **Thymus Gland**

The thymus grows during childhood but gradually decreases in size after puberty.

*Lymphocytes* that have passed through the thymus are transformed into *T cells*.

Lymphocytes are white blood cells that function to fight infection. There are two kinds of lymphocytes: B cells and T cells. T cells participate in identifying and destroying body cells that are infected.

Thymus hormones called *thymosins* stimulate the development and differentiation of T lymphocytes. They play a role in regulating the immune system by stimulating other kinds of immune cells as well.



## **Pineal Gland**

### ***Fish and Amphibians***

The pineal gland of fish and amphibians is located near the skin and functions to detect light.

## ***Birds and Mammals***

In birds, it is located on the brain but still receives direct light stimulus through the skull.

In mammals, it is located within the brain and therefore cannot receive light stimulation directly. Light from the eyes stimulates the gland via the optic nerve.

Melatonin is produced at night. During the winter, nights are longer and as a result the level of melatonin in the blood is higher. The level of melatonin in the blood therefore varies with season and can be used to help animals time events such as when to breed, nest, migrate, etc.

These annual cycles are called ***circannual rhythms***. Melatonin may also participate in producing 24-hour cycles called ***circadian rhythms***.

In humans, the gland may be involved in sexual development.