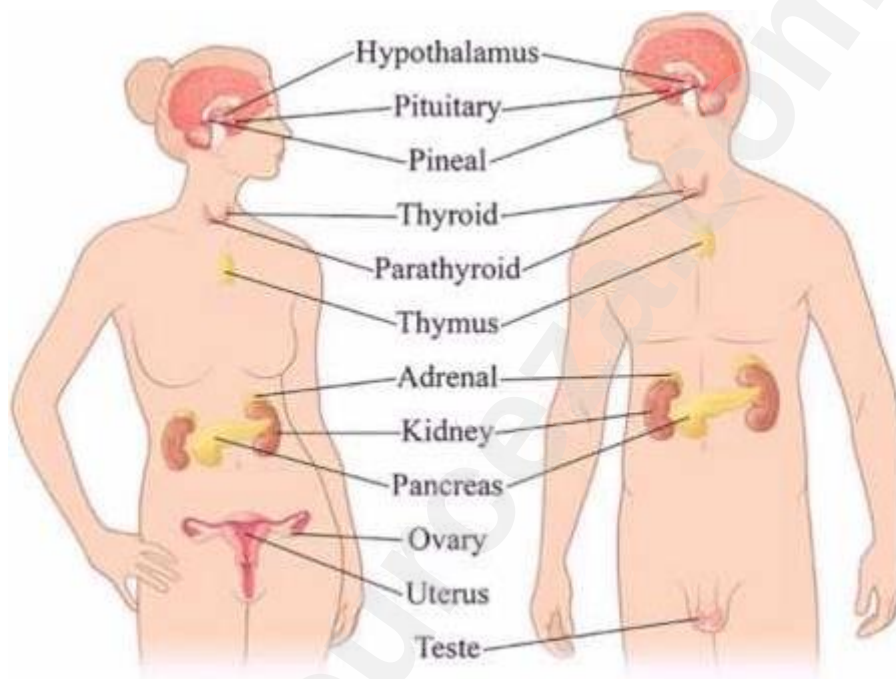




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The human endocrine system



1. Terms:

- **Endocrine glands:** Ductless glands secreting hormones directly into bloodstream
- **Exocrine glands:** secrete substances into **ducts** that lead **into cavities** in the body or lead directly to the external environment. (Examples: sweat glands, mammary glands, the liver, salivary glands and the pancreas.)
- **Hormones:** organic chemical messengers secreted directly into the blood by an endocrine gland.
- **Homeostasis:** is the process of **maintaining a constant internal environment** within narrow limits, despite changes that take place internally and externally.
- **Negative feedback mechanism:** when there is an increase from normal, a corrective mechanism causes a decrease and vice versa to maintain a balanced system.

2. What is the endocrine system?

- The Endocrine system works in conjunction with the Nervous system. The endocrine system is responsible for **chemical coordination**, regulating the functioning of all the organs in the body
- Consists of glands situated throughout the body
- These endocrine glands secrete organic chemical messengers called hormones in the bloodstream
- **Hormones** are organic substances and are mostly proteins, but a few are lipids(fats) (usually the sex hormones)
- Hormones are produced in small quantities
- They are carried in blood stream to target organ/tissue where they control the activities of a target organ to perform a specific function
- Hormones work together as an **integrated system** where they either stimulate or inhibit organs

3. The differences between the endocrine system and the nervous system

- The nervous system and endocrine system controls different types of activities in the body.
- They are jointly responsible for the functioning of all the different organs and systems, this is known as coordination
- The nervous system co-ordinates very quick responses to external stimuli
- The endocrine system controls responses that are not that fast but are long-lasting and reflect the body's internal environments

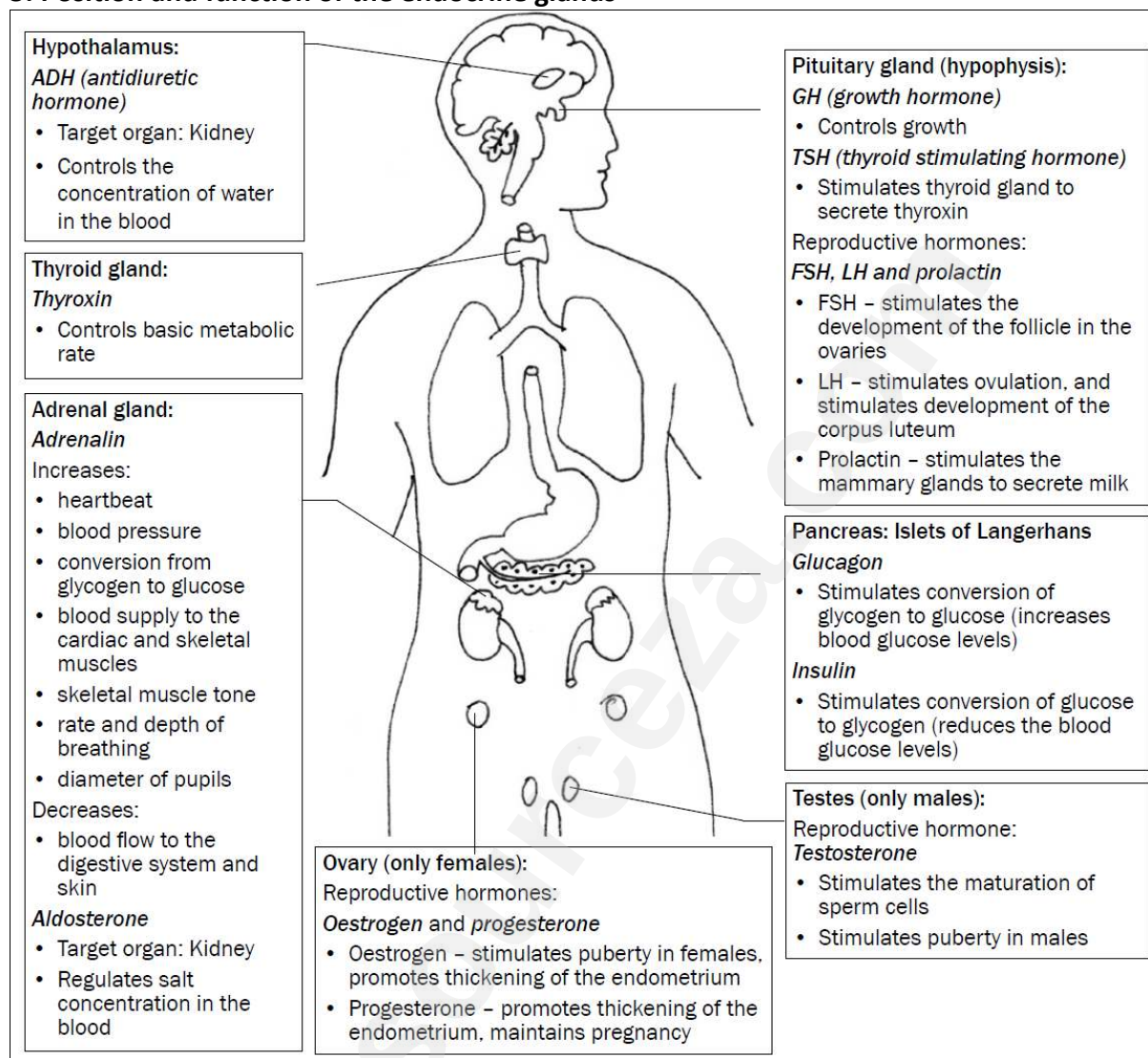
Endocrine system	Nervous system
1. Made up of glands 2. Produces hormones 3. Hormones transported by the blood 4. Effects are slower and more general 5. Hormones control long-term changes (e.g. growth)	1. Made up of nerves 2. Produces nerve impulses 3. Impulses transmitted along the nerves 4. Effects are very quick and very specific 5. Nerve impulses control short-term changes (e.g. sneezing, lifting your arm)

4. The differences between endocrine glands and the exocrine glands

Endocrine glands	Exocrine glands
Glands are ductless, secrete directly into bloodstream	Secrete their substances into ducts and not the bloodstream (think of the salivary glands secreting saliva in ducts that transports it to the mouth)
Secrete hormones	Does not secrete hormones

The pancreas is the only gland that is both exocrine (pancreatic juices for digestion) and endocrine (insulin and glucagon).

5. Position and function of the endocrine glands



Hormone	Gland	Location	Function
Antidiuretic hormone (ADH)	Neurosecretory cells of the hypothalamus ADH is stored in the Pituitary gland	In the centre of the brain	Regulates osmoregulation in the kidneys (in the distal convoluted tubules and the collecting tubules)
Thyroxin	Thyroid gland	Below the larynx in the neck region	- Regulates the basal metabolic rate of the cells in the body - Affects growth and functioning of the

Hormone	Gland	Location	Function
			heart and the nervous system - Stimulates growth and differentiation of tissue in a foetus and in children - Regulates the body temperature when stimulated by the hypothalamus
Adrenalin (fight-and-flight hormone)	Adrenal gland	Above the kidney	Prepares the body to deal with stress: - Increase in heartbeat rate - Increase in breathing rate - Increase in blood pressure - Increase in muscle tone - Increase in blood sugar levels - Decrease in blood supply to the skin and digestive system - Causes pupils to dilate
Aldosterone	Adrenal gland	Above the kidney	Helps the uptake of sodium ions in the loop of Henle in the kidneys
Prolactin	Pituitary gland:	Base of the brain and attached to the hypothalamus	- Stimulates the mammary glands to produce milk - Counteracts the effect of dopamine which is responsible for sexual arousal
Oestrogen	Gonads: ovaries	Located in the lower abdominal region with each ovary located within the pelvic	Oestrogen promotes the development of the secondary sexual characteristics in

Hormone	Gland	Location	Function
		bones (in line with the ball-and-socket joints of the femurs)	females like breasts, the thickening of the endometrium (uterus) and the female body shape • Necessary for the process of ovulation • Oestrogen inhibits the secretion of FSH by the anterior pituitary gland so that only one follicle is produced during ovulation • High oestrogen levels will trigger the secretion of luteinising hormone (LH)
Progesterone	Gonads: ovaries	Located in the lower abdominal region with each ovary located within the pelvic bones (in line with the ball-and-socket joints of the femurs)	• Progesterone prepares the endometrium of the uterus for implantation once fertilisation of the ovum has occurred • Necessary for the production of the mucus plug to prevent sperm or other substances from entering the uterus during pregnancy • Decrease in progesterone levels causes menstruation • Progesterone improves memory and cognitive ability
Testosterone	Gonads: testes	Leydig cells in the testes of males	• Testosterone is responsible for the

Hormone	Gland	Location	Function
		located in the scrotum at the bottom of the pelvis	secondary sexual characteristics in males like a deeper voice, pubic hair, hair on face • Necessary for the normal development of sperm • Activates genes in the cells of Sertoli to promote the differentiation of the spermatogonia
Glucagon	Pancreas: Islets of Langerhans	Endocrine cells of the pancreas	Controls the increase in the blood sugar level by causing the conversion of glycogen to glucose
Insulin	Pancreas: Islets of Langerhans	Endocrine cells of the pancreas	• Controls blood sugar by causing the conversion of glucose into glycogen • Inhibits the functioning of glucagon
Growth hormone (somatotrophin)	Pituitary gland:	Base of the brain and attached to the hypothalamus	For growth, repair and replacement of cells
Follicle stimulating hormone (FSH)	Pituitary gland:	Base of the brain and attached to the hypothalamus	In males: stimulates spermatogenesis In females: stimulates the development of the follicle for process of ovulation
Luteinising hormone (LH)	Pituitary gland:	Base of the brain and attached to the hypothalamus	In males: stimulates the synthesis of the hormone testosterone by the Leydig cells in the testes In females: LH stimulates the release of the secondary oocyte from

Hormone	Gland	Location	Function
			the Graafian follicle and then the development into the corpus luteum
Thyroid-stimulating hormone (TSH)	Pituitary gland:	Base of the brain and attached to the hypothalamus	Stimulates the production of thyroxin by the thyroid gland
Prolactin	Pituitary gland	Base of the brain and attached to the hypothalamus	Stimulates mammary glands to secrete milk

6. Homeostasis

It is a process of maintaining a constant internal environment (blood and tissue fluid) within the body. This enables the body to function efficiently, despite changes in the external or internal environment

The following changes of the internal environment in the tissue fluid and blood, will affect the homeostatic balance of the body:

- temperature
- glucose levels
- carbon dioxide levels
- water levels and
- salt levels

7. NEGATIVE FEEDBACK MECHANISMS

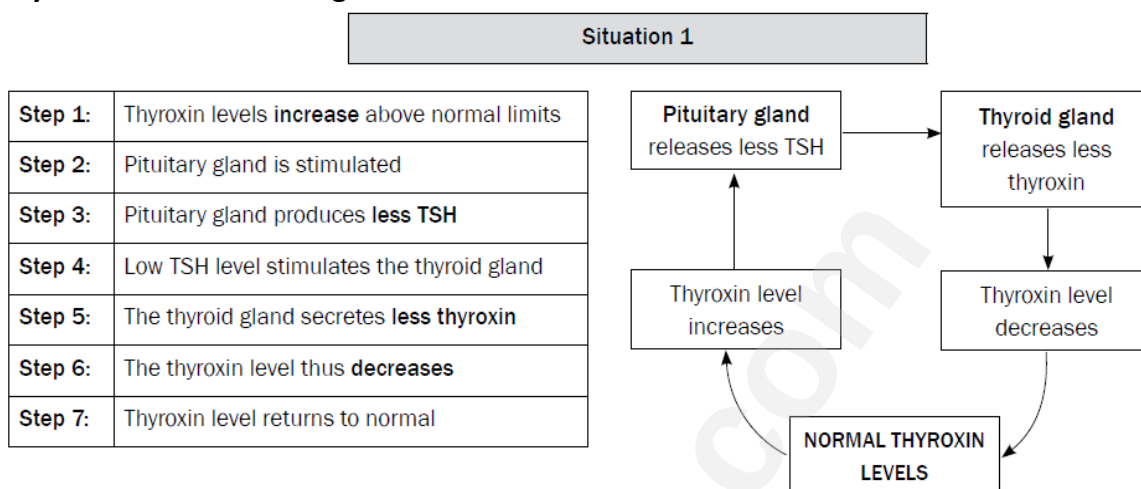
They operate in the human body to detect changes or imbalances in the internal environment and to restore the balance.

General sequence of events in a negative feedback mechanism:

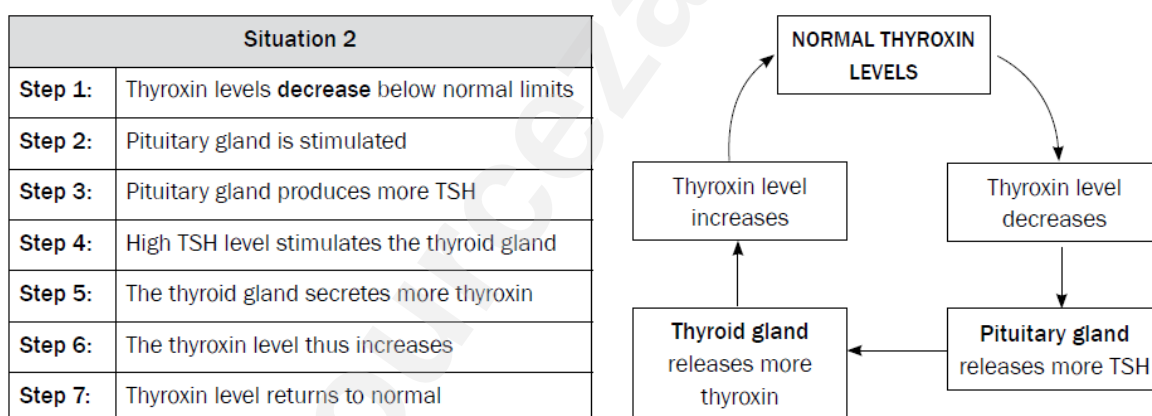
- **STEP 1-** An **imbalance** is **detected**
- **STEP 2 -** A **control** centre is **stimulated**
- **STEP 3-** Control centre **responds**
- **STEP 4-** Message sent to **target organ/s**
- **STEP 5-** The **target organ** **responds**
- **STEP 6-** It **opposes/reverses** the **imbalance**
- **STEP 7-** **Balance** is **restored**

7. Regulation of thyroxin levels in body

- Thyroxin levels are too high:



- Thyroxin levels are too low

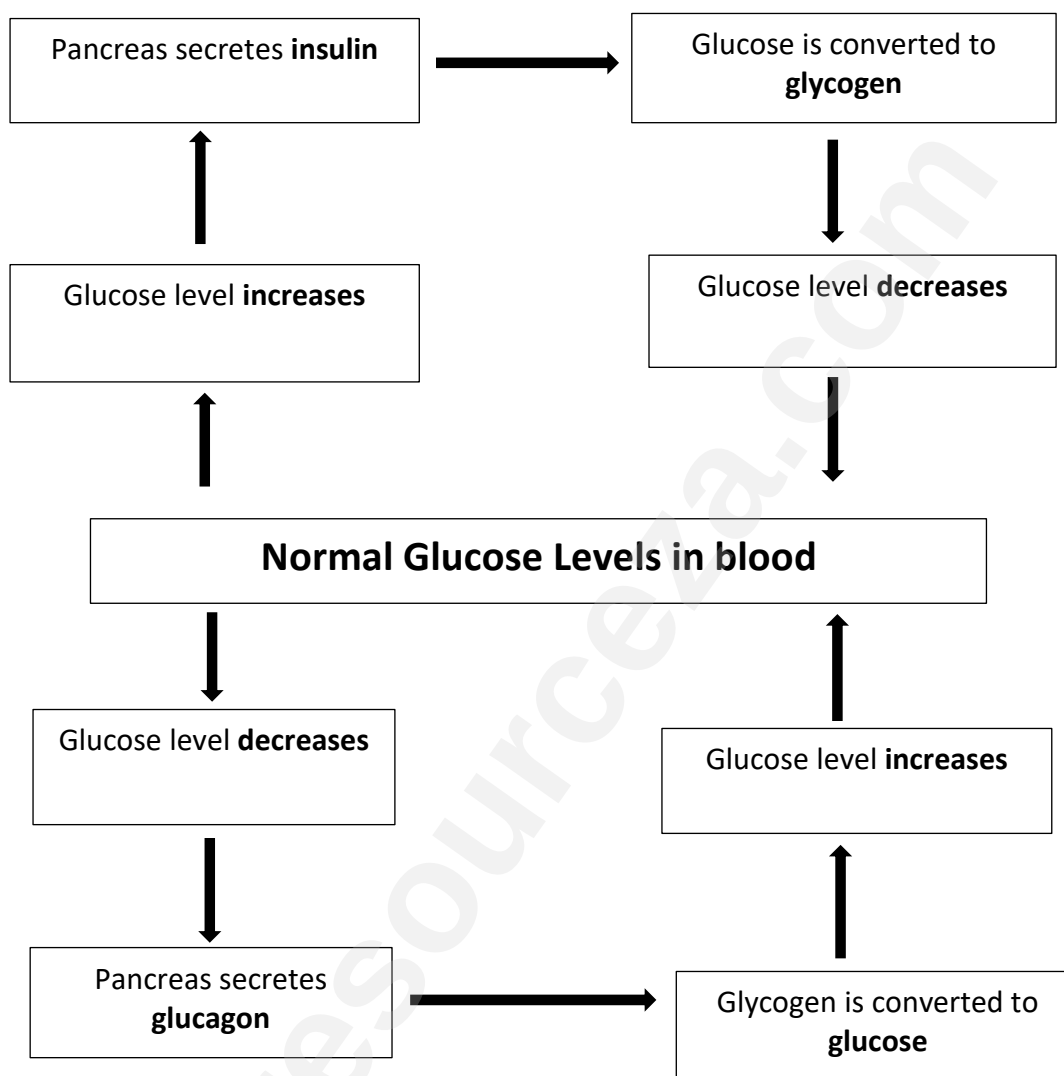


8. Regulation of Glucose levels through negative feedback mechanism

When the glucose level in the blood INCREASES above normal levels:	
Step 1	Glucose levels in the blood increase above normal levels
Step 2	The beta cells of the pancreas are stimulated
Step 3	to secrete insulin into the blood
Step 4	Insulin travels in the blood to the liver and muscle cells (target organ/s)
Step 5	where it stimulates the conversion of excess glucose to glycogen which is then stored
Step 6	The glucose level in the blood now decreases
Step 7	and returns to normal
When the glucose level in the blood DECREASE below normal levels:	
Step 1	Glucose levels in the blood decrease below normal levels
Step 2	The alpha cells of the pancreas are stimulated
Step 3	to secrete glucagon into the blood
Step 4	Glucagon travels in the blood to the liver and muscle cells (target organ/s)
Step 5	where it stimulates the conversion of stored glycogen to glucose

Step 6	The glucose level in the blood now increases
Step 7	and returns to normal

9. A flowchart depicting the negative feedback mechanism of glucose levels in the blood



10. The regulation of Carbon dioxide levels in the blood:

When the CO ₂ level in the blood increases above normal levels:	
Step 1	CO ₂ levels in the blood increase above normal levels
Step 2	Receptor cells in the carotid artery in the neck are stimulated
Step 3	To send impulses to the medulla oblongata in the brain
Step 4	Medulla oblongata stimulates breathing muscles (intercostal muscles and diaphragm) and heart
Step 5	Breathing muscles contract more actively – increases the rate and depth of breathing. The heart beats faster.
Step 6	More CO ₂ is taken to and exhaled from the lungs
Step 7	The CO ₂ level in the blood returns to normal

11. The regulation of water balance in the blood. Osmoregulation in the blood.

When the blood has less water than normal:	
Step 1	Blood has less water than normal
Step 2	The hypothalamus is stimulated
Step 3	and sends impulses to the pituitary gland to secrete more ADH
Step 4	ADH travels in the blood to the kidneys
Step 5	ADH increases the permeability of the collecting ducts and the distal convoluted tubules of the kidney
Step 6	More water is re-absorbed and passed to the surrounding blood vessels
Step 7	The water level in the blood returns to normal

When the blood has more water than normal:	
Step 1	Blood has more water than normal
Step 2	The hypothalamus is stimulated
Step 3	and sends impulses to the pituitary gland to stop secreting ADH/to secrete less ADH
Step 4	No ADH/less ADH travels in the blood to the kidneys
Step 5	The collecting ducts and the distal convoluted tubules of the kidney become less permeable to water
Step 6	Less water is re-absorbed and passed to the surrounding blood vessels. More water is now lost
Step 7	The water level in the blood returns to normal

12. The regulation of Salt levels in the bloodstream

When the salt level in the blood increases:	
Step 1	The salt level in the blood increases
Step 2	Receptor cells in the afferent and efferent arterioles of the kidney detect the high salt level
Step 3	The adrenal gland is stimulated
Step 4	to stop secreting aldosterone/to secrete less aldosterone
Step 5	This decreases the re-absorption of sodium ions from the renal tubules in the kidney into the surrounding blood vessels
Step 6	The salt level in the blood vessels decreases
Step 7	and returns to normal

When the salt level in the blood decreases:	
Step 1	The salt level in the blood decreases
Step 2	Receptor cells in the afferent and efferent arterioles of the kidney detect the low salt level
Step 3	The adrenal gland is stimulated
Step 4	into secreting more aldosterone
Step 5	Aldosterone increases the re-absorption of sodium ions from the renal tubules in the kidney into the surrounding blood vessels
Step 6	The salt level in the blood vessels increases
Step 7	and returns to normal

Flow chart depicting the regulation of salt levels in the bloodstream

