ENDOCRINE SYSTEM OF MAN

Students' learning outcomes
After studying this chapter, students will be able to:

1. [B-12-G-23] State the role of hormones as chemical messengers.
2. [B-12-G-24] Describe the chemical nature of hormones and correlate it with important hormones.
3. [B-12-G-25] Locate the endocrine glands in human body name the hormones they release and their functions; (pituitary, thyroid, parathyroid, pancreas, adrenal, gonads).
4. [B-12-G-26] Relate problems associated with the imbalance of these hormones.
5. [B-12-G-27] Explain the neurosecretory role of hypothalamus.
6. [B-12-G-28] Outline the concept of Feedback mechanism of hormones. Describe positive feedback with reference to oxytocin and negative feedback with reference to insulin and glucagon.

The cellular functions needed to be continuously regulated. The nerve fibres do not innervate all the cells of the body; a special kind of coordination system is thus required. The endocrine system serves the role to coordinate most body cells. The hormonal system is concerned with control of the different metabolic functions of the body, such as the rate of chemical reactions, the transport of substances through the cell membranes, growth, and secretions. This coordination is called **chemical coordination.**

6.1 HORMONES

Hormones are organic chemicals secreted by a cell.They coordinate different functions in the body by carrying messages through blood to various organs and tissues. Scientists have identified over 50 hormones in the human body so far. Hormones control many different bodily processes, such as: metabolism, homeostasis (constant internal balance), such as blood pressure and blood sugar regulation, fluid (water) and electrolyte balance and body temperature, growth and development, sexual function, reproduction, sleep-wake cycle and mood. Hormones can stimulate changes in target cells even though they are present in extreme concentration. Chemically most hormones are either amines, peptides, proteins or glycoproteins and steroids.

6.1.1 Hormone as a Chemical Messenger

A hormone is a small soluble organic molecule which is effective in low concentration. It is essentially a **chemical messenger** that transports a signal from one cell to another. It has its effect at a site where specific receptors are present, called the target; hence it is termed as **messenger.**

Hormones are chemical messengers that affect and manage hundreds of processes occurring in the body. Often, a bodily process involves a chain reaction of several different hormones.

A hormone will only act on a part of the body, if the cells in the target tissue have receptors that receive the message of the hormone. It's action is like the lock and key model of enzyme action. Think of a hormone as a key and the cells of its target tissue, as specially shaped locks. If the hormone fits the lock (receptor) on the cell membrane, then it'll work; the hormone will deliver a message that causes the target site to take a specific action.

The body uses hormones for two types of communication. The first type is communication between two endocrine glands. One gland releases a hormone, which stimulates another gland to change the levels of hormones that it's releasing. An example of this is the communication between pituitary gland and thyroid. The pituitary gland releases thyroid-stimulating hormone (TSH), which triggers thyroid gland to release its hormones, which then affect various aspects of body.

The second type of communication is between an endocrine gland and a target organ. An example of this is when the pancreas releases insulin, which then acts on the muscles and liver to help analyse glucose.

SCIENCE TITBITS

In 1902, Bayliss and Starling, prepared an extract from the duodenum which stimulated secretion of pancreatic digestive juices when it was injected into the bloodstream. They called the product 'secretin', and coined the term 'hormone', meaning 'to excite' or 'to set in motion.'

6.1.2 Chemical nature of hormones

All the hormones are organic substances of varying structural complexity. Chemically, they may belong to any of the following categories.

(a) **Steroid hormones:** The hormones secreted by the adrenal cortex, testes, ovaries and placenta are composed of steroids e.g., cortisone, aldosterone, testosterone, estrogen, progesterone.

(b) **Proteinaeous hormones:** These are also known as polypeptide or peptide hormones. Somatotrophic, thyrotrophic and gonadotrophic hormones are secreted by the anterior lobe of pituitary gland and insulin hormone is secreted by pancreas.

(c) **Catecholamine:** Adrenaline and noradrenaline are secreted by the adrenal medulla.

(d) **Amino acid derivative:** Thyroxine hormone is secreted by the thyroid gland.

(e) **Peptide Hormones:** These include melanocyte stimulating hormone, the hormones oxytocin and vasopressin, adrenocorticotrophic hormone, calcitonin and parathormone.

6.2 ENDOCRINE SYSTEM OF MAN

Endocrine system is the type of glandular system, consists of some 20 ductless glands lying in different parts of the body. Some of the major endocrine glands, their locations and hormonal secretions are shown in the given figure.

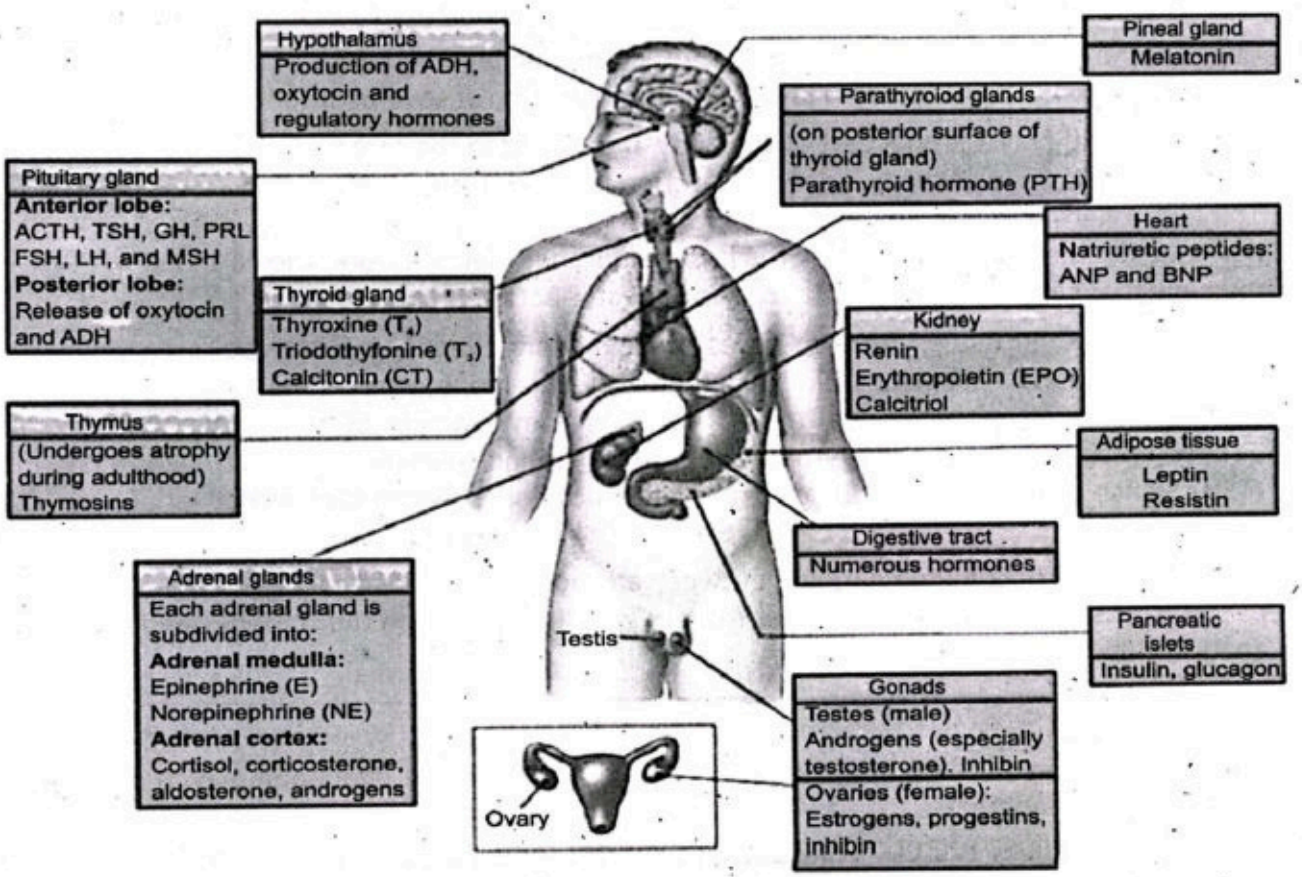


Fig. 6.1: Major endocrine glands and their locations in human

6.2.1 Pituitary Gland

Pituitary gland is located just below the hypothalamus. It is attached to hypothalamus by a stalk called **infundibulum** which is composed of blood vessels and the fibres of neurosecretory cells. Pituitary gland is divided into three lobes, the anterior, posterior and the median.

Anterior lobe of pituitary

Classically, the anterior pituitary is considered the **master gland** of the endocrine system because it secretes numerous hormones, many of which regulate the activity of other endocrine glands. It secretes six hormones, all of which regulate the secretory action of other endocrine glands.

Growth hormone (GH) or Somato-trophic hormone (STH). It is released under influence of hypothalamic **growth hormone releasing factor (GHRF)** and are inhibited by **hypothalamic somatostatin.** GH has a direct effect on growth and development. GH stimulates cell growth and cell division. It also stimulates uptake of amino acids into cells and increases rate of protein synthesis.

Deficiency of GH results in **Dwarfism** in which development is much slower and individual has short stature, however, the body parts stay in proportion and brain development and IQ are unaffected.

Gigantism is result of over secretion of GH during childhood in which the bones are still capable of growth and person increase in height abnormally. Over secretion of GH in adult life causes **acromegaly** in which bones are no longer capable of increasing in length but grow in thickness. Acromegaly is characterised by enlarging the hands, feet, skull, nose and jawbone.

Thyroid stimulating hormone (TSH): Thyrotrophin releasing factor (TRF) from hypothalamus stimulates the synthesis and release of **thyroid stimulating hormone (TSH)** from the anterior pituitary. TSH regulates the endocrine function of the thyroid gland. It increases the number of cells and secretory activity of the thyroid gland. Over secretion of TSH causes **hyperthyroidism** i.e., excess of thyroxin and its under secretion causes hypothyroidism i.e., lack of thyroxin.

Adrenocorticotropic Hormone (ACTH): It is secreted by the release of **corticotrophin releasing factor (CRF)** from hypothalamus which is controlled by steroid level in the blood and by direct nervous stimulation of the hypothalamus as a result of stress e.g., cold, heat, pain, fright and infections. ACTH acts on adrenal cortex and stimulates the secretion of corticosteroids (cortisone and aldosterone).

Follicle stimulating hormone (FSH), luteinising hormone (LH, also called **interstitial cell stimulating hormone, ICSH** in the male) and **prolactin** or **leuteotrophic hormone (LTH)**, are all collectively known as **gonadotropic hormones.** These hormones act upon reproductive system and regulate its function.

Median lobe of pituitary

In humans, median lobe of pituitary is not very prominent. It is a thin layer of cells between the anterior and posterior pituitary. It produces **melanocyte stimulating hormone (MSH).** Secretion of MSH is regulated by hypothalamic MSH inhibitory hormone. Melanocyte stimulating hormone increases in humans during pregnancy too. It stimulates the production and release of melanin by melanocytes in skin and hair.

Exocrine glands are organs or tissues that release substances through ducts or openings onto body surfaces or into body cavities. These substances can include sweat, saliva, tears, breast milk, and digestive juices.

Posterior lobe of Pituitary

Posterior pituitary is not glandular by itself. It does not synthesize any hormone. It is largely made up of axons of neurosecretory cells of hypothalamus.

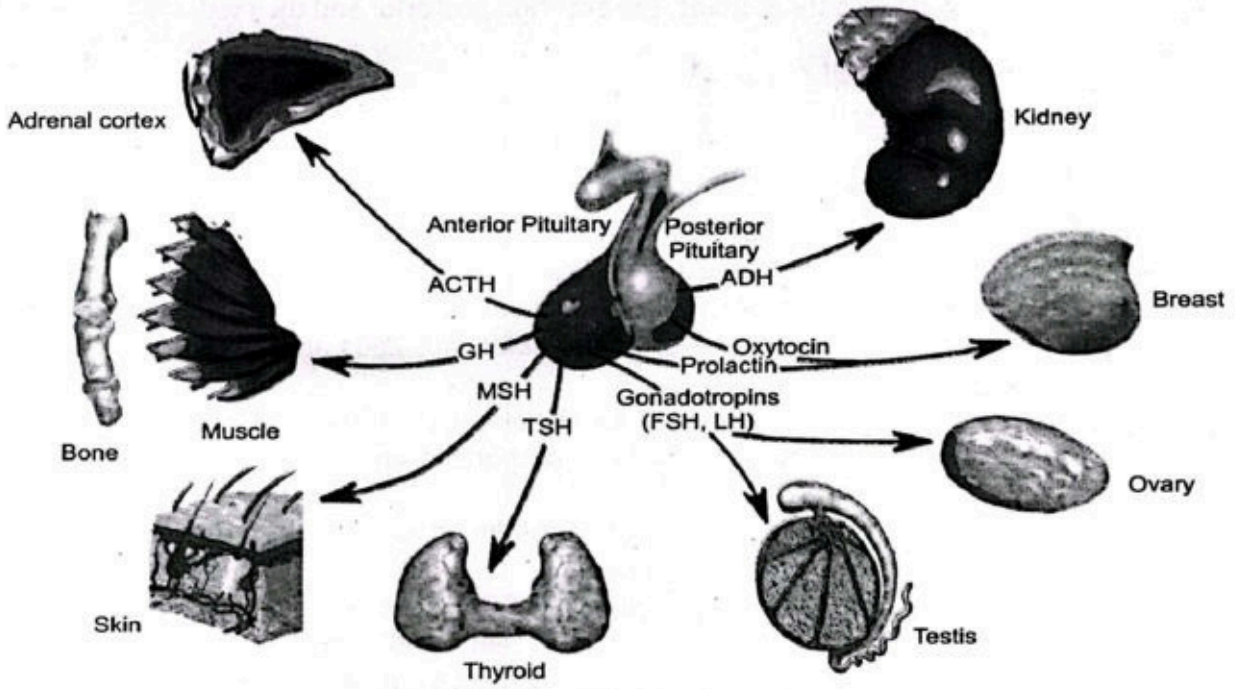


Fig. 6.2: Role of pituitary hormones

Antidiuretic hormone: Posterior pituitary stores antidiuretic hormone (ADH or vasopressin) and oxytocin. These hormones are released in response to nerve impulses from hypothalamus. **ADH** is produced during the state of dehydration, decreased blood volume and low blood pressure. Under secretion of ADH causes **diabetes inspidus** which is characterized by excessive production of diluted urine and frequent thirst. Over secretion may leads to the kidney problems.

Oxytocin: It is released during child birth and in nursing women. During birth it is released in waves, and results in labour contractions. **Over secretion** causes rupturing of uterine wall while **under secretion** of oxytocin inhibits normal labour process. In lactating women, suckling causes the release of oxytocin. During this feeding process it causes the dilation of milk ducts of mother's mammary glands and thus promotes milk ejection.

SCIENCE TITBITS

Under certain conditions, such as severe blood loss, exceptionally large amounts of ADH are released, causing a rise in blood pressure. The alternative name for this hormone, vasopressin, reflects this particular effect.

6.2.2 Thyroid Gland

Thyroid gland is composed of two lobes which are located on either side of the trachea inferior to the larynx. Thyroid gland produces three active hormones, tri iodothyronine (T3), tetra iodothyronine (T4) or thyroxin, and calcitonin.

T3 and T4: These are iodine containing hormones. Tri iodothyronine contains three iodine atoms in structure and thyroxin contains four, hence the names T3 and T4. TSH from anterior pituitary stimulates production and release of these hormones. These hormones show a variety of physiological effects: (1) They promote basal metabolic rate of the body. (2) Enhance glucose

catabolism and synthesis of cholesterol in the liver. (3) Promote development of nervous system in foetus and infants. (4) They act on muscles for their development and functioning. (5) Promote growth and maturation of skeleton. (6) These hormones also promote normal motility of the gastrointestinal tract.

Hyperthyroidism term is applied to excess of these hormones. **Over secretion** of T_3 and T_4 causes **Graves' disease.**

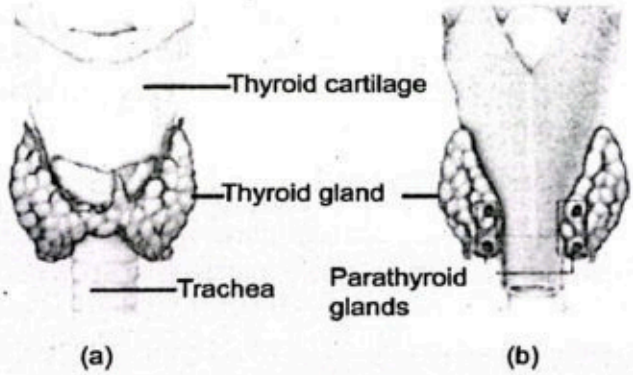


Fig. 6.3: Thyroid and parathyroid gland

SCIENCE TITBITS

T_4 (also known as thyroxin) is the major hormone, about 90%, secreted by the thyroid; T_3 is only 10%. T_3 is four times more potent than T_4; however, action duration of T4 is four times more than T_3.

Do you know?

Graves' disease is believed to be an autoimmune disease. The serum of patients contains abnormal antibodies that mimic TSH and continuously stimulate thyroxin release. The symptoms include high metabolic rate, rapid and irregular heartbeat, increased breathing rate,increased body temperature, sweating and weight loss despite adequate food intake. Mostly exophthalmia (protrusion of the eyeballs) results from Graves's disease and is a classic symptom of hyperthyroidism.

SCIENCE TITBITS

Hormones released from kidney

Renin monitors blood pressure and takes corrective action if it drops.

Erythropoietin acts on the bone marrow to increase the production of red blood cells. Stimuli such as bleeding or moving to high altitudes (where oxygen is scarcer) trigger the release of EPO.

Calcitriol acts on the cells of the intestine to promote the absorption of calcium from the diet.

Hypothyroidism is the **under secretion** of thyroxin. In adults, the full-blown hypothyroid syndrome is called **myxedema** which is characterized by low metabolic rate, feeling chilled, puffy eyes, thick and dry skin with hair lost from the scalp and eyebrows, oedema, tongue swelling, constipation; and enlarged thyroid gland i.e., goiter. Myxedema may result due to deficiency of iodine in diet. **Congenital under secretion** results in a severe **hypothyroidism** in infants called **cretinism** which is characterized by mental retardation with poor physical growth and disproportionate body size. Bone maturation and puberty are severely delayed and infertility is common.

Calcitonin: The C-cells in thyroid gland produce calcitonin. Excessive calcium level of blood stimulate release of calcitonin whereas declining blood calcium levels inhibit its secretion. **Calcitonin** increases the deposition of calcium in bone matrix. Calcitonin inhibits calcium absorption by the intestine and decreases its reabsorption by the kidney tubules allowing its excretion in urine.

Calcitonin appears more important in childhood, when the skeleton grows quickly and the bones are changing dramatically in mass, size, and shape. If deficient, calcium are not deposited in bones and high blood calcium level causes disturbance in the functioning of muscles and nervous system and may lead to kidney stones.

6.2.3 Parathyroid Glands

In human, there are four parathyroid glands. All four glands are located on the thyroid gland. They are small, light coloured masses that stick out from the posterior surface of the thyroid gland. The **parathormone** is the single most important hormone of parathyroid controlling the calcium balance of the blood. Its release is triggered by low blood calcium levels and inhibited by high blood calcium levels. Parathormone works antagonistically to the calcitonin.

Over secretion of parathormone is usually a result of a parathyroid gland tumour. Calcium is released from the bones and bones deform soften and tend to fracture spontaneously. Blood calcium level elevates **(hypercalcemia)** which depresses nervous system and causes weakness of muscles. Excess calcium salts precipitate in the kidneys leading to stone formation.

Under secretion of parathormone causes **hypocalcemia**. This increases the excitability of neurons. Also it can lead to tetany in which muscles remain in contracted state. If untreated, it can be fatal.

6.2.4 Pancreas

Pancreas is composed of two types of tissues. **Exocrine tissue** produces and secretes digestive juice. **Endocrine tissues** are distributed in the form of patches in the pancreas and these patches are called **Islets of Langerhans.** Islets of Langerhans secrete two hormones **insulin and glucagon.**

Insulin is secreted by the **Beta (β) cells** which are larger in number and glucagon is secreted by **alpha (α) cells** which are lesser in number. These cells respond directly to the level of blood glucose. **Insulin** is secreted when the level of blood sugar rises, such as right after a meal. Its overall effect is to reduce blood glucose level to the normal level by increasing the rate of glucose uptake by most body cells especially skeletal muscles and fat cells. It promotes glycogenesis (conversion of glucose to glycogen), increases the use of glucose in cellular respiration, promotes the conversion of excess glucose to fats and inhibits gluconeogenesis (glucose synthesis).

SCIENCE TITBITS

Pancreatic acinar cells are functional units of the exocrine pancreas. They synthesize, store, and secrete inactive digestive enzymes into the lumen of the acinus.

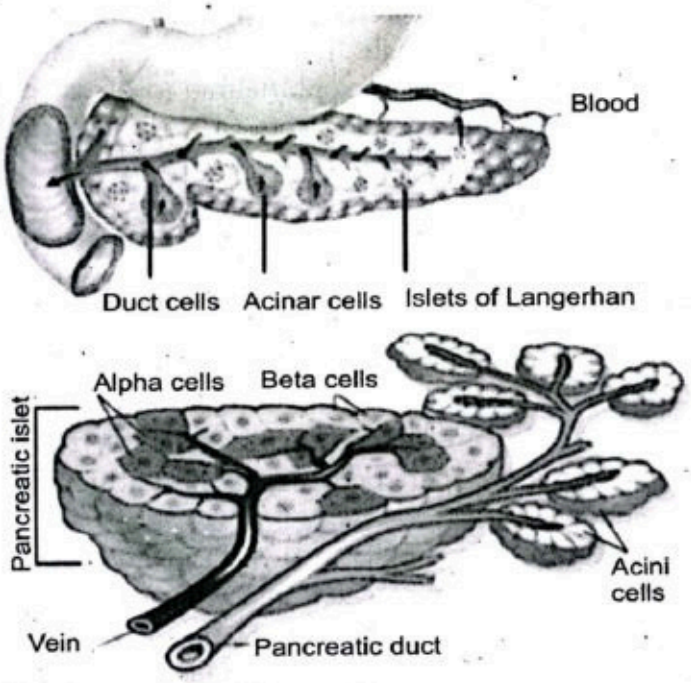


Fig. 6.4: Pancreas and Islets of Langerhans

The **under secretion** of insulin leads to the metabolic disease known as **diabetes mellitus** which is characterized by high glucose level in the blood and urine. If excess of insulin is produced the utilization of glucose is too great and its level falls in the blood which upsets nerve and muscles functioning.

Glucagon is released by **α cells** when blood glucose level is low. Sympathetic nervous system also stimulates its secretion. High blood glucose levels, insulin and somatostatin suppress its secretion. Its role is to increase the blood glucose level. It acts antagonistically to the insulin and thus reverses the activities performed by insulin.

6.2.5 Adrenal Glands

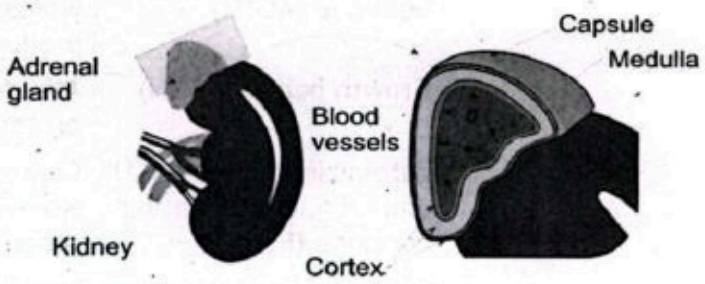


Fig. 6.5: Adrenal gland

Each of the two adrenal glands rests on a kidney. Each adrenal gland is composed of an inner portion called the **medulla** and outer portion the **cortex**.

Epinephrine (adrenaline) and **norepinephrine** are produced by the **adrenal medulla**. Both are released during the state of emergency under the influence of sympathetic nervous system. Both are involved in the body's immediate response to stress. The two hormones exert the same effects in different ways i.e., **synergistic effect**. Epinephrine is the more potent stimulator of metabolic activities, bronchial dilation and increased blood flow to skeletal muscles and the heart but norepinephrine has the greater influence on peripheral vasoconstriction. The net effect is the rise in blood pressure.

Over secretion of these hormones may cause hypertension and aggressive behaviour during routine life. Under secretion causes failure to combat with emergency situation.

The two major types of hormones produced by the **adrenal cortex** are **glucocorticoids**, e.g., **cortisone**, which help to regulate the blood glucose level and mineralocorticoids, e.g., **aldosterone**, which help to regulate the level of minerals in the blood. Both are produced under the influence of ACTH. **Under secretion** of cortical hormones will lead to **Addison's disease** which is characterized by general metabolic disturbance, in particular, weakness of muscle action and loss of salts. Stress situation, such as cold which may leads to collapse and death. **Over secretion** of cortical hormone cause Cushing's disease which is characterized by excessive protein breakdown resulting muscular and bone weakness. Another hormone **androgen** (testosterone) is also produced from adrenal cortex in small amount in both male and female bodies. Its major site of secretion are testes, which are male gonads.

6.2.6 Gonads

Gonads are special type of endocrine glands which beside hormone secretions also produce gametes. Female gonads are ovaries while male gonads are testes.

Ovaries: The ovaries secrete female sex hormones estrogen and progesterone. **Estrogen** is secreted by **Graffian follicle** under the stimulation of FSH but estrogen has negative feedback upon FSH. Estrogen is secreted at the time of puberty and is responsible for secondary sex characteristics in females. It aids in healing and repair of uterine wall after menstruation. Due to its **under secretion** in the young females, they fail to mature sexually. Deficiency of this hormone in adults leads to sterility. Its oversecretion may leads to the development of fibroids (abnormal growth) in uterus and polycystic ovaries.

Table 6.1 Endocrine glands and their hormones

Site of production	Hormone(s) secreted	Hormone function
Pituitary gland	Antidiuretic hormone (vasopressin)	Affects water retention in kidneys; controls blood pressure
	Adrenocorticotropic hormone (ACTH)	Controls production of sex hormones (estrogen in women and testosterone in men) and the production of eggs in women and sperm in men.
	Growth hormone (GH)	Affects growth and development; stimulates protein production; affects fat distribution
	Luteinizing hormone(LH) and follicle-stimulating hormone (FSH)	Controls production of sex hormones (estrogen in women and testosterone in men) and the production of eggs in women and sperm in men
	Oxytocin	Stimulates contraction of uterus and milk ducts in the breast
	Prolactin	Initiates and maintains milk production in breasts; impacts sex hormone levels
	Thyroid-stimulating hormone (TSH)	Stimulates the production and secretion of thyroid hormones
Median lobe of the pituitary gland	Melanocyte-stimulating hormone (MSH)	MSH plays a role in melanin production in the skin, influencing skin pigmentation. It also influences appetite and sex drive.
Kidneys	Renin and angiotensin	Controls blood pressure, both directly and also by regulating aldosterone production from the adrenal glands
	Erythropoietin	Affects red blood cell (RBC) production
Pancreas	Glucagon	Raises blood sugar levels
	Insulin	Lowers blood sugar levels; stimulates metabolism of glucose, protein, and fat
Ovaries	Estrogen	Affects development of female sexual characteristics and reproductive development, important for functioning of uterus and breasts; also protects bone health
	Progesterone	Stimulates the lining of the uterus for fertilization; prepares the breasts for milk production
Parathyroid glands	Parathyroid hormone (PTH)	Most important regulator of blood calcium levels
Thyroid gland	Thyroid hormone	Controls metabolism; also affects growth, maturation, nervous system activity, and metabolism

Adrenal glands	Aldosterone	Regulates salt, water balance, and blood pressure
	Corticosteroid	Controls key functions in the body; acts as an anti-inflammatory; maintains blood sugar levels, blood pressure, and muscle strength; regulates salt and water balance
	Epinephrine	Increases heart rate, oxygen intake, and blood flow
	Norepinephrine	Maintains blood pressure
Testes (testicles)	Testosterone	Develop and maintain male sexual characteristics and maturation
Pineal gland	Melatonin	Releases melatonin during night hours to help with sleep
Hypothalamus	Growth hormone releasing hormone (GHRH)	Regulates growth hormone release in the pituitary gland
	Thyrotropin releasing hormone (TRH)	Regulates thyroid stimulating hormone release from the pituitary gland
	Gonadotropin releasing hormone (GnRH)	Regulates LH/FSH production in the pituitary gland
	Corticotropin releasing hormone (CRH)	Regulates adrenocorticotropin release in the pituitary gland
Thymus	Humoral factors	Helps develop the lymphoid system

Progesterone is produced by **corpus luteum** in response to LH during normal menstrual cycle but it is produced and released from placenta during pregnancy. It inhibits further FSH secretion from pituitary, thus preventing any more follicles from ripening. It causes further thickening and vascularisation of the uterus wall for maintaining state of pregnancy. Progesterone suppresses ovulation. Under secretion of progesterone during menstrual cycle, decreases the chance of pregnancy and may cause early menstruation. Under secretion during pregnancy may leads to the miscarriage.

Testes: The male gonads are testes. Testes produce sperm and male sex hormones called **testosterone** which is secreted from interstitial cells among seminiferous tubules under the influence of ICSH. During puberty, testosterone initiates the maturation of the male reproductive organs and the appearance of secondary sex characteristics and sex drive. In addition, testosterone is necessary for normal sperm production and maintains the reproductive organs in their mature functional state in adult males. Under secretion of this hormone causes the development of feminine characteristics and male sterility.

Skills: Interpreting and Communication

- **Explain on what grounds some companies claim that growth is possible in people having short heights.**

  If growth hormone is administered to young people before growth of their long bones is completed, it causes long bones to grow and they will grow taller. To accomplish this however, GH would have to be administered over a considerable period of time.

Skills: Interpreting and Communication

- **Explain the role of artificially synthesized steroids in sports and their long term effects on its users.**

Steroids are artificial substances. Steroids are developed in order to do the job of testosterone. It can be classified as either anabolic or androgenic. Anabolic functions include those that promote formation of muscles, vertical growth and regulation of weight gain or loss. Androgenic refers to masculine attributes such as agility, strength, and endurance. By the help of these drugs, sportsmen can become bigger, stronger, more agile, and hence more competitive. Artificial steroid users carry many severe health risks. Major medical problems associated with steroids include a weakened immune system, liver disease, kidney disease, high blood pressure, high cholesterol, increased risk for heart disease, blood clots, strokes, tissue damage and cancer.

6.3 NEUROSECRETORY ROLE OF HYPOTHALAMUS

Hypothalamus is part of forebrain. It regulates a wide spectrum of physiological functions such as hunger, thirst, sleep and temperature. Hypothalamus also monitors metabolites and hormone levels in the blood. The hypothalamus is the master control centre of the endocrine system. Its endocrine signals directly control the pituitary gland. It contains special groups of neurosecretory cells. These cells conduct impulses and have developed secretory capacity to a high level. These cells produce regulatory hormones which regulate the synthesis and secretion of pituitary hormones. The hormones produced by the hypothalamus are either the releasing factors which stimulate secretions of pituitary hormones or inhibiting factors which inhibit secretion of pituitary hormones. These are produced in the cell bodies of the cells and packed into the granules and are transported down to the axon by cytoplasmic streaming. The axon endings of the neurosecretory cells synapse with blood capillaries and release their hormones into the blood when stimulated, which carry them to target area. The hormones from hypothalamus and their functions are given in the given table.

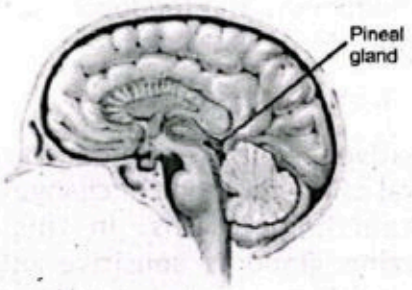
In addition, the neurosecretory cells that arise from the hypothalamus also produce two primary hormones i.e., antidiuretic hormone (ADH) and oxytocin which are stored in posterior lobe of pituitary gland and are released from here when needed.

Table 6.2 Hypothalamic hormones and their effect on pituitary gland

Hormone from the hypothalamus	Anterior pituitary response
Growth hormone releasing factors (GHRF)	Secretion of growth hormone (GH)
Somatostatin	Inhibition of GH
Thyrotrophin releasing factor (TRF)	Secretion of thyroid stimulating hormone (TSH)
Adrenocorticotrophin releasing factor (CRF)	Secretion of adrenocorticotrophic hormone (ACTH)
Prolactin inhibiting factor (PIF)	Inhibits secretion of prolactin
Gonadotrophin releasing hormone (GnRH)	Secretion of FSH and LH

SCIENCE TITBITS

The pineal gland is attached to the hypothalamus. Its primary hormone is **melatonin**. It influences daily rhythms called circadian rhythm. The **thymus** reaches its largest size and is most active during childhood. Thymus produces various hormones called **thymosin**. Certain lymphocytes that originate in the bone marrow and then pass through the thymus are transformed into T lymphocytes with the help of this hormone.



Pineal gland

SCIENCE TITBITS

Other Endocrine Tissues/Cells

Hormones are also produced by organs or tissues whose function is not primarily an endocrine one. Even nerve cells produce hormones. The hormone gastrin, produced by the stomach wall, travels in the blood stream but exerts its effect locally, stimulating the production of pepsinogen and hydrochloric acid. Secretin and cholecystokinin control pancreatic and liver secretions. Both are formed in the cells of duodenal wall. The placenta secretes progesterone, which maintains pregnancy. Prostaglandins are a group of localized hormone. They provide protection during infections. Endorphins are produced in the brain. Endorphins bind to pain receptors and so block sensation of pain.

6.4 FEEDBACK MECHANISM

It is a type of interaction in which a controlling mechanism is itself controlled by the product of reactions it is controlling. After receiving the signal, a change occurs to correct the deviation by depressing it with negative feedback or enhancing it with positive feedback.

6.4.1 Positive feedback

In positive feedback an end product speeds up its production. These responses are not homeostatic and are rare in healthy individuals An example of positive feedback is childbirth. The early contractions of labour begin to force the baby's head against the cervix to dilate (open). Stretch-receptive neurons in the cervix respond to this extension by signalling the hypothalamus, which response by triggering the release of the hormone oxytocin that stimulates more and stronger uterine contractions.

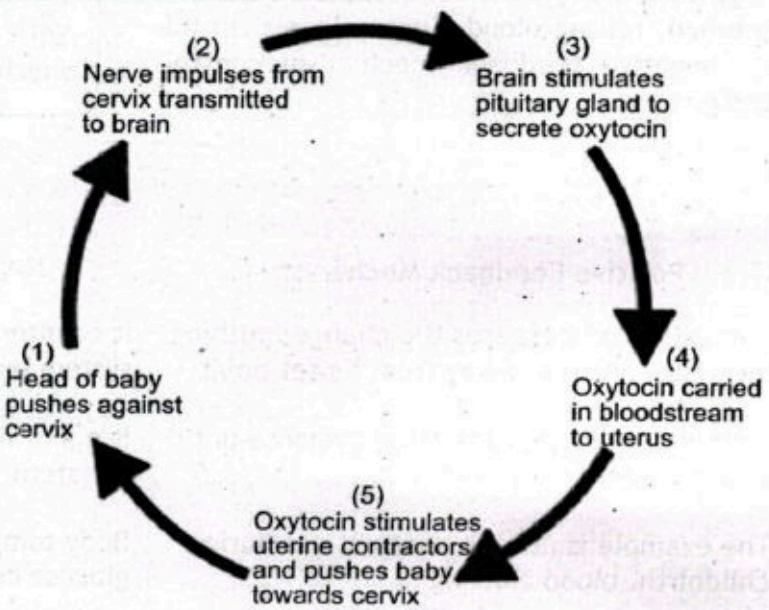


Fig. 6.6: Positive feedback mechanism

Stronger contractions create further pressure on the cervix, which in turn prompts the release of more hormones. The feedback cycle is finally terminated by the expulsion of the baby and its placenta.

6.4.2 Negative feedback

In negative feedback end products results in the reversal of the direction of change and tends to maintain homeostasis. In this system an endocrine gland is sensitive either to the concentration of a substance it regulates or to the concentration of a product from a process it controls. For example if blood glucose becomes too high, beta (β) cells in the islets of Langerhans respond by releasing insulin. Insulin lowers blood glucose by making cell surface membranes more permeable to glucose. It activates transport proteins in the membranes, allowing glucose to pass into the cells. Insulin also activates enzymes inside the cells. Some of these enzymes convert glucose to glycogen. If the levels of blood glucose get too low, alpha (α) cells in the islets of Langerhans secrete glucagon. This hormone fits into the receptor sites on the cell surface membranes, and activates the enzymes inside the cells that convert glycogen to glucose. The glucose then passes out of the cells and into the blood, raising blood glucose levels. In this way, negative feedback mechanism controls blood glucose.

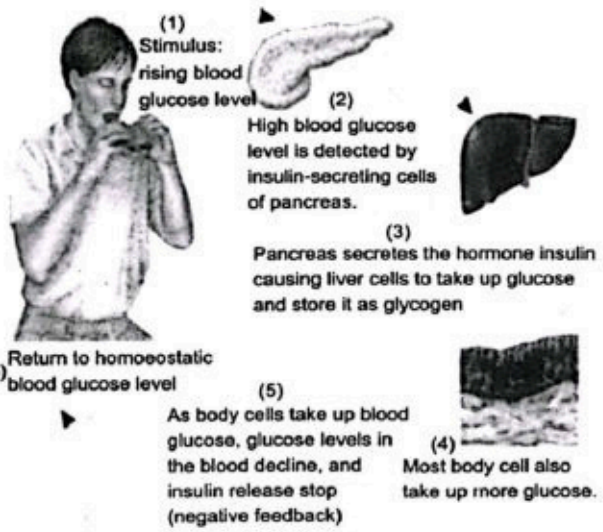


Fig. 6.7: Negative feedback mechanism

CRITICAL THINKING

Is the sensation of thirst associated with a negative or positive-feedback mechanism?

Table 6.3 Difference between positive feedback mechanism and negative feedback mechanism

Positive Feedback Mechanism	Negative Feedback Mechanism
It amplifies or increases the change, pushing *the system fur*ther away from its set point	It counteracts the change, bringing the system back to its set point
It leads to a rapid, escalating response until a specific endpoint is reached	It maintains stability and homeostasis within a system
The example is uterine contractions during childbirth. blood clotting	Body temperature regulation, blood glucose control
The response reinforces the initial stimulus	The response opposes the initial stimulus
The overall function is to rapidly complete a process or reach a specific outcome	The overall function is to maintain a stable internal environment

STEAM ACTIVITY 6.1

1. Hormone Assignment and Role-Playing

a. **Hormone Groups:** Divide the class into groups, with each group representing a specific endocrine gland and its associated hormones (e.g., the pituitary gland could be represented by a group working with growth hormone, LH, and FSH).

b. **Hormone Functions:** Each student within the group will research and understand the specific function of their assigned hormone and how it interacts with other body systems. For example, students representing the thyroid gland would research the role of thyroxine in metabolism.

c. **Role-Playing:** Students act out how their hormone travels in the bloodstream, interacts with target cells (represented by other students or props), and affects the body.

2. Simulating the Endocrine System

a. **Bloodstream:** Use a large space, a hallway, or even an open classroom to represent the bloodstream. Students carrying their hormone "message" (written on a card or prop) will move through this "bloodstream".

b. **Target Organs:** Assign different areas or objects in the "bloodstream" to represent target organs (e.g., a table can be the liver, a chair the heart).

c. **Interactions:** As hormones "travel," students interacting with target organs describe how their hormone affects the organ, using their research as a guide.

3. Assessment

a. **Observation:** Observe student engagement and understanding of hormone functions and interactions during the role-playing simulation.

b. **Written Reports:** Have students write a brief report summarizing the hormone they represented, its function, and how it interacts with different body systems.

c. **Group Presentations:** Encourage groups to present their findings to the class, further reinforcing their understanding.

Example Scenario

A student representing growth hormone (GH) from the pituitary gland "enters the bloodstream" and travels towards a student representing the bones. The GH student would then act out how GH promotes bone growth, possibly by using hands to simulate bone development or explaining how GH influences protein production.

Benefits of this activity

- **Hands-On Learning:** Students actively participate and learn through movement and interaction.
- **Visual Representation:** The simulation creates a visual representation of a complex process, making it easier to understand.
- **Role-Playing:** Students develop a deeper understanding of how hormones work and their functions by actively "becoming" the hormones.
- **Collaborative Learning:** Students work together in groups, fostering collaboration and communication.

EXERCISE

Section I: Multiple Choice Questions
Select the correct answer:

1. Steroid hormones are secreted by
   A. the adrenal cortex
   B. the gonads
   C. the thyroid
   D. both A and B
2. Examples of posterior pituitary hormones are
   A. FSH and LH
   B. prolactin and parathormone
   C. melatonin and prostaglandin
   D. ADH and oxytocin
3. The primary targets for FSH are cells in the
   A. hypothalamus
   B. ovary
   C. thyroid
   D. pituitary
4. Which of the following controls the activity of all others?
   A. thyroid
   B. pituitary
   C. adrenal cortex
   D. gonads
5. Which of the following have antagonistic (opposing) effects?
   A. parathyroid hormone and calcitonin
   B. glucagons and thyroxine
   C. growth hormone and epinephrine
   D. cortisone and ACTH
6. Which of the following hormones has broadest range of targets?
   A. ADH
   B. oxytocin
   C. TSH
   D. epinephrine
7. The pancreas increases its output of insulin in response to
   A. an increase in body temperature
   B. changing cycle of dark and light
   C. a decrease in blood glucose
   D. an increase in blood glucose
8. Name the gland that is located at the base of the throat, just inferior to the laryngeal prominence (Adam's apple) .
   A. pituitary.
   B. pineal gland.
   C. hypothalamus.
   D. thyroid
9. Action of parathormone in the human body
   A. decreases blood sodium level
   B. increases blood sodium level
   C. decreases blood calcium level
   D. increases blood calcium level
10. Which of the following endocrine glands secretes growth hormones?
   A. thyroid gland
   B. pituitary gland
   C. adrenal gland
   D. testes
11. Which of the following pair of endocrine glands is located in the brain?
   A. hypothalamus and thymus
   B. pituitary and parathyroid
   C. thyroid and pineal
   D. hypothalamus and pineal

12.What gland is located just superior to the kidneys?

A. pituitary
B. adrenal
C. pancreas
D. ovaries

13.Which if the following gland which can be classified as an endocrine and an exocrine gland?

A. thyroid
B. thymus
C. pancreas
D. pituitary

14.Which of these hormones is made by the posterior pituitary?

A. FSH
B. LH
C. ACTH
D. ADH

15.Which one of the following is the smallest in the human body?

A. pineal gland
B. pituitary gland
C. adrenal gland
D. parathyroid glands

16. Which of the following hormones are responsible for the "fight-or-flight" response?

A. epinephrine and norepinephrine
B. insulin and glucagon
C. esrtogen and progesterone
D. thyroxin and melatonin

17. Calcitonin is a hormone of which of following:

A. adrenal cortex
B. thyroid gland
C. pituitary gland
D. thymus gland

18. All of the following are hormones of the anterior pituitary except:

A. human growth hormone (GH)
B. follicle-stimulating hormone (FSH)
C. parathyroid hormone (PTH)
D. thyroid-stimulating hormone (TSH)

19. The secretions from which of these glands differs between males and females?

A. adrenal
B. parathyroid
C. gonadal
D. pancreas

20. Calcium level in the blood is regulated by the:

A. thyroid
B. parathyroid
C. posterior pituitary
D. A and B

Section II: Short Answer Questions

1. Why hormones are called chemical messengers?
2. What are neurosecretory cells?
3. Name the hormones of anterior pituitary gland.
4. Why the anterior lobe of pituitary gland is called master gland?
5. Describe the median lobe of pituitary gland.
6. How the secretion of ADH is controlled?
7. Write the differences between:
   a. exocrine and endocrine glands
   b. steroid hormones and proteinous hormones
   c. first messenger and second messenger
   d. receptor of proteinous hormones and steroid hormones

e. hypothyroidism and hyperthyroidism
f. calcitonin and parathormone
g. beta and alpha cells of Islets of Langerhans
h. insulin and glucagon
i. diabetes inspidus and diabetes mellitus
j. estrogen and progesterone
k. positive and negative feedback

8. What is the relationship between a hormone and a target cell?
9. Locate the endocrine glands in the human body.
10. How does a feedback mechanism regulate the activity of the endocrine system?
11. Make a diagram of positive feedback involving the hormone oxytocin.
12. Predict the effects that insufficient amounts of FSH and LH will have on the menstrual cycle.

Section III: Extensive Answer Questions

1. Describe the function of the endocrine system in the human body.
2. State the role of hormone as chemical messenger.
3. Describe chemical nature of hormone and correlate it with important hormones.
4. Describe the hormones secreted by the anterior lobe of pituitary gland.
5. Describe the hormones secreted by the posterior lobe of pituitary gland.
6. Name the hormones, their functions and imbalance of the Pituitary gland
7. Name the hormones, their functions and imbalance of the Thyroid gland
8. Name the hormones, their functions and imbalance of the Parathyroid glands.
9. Name the hormones, their functions and imbalance of the Pancreas
10. Name the hormones, their functions and imbalance of the Adrenal glands
    a. Gonads
11. Describe the neurosecretory role of hypothalamus.
12. What is feedback mechanism? Describe the positive and negative feedback mechanism with reference to oxytocin, insulin and glucagon.