

CHAPTER - 5

THE ENDOCRINE SYSTEM

INTRODUCTION

The nervous system coordinates rapid and precise responses to stimuli using action potentials. The endocrine system maintains homeostasis and long-term control using chemical signals.

The endocrine system works in parallel with the nervous system to control growth and maturation along with homeostasis.

HORMONES

The endocrine system is a collection of glands that secrete chemical messages we call hormones. These signals are passed through the blood to arrive at a target organ, which has cells possessing the appropriate receptor. Exocrine glands (not part of the endocrine system) secrete products that are passed outside the body. Sweat glands, salivary glands, and digestive glands are examples of exocrine glands. Hormones are grouped into three classes based on their structure:

1. steroids
2. peptides
3. amines

1. STEROIDS

Steroids are lipids derived from cholesterol.

Testosterone is the male sex hormone.

Estradiol, similar in structure to testosterone, is responsible for many female sex characteristics.

Steroid hormones are secreted by the gonads, adrenal cortex, and placenta.

2. PEPTIDES AND

3. AMINES

Peptides are short chains of amino acids; most hormones are peptides. They are secreted by the pituitary, parathyroid, heart, stomach, liver, and kidneys. Amines are derived from the amino acid tyrosine and are secreted from the thyroid and the adrenal medulla. Solubility of the various hormone classes varies.

Synthesis, Storage, and Secretion

- 8 Steroid hormones are derived from cholesterol by a biochemical reaction series. Defects along this

series often lead to hormonal imbalances with serious consequences. Once synthesized, steroid hormones pass into the bloodstream; they are not stored by cells, and the rate of synthesis controls them.

- 8 Peptide hormones are synthesized as precursor molecules and processed by the endoplasmic reticulum and Golgi where they are stored in secretory granules. When needed, the granules are dumped into the bloodstream. Different hormones can often be made from the same precursor molecule by cleaving it with a different enzyme.
- 8 Amine hormones (notably epinephrine) are stored as granules in the cytoplasm until needed.

EVOLUTION OF ENDOCRINE SYSTEMS

Most animals with well-developed nervous and circulatory systems have an endocrine system. Most of the similarities among the endocrine systems of crustaceans, arthropods, and vertebrates are examples of convergent evolution. The vertebrate endocrine system consists of glands (pituitary, thyroid, adrenal), and diffuse cell groups secreted in epithelial tissues. More than fifty different hormones are secreted. Endocrine glands arise during development for all three embryologic tissue layers (endoderm, mesoderm, ectoderm). The type of endocrine product is determined by which tissue layer a gland originated in. Glands of ectodermal and endodermal origin produce peptide and amine hormones; mesodermal-origin glands secrete hormones based on lipids.

i. Endocrine Systems and Feedback Cycles

The endocrine system uses cycles and negative feedback to regulate physiological functions. Negative feedback regulates the secretion of almost every hormone. Cycles of secretion maintain physiological and homeostatic control. These cycles can range from hours to months in duration.

ii. Mechanisms of Hormone Action

The endocrine system acts by releasing hormones that in turn trigger actions in specific target cells. Receptors on target cell membranes bind only to one type of hormone.



Download FREE UPSC E-BOOKS

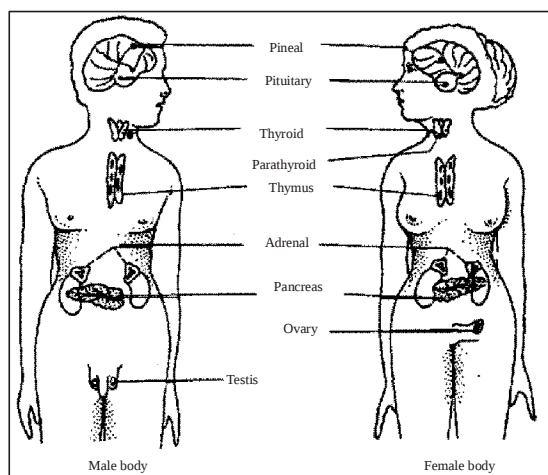
FREE!

CLICK HERE

More than fifty human hormones have been identified; all act by binding to receptor molecules. The binding hormone changes the shape of the receptor causing the response to the hormone. There are two mechanisms of hormone action on all target cells.

iii. Nonsteroid Hormones

Nonsteroid hormones (water soluble) do not enter the cell but bind to plasma membrane receptors, generating a chemical signal (second messenger) inside the target cell. Five different second messenger chemicals, including cyclic AMP have been identified. Second messengers activate other intracellular chemicals to produce the target cell response.



iv. Steroid Hormones

The second mechanism involves steroid hormones, which pass through the plasma membrane and act in a two step process. Steroid hormones bind, once inside the cell, to the nuclear membrane receptors, producing an activated hormone-receptor complex. The activated hormone-receptor complex binds to DNA and activates specific genes, increasing production of proteins.

THE NERVOUS AND ENDOCRINE SYSTEMS

The pituitary gland (often called the master gland) is located in a small bony cavity at the base of the brain. A stalk links the pituitary to the hypothalamus, which controls release of pituitary hormones. The pituitary gland has two lobes: the anterior and posterior lobes. The anterior pituitary is glandular. The hypothalamus contains neurons that control release from the anterior pituitary. Seven hypothalamic hormones are released into a portal system connecting the hypothalamus and pituitary, and cause targets in the pituitary to release eight hormones.

I. ANTERIOR PITUITARY

Growth hormone (GH) is a peptide anterior pituitary hormone essential for growth. GH-releasing hormone

stimulates release of GH. GH-inhibiting hormone suppresses the release of GH. The hypothalamus maintains homeostatic levels of GH. Cells under the action of GH increase in size (hypertrophy) and number (hyperplasia). GH also causes increase in bone length and thickness by deposition of cartilage at the ends of bones. During adolescence, sex hormones cause replacement of cartilage by bone, halting further bone growth even though GH is still present. Too little or too much GH can cause dwarfism or gigantism, respectively. Hypothalamus receptors monitor blood levels of thyroid hormones. Low blood levels of Thyroid-stimulating hormone (TSH) cause the release of TSH-releasing hormone from the hypothalamus, which in turn causes the release of TSH from the anterior pituitary. TSH travels to the thyroid where it promotes production of thyroid hormones, which in turn regulate metabolic rates and body temperatures. Gonadotropins and prolactin are also secreted by the anterior pituitary. Gonadotropins (which include follicle-stimulating hormone, FSH, and luteinizing hormone, LH) affect the gonads by stimulating gamete formation and production of sex hormones. Prolactin is secreted near the end of pregnancy and prepares the breasts for milk production.

II. THE POSTERIOR PITUITARY

The posterior pituitary stores and releases hormones into the blood. Antidiuretic hormone (ADH) and oxytocin are produced in the hypothalamus and transported by axons to the posterior pituitary where they are dumped into the blood. ADH controls water balance in the body and blood pressure. Oxytocin is a small peptide hormone that stimulates uterine contractions during childbirth.

OTHER ENDOCRINE ORGANS

I. THE ADRENAL GLANDS

Each kidney has an adrenal gland located above it. The adrenal gland is divided into an inner medulla and an outer cortex. The medulla synthesizes amine hormones, the cortex secretes steroid hormones. The adrenal medulla consists of modified neurons that secrete two hormones: epinephrine and norepinephrine. Stimulation of the cortex by the sympathetic nervous system causes release of hormones into the blood to initiate the "fight or flight" response. The adrenal cortex produces several steroid hormones in three classes: mineralocorticoids, glucocorticoids, and sex hormones.

Mineralocorticoids maintain electrolyte balance. Glucocorticoids produce a long-term, slow response to stress by raising blood glucose levels through the breakdown of fats and proteins; they also suppress the immune response and inhibit the inflammatory response.



Download FREE UPSC E-BOOKS

FREE!

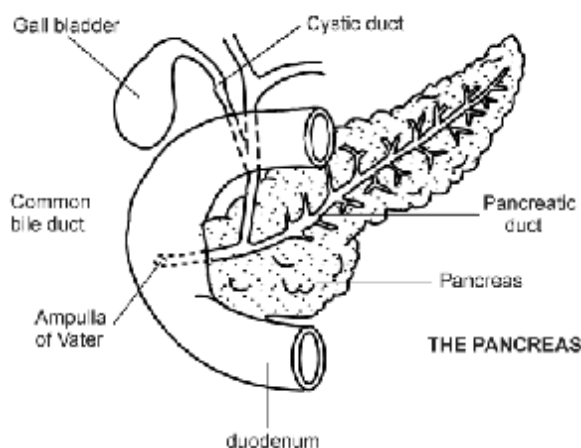
CLICK HERE

II. THE THYROID GLAND

The thyroid gland is located in the neck. Follicles in the thyroid secrete thyroglobulin, a storage form of thyroid hormone. Thyroid stimulating hormone (TSH) from the anterior pituitary causes conversion of thyroglobulin into thyroid hormones T₄ and T₃. Almost all body cells are targets of thyroid hormones. Thyroid hormone increases the overall metabolic rate, regulates growth and development as well as the onset of sexual maturity. Calcitonin is also secreted by large cells in the thyroid; it plays a role in regulation of calcium.

III. THE PANCREAS

The pancreas contains exocrine cells that secrete digestive enzymes into the small intestine and clusters of endocrine cells (the pancreatic islets). The islets secrete the hormones insulin and glucagon, which regulate blood glucose levels.



After a meal, blood glucose levels rise, prompting the release of insulin, which causes cells to take up glucose, and liver and skeletal muscle cells to form the carbohydrate glycogen. As glucose levels in the blood fall, further insulin production is inhibited. Glucagon causes the breakdown of glycogen into glucose, which in turn is released into the blood to maintain glucose levels within a homeostatic range. Glucagon production is stimulated when blood glucose levels fall, and inhibited when they rise. Diabetes results from inadequate levels of insulin. Type I diabetes is characterized by inadequate levels of insulin secretion, often due to a genetic cause. Type II usually develops in adults from both genetic and environmental causes. Loss of response of targets to insulin rather than lack of insulin causes this type of diabetes.

OTHER CHEMICAL MESSENGERS

- 8 Interferons are proteins released when a cell has

been attacked by a virus. They cause neighboring cells to produce antiviral proteins. Once activated, these proteins destroy the virus.

- 8 Prostaglandins are fatty acids that behave in many ways like hormones. They are produced by most cells in the body and act on neighboring cells.
- 8 Pheromones are chemical signals that travel between organisms rather than between cells within an organism. Pheromones are used to mark territory, signal prospective mates, and communicate. The presence of a human sex attractant/pheromone has not been established conclusively.

BIOLOGICAL CYCLES

Biological cycles ranging from minutes to years occur throughout the animal kingdom. Cycles involve hibernation, mating behavior, body temperature and many other physiological processes. Rhythms or cycles that show cyclic changes on a daily (or even a few hours) basis are known as circadian rhythms. Many hormones, such as ACTH-cortisol, TSH, and GH show circadian rhythms. Thyroid secretion is usually higher in winter than in summer. Childbirth is hormonally controlled, and is highest between 2 and 7 AM. Internal cycles of hormone production are controlled by the hypothalamus, specifically the suprachiasmatic nucleus (SCN). According to one model, the SCN is signaled by messages from the light-detecting retina of the eyes. The SCN signals the pineal gland in the brain to signal the hypothalamus, etc.

ENDOCRINES: THE POSTAL SYSTEM OF COMMUNICATION AND CO-ORDINATION

- 8 Hormones are chemical substances manufactured by organs called endocrine glands or ductless glands. Ductless glands are also sometimes called 'exocrine glands'.

ENDOCRINE GLAND OF THE BODY

- 8 Thyroid is situated in the neck in front of the wind pipe. It manufactures two hormones: triiodothyro (T₃) and tetraiodothysonine (T₄), are called tyrosine. Both these hormones contain iodine.
- 8 Hypothyroidism (hypo, 'under')– diminished thyroid activity. Hypothyroidism in childhood gives rise to a conditions called cretinism.



Download FREE UPSC E-BOOKS

FREE!

CLICK HERE

Goiter— is called enlargement of the thyroid gland. It manifests itself as a swelling in the neck. A goiter may be associated with increased, normal or decreased activity of the thyroid gland.

8 Government of India launched the Universal salt iodisation programme in 1986.

Pancreas— the endocrine department of the pancreas is scattered throughout its substance in the form of tiny islands. The islands have been named as 'islets of Langerhans'. The islets have two major type of cells called A and B. The A cells secrete the hormone 'glucagon' while the B cells secrete insulin. Insulin has discovered by Frederick Grand banting and Charles Herbert Best. Reduction on the quantity of effective insulin gives rise to diabetes mellitus (diabetes, siphon, mellitus of honey) commonly called simply diabetes. Food and glucose to be blood, while exercise and insulin remove it.

The six endocrine glands of the body are.

1. Thyroid
2. Pancreas
3. Adrenals
4. Gonads
5. Parathyroids
6. Pituitary

FOOD: THE FUEL AND THE FRAME

- 8 Carbohydrates, fats and proteins are the three classes of chemicals for procuring energy for the human body.
- 8 Starch is the most abundant carbohydrate in the diet. It is obtained largely from cereal and Potatoes. Sugar is also a carbohydrate.
- 8 Some carbohydrates is stored as glycogen in the liver and muscles. Surplus carbohydrate can be converted into fat.

Proteins— are made up of amino acids.

The body itself can manufacture more than half the amino acids from carbohydrate and fat source as well these which the body cannot make must come from food, and are called essential amino acids. Fats-are concentrated sources of energy. They improve palatability of food.

One gram of carbohydrate provides four calories so does one gram of protein.

PROCESSING OF FOOD

- 8 The process of digestion and absorption of food takes place in the alimentary canal.
- 8 The alimentary canal is a 9-metre long tube extending from the hips to the anus-
- 8 Saliva is secreted by a set of three pairs of glands situated near the month. It helps in the process a digestion. It contain an enzyme called 'amylase' which breaks down the starch in food into maltose.
- 8 The food in the stomach is homogenised by the action of the acidic juice. The juice also contains an enzyme called pepsin, which splits proteins into smallest units called peptides.

Small Intestine:— The food, after being digested in the stomach is transferred; but by bit from the stomach into the small intestine. The first portion of the small intestine which the food enters is called the 'duodenum'. Juices from pancreas and gall bladder are discharged into the duodenum.

- 8 Pancreatic juice contains enzymes for digestion of carbohydrates, protein as well as fat.

Bite is an essential supplement to the recreations enzyme for digestion of fats.

- 8 Discharge of Pancreatic and biliary secretions into the intestine is under the control of two hormones: 'secretin' and cholecystokinin'.

Large Intestine (colon)– The absorption of water is an important function.

Region	Juice produces	Enzyme	Enzyme action	Enzyme action
Mouth	Saliva	Amylase	Starch	Maltose
Stomach	Gastric Juice	Pepsin	Proteins	Protein fragments
Duodenum	Pancreatic Juice	Amylase	Starch	Maltose
Duodenum	Pancreatic Juice	Trypsin	Product protein fragments	Small protein fragments
Duodenum	Pancreatic Juice	Chymotrypsin	Product protein fragments	Small protein amino acids fragments and
Duodenum	Pancreatic Juice	Lipase	Fat	Fatty acids and glycerol
Small intestine	—	Disaccharisases	Maltose	Glucose and similar substances
	—	Amnnopeptidose	Lactose ⁺ and Sucrose ⁺⁺	Very fragments and small poling amino acids.
	—	fragments		
	—	Dipeptidase	2-amino acid fragments	Amino acids



Download FREE UPSC E-BOOKS

FREE!

CLICK HERE

KIDNEYS; THE FASCINATING FILTERS

- 8 Kidneys are often described as bean shaped.
- 8 Each kidney is made up of about a million narrow tube-like structures called 'nephrons'. The urine formed by a kidney is a sum total of the urine formed by its nephrons.
- 8 A Nephron consists of a receptacle (Bowman's capsule) enclosing a bunch of capillaries (glomerular) like a closed fist. The glomerulus and Bowman's capsule filter the blood.

Filtration: The glomerular capillaries are fed blood by a blood vessel called 'afferent arteriole' and drained by a narrower blood vessel called the 'efferent arteriole'.

- 8 By secreting acids, the kidneys help in maintaining the acidity of the body fluids constant.
- 8 Urine excreted is the result of these basic processes: filtration, reabsorption and secretion.

- 8 Excessive eating (polyphagia), excessive drinking (polydipsia) and too much of urine (polyuria) are three cardinal symptoms of diabetes. The 'hypothesis' produces a chemical substance called 'antidiuretic hormone (ADH)'. This substance travels in the bloodstream to the kidneys and increases the reabsorption of water so that the blood gets a little thinner.
- 8 The Adrenal gland maintains the regulating salt in the body and is located in an organ lying just over the kidney. As soon as the salt (sodium) concentration becomes just a little less than normal, it releases into the blood stream a substance called 'aldosterone'.
- 8 Renal transplantation or dialysis (artificial kidney) are the supportive measures when the damage to kidney reaches a certain point.

