UNIT IV

Chapter 11

Chemical Coordination and Integration

Chapter Outline

Klotho an anti-aging hormone makes people smart, enhances cognitive abilities and longevity.

Learning Objectives:

- *Understands the positions of the various endocrine glands and their secretions.*
- *Learns the mechanism of hormone action.*
- *Understands the disorders related to hypo and hyper activity of the endocrine glands.*
- *Learns the role of gastro intestinal hormones.*

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While hearing your test marks, some may have anxiety and some may hesitate to hear and some may be worried. Do you know the reasons for such immediate changes? While seeing any unexpected happenings, we get goose bumps. Do you know the reason, why?

These are all due to the biochemical changes happening in our body, Which are created by the endocrine system. The above mentioned biochemical changes are due to the hormone adrenalin (flight, fright and fight hormone).

11.1 Endocrine glands and hormones

Physiological functions of our human body is regulated and coordinated by both neural and endocrine systems. The endocrine system influences the metabolic activities by means of **hormones** (hormone means *to excite*) which are chemical messengers released into the blood and circulated as chemical signals and acts specifically on certain organs or tissues called target organs or target tissues. Hormones may speed up or slow down or alter the activity of the target organs. The hormones secreted do not remain permanently in the blood but are converted by the liver into inactive compounds and excreted by the kidneys.

Hormones are chemical messengers because they act as organic catalysts and coenzymes to perform specific functions in the target organs. The target organs contain receptor molecules either on the surface or within the cell. Although different hormones come in contact with cells, only

the cells that contain receptor molecules specific for the hormone are physiologically activated. A single hormone may have multiple effects on a single target tissue or on different target tissues.

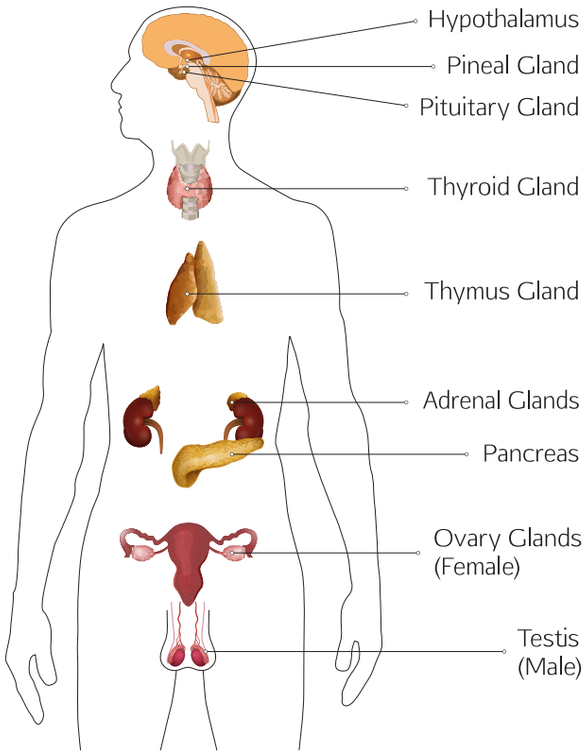


Figure 11.1 Location of various endocrine glands

Many hormones exhibit long term changes like growth, puberty and pregnancy. Hormones often influence many organs and organ systems at the same time. Serious deficiency or excess secretion of hormones leads to disorders. Hormones coordinate different physical, physiological, mental activities and maintain **homeostasis.** Hormones are composed of water soluble proteins or peptides or amines or fat soluble steroids.

Homeostasis: Maintenance of constant internal environment of the body by the different coordinating system.

11.2 Human endocrine system

There are two glandular systems such as the exocrine glands and the endocrine glands. The exocrine glands secrete enzymes, saliva and sweat and have ducts that carry their substances to the membrane surfaces. Example: salivary gland and gastric gland. The endocrine glands, called ductless glands produce hormones and lack ducts; they release their hormone to the surrounding tissue fluid. The hormones circulate around the body and eventually reach the target organs. Endocrine glands (Figure: 11. 1) include the pituitary, thyroid, parathyroid, pineal, adrenal, thymus and are also known as **exclusive endocrine glands**. The hypothalamus along with its neural function also produces hormones and is considered as a **neuro endocrine gland.** In addition several organs such as pancreas, gastro intestinal tract epithelium, kidney, heart, gonads and placenta are also have endocrine tissues and are known as **partial endocrine glands.**

Table 11.1. Chemical nature of hormones

Class	Chemical properties	Example
Amines	Small, water soluble derived from tyrosine or tryptophan	Adrenalin, nor adrenalin, melatonin and thyroid hormone
Protein/Peptides	Water soluble	Insulin, glucagon and pituitary hormones
Steroids	Derived from cholesterol mostly lipid soluble	Cortisol, aldosterone, testosterone, oestrogen, progesterone.

11.2.1 Hypothalamus

Hypothalamus is a small cone shaped structure that projects downward from the brain ending into the pituitary stalk. It interlinks both the nervous system and endocrine system. Though pituitary gland is known as master endocrine glands that controls the other endocrine glands, but it is, in turn controlled by the hypothalamus. Hypothalamus contains groups of neurosecretory cells. It produces neurotransmitters which regulate the secretions of the pituitary (Figure11. 2). The hormones produced by the hypothalamus act either as a releasing hormone or as an inhibitory hormone.

In the basal region of the brain, the **hypothalamic hypophyseal portal blood vessel** connects hypothalamus and anterior pituitary. It allows hypothalamic hormones to control anterior pituitary secretion. The posterior pituitary is connected with hypothalamus by a nerve bundle called **hypothalamic hypophyseal axis**. It produces nerve signal that control the posterior pituitary secretion. Hypothalamus maintains homeostasis, blood pressure, body temperature, cardio and fluid electrolyte balance of the body. As the part of limbic system it influences various emotional responses.

In mammals, the role of pars intermedia is insignificant, but in other vertebrates it secretes **melanocyte stimulating hormone** (MSH). MSH induces pigmentation in skin.

11.2.2 Pituitary gland or Hypophysis

The pituitary gland (means to grow under) is ovoid in shape and is located in the **sella turcica**, a bony cavity of the sphenoid bone at the base of brain and connected to the hypothalamic region of the brain by a stalk called **infundibulum**. It is about one centimetre in diameter and 0.5 gm in weight. The pituitary consists of two lobes, anterior glandular adenohypophysis and posterior neural neurohypophysis. The anterior lobe originates from the embryonic invagination of pharyngeal epithelium called **Rathke's pouch** and the posterior lobe is originates from the base of the brain as an outgrowth of hypothalamus. Anatomically the adenohypophysis has three lobes or zones namely pars intermedia, pars distalis and pars tuberalis. The neurohypophysis is otherwise known as pars nervosa.

Table 11.2 The major hypothalamic hormones and their functions

S.No.	Hormones	Functions
1.	Thyrotropin releasing hormone (TRH)	Stimulates the secretion of TSH
2.	Gonadotropin releasing hormone(GnRH)	Stimulates the secretion of FSH
3.	Corticotropin releasing hormone (CRH)	Stimulates the secretion of ACTH
4.	Growth hormone releasing hormone(GHRH)	Stimulates the secretion of GH
5.	Prolactin releasing hormone (PRH)	Stimulates the secretion of Prolactin
6.	Luteinizing hormone releasing hormone (LHRH)	Stimulates the secretion of LH
7.	MSH releasing hormone	Stimulates the secretion of MSH
8.	Growth hormone-inhibiting hormone (GHIH)	Inhibits the secretion of GH
9.	Prolactin inhibiting hormone (PIH)	Inhibits the secretion of Prolactin
10.	MSH inhibiting hormone	Inhibits the secretion of MSH

The anterior lobe of pituitary secretes six tropic hormones such as growth hormone (GH), thyroid stimulating hormone (TSH), adreno corticotropic hormone (ACTH), follicle stimulating hormone (FSH), luteinizing hormone (LH), luteotropic hormone (LTH) and melanocyte stimulating hormone (MSH) (in lower animals only). The posterior lobe of pituitary secretes the hormones namely vasopressin and oxytocin.

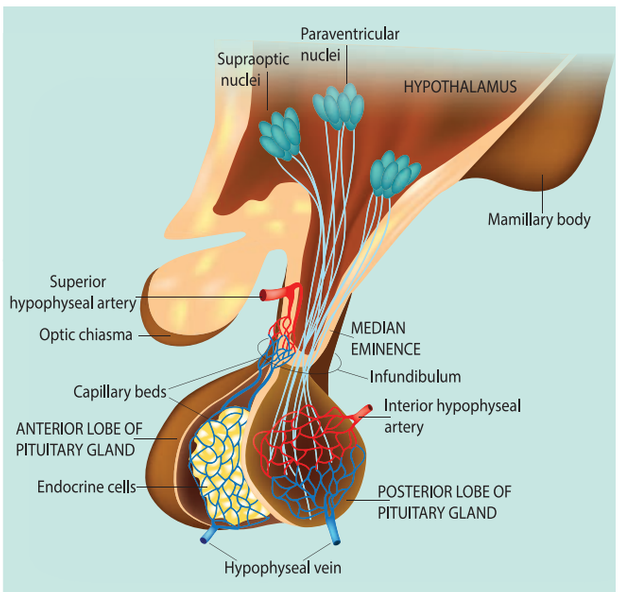


Figure 11. 2 Hypothalamus and pituitary gland

Hormones of Adenohypophysis

i) Growth hormone (GH): It is also known as somatotropic hormone (STH) or Somatotropin. It is a peptide hormone. Growth hormone promotes growth of all the tissues and metabolic process of the body. It influences the metabolism of carbohydrates, proteins and lipids and increases the rate of protein biosynthesis in the cells. It stimulates chondrogenesis (cartilage formation), osteogenesis (bone formation) and helps in the retention of minerals like nitrogen, potassium, phosphorus, sodium etc., in the body. GH increases the release of fatty acid from adipose tissue and decreases the rate of glucose utilization for energy by the cells. Thus it conserves glucose for glucose dependent tissues, such as the brain.

ii) Thyroid stimulating hormone (TSH) or thyrotropin: TSH is a glycoprotein hormone, which stimulates the thyroid gland to secrete Tri-iodothyronine (T_3) and thyroxine (T_4). TSH secretion is regulated by negative feedback mechanism. It's release from the anterior pituitary is induced by the thyrotropin releasing hormone (TRH). When thyroxine level in the blood increases, TRH acts on both the pituitary and hypothalamus to inhibit TSH secretion.

iii) Adreno cortico tropic hormone (ACTH): ACTH is a peptide hormone that stimulates the adrenal cortex to secrete glucocorticoids and mineralocorticoids. It stimulates melanin synthesis in melanocytes, induces the release of fatty acids from adipose tissues and stimulates insulin secretion. ACTH secretion is regulated by **negative feedback mechanism.**

iv) Follicle stimulating hormone (FSH): FSH is a glycoprotein hormone which regulates the functions of the gonads (ovary and testis). In males, FSH along with androgens acts on the germinal epithelium of seminiferous tubules and stimulates the production and release of sperms (spermatogenesis). In females, FSH acts on the ovaries and brings about the development and maturation of graffian follicles.

v) Luteinizing hormone (LH): LH is a glycoprotein hormone which is also known as interstitial cell stimulating

hormone (ICSH). In males, ICSH acts on the interstitial cells of testis to produce the male sex hormone, testosterone. In females, LH along with FSH matures the ovarian follicles. LH independently induces ovulation, maintains the corpus luteum and promotes synthesis and release of ovarian hormones. FSH and LH are collectively referred as gonadotropins. FSH and LH are not produced during childhood. The secretion of FSH and LH starts only during pre pubertal period.

vi) Luteotropic hormone (LTH): LTH is also called luteotropin or lactogenic hormone or prolactin or mammotropin. It is a protein hormone which stimulates milk secretion after the child birth in females. High prolactin secretion during lactation suppresses LH secretion and ovulation since it induces the corpus luteum hence named as luteo tropic hormone.

Hormones of neurohypophysis

i) Vasopressin or antidiuretic hormone (ADH) : ADH is a peptide hormone which promotes reabsorption of water and electrolytes by distal tubules of nephron and thereby reduces loss of water through urine. Hence it is called as anti diuretic hormone. It also causes constriction of blood vessels when released in large amount and increases blood pressure. ADH deficiency causes ***Diabetes insipidus*** which induces the production of large amount of urine.

ii) Oxytocin (means quick birth): It is a peptide hormone which stimulates vigorous contraction of the smooth muscles of uterus during child birth and ejection of milk from the mammary glands.

Vasopressin and oxytocin are composed of nine amino acids and are almost identical and they differ in only **two amino acids** and yet they have dramatically different physiological effects.

Amino acid sequence of **vasopressin**: cysteine-tyrosine-**phenyl alanine**-glutamine-aspargine-cysteine-proline-**arginine**-glycine.

Amino acid sequence of **oxytocin**:cysteine-tyrosine-**isoleu sine**-glutamine-aspargine-cysteine-proline-**leucine**-glycine.

Pituitary gland is located in a depression in the sphenoid bone of skull below the brain, so is also called hypothalamus cerebri. Discuss the following :

a. Pituitary gland is commonly called "master gland" of the body.
b. Discuss the role of hypothalamus and pituitary as a coordinated unit in maintaining physiological processes.
c. How does the posterior lobe of pituitary help in osmoregulation?

11.2.3 Pineal gland

In human, the pineal gland or epiphysis cerebri or conarium is located behind the third ventricle of brain and is formed of parenchymal cells and interstitial cells. It secretes the hormone, **melatonin**, which plays a central role in the regulation of circadian rhythm of our body and maintains the normal sleep wake cycle. It also regulates the timing of sexual maturation of gonads. In addition melatonin also influences metabolism, pigmentation, menstrual cycle and defence mechanism of our body.

DO YOU KNOW?

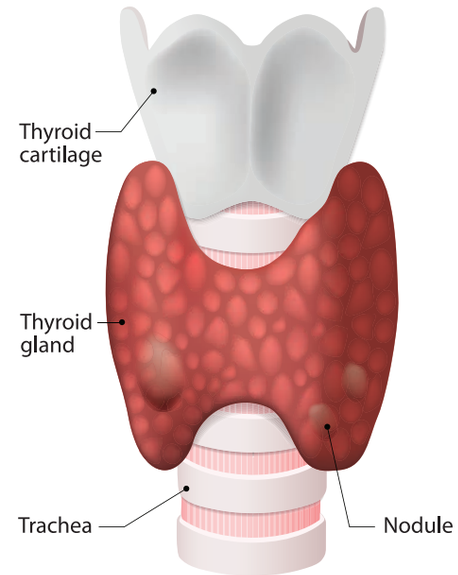
Melatonin is secreted at night, Light falling on the retina of eye decreases melatonin production.

Circadian rhythm is the 24 hour cycle of biological activities associated with natural periods of light and darkness. Example sleep wake cycle, body temperature, appetite etc.

11.2.4 Thyroid gland

The butterfly shaped thyroid gland is a bilobed gland located below the larynx on each side of upper trachea. It is the largest endocrine gland in the body. Its two lateral lobes are connected by a median tissue mass called **isthmus**. Each lobe is made up of many lobules .The lobules consist of follicles called **acini (acinus in singular)**. Each acinus is lined with glandular, cuboidal or squamous epithelial cells. The lumen of acinus is filled with colloid, a thick glycoprotein mixture consisting of thyroglobulin molecules.

Hormones of the thyroid gland are often called the major metabolic hormones. The follicular cells of thyroid gland secrete two hormones namely tri-iodothyronine (T_3) and thyroxine or tetra- iodothyronine (T_4). The parafollicular cells or 'C' cells of thyroid gland secrete a hormone called thyrocalcitonin. Iodine is essential for the normal synthesis of thyroid hormones. Thyroid releasing hormone from the hypothalamus stimulates the adenohypophysis to secrete TSH, which inturn stimulates the thyroid gland to secrete the thyroid hormones. Thyroid hormones show a negative feedback effect on the hypothalamus and pituitary (Figure11. 4).



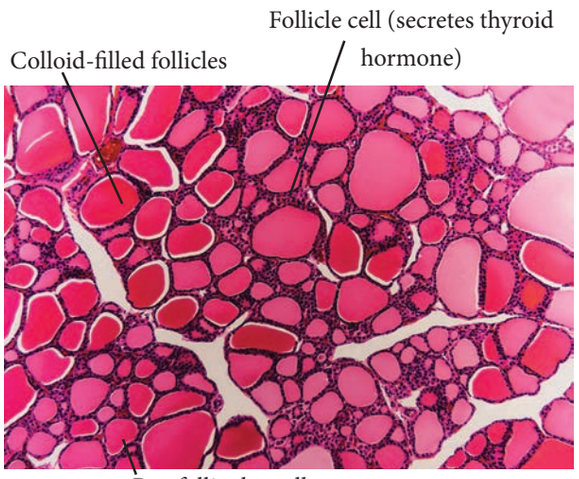


Figure 11. 3 Structures of thyroid gland

Functions of thyroxine or tetra-iodothyronine (T4): Thyroxine regulates the basal metabolic rate (BMR) and body heat production. It stimulates protein synthesis and promotes growth. It is essential for the development of skeletal and nervous system. Thyroxine plays an important role in maintaining blood pressure. It reduces serum cholesterol levels, Optimum levels of thyroxine in blood is necessary for gonadial functions.

Sporodic goitre is a genetic disease and is not caused by iodine or thyroxine deficiency.

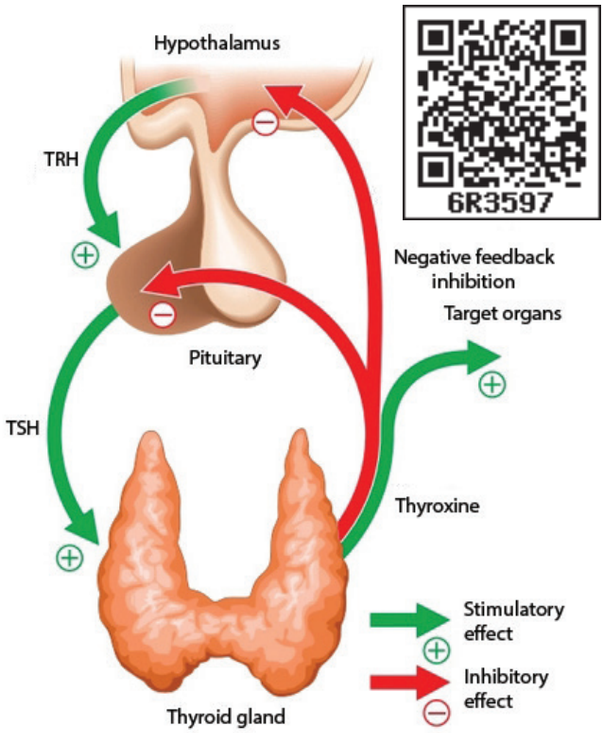


Figure 11.4 Negative feedback mechanism

Functions of thyrocalcitonin (TCT): TCT is a polypeptide hormone, which regulates the blood calcium and phosphate levels. It reduces the blood calcium level and opposes the effects of parathyroid hormone.

Iodine is required for formation of thyroxine: To produce normal quantities of thyroxine, about 1mg/week of iodine is required. To prevent iodine deficiency common table salt is iodised with 1 part sodium iodide to every 1,00,000 parts of sodium chloride

11.2.5 Parathyroid gland

In human, four tiny parathyroid glands are found in the posterior wall of the thyroid glands. This gland is composed of two types of cells, the chief cells and oxyphil cells. The chief cells secrete parathyroid hormone (PTH) and the functions of oxyphil cells are not known.

Parathyroid hormone or Parathormone (PTH)

PTH is a **hypercalcemic hormone**. It is a peptide hormone involved in controlling the calcium and phosphate homeostasis. The secretion of PTH is controlled by calcium level in the blood. It increases the blood calcium level by stimulating osteoclasts to dissolve the bone matrix. As a result calcium and phosphate are released into the blood. PTH enhances the reabsorption of calcium and excretion of phosphates by the renal tubules and promotes activation of vitamin D to increase calcium absorption by intestinal mucosal cells.

11.2.6 Thymus gland

Thymus gland is partially an endocrine and partially a lymphoid organ. It is a bilobed structure located just above the heart and aorta, behind the sternum. It is covered by fibrous capsule and anatomically it is divisible into an outer cortex and an inner medulla. It secretes four hormones such **as thymulin, thymosin, thymopoietin and thymic humoral factor (THF).** The primary function of thymus is the production of immuno competent 'T' lymphocytes which provides cell mediated immunity.

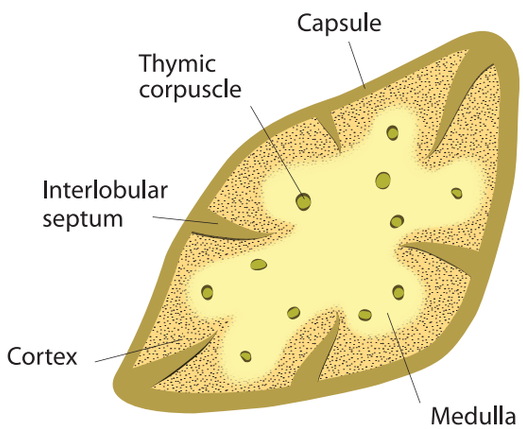


Figure 11.5 Structure of thymus gland

Old age people are sick often, why?
Due to degeneration of thymus gland, thymosine level decreases, as a result the immunity of old age people becomes weak and causes sickness.

11.2.7 Adrenal gland

A pair of adrenal glands are located at the anterior end of the kidneys, hence also called suprarenal glands. Anatomically the outer region is the cortex and the inner region is the medulla. Histologically the adrenal cortex has three distinct zones, zona glomerulosa, zona fasciculata and zona reticularis. **Zona glomerulosa** an outer thin layer constitutes about 15% of adrenal cortex, and secretes mineralocorticoids. **Zona fasciculata**, the middle widest layer constitutes about 75% of adrenal cortex and secretes glucocorticoids such as cortisol, corticosterone and trace amounts of adrenal androgen and oestrogen. **Zona reticularis**, an inner zone of adrenal cortex constitute about 10% of adrenal cortex and secretes the adrenal androgen, trace amount of oestrogen and glucocorticoids.

Laughing is good for health, because it reduces the stress hormone (adrenalin) secretion and makes us to relax.

Adrenal medulla: It is the central part of adrenal gland and is composed of ovoid and columnar cells, which are found around the network of blood capillaries. Adrenalin (epinephrine) and nor adrenalin (nor epinephrine) are the two hormones secreted by the adrenal medulla. Both adrenalin and nor adrenalin are **catecholamines.**

Function of adrenal hormones: **Glucocorticoids** stimulate gluconeogensis, lipolysis and proteolysis (the life saving activity). **Cortisol** is a glucocorticoid involved in maintaining cardio vascular and kidney functions. It produces anti-inflammatory reactions and suppresses the immune response. It stimulates the RBC production. It is also known as stress combat hormone. **Mineralocorticoid**s regulates water and electrolyte balance of our body. **Aldosterone** stimulates the reabsorption of sodium and water and eliminates potassium and phosphate ions through excretion, thus it helps in maintaining electrolytes, osmotic pressure and blood pressure. Adrenal androgen plays a role in hair growth in the axial region, pubis and face during puberty.

The **adrenal medulla** secretes the hormones adrenalin and noradrenalin and are referred as "3F hormone" (fight, flight and fright hormone). Adrenalin increases liver glycogen breakdown into glucose and increases the release of fatty acids from fat cells. During emergency it increases heart beat rate and blood pressure. It stimulates the smooth muscles of cutaneous and visceral arteries to decrease blood flow. It increases blood flow to the skeletal muscles thereby increases the metabolic rate of skeletal muscles, cardiac muscles and nervous tissue.

The general function of noradrenalin is to mobilize the brain and body for action. It's secretion is less during sleep, more during wakefulness and reaches much higher levels during stress situations. This response is known as **'fight or flight'** response.

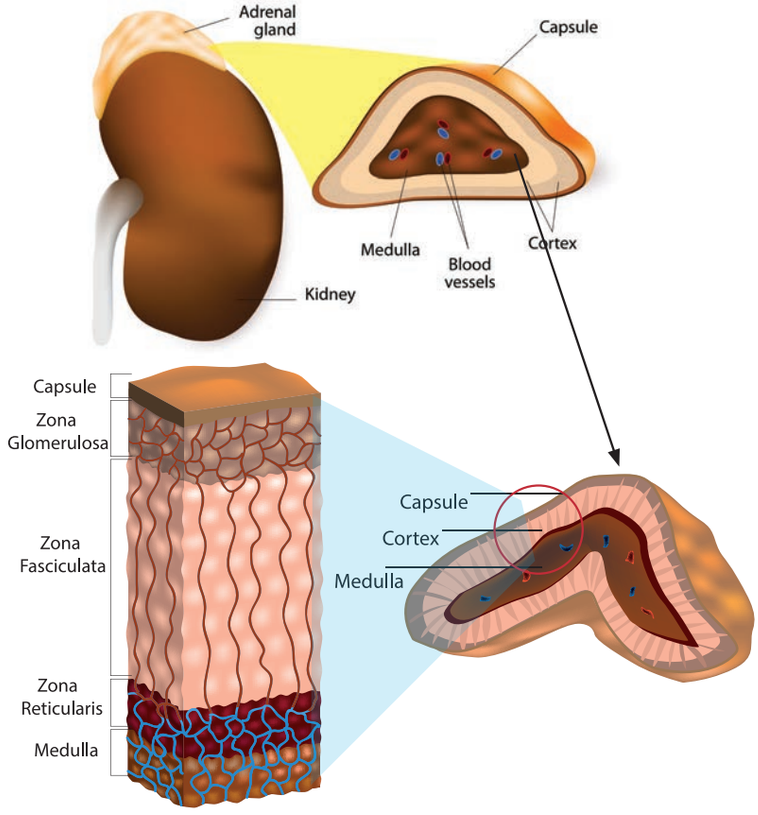


Figure 11.6 Structure of adrenal gland

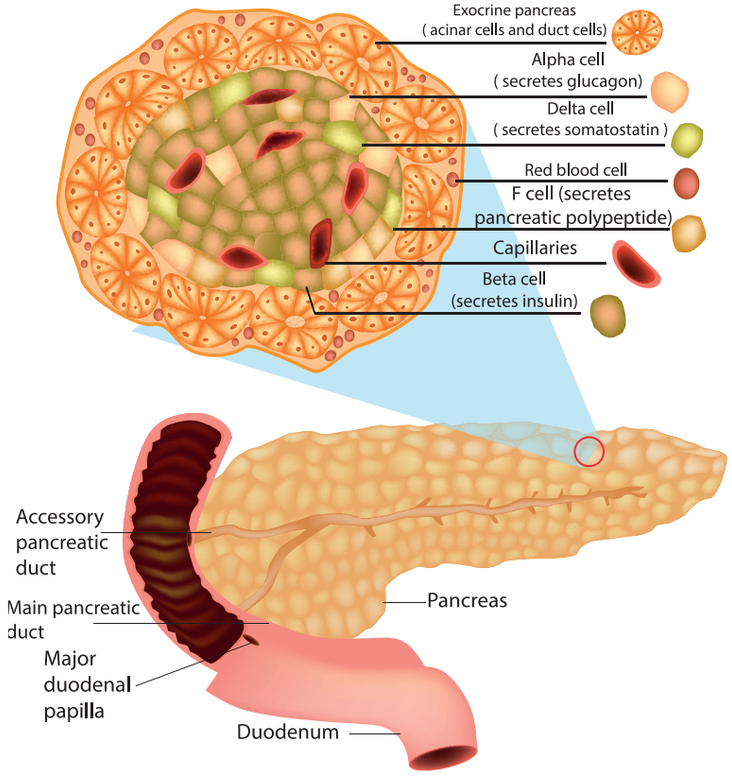


Figure 11.7 Structure of Islets of langerhans (pancreas)

11.2.8 Pancreas

Pancreas is a composite gland which performs both exocrine and endocrine functions. It is located just below the stomach as a leaf like structure. The pancreas is composed of two major tissues such the acini and islets of langerhans. Acini secretes digestive enzymes and the islets of langerhans secretes hormones like insulin and glucagon. Human pancreas has one to two million islets of langerhans. In each islet about 60% cells are beta cells, 30% cells are alpha cells and 10% cells are delta cells. The alpha cells secrete glucagon, the beta cells secrete insulin and delta cells secrete somatostatin.

Insulin: Insulin is a peptide hormone and plays an important role in glucose homeostasis. It's main effect is to lower blood glucose levels by increasing the uptake of glucose into the body cells, especially muscle and fat cells. Insulin also inhibits the breakdown of glycogen to glucose, the conversion of amino acids or fats to glucose, so insulin is rightly called a hypoglycemic hormone.

Glucagon: Glucagon is a polypeptide hormone. It is a potent hyperglycemic hormone that acts on the liver and promotes the breakdown of glycogen to glucose (Glygogenolysis), synthesis of glucose from lactic acid and from non-carbohydrate molecules (Gluconeogenesis). Glucagon releases glucose from the liver cells, increasing the

blood glucose levels. Since glucagon reduces the cellular uptake and utilisation of glucose it is called a hyperglycemic hormone. Prolonged hyperglycemia leads to the disorder called diabetes mellitus.

Humulin N: Human insulin is produced by recombinant DNA technology (genetic engineering) and administered to diabetic patients as injection and not by oral consumption. Reason: Digestive enzymes digest it.

Insulin: The half life period of insulin (in plasma) is 6 minutes

It is cleared from the circulation within 10-15 minutes

Endocrine glands control and coordinate the body functions through secreting certain chemical messengers called hormones. Due to certain physiological reasons, the blood glucose level of an otherwise normal person.

a. Give the possible cause for the increases in blood glucose level.

b. What is the chemical nature of this hormone? Discuss its role in the body.

c. How can this condition be reversed?

11.2.9 Gonads

Testis: A pair of testis is present in the scrotal sac of males. The testis functions as a sex organ and also as an endocrine gland. The testis is composed of seminiferous tubules and interstitial cells or Leydig cells. The Leydig cells secrete several male sex hormones, collectively called androgens, mainly testosterone.

Functions of testosterone: Under the influence of FSH and LH, testosterone initiates maturation of male reproductive organs, and the appearance of secondary sexual characters, muscular growth, growth of facial and axillary hair, masculine voice and male sexual behaviour. It enhances the total bone matrix and plays a stimulating role in the process of spermatogenesis.

Ovary: Females have a pair of ovaries located in the pelvic region of the abdomen. The ovary is composed of ovarian follicles and stromal tissues. It produces the eggs or ova. The ovaries secrete the steroid hormones oestrogen and progesterone. **Oestrogen** is responsible for the maturation of reproductive organs and the development of secondary sexual characters at puberty. Along with progesterone, oestrogens promotes breast development and initiate the cyclic changes during menstrual cycle. **Progesterone** prepares the uterus for implantation of the fertilized ovum. It decreases the uterine contraction during pregnancy and stimulates the development of mammary glands and milk secretion. It is responsible for premenstrual changes in the uterus and is essential for the formation of placenta.

Identify the peaks of FSH, LH, Oestrogen and Progesterone hormones through out the menstrual cycle.

Urine pregnancy test is done to test the presence of Human Chorionic Gonadotrophin (HCG) in the urine. HCG can be detected in the urine one or two weeks after conception.

11.2.10 Hormones of heart, kidney and gastro intestinal tract

Some tissues of the heart, kidney and gastro intestinal tract acts as partial endocrine glands. In the heart, cardiocytes on the atrial wall's secretes an important peptide hormone called atrial natriuretic factor (ANF). When blood pressure is increased, ANF is secreted and causes dilation of the blood vessels to reduce the blood pressure.

In kidneys, hormones such as renin, erythropoietin and calcitriol are secreted. **Renin** is secreted by juxta glomerular cells (JGA), which increases blood pressure when angiotensin is formed in blood. **Erythropoietin** is also secreted by the JGA cells of the kidney and stimulates erythropoiesis (formation of RBC) in bone marrow. **Calcitriol** is sercreted by proximal tubules of nephron. It is an active form of vitamin D_3 which promotes calcium and phosphorus absorption from intestine and accelerates bone formation.

Gastro intestinal tract hormones

Group of specialized endocrine cells present in gastro-intestinal tract secretes hormones such as gastrin, cholecystokinin (CCK), secretin and gastric inhibitory peptides (GIP). **Gastrin** acts on the gastric glands and stimulates the secretion of HCl and pepsinogen. **Cholecystokinin (CCK)** is secreted by duodenum in response to the presence of fat and acid in the diet. It acts on the gall bladder to release bile into duodenum and stimulates the secretion of pancreatic enzymes and its discharge. **Secretin** acts on acini cells of pancreas to secrete bicarbonate ions and water to neutralize the acidity. **Gastric inhibitory peptide (GIP)** inhibits gastric secretion and motility.

11.3 Hypo and Hyper activity of endocrine glands and related disorders

The hyper secretion and hypo secretion of hormones leads to several disorders

Dwarfism is due to hyposecretion of growth hormone (GH) in children, skeletal growth and sexual maturity is arrested. They attain a maximum height of 4 feet only (Figure 11.8).

Figure 11.8 Dwarfism

Gigantism is due to hypersecretion of growth hormone (GH) in children. Overgrowth of skeletal structure occurs (up to 8 feet) and the visceral growth is not appropriate with that of limbs. Figure 11.9.

Acromegaly is due to excessive secretion of growth hormone in adults. Over growth of hand bones, feet bones, jaw bones, malfunctioning of gonads, enlargement of viscera, tongue, lungs, heart, liver, spleen and endocrine gland like thyroid, adrenal etc., are the symptoms of acromegaly. (Figure 11.10)

Figure 11.9 Gigantism

Figure 11.10 Acromegaly

In infants, hypothyroidism causes **cretinism.** A cretin shows retarded skeletal growth, absence of sexual maturity, retarded mental ability, thick wrinkled skin, protruded enlarged tongue, bloated face, thick and short limbs occurs. The other symptoms are low BMR, slow pulse rate, subnormal body temperature and elevated blood cholesterol levels. (Figure 11.11)

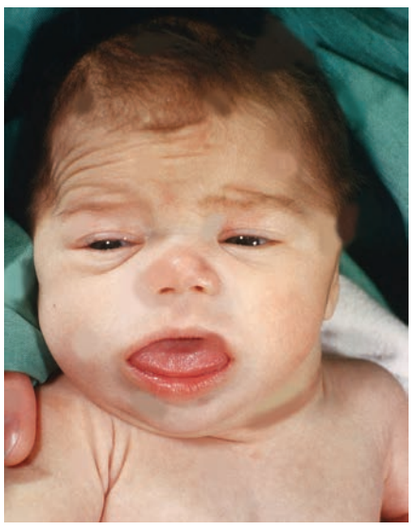


Figure 11.11 Cretinism

Hyposecretion of thyroid in adults causes **myxodema**. It is otherwise called **Gull's disease**. This disease is characterised by decreased mental activity, memory loss, slowness of movement, speech, and general weakness of body, dry coarse skin, scarce hair, puffy appearance, disturbed sexual function, low BMR, poor appetite, and subnormal body temperature. (Figure 11.12)

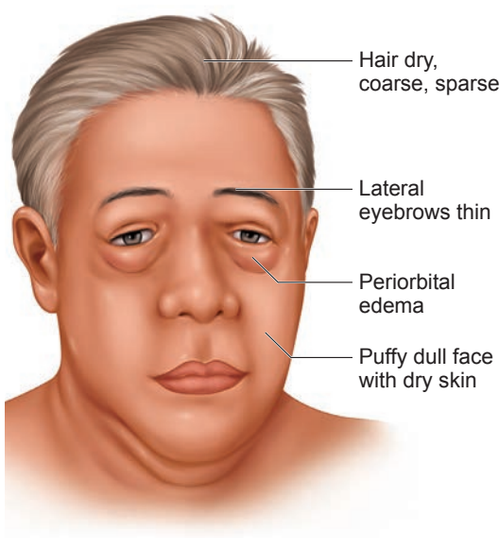


Figure 11.12 Myxodema

Grave's disease also called as **thyrotoxicosis** or **exophthalmic goitre**. This disease is caused due to hyper

secretion of thyroid. It is characterised by enlargement of thyroid gland, increased BMR (50% - 100%), elevated respiratory and excretory rates, increased heart beat, high BP, increased body temperature, protrusion of eyeball and weakness of eye muscles and weight loss. (Figure 11.13)

Figure 11.13 Grave's disease

Simple goitre is also known as **Endemic goitre**. It is caused due to hyposecretion of thyroxine. The symptoms includes enlargement of thyroid gland, fall in serum thyroxine level, increased TSH secretion. (Figure 11.14)

Figure 11.14 Simple goitre

Tetany is caused due to the hyposecretion of parathyroid hormone (PTH). Due to hyposecretion of PTH serum calcium level decreases (Hypocalcemia), as a result serum phosphate level increases. Calcium and phosphate excretion level decreases. Generalized convulsion, locking of jaws increased heart beat rate, increased body temperature, muscular spasm are the major symptoms of tetany.

Hyperparathyroidism is caused due to excess PTH in blood. Demineralisation of bone, cyst formation, softening of bone, loss of muscle tone, general weakness, renal disorders are the symptoms of hyperparathyroidism.

Addison's disease is caused due to hyposecretion of glucocorticoids and mineralocorticoids from the adrenal cortex. Muscular weakness, low BP., loss of appetite, vomiting, hyper pigmentation of skin, low metabolic rate, subnormal temperature, reduced blood volume, weight loss are the symptoms that occur in Addison's disease (Figure 11.15). Reduced aldosterone secretion increases urinary excretion of Na Cl. and water and decreases potassium excretion leading to dehydration.

Figure 11.15 Addison's disease

Cushing's syndrome is caused due to excess secretion of cortisol. Obesity of the face and trunk, redness of face, hand, feet, thin skin, excessive hair growth, loss of minerals from bone (osteoporosis) systolic hypertension are features of Cushing's syndrome. Suppression of sexual function like atrophy of gonads are the other symptoms of Cushing's syndrome. (Figure 11.16)

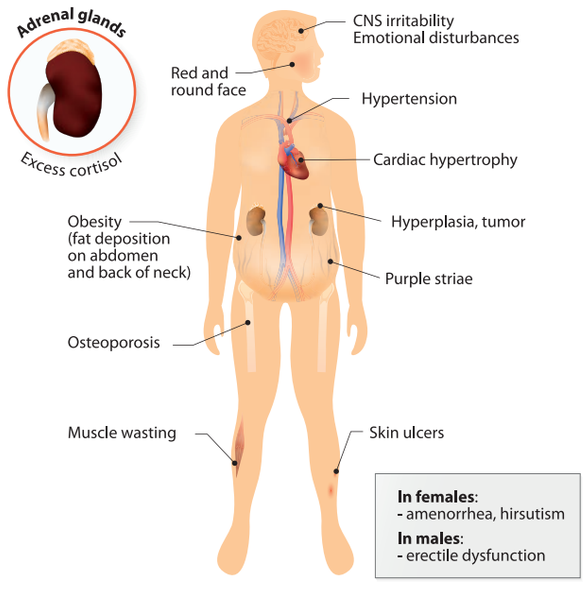


Figure.11.16 Cushing's syndrome

Hypoglycaemia is due to increased secretion of insulin thereby blood glucose level decreases. In this disorder blood glucose level lowers than normal fasting index. Increased heartbeat, weakness, nervousness, headache, confusion, lack of co-ordination, slurred speech, serious brain defects like epilepsy and coma occurs.

Normal blood glucose level:

Preprandial : 70 – 110 mg/dl (Before food) – (Fasting)

Postprandial : 110 – 140 mg/dl (About two hours after food)

Hyperglycaemia is otherwise known as **Diabetes mellitus**. It is caused due to reduced secretion of insulin. As the result, blood glucose level is elevated. Diabetes mellitus is of two types, **Type I Diabetes** and **Type II Diabetes**. Type I diabetes is also known Insulin dependent diabetes, caused by the lack of insulin secretion due to illness or viral infections. Type II diabetes is also known as Non- Insulin dependent diabetes, caused due to reduced sensitivity to insulin, often called as insulin resistance. Symptoms of diabetes includes, polyurea (excessive urination), polyphagia (excessive intake of food), polydipsia (excessive consumption liquids due to thirst), ketosis (breakdown of fat into glucose results in accumulation of ketone bodies) in blood. Gluconeogenesis (Conversion of non- carbohydrate form like amino acids and fat into glucose) also occur in diabetes.

Avoid use of synthetic soft drinks

The branded soft drinks damage our endocrine system. While consuming soft drinks, the sugar level increases in blood which leads to elevated insulin secretion to reduce the blood glucose level. The elevated insulin level diminishes immunity and cause obesity, cardio-vascular disorders etc.

Diabates insipidus is caused due to hyposecretion of vasopressin (ADH) from neurohypophysis. The symptom includes frequent urination (polyurea) and excessive consumption of liquids due to thirst (polydipsia).

11.4 Mechanism of hormone action

Hormones circulate in the blood but their concentration can increase or decrease based on the requirement of the body. This is controlled by feedback mechanisms. These mechanisms control the secretion of endocrine glands by stimulating the hypothalamus, pituitary or both, which inturn governs the secretion of a particular hormone. In positive feedback, the secretion of the hormone increases where as in negative feedback further secretion of hormone slows down. Feedback mechanisms are the key factors for maintaining homeostasis in our body.

Hormones are classified into three major groups as peptide hormones, steroid hormones and amino acid derived hormones based on their chemical structure.

Peptide hormones cannot cross the phospolipid cell membrane and bind to the receptors on the exterior cell surface. They are are transported to the golgi, which is the site of modification. It acts as a **first messenger** in the cell. Hormones on binding to their receptors do not enter the target cell but generate the production of **second messengers** such as cyclic AMP (c AMP), which in turn regulates cellular metabolism. This is catalyzed by the enzyme **adenylate cyclase**. The interaction between the hormone at the surface and the effect brought out by cAMP within the cell is known as signaling cascade. At each step there is a possibility of amplification. (Figure 11.17)

1. One hormone molecule may bind to multiple receptor molecules before it is degraded.
2. Each receptor may activate several adenylate cyclases each of which make much c AMP.
3. Thus there is more signal after each step.

The actions of cAMP are terminated by phosphodiesterases. The effect of peptide hormones like insulin, glucagon, somatotropin are usually short lived because they work through second messenger system.

Steroid hormones can easily cross the cell membrane, and bind to their receptors, which are intracellular or intranuclear. Upon binding to the receptors, they pair up with another receptor – hormone complex (dimerize).This dimer can then bind to DNA and alter its transcription. (Figure 11.18)

The effect of steroid hormones such as aldosterone, oestrogen, FSH are long lived, as they alter the amount of mRNA and protein in a cell.

Amino acid derived hormones are derived from one or two aminoacid with a few additional modifications. Thyroid hormone is synthesised from tyrosine and includes the addition of several

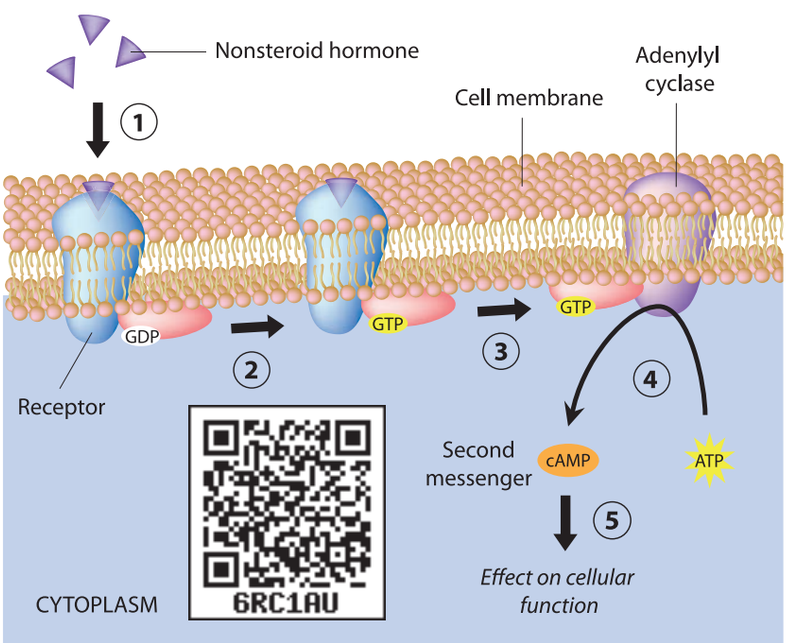


Figure 11.17 Mechanism of peptide hormone action

iodine atoms. Epinephrine an amino acid derivative may function through second messenger system like peptide hormones or they may actually enter the cell and function like steroid hormones.

Avoid use of steroid components

The abuse of anabolic steroids can cause serious health problems like high BP, heart diseases, liver damage, cancer, stroke and blood clots. Other side effects of steroid use includes nausea, vomiting, ligament and tendon injuries, head ache, joint pain, muscle cramps, diarrhoea, sleep problem etc.

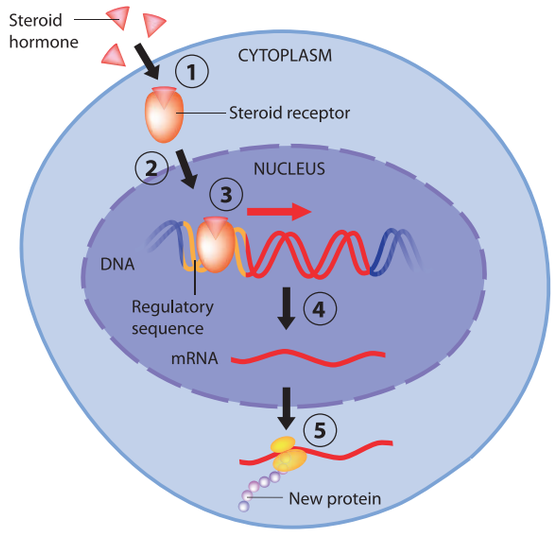


Figure 11.18 Mechanism of steroid hormone action

Summary

Endocrine glands: secrete hormones which diffuse into blood and induce the target organs. They are chemical messengers or organic catalysts which interact with receptor in the target organs.

Hormones speed up or slow down or alter the activities of target organs. The hypo or hyper secretion of hormones leads to serious effects on human beings. Hormones coordinate different physical and mental activities to maintain homeostasis.

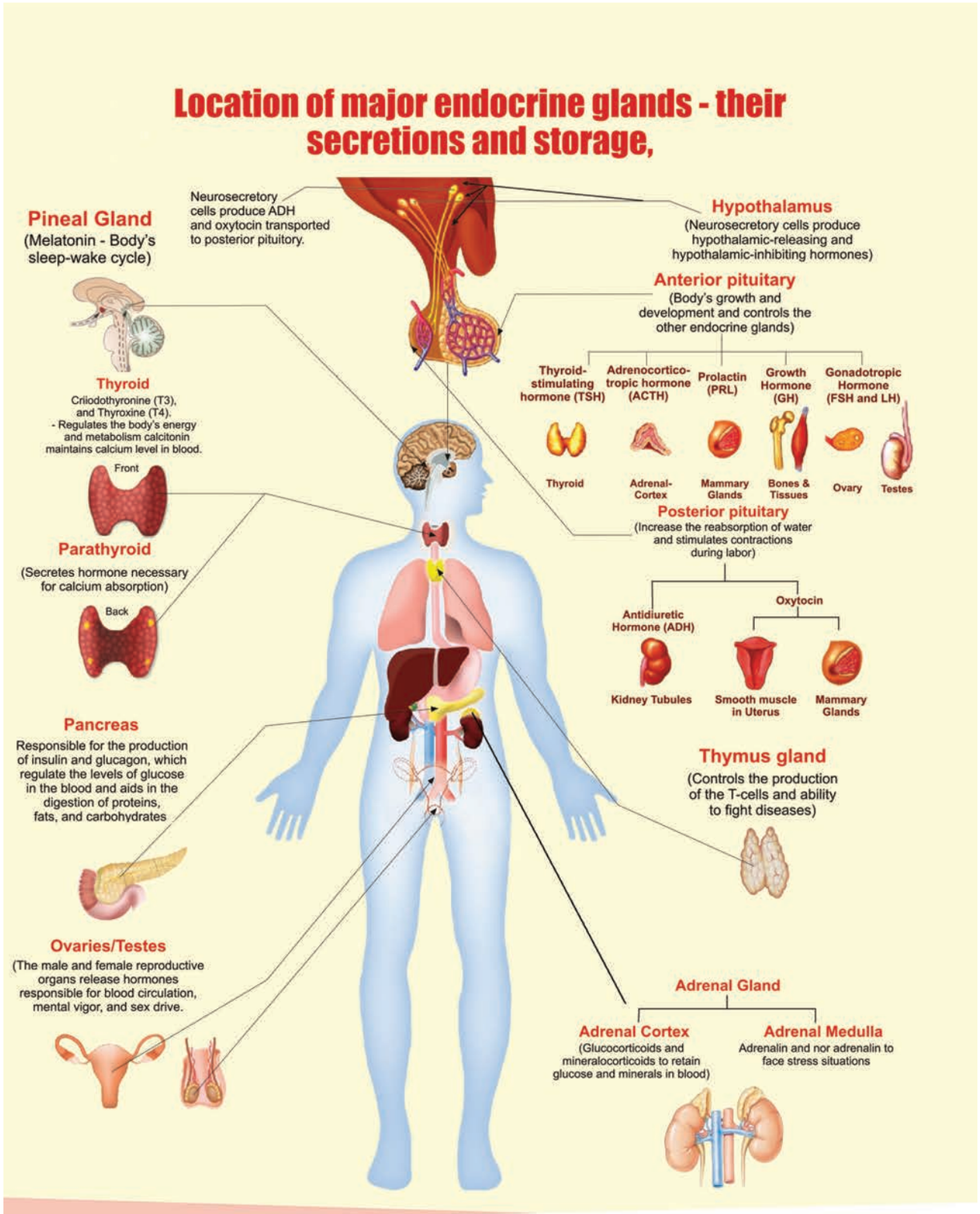
Hypothalamus interlinks nervous system and endocrine system. It is located in the diencephalon of cerebrum and controls the pituitary secretion. Pituitary gland secretes six tropic hormones which regulates various physiological functions of our body. Posterior pituitary gland secretes vasopressin that regulates water and electrolyte balance. Oxytocin helps during child birth. Melatonin secreted by pineal gland regulates circadian rhythm of our body. The thyroid gland secretes thyroxine which stimulates the nervous system, skeletal growth, and regulates basal metabolic rate.

Parathyroid gland regulates calcium level in our body. Thymus gland plays a vital role in cell mediated immunity by promoting T lymphocytes maturation. Pancreas regulates blood glucose homeostasis through its secretion of insulin and glucagon.

Adrenal cortex secretes mineralocorticoids which regulates mineral metabolism, glucocorticoids regulates carbohydrate metabolism. Adrenal medulla secretes the hormones adrenalin and noradrenalin. In male, reproductive functions are controlled by testosterone secreted by the testis. In female, ovary secretes three hormones oestrogen, progesterone and relaxin that regulates reproductive functions.

Hormonal deficiency causes serious harmful effects in human. It alters physiological and biochemical functions of the body. This leads into various disorders like acromegaly, dwarfism, tetany, diabetes etc.

Location of major endocrine glands - their secretions and storage,



Hypothalamus found deep inside the brain, its products are releasing and inhibiting hormones and controls the pituitary. Together, the hypothalamus and pituitary control the other endocrine glands in our body to make the hormones that control and co-ordinates various physical and physiological activities.

Evaluation

4HILBV

1. The maintenance of constant internal environment is referred as
   a. Regulation
   b. homeostasis
   c. co-ordination
   d. hormonal control
2. Which of the following are exclusive endocrine glands?
   a. Thymus and testis
   b. adrenal and ovary
   c. parathyroid and adrenal
   d. pancreas and parathyroid
3. Which of the following hormone is not secreted under the influence of pituitary gland?
   a. thyroxine b. insulin
   c. oestrogen d. glucocorticoids
4. Spermatogenesis in mammalian testes is controlled by
   a. Luteinising hormone
   b. Follicle stimulating hormone
   c. FSH and prolactin
   d. GH and prolactin
5. Serum calcium level is regulated by
   a. Thyroxine b. FSH
   c. Pancreas d. Thyroid and parathyroid
6. Iodised salt is essential to prevent
   a. rickets b. scurvy
   c. goitre d. acromegaly
7. Which of the following gland is related with immunity?
   a. Pineal gland b. adrenal gland
   c. thymus d. parathyroid gland
8. Which of the following statement about sex hormones is correct?
   a. Testosterone is produced by Leydig cells under the influence of luteinizing hormone
   b. Progesterone is secreted by corpus luteum and softens pelvic ligaments during child birth
   c. Oestrogen is secreted by both sertoli cells and corpus luteum
   d. Progesterone produced by corpus luteum is biologically different from the one produced by placenta.
9. Hypersecretion of GH in children leads to
   a. Cretinism b. Gigantism
   c. Graves disease d. Tetany
10. A pregnant female delivers a baby who suffers from stunted growth, mental retardation, low intelligence quotient and abnormal skin. This is the result of
    a. Low secretion of growth hormone
    b. Cancer of the thyroid gland
    c. Over secretion of pars distalis
    d. Deficiency of iodine in diet.
11. The structure which connects the hypothalamus with anterior lobe of pituitary gland is the
    a. Dendrites of neuro hypophysis
    b. Axons of neurohypophysis
    c. Bands of white fibers from cerebellar region
    d. Hypophysial portal system
12. Which one of the following statement is correct
    a. Calcitonin and thymosin are thyroid hormones
    b. Pepsin and prolactin are secreted in stomach
    c. Secretin and rhodopsin are polypeptide hormones
    d. Cortisol and aldosterone are steroid hormones
13. which of the given option shows all wrong statements for thyroid gland

    Statements

    (i) It inhibits process of RBC formation

(ii) It helps in maintenance of water and electrolytes

(iii) Its more secretion can reduce blood pressure

(iv) It Stimulates osteoblast

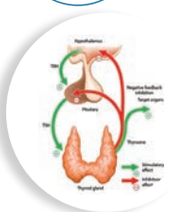
(a) (i) and (ii) (b) (iii) and (iv)

(c) (i) and (iv) (d) (i) and (iii)

14. Comment on homeostasis.
15. Hormones are known as chemical messenger. Justify.
16. Write the role of oestrogen in ovulation.
17. Comment on Acini of thyroid gland.
18. Write the causes for diabetes mellitus and diabetes insipidus.
19. Specify the symptoms of acromegaly.
20. Write the symptoms of cretinism.
21. Briefly explain the structure of thyroid gland.
22. Name the layers of adrenal cortex and mention their secretions.
23. Differentiate hyperglycemia from hypoglycemia.
24 Write the functions of (CCK) Cholecystokinin.
25. Growth hormone is important for normal growth. Justify the statement.
26. Pineal gland is an endocrine gland, write its role.
27. Comment on the functions of adrenalin.
28. Predict the effects of removal of pancreas from the human body.
29. Enumerate the role of kidney as an endocrine gland.
30. Write a detailed account of gastro intestinal tract hormones.

ICT Corner

Endocrine system



Let's explore the position and functions of **Endocrine system.**

Step – 1 Use the URL to land in the Endocrine system page.

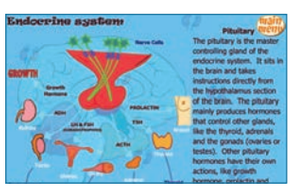
Step – 2 Click on the gland to find out the position and functions of the gland.

Step – 3 Click on the Hormone name to get additional details about it.

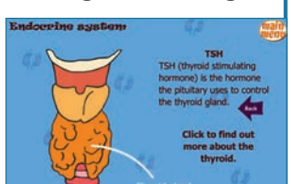
Step – 4 Click the main menu on the top right corner to search back and go through the next gland.

Step 1

Step 2



Step 3



Step 4

Endocrine system's URL:

http://www.e-learningforkids.org/health/lesson/endocrine-system/

* Pictures are indicative only

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