BIOLOGY

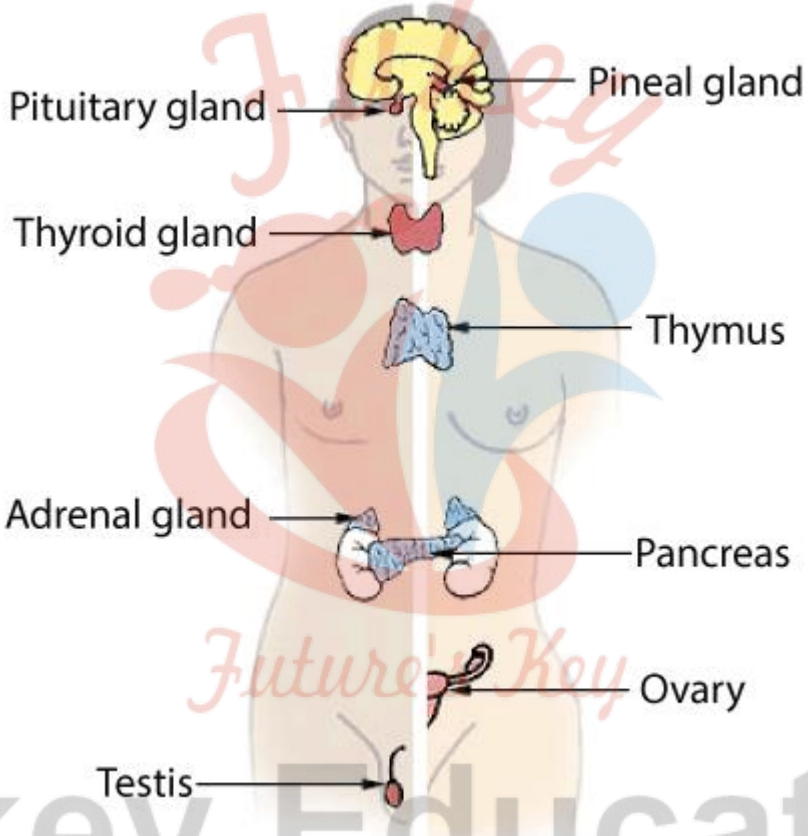
Chapter 19: Chemical Coordination and Integration

CHEMICAL COORDINATION AND INTEGRATION

Control and coordination

In animals, control and coordination is performed by neural system and endocrine system jointly. As the nerve fibers do not innervate all cells of the body, the endocrine system is required to coordinate the functions.

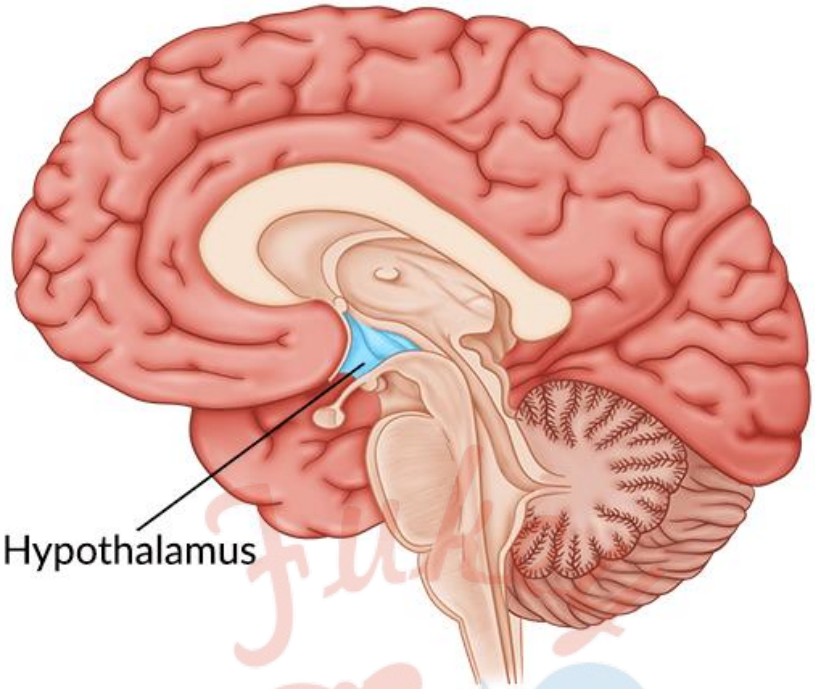
Endocrine Glands.



Endocrine glands are ductless glands. They release their secretion directly into blood which is then transported to specific target organs to initiate a particular metabolic change. The endocrine glands secrete chemicals called hormones. Hormones are non-nutrient chemicals which act as intercellular messengers and are produced in trace amount.

Human Endocrine System: The endocrine glands and hormone producing tissues/ cells are located in different parts of the body. Gastrointestinal tract, kidney, liver, and heart also produce small quantity of hormones to control and coordinate the function of respective organs.

Hypothalamus



Hypothalamus contains several groups of neurosecretory cells called nuclei which produce hormones. Hormones released by Hypothalamus regulate the synthesis and secretion of pituitary hormones.

Hypothalamus produces two types of Hormones:

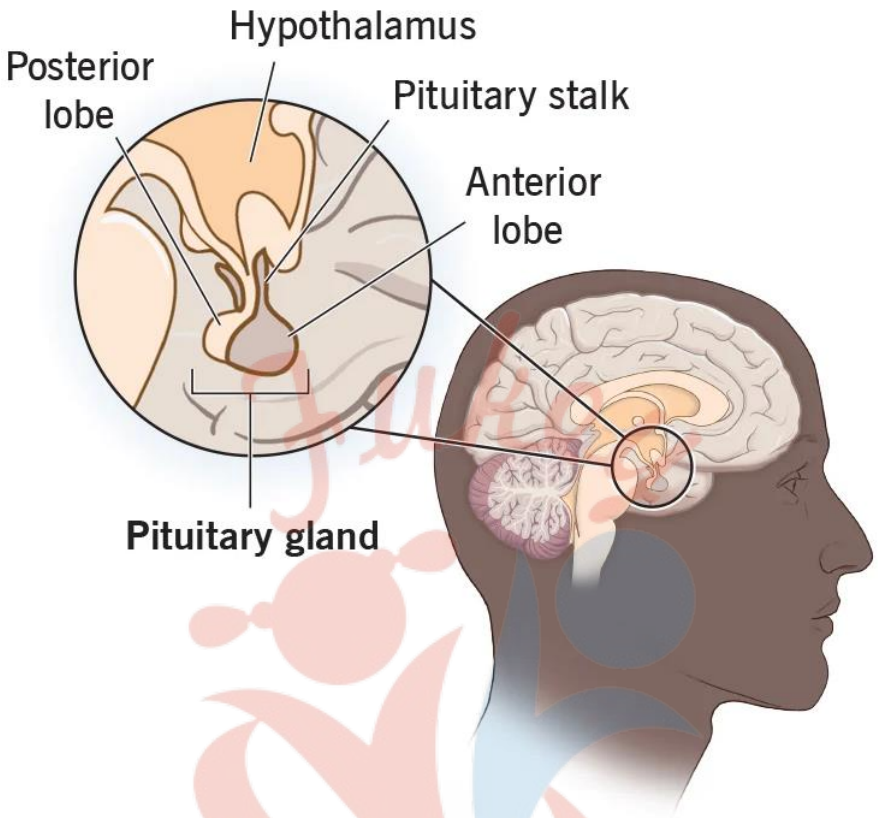
- Releasing hormones (Gonadotrophin releasing hormones GnRH)
- Inhibiting hormones (Somatostatin)

The hormones released from hypothalamus reaches the anterior pituitary through portal circulatory system and regulate its function.

The posterior pituitary is under direct control of hypothalamus.

Pituitary Gland

Pituitary Gland



Pituitary Gland is located in sella tursica, a bony cavity. It is attached to the hypothalamus by a stalk.

Pituitary Gland are divided into two parts:

- Adenohypophysis.
- Neurohypophysis/ posterior pituitary (oxytocin, vasopressin).

Adenohypophysis are divided into two parts:

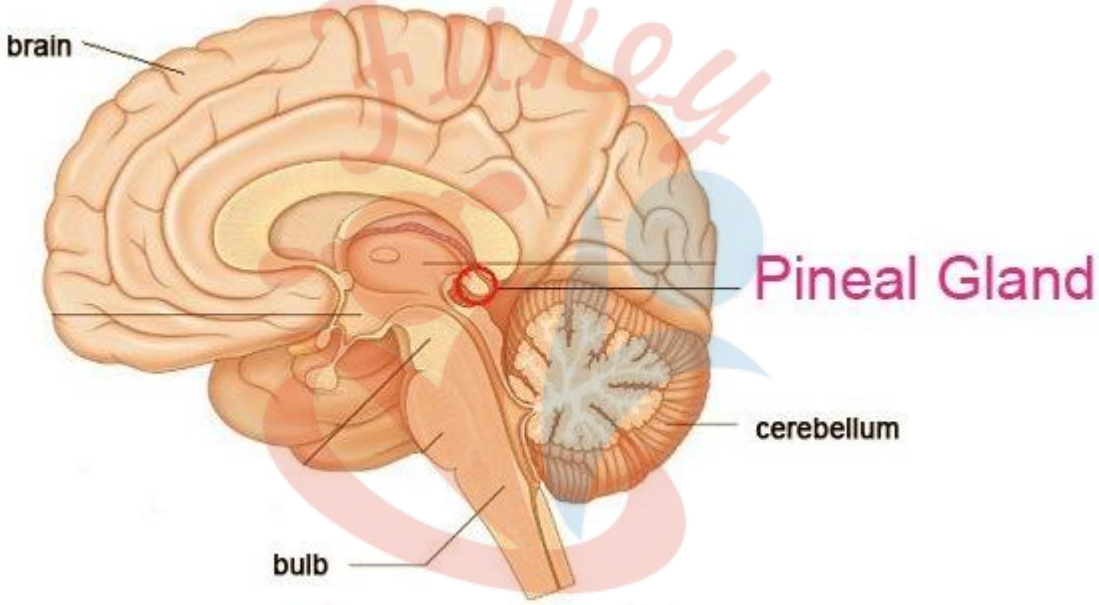
- Pars distalis/ Anterior pituitary (GH, Prolactin, TSH, ACTH, LH & FSH)
- Para intermedia (Melanocyte stimulating hormone)

Pituitary gland:

- Excess secretion of Growth Hormone causes overgrowth of the body leading to gigantism and low secretion causes stunted growth called dwarfism.
- Prolactin stimulates growth of mammary gland and production of milk.
- TSH stimulates production and release of thyroid hormone.

- LH and FSH stimulate activity of the gonads. In male, LH stimulates synthesis and secretion of androgen hormone from testis. In female, LH induces ovulation of fully mature ovum from ovary.
- Oxytocin helps in contraction of uterus during childbirth and milk ejection from mammary glands.
- Vasopressin stimulates absorption of water and electrolyte in kidney.
- MSH acts on the melanocytes and regulates skin pigmentation.

The pineal Gland



The pineal Gland located on dorsal side of forebrain and release melatonin hormone that helps to regulate diurnal rhythm of body like sleeps wake cycle and body temperature.

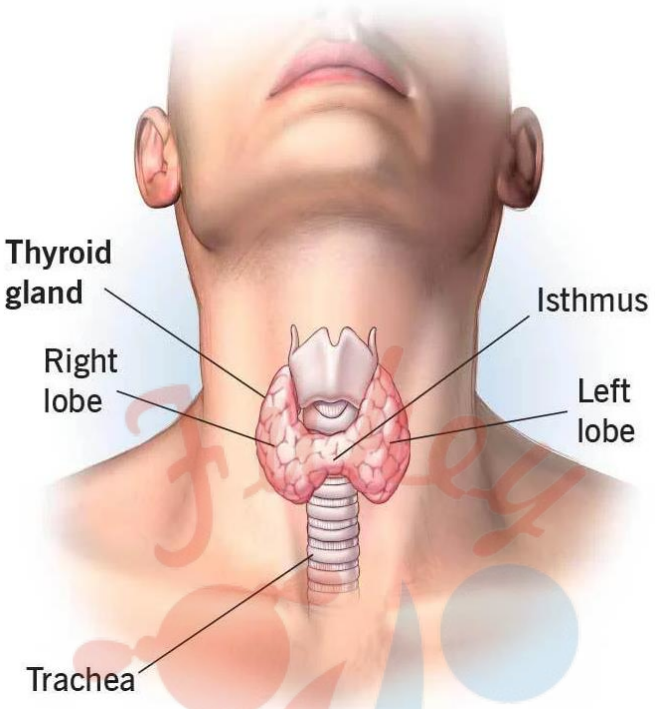
Thyroid Gland

It is composed of two lobes on either side of trachea connected by isthmus.

Thyroid gland is made of follicles and stromal tissues:

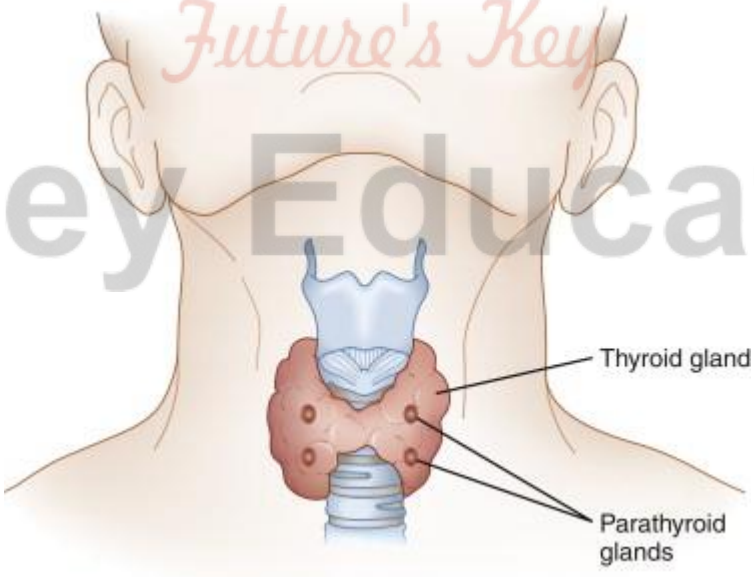
- Iodine is essential for synthesis of thyroid hormones. Deficiency of iodine leads to hypothyroidism (Goiter). During pregnancy, hypothyroidism may cause stunted growth of baby and mental retardation.
- Thyroid hormones regulate the basal metabolic rate. They support the process of red blood cell formation. They control the metabolism of carbohydrates, proteins and fats. Thyrocalcitonin hormone regulates blood calcium levels.

Thyroid



Parathyroid Gland

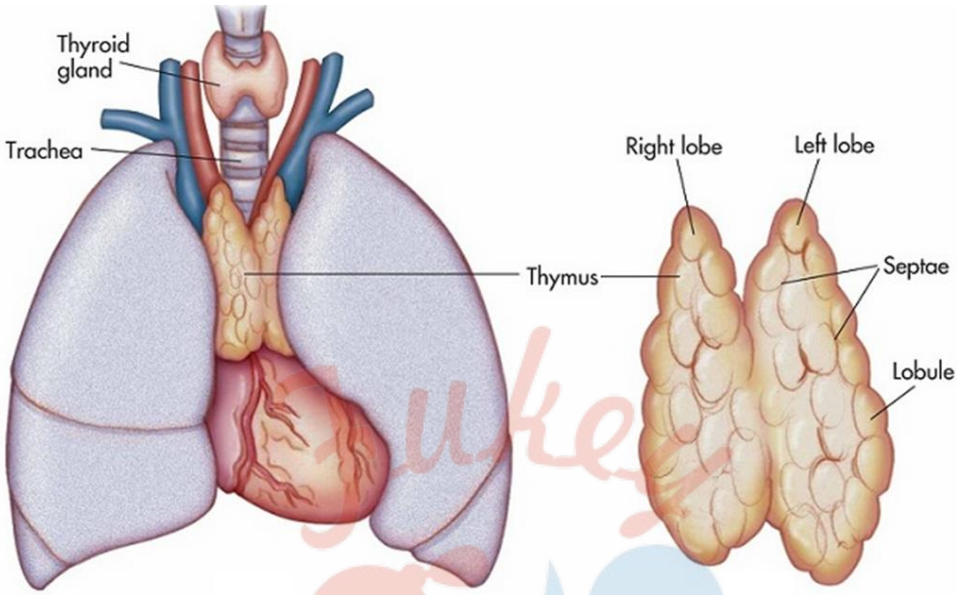
It is located on the back side of thyroid gland, secretes peptide hormone called parathyroid hormone (PTH). PTH regulates the calcium ion concentration in the blood. It also helps in reabsorption of calcium from renal tubules and digestive tracts.



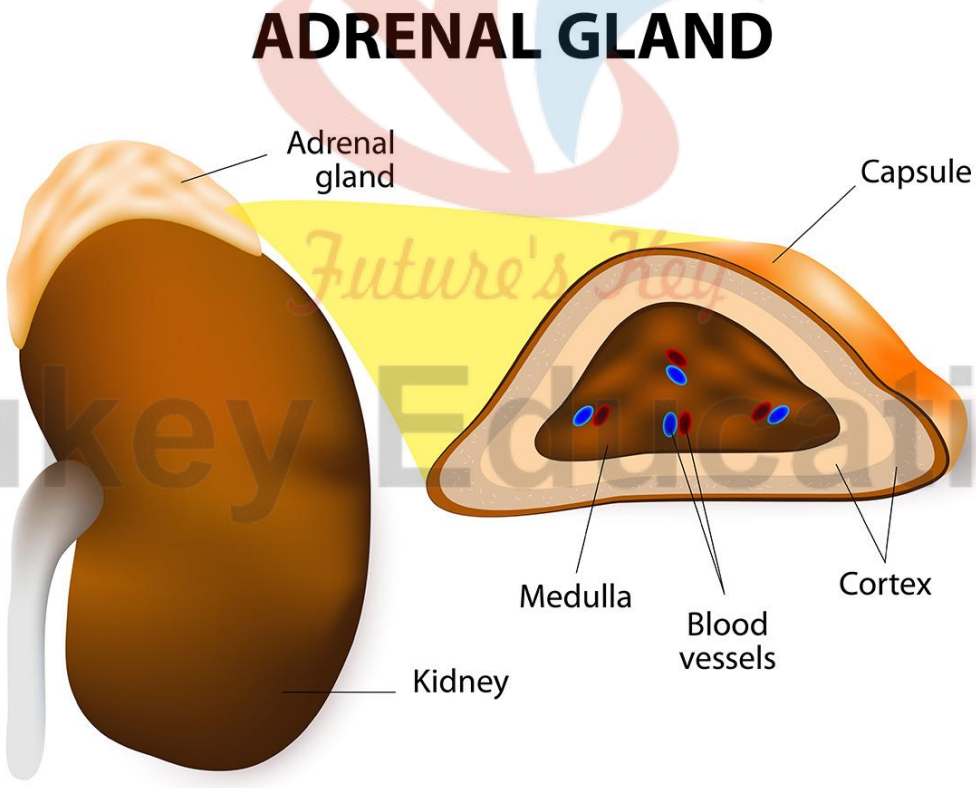
Thymus

It is located on the dorsal side of heart and the aorta. This gland releases peptide

hormone thymosin's that help in differentiation of T-Lymphocytes for cell-mediated immunity. It also promotes production of antibodies to provide humeral immunity.



Adrenal Gland

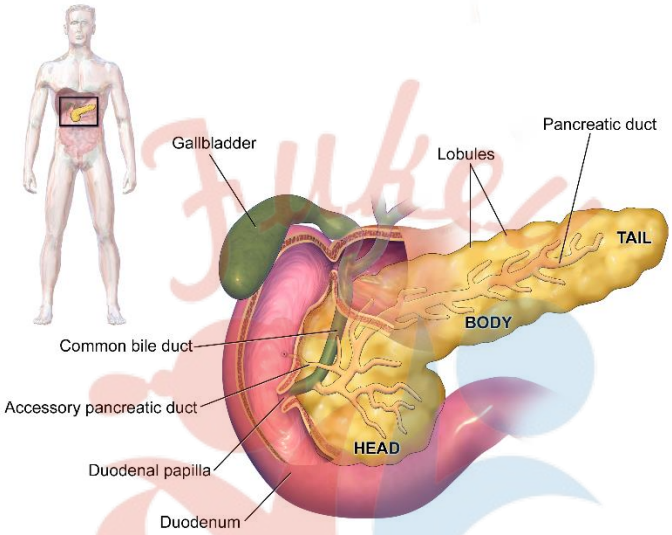


It is located on anterior part of each kidney, composed of two types of tissues central adrenal medulla and outside adrenal cortex. Adrenal medulla secretes adrenaline and noradrenaline hormone commonly called as catecholamines. These hormones are also

called as emergency hormone. These hormones increase alertness, pupillary dilation, sweating, heartbeat, rate of respiration, glycogenolysis.

The adrenal cortex secretes glucocorticoids and mineralocorticoids. Glucocorticoids stimulate gluconeogenesis. Mineralocorticoids regulate water and electrolyte contents of the body.

Pancreas



- They act as both endocrine and exocrine gland. Endocrine pancreas consists of "Islets of Langerhans" which contain α-cells and β-cells. The α-cells secrete hormone glucagon and β-cells secrete insulin. Both hormones are involved in maintenance of blood sugar levels.
- Glucagon is a peptide hormone that stimulates glycogenolysis resulting in increased blood sugar (hyperglycemia).
- Insulin is a peptide hormone that play major role in regulation of glucose homeostasis. It triggers rapid movement of glucose from blood to hepatocytes and adipocytes resulting in decreased blood glucose levels (hypoglycemia).

Testis

They perform dual functions as a primary sex organ as well as endocrine glands. Leydig cells or interstitial cells produce androgen mainly testosterone which regulate maturation of primary sex organs and spermatogenesis.

Ovary

Produce two groups of steroid hormones called estrogen and progesterone. Estrogen is synthesized and secreted by growing ovarian follicles. After ovulation, ruptured ovum

called corpus luteum, secretes progesterone. Estrogen produces wide range actions like growth of female secondary sex organs, development of growing ovarian follicles, and regulation of female sexual behavior. Progesterone regulates pregnancy.

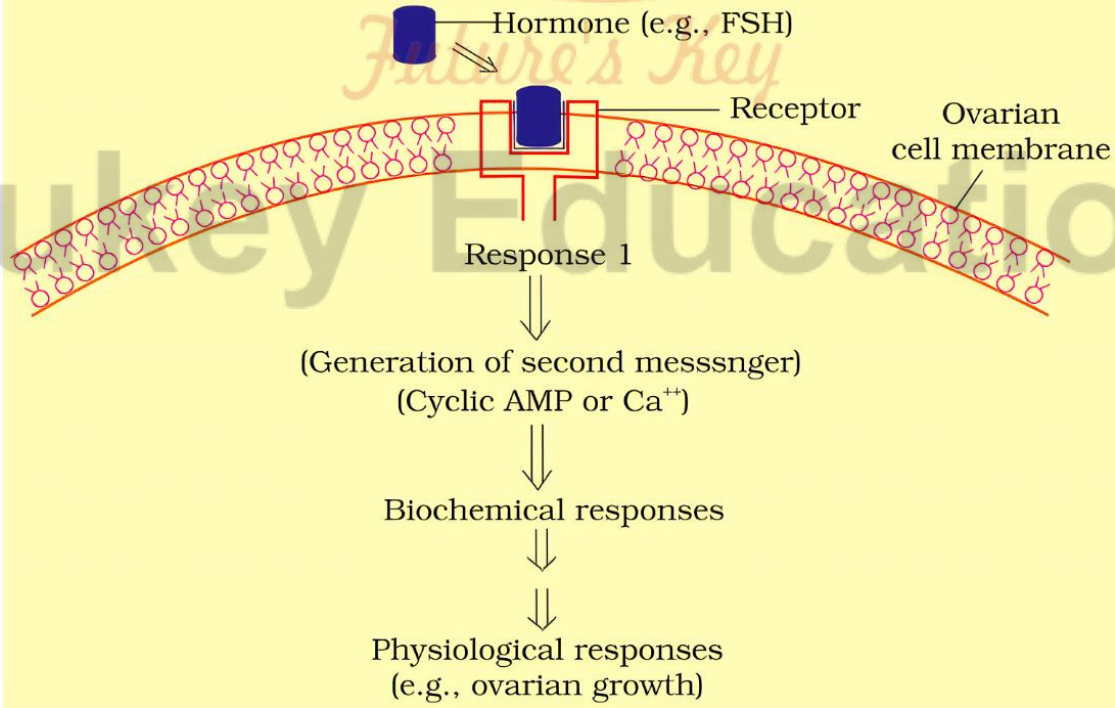
Hormones of Heart, Kidney and Gastrointestinal Tract

- Atrial wall of heart secretes peptide hormone called atrial natriuretic factor (ANF) which decreases blood pressure.
- The juxtaglomerular cells of kidney produce erythropoietin hormone which stimulate erythropoiesis.
- Gastro-intestinal tract secrete four major peptide hormones:
- Gastrin stimulates the secretion of hydrochloric acid and pepsinogen.
- Secretin acts on the exocrine pancreas and stimulates secretion of water and bicarbonate ions.
- Cholecystokinin (CCK) stimulates the secretion of pancreatic enzymes and bile juice
- Gastric inhibitory peptide (GIP) inhibits gastric secretion and motility.

Mechanism of Hormone Action

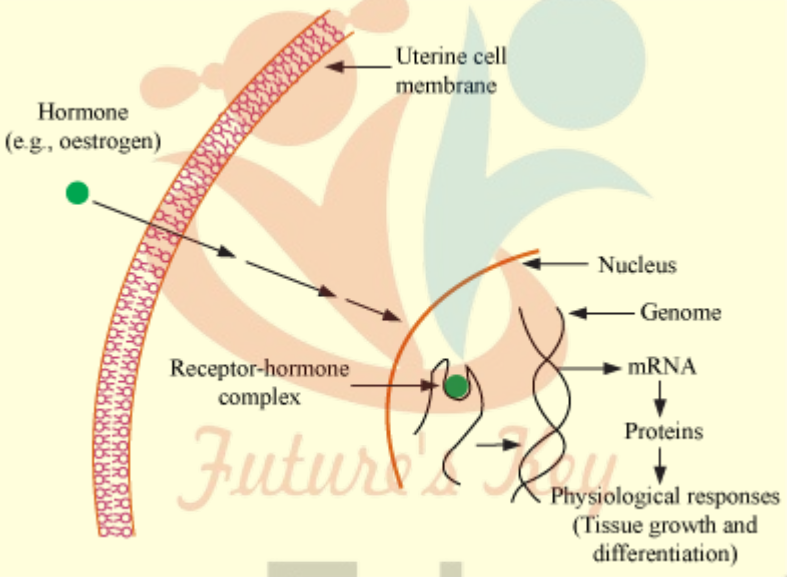
- Hormone produce their effects on target tissues by binding to specific protein called hormone receptors located in the target tissue.

- Binding of hormones to receptor leads to the formation of hormone receptor complex. This binding leads to change in target tissue.



On the basis of chemical nature, hormones are grouped as

- Peptide, polypeptide and protein hormones- insulin, glucagon, pituitary hormone, hypothalamic hormones.
- Steroids- cortisol, testosterone, progesterone.
- Iodothyronines- thyroid hormones.
- Amino acid derivatives- epinephrine.
- The hormones that bind with membrane bound receptors normally do not enter the target cells but generate second messenger which in turn regulate cellular metabolism.
- The hormones (steroid hormones) which interact with intracellular receptors mostly regulate gene expression or chromosome function by interaction with hormone-receptor complex with the genome. These biochemical actions result in physiological and developmental effects.

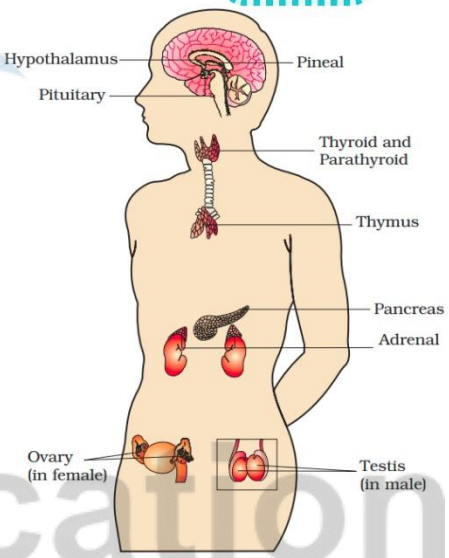


Class : 11th Biology
Chapter- 22 : Chemical Coordination and integration

Chemical Coordination and integration

Human Endocrine System

- Adrenal
  - **Adrenal cortex**
    - Mineralocorticoids
    - Glucocorticoids
  - **Adernal medulla**
    - Adrenaline
    - Noradrenaline
- Thyroid
  - Thyrocalcitonin
  - T3
  - T4 (Thyroxine)
- Pancreas
  - Beta cells → Insulin
  - Alpha cells → Glucagon
- **Parathyroid** → Parathyroid hormone
- Pineal → Melatonin
- **Thymus** → Thymosins
- Pituitary
  - Adenohypophysis
  - Neurohypophysis
- **Testis** → Testosterone
- **Ovary**
  - Estrogen
  - Progesterone
- Hypothalamus
  - Releasing hormone
  - Inhibiting hormone

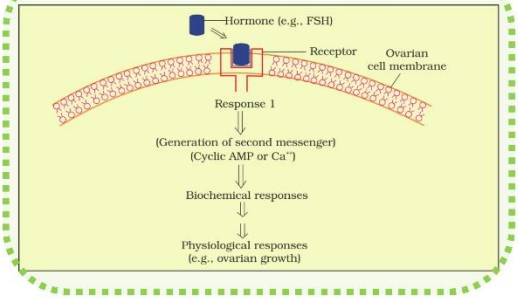


Glands
- **Secretes** Hormones (Chemical messengers of the body)
- **Types**
  - Exocrine (With duct)
  - Endocrine (Without duct)
  - Heterocrine (Partly endocrine and partly exocrine)

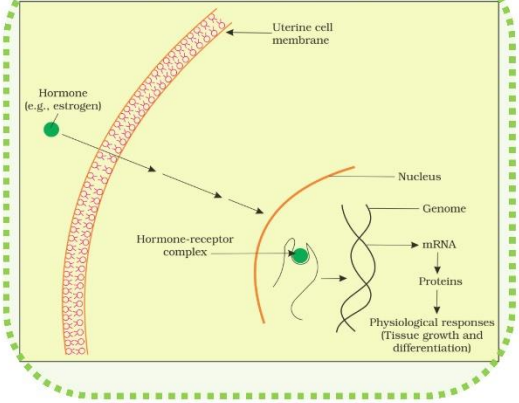
Hormones of Heart, Kidney and Gastrointestinal Tract
- Heart → ANF
- Gastrointestinal Tract → Gastrin, GIP, Secretin, Cholecystokinin, Duocrinin, Villikinin, Enterocrinin
- Kidney → Renin, Erythropoietin and calcitriol

Mechanism of Hormone Action

Water soluble hormones



Lipid soluble hormones



Important Questions

➢ Multiple Choice Questions:

Question 1. Blood pressure is under the control of

(a) Pituitary

(b) Adrenal

(c) Thyroid

(d) Thymus

Question 2. Master endocrine gland is

(a) Pituitary

(b) Parathyroid

(c) Thyroid

(d) Pineal

Question 3. Largest completely endocrine gland is

(a) Adrenal

(b) Thyroid

(c) Pituitary

(d) Parathyroid

Question 4. Implantation of embryo and production of placenta in controlled

(a) FSH

(b) Oestrogen

(c) Progesterone

(d) Estradiol

Question 5. Insulin is secreted by pancreas in

(a) Acinus

(b) a cells

(c) P cells

(d) y cells

Question 6. Hormone is

(a) Nerve impulse

(b) Chemical messenger

(c) Excretory product

(d) Enzymatic product

Question 7. The hormone that causes change in appearance of males during puberty is

(a) Thyroxine

(b) Progesterone

(c) Testosterone

(d) Oestrogen

Question 8. Diabetes insipides is caused by reduced activity in

(a) Thyroid

(b) Anterior lobe of pituitary

(c) Intermediate pituitary lobe

(d) Posterior lobe of pituitary

Question 9. The hormone converts glucose to glycogen inside liver, is pro-duced in

(a) Thymus

(b) Pancreas

(c) Parathyroid

(d) Adrenal

Question 10. Iodine of iodised salt is stored in

(a) Pituitary

(b) Thyroid

(c) Liver

(d) Parathyroid

Question 11. Hormone produced during emotional stress is

(a) Adrenaline

(b) Melatoijiri

(c) Calcitonin

(d) Norepinephrine

Question 12. Which of the following is a hormonal disease

(a) Scurvy

(b) Malaria

(c) Prolactin

(d) Insulin

Question 13. Adrenaline is secreted by

(a) Adrenal medulla

(b) Thymus

(c) Pineal

(d) Adrenal cortex

Question 14. Control of body temperature depends on the

(a) Pancreas

(b) Medulla

(c) Pituitary

(d) Hypothalamus

Question 15. Which of the following is not an endocrine gland:

(a) Thyroid

(b) Pancreas

(c) Pituitary

(d) Sebaceous

➢ Fill In the Blanks:

1. Endocrine glands lack ducts and are hence, called …….
2. The endocrine glands and hormone producing diffuse …… located in different parts of our body constitute the ……
3. Hypothalamus is the basal part of ……., ……. and it regulates a wide spectrum of body functions.
4. The …… is under the direct neural regulation of the hypothalamus.
5. Pituitary gland is divided into …… and ……
6. ……. stimulates synthesis and secretion of thyroid hormones from the thyroid gland.

➢ True or False:

1. Glucagon is a hyperglycemic hormone.
2. Pupilary dilation, piloerection, sweating the hormones increase the heart beat, the strength of heart contraction and the rate of respiration.
3. Ovary is composed of ovarian follicles and stromal tissues.

4. The atrial wall of our heart secretes a very important peptide hormone called atrial natriuretic factor
5. Secretion acts on the exocrine pancreas and stimulates secretion of water and bicarbonate ions.
6. CCK inhibits gastric secretion and motility

➢ Very Short Question:

1. What is an endocrine gland?
2. What are hormones?
3. Expand the term BMR.
4. Which hormone is responsible for the metamorphosis of tadpoles into adult frogs?
5. What is castration?
6. What is adrenal virilism?
7. What condition is caused due to failure of production of [testosterone?
8. What function do glucagons have?
9. Name the gland which functions as both the endocrine and exocrine?
10. Name the hormone which is antidiuretic in its effect.

➢ Short Questions:

1. Work out the contrast between diabetes Mellitus and diabetes insipidus.
2. Name and state briefly the functions of the hormones secreted by the adrenal cortex.
3. Describe different disorders caused by thyroid hormone imbalance.
4. State different functions of thyroid hormones.
5. State chief characteristics of the hormones.
6. Describe in brief different disorders caused by the adrenal cortex.
7. Why do you suppose the brain goes to the trouble of synthesizing releasing hormones, rather than simply directing the production of the pituitary hormones immediately?
8. Which endocrine gland is controlled by the secretion of other endocrine glands?

➢ Long Questions:

1. What are thyroids? Describe the disorders of thyroids hor¬mones.
2. Give an account of the primary male sex organ in man and mention briefly the functions of the hormone testosterone.

Assertion Reason Question-

1. In these questions, a statement of assertion followed by a statement of reason is given. Choose the correct answer out of the following choices.

   (a) If both Assertion and Reason are true and Reason is the correct explanation of Assertion.

   (b) If both Assertion and Reason are true but Reason is not the correct explanation of Assertion.

   (c) If Assertion is true but Reason is false.

   (d) If both Assertion and Reason are false.

   Assertion: Failure of secretion of somatotropin from an early age causes dwarfism in the patient.

   Reason: Somatotropin hormone stimulates the body growth and elongation of long bones.

2. In these questions, a statement of assertion followed by a statement of reason is given. Choose the correct answer out of the following choices.

   (a) If both Assertion and Reason are true and Reason is the correct explanation of Assertion.

   (b) If both Assertion and Reason are true but Reason is not the correct explanation of Assertion.

   (c) If Assertion is true but Reason is false.

   (d) If both Assertion and Reason are false.

   Assertion: Neurohypophysis is under the direct regulation of the hypothalamus.

   Reason: Neurohypophysis stores and releases two hormones called oxytocin and vasopressin which are actually synthesized by the hypothalamus.

✓ Answer Key-

➢ Multiple Choice Answers:

1. (b) Adrenal
2. (a) Pituitary
3. (b) Thyroid
4. (c) Progesterone
5. (c) P-cells
6. (b) Chemical messenger

7. (c) Testosterone.
8. (d) Posterior lobe of pituitary
9. (b) Pancreas
10. (b) Thyroid
11. (a) Adrenaline
12. (d) Insulin
13. (a) Adrenal medulla
14. (b) Medulla
15. (d) Sebaceous

➢ Fill In the Blanks:

1. ductless glands
2. tissues/cells, endocrine system
3. diencephalon, forebrain
4. posterior pituitary
5. adenohypophysis, a neurohypophysis
6. TSH

➢ True or False:

1. True
2. True
3. True
4. True
5. True
6. False

➢ Very Short Answers:

1. Answer: The gland without duct, which secretes hormones, is called the endocrine gland.
2. Answer: The endocrine glands secrete chemical substances which affect various body activities in target organs, by reaching there through blood.
3. Answer: Basal Metabolic Rate.
4. Answer: The hormone thyroxine secreted by the thyroid gland is responsible for the metamorphosis of tadpoles into adult frogs.

5. Answer: The surgical removal of the testis is called castration.
6. Answer: The hypersecretion of sex corticoids causes the development of external male characters in females, called adrenal virilism.
7. Answer: Eunuchoidism.
8. Answer: It causes the formation of glucose from the breakdown of glycogen and from amino acids.
9. Answer: Pancreas.
10. Answer: Vasopressin (ADH) secreted by the posterior pituitary.

➢ Short Answer:

1. Answer: Diabetes Mellitus: It is the disorder in which blood sugar is present well beyond the renal threshold, consequently glucose is present in urine. It is caused due to deficiency of insulin hormone.

   Diabetes insipidus: It is the disorder in which hypotonic urine is excessively excreted. It is caused by the deficiency of the secretion of the ADH hormone.

2. Answer: Mainly the hormones secreted by the adrenal cortex are:

   1. Glucocorticoids: These regulate the metabolism of carbohydrates, fats, and proteins.

   2. Mineralocorticoids: These maintain the sodium, potassium level in the blood.

   3. Sex corticoids: These stimulate the development of external sex characters like male patterns of body hair distribution. Androstenedione and dehydroepiandrosterone are sex corticoids.

3. Answer: Other than simple goiter, the main thyroid hormone imbalances are:
   - Cretinism: Hypoactivity of thyroxine in children causes poor physical and mental development, low metabolism. The affected individual is potbellied and pigeon-chested.
   - Myxedema: Hypoactivity of thyroxine in adults causes poor physical and mental development, low metabolism, puffy appearance, and reproductive failure.
   - Grave's disease: (exophthalmic goiter) Hyperactivity of thyronine causes increased metabolism, bulging of eyeballs, emaciation, and restlessness.

4. Answer:

   i. These affect the metabolism.

   ii. These maintain BMR (Basal Metabolic Rate).

   iii. These affect physical growth.

   iv. These affect the development of mental faculties.

v. These affect the process of differentiation.

vi. Affect metamorphosis in tadpoles.

5. Answer:

i. The effect produced is marked even in minute concentrations.

ii. Directly sent to target organs through blood circulations.

iii. Storage is not possible.

iv. The target organ is distantly placed from the organ in which these are produced.

v. These are secreted as a response to some sort of stimulus.

vi. Chemicals are biological in origin, i.e., biogenic, e.g., amine, peptides, steroids, etc.

6. Answer: Different disorders related to the adrenal cortex are:

i. Addison's disease: Atrophy or destruction of adrenal cortex causes failure of secretion of minerals corticoids and glucocorticoids leads to low blood Na+, high plasma K+ and urinary Na+, bronze skin pigmentation.

ii. Cushing's syndrome: Increased production of cortical causes low' plasma K+, high plasma Na+, rise in blood pressure and volume.

iii. Aldosteronism: Hyperactivity of aldosterone cause Na+ and K+ conditions like Cushing's syndrome, muscular weakness.

iv. Adrenal virilism: Hypersecretion of sex corticoids causes the development of male-type external features in female-like beard and mustache, low pitch male voice, and mensural cessation.

7. Answer: Hormones secreted by the posterior lobe of the pituitary gland are actually synthesized by the neurons in the hypothalamus and stored in their axon ends in the posterior lobe for release, when required.

The pituitary was called the Master endocrine gland, because of the number of hormones it produces and the control it exercises over other endocrine glands. However, it itself is under control of the releasing hormones secreted by the hypothalamus of the brain. Thus there is a chain of disorders, the hypothalamus directs the pituitary output, which controls the secretion of hormones by other endocrine glands.

8. Answer: The thyroid gland is the only endocrine gland that is controlled by the secretion of another endocrine gland. It stores its secretary product in large quantity.

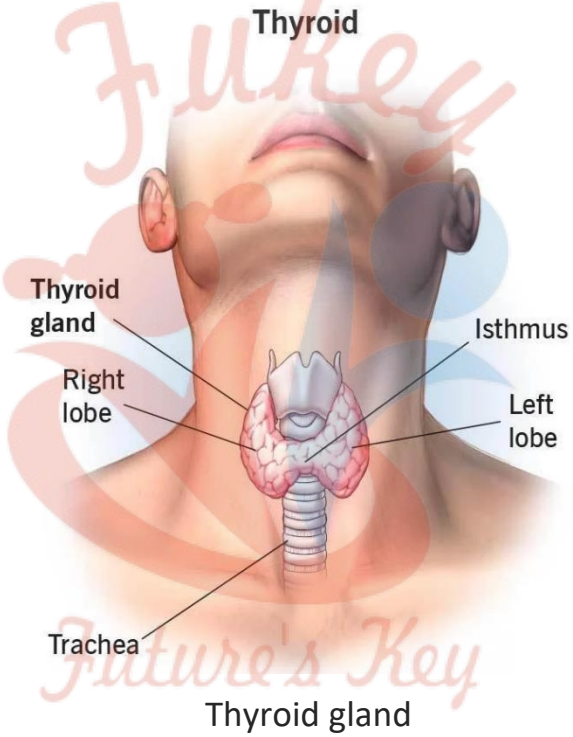
Homopothalamus, in response to some external stimulus, produces a thyrotropin-releasing hormone (TRH) for the secretion of the thyrotrophic hormone. The thyrotropin-releasing hormone stimulates the anterior pituitary lobe to secrete thyrotrophic hormone. The latter, in turn, stimulates the thyroid gland to produce thyroxine, thereby restoring the normal blood- thyroxine level.

➢ Long Answer:

1. Answer:

The thyroid gland is situated in the neck close to the trachea in human beings. It consists of two elongated oval lobes joined together by a narrow band called ISTHMUS. It highly vascular organ and contains many- spherical or oval sac-like follicles.

Cells of the follicle secrete jelly-like semi-fluid called Colloid of Thyroid stored in the lumen of the follicle. This contains iodinated forms of an amino acid called THYRONINE. When required, two thyroid hormones, THYROXINE, and TRIIODOTHYRONINE are released from the colloid to the blood.



Thyroid gland

Disorders:

i. Failure of the thyroid from infancy or childhood causes a disease called cretinism. In it, there is slow body growth and mental development. There is also a low metabolic rate.

ii. The deficiency of thyroid hormones in adults produces Myxedema. The patient shows a puffy appearance and lacks intelligence, lateness, and initiative. There is also a low metabolic rate.

iii. The deficiency of iodine produces enlargement of thyroids causing Iodine Deficiency to Goitre.

iv. Some thyroid enlargement is accompanied by a bulging of the eyeball.

The disease is called Grave's Disease or Exophthalami Goitre. The excessive amount of thyroid is secreted.

2. Answer: The testis is the primary sex organ. There are pair of tests. Each testis is covered

by a thick connective tissue sheath, Tunica Albuginea. Both testes normally remain suspended in a pouch called Scrotum outside the abdominal cavity. Each testis consists of many small and highly convoluted tubules, called seminiferous tubules, constituting its spermatogenic tissue.

Cells lining the tubules give rise to spermatozoa, which are released into the lumen of the tubule. These are present groups of polyhedral cells.

Interstitial cells of Leydig in the connective tissue around the seminiferous tubules. This constitutes the endocrine tissue of the testis. These cells secrete Testosterone into the blood. Somniferous tubules unite to form a large number of straight tubules, which open into irregular cavities in the posterior part of the testis. The vasa efferentia arise from these cavities and conduct spermatozoa out from the testis.

Functions of Testosterone:

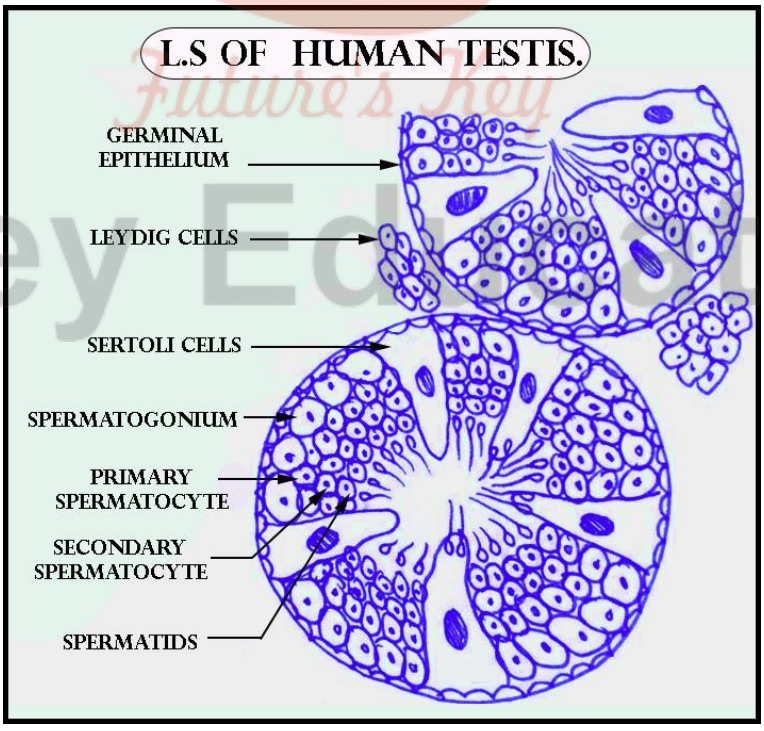
i. It stimulates the growth and development of male secondary sex organs (prostate, seminal vesicles, and penis).

ii. It stimulates and maintains the normal function of secondary sex organs in reproduction.

iii. It also stimulates and maintains the development of external male characters such as beards, mustaches, and low-pitch male voices in males and combs and wattles in cock.

iv. It also stimulates the formation of sperms in the testes.

v. It promotes the growth of many body tissues including bones and muscles.



T.S. of testis of an adult man

Assertion Reason Answer-

1. (a) If both Assertion and Reason are true and Reason is the correct explanation of Assertion.

   Explanation: The somatotropin (STH), also called growth hormone (GH) is secreted by the anterior lobe of pituitary gland. Somatotropin stimulates body growth by stimulating retention of proteins and calcium in the body, synthesis and deposition of proteins in tissues, growth and elongation of long bones, and proportionate growth of muscles and visceral organs. The failure of secretion of growth hormone from an early age stops the growth of long bones and of the body prematurely; this makes the patient dwarf and the condition is called dwarfism.

2. (c) If Assertion is true but Reason is false.

   Explanation: Neurohypophysis also known as posterior pituitary stores and releases two hormones called oxytocin and vasopressin which are actually synthesized by the hypothalamus and are transported axonally to neurohypophysis. Therefore, the posterior pituitary is under the direct neural regulation of the hypothalamus.