Chemical Coordination and Integration

INTRODUCTION

- For control and coordination in higher animals, besides nervous system, there is Endocrine System.
- Endocrine system consists of endocrine glands which secrete their secretions directly in the blood stream, unlike exocrine glands which have ducts to deliver their secretion.
- Thus, endocrine glands are ductless glands which secrete hormones. Hormones are informational molecules which are secreted in response to changes in the environment inside or outside the body.
- There is a considerable coordination between nerves and hormones. Synthesis and release of hormones are regulated by nerves, hormones may also influence nerve activities.

Definition

Gland: A cell or an aggregation of cells specialized to secrete or excrete materials.

Rack Your Brain

Who called hormones as chemical messengers?

HORMONES

- These are the non-nutrient chemicals (chemical messengers) produced by the endocrine glands, transported via blood to the distantly located target organs.
- These are messengers, required for regulating different metabolic and physiological functions which help in maintaining homeostasis in the body.
- Some of the hormones also control the production of other hormones by the various endocrine glands (like hormones secreted by hypothalamus and pituitary body).

Definition

Hormones: These are chemicals which act as intercellular messengers and are produced in minute amounts by the endocrine glands.

Types of Hormones

- On the basis of chemical nature hormones are of three types-
  - Peptide or proteins hormones: These are made up of short polypeptide chain, small proteins or large glycoproteins. For example, antidiuretic hormone, oxytocin, growth hormone, insulin and follicle stimulating hormone.

Gray Matter Alert!!!

The term hormone was introduced by Starling in 1905.

- Amino acid derivatives: These are relatively small molecules that are derived from amino acids, tyrosine and tryptophan. When a hormone is derived from an amino acid its name ends with '-ine'. For example, epinephrine and norepinephrine.
- Lipid derived hormones: These are derived from cholesterol. Chemically the hormones are either ketones or alcohols and their chemical names end with '-ol' for alcohols or '-one' for ketones. For example, estradiol (estrogen), testosterone, aldosterone, cortisol, etc.

Note: Steroids are lipid soluble hormones so can easily pass through the plasma membrane while peptide or amino acid hormones are water soluble so cannot pass through the plasma membrane therefore, their receptors are found on the cell membranes.

Rack Your Brain

Hormones may be ....., ... and ..... derivatives.

Gray Matter Alert!!!

Secretin was the first hormone discovered by Bayliss and Starling in 1903.

Previous Year's Question

Which pair is tryrosine derivatives?
(1) Calcitonin and insulin
(2) FSH and GH
(3) Thyroxine and adrenaline
(4) Insulin and glucagon

Difference between Hormones and Enzymes

Hormones	Enzymes
Hormones may or may not contain proteins. These are either amino acids, peptides, proteins, phenolic compounds or steroids.	Enzymes invariably contain proteins (few exceptions are there i.e ribozyme).
These have low molecular weight.	These have high molecular weight.
These are carried via blood to the target tissues.	These are used either locally or reach the target organ by ducts of the glands.
These are diffusible through cell membrane.	These are non-diffusible through the cell membrane.

Hormones	Enzymes
These are synthesised by the endocrine glands.	These are produced by exocrine glands.
These are not catalysts and after participating in specific biochemical reactions their chemical composition changes.	These are catalysts so at the end of the biochemical reaction remains unchanged.
These are used up during the biochemical reactions.	These are not used up during the biochemical reactions.
These are either excitatory or inhibitory in their actions.	These accelerate the rate of biochemical reaction.
Biochemical reactions controlled by hormones are irreversible.	Biochemical reactions controlled by enzymes are irreversible.

SITES FOR HORMONE ACTION

Three sites of action for hormones can be postulated.

The Cell Membrane

- By altering permeability or active transport mechanisms for a particular molecule. For example, increase in glucose uptake by the target organs of TSH and LH.
- By activation of some membrane bound enzyme system which can then produce an intra-cellular metabolic controller.

Pre-Existing Intracellular Enzyme System

- Hormones may activate or inhibit specific enzyme or enzyme systems within the cell. For example, insulin secreted by pancreatic cells forms complex with hexokinase.

Previous Year's Question

A molecule acting as 'second messenger' in biological system is
(1) c- RNA
(2) c-AMP
(3) t-RNA
(4) hn- RNA

Gray Matter Alert!!!

Father of endocrinology is Thomas Addison.

The Cell Nucleus

- Certain hormones are able to control the activity of specific genes and thus regulate the enzyme content.

ENDOCRINE GLANDS

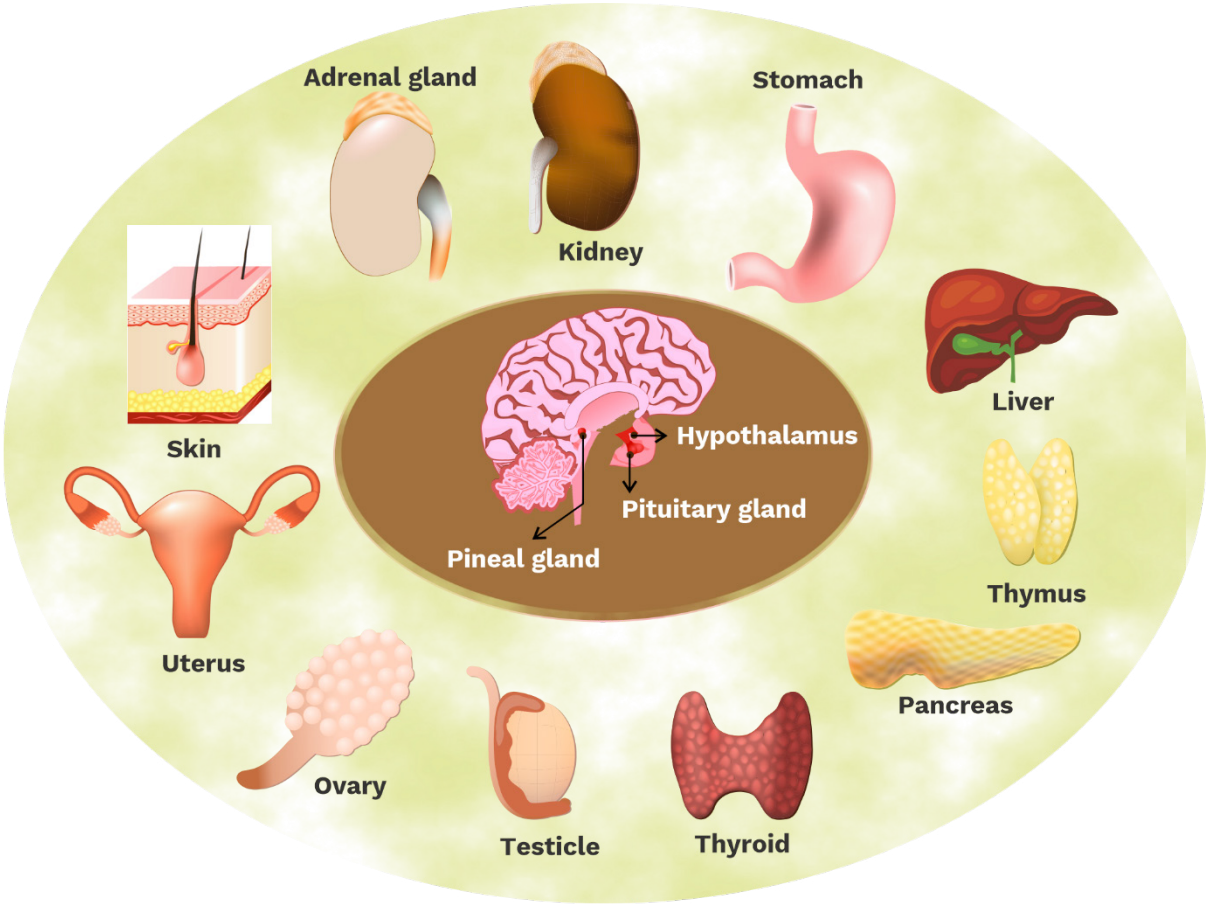
- The following endocrine glands are present in the human body:
  - Hypothalamus
  - Pituitary
  - The pineal body
  - The islets of Langerhans in the pancreas
  - The adrenal glands
  - The thyroid
  - The thymus
  - Certain cells near the glomerular region

Definition

Endocrine glands: The glands which do not have ducts and pour their secretions directly into the blood for transport to the target tissues or organs.

Definition

Endocrine system: All hormone secreting endocrine glands and cells constitute endocrine system.

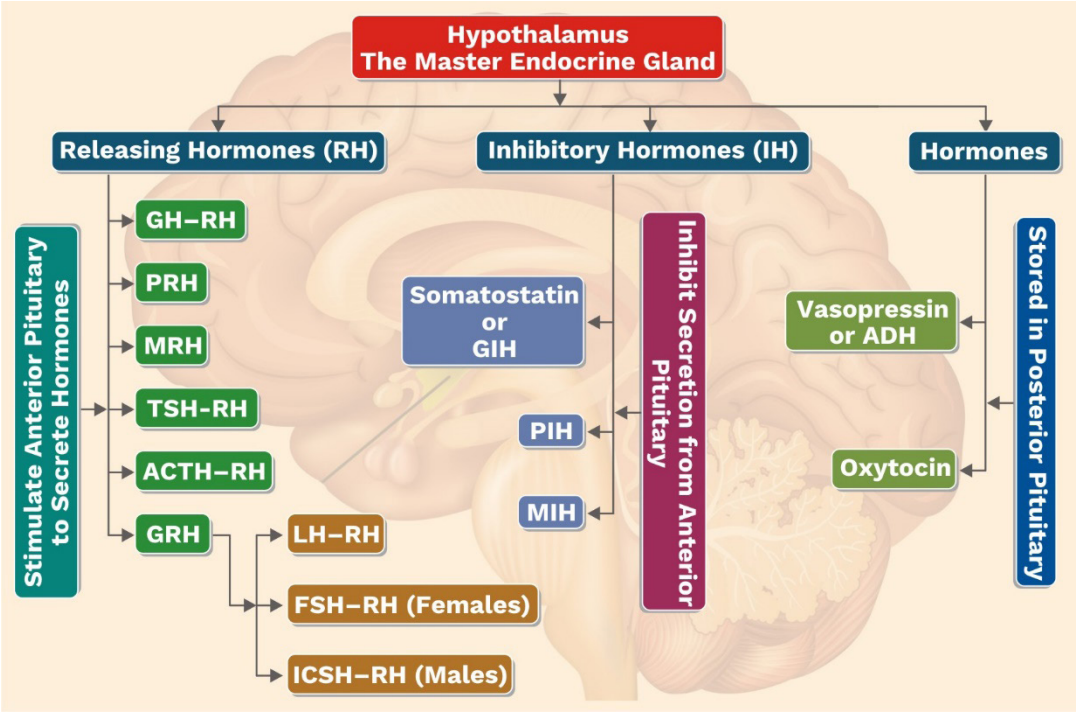


HYPOTHALAMUS (MASTER ENDOCRINE GLAND)

- The hypothalamus is the part of diencephalon which is found at the base of the brain (floor of the third cerebral ventricle). It is attached with brain by many nerve tracts.
- The hypothalamus contains many nuclear masses. These masses of grey matter are called **Hypothalamic Nuclei.** Neurons of the hypothalamic nuclei control pituitary gland. They secrete several hormones called **neurohormones** into the blood called releasing hormones.

Rack Your Brain

Name two hormones that are secreted with the help of neurosecretory axons?



Hormones Secreted by Hypothalamus

- The hypothalamus secretes six different releasing hormones (RH), chemically which are small peptide molecules and two more hormones.
- These releasing hormones are translocated by the portal vessels to the anterior lobe of the pituitary. Releasing hormones regulate the synthesis the release of six hormones by the anterior pituitary lobe.

Previous Year's Question

Which of the following secretes with the help of neurosecretory axons?
(1) Pineal gland
(2) Adrenal cortex
(3) Anterior pituitary
(4) Posterior pituitary

- Some hypothalamic neurons send their axons through the pituitary stalks to posterior pituitary. These neurons synthesize two hormones called **vasopressin** and **oxytocin** which remain stored at their axon terminals inside the posterior lobe of pituitary. These hormones are released when neurons are properly stimulated.
- Hypothalamus also secretes the hormone **somatostatin** which inhibits the secretion of the growth hormone by the anterior pituitary.
- **The hypothalamus releasing hormones as follows:**
  - **TSH-RH (Thyroid stimulating hormone-releasing hormone)-** It controls the secretion of thyroid stimulating hormone from the pituitary gland.
  - **ACTH-RH (Adrenocorticotropic hormone-releasing hormone)-**It regulates the release of adrenocorticotropic hormone.
  - **FSH-RH (Follicle stimulating hormone-releasing hormones)-** It controls the release of follicle stimulating hormone.
  - **LH-RH (Luteinising hormone-releasing hormone)-** It controls the release of luteinising hormone.
  - **GH-RH (Growth hormone-releasing hormone)-** It regulates the secretion of growth hormone of anterior pituitary.
  - **PIF-RH (Prolactin inhibitory factor-releasing hormone)-** It inhibits the secretion of prolactin from anterior pituitary.

Note: Thermoregulatory centre of the body is in hypothalamus.

- Precise signals of hypothalamus are delivered to the pituitary gland which in turn releases hormones that trigger the other endocrine glands to function accordingly.

Gray Matter Alert!!!

The posterior pituitary is connected with hypothalamus by neurosecretory neurone with their terminal called Herring body.

Rack Your Brain

The chemical mediator of nerve impulse on effectral organs are called _____.

Previous Year's Question

What is true about neurohypophysis?
(1) Stores hormones produced by adenohypophysis
(2) Functionless in humans
(3) Stores and releases neurohormones secreted by hypothalamus
(4) Secretes its own hormone

Previous Year's Question

Hypothalamus controls the production of pituitary hormones
(1) ACTH (corticotropin), GH (growth hormone) and ADH (vasopressin)
(2) FSH and progesterone
(3) TSH (thyrotropin) and cortisol
(4) LH (lutenising hormone), ACTH (corticotropin) and TSH (thyrotropin)

PITUITARY GLAND

- It is a small gland, weighing less than a gram. The pituitary is attached with hypothalamus by a stalk called infundibulum.

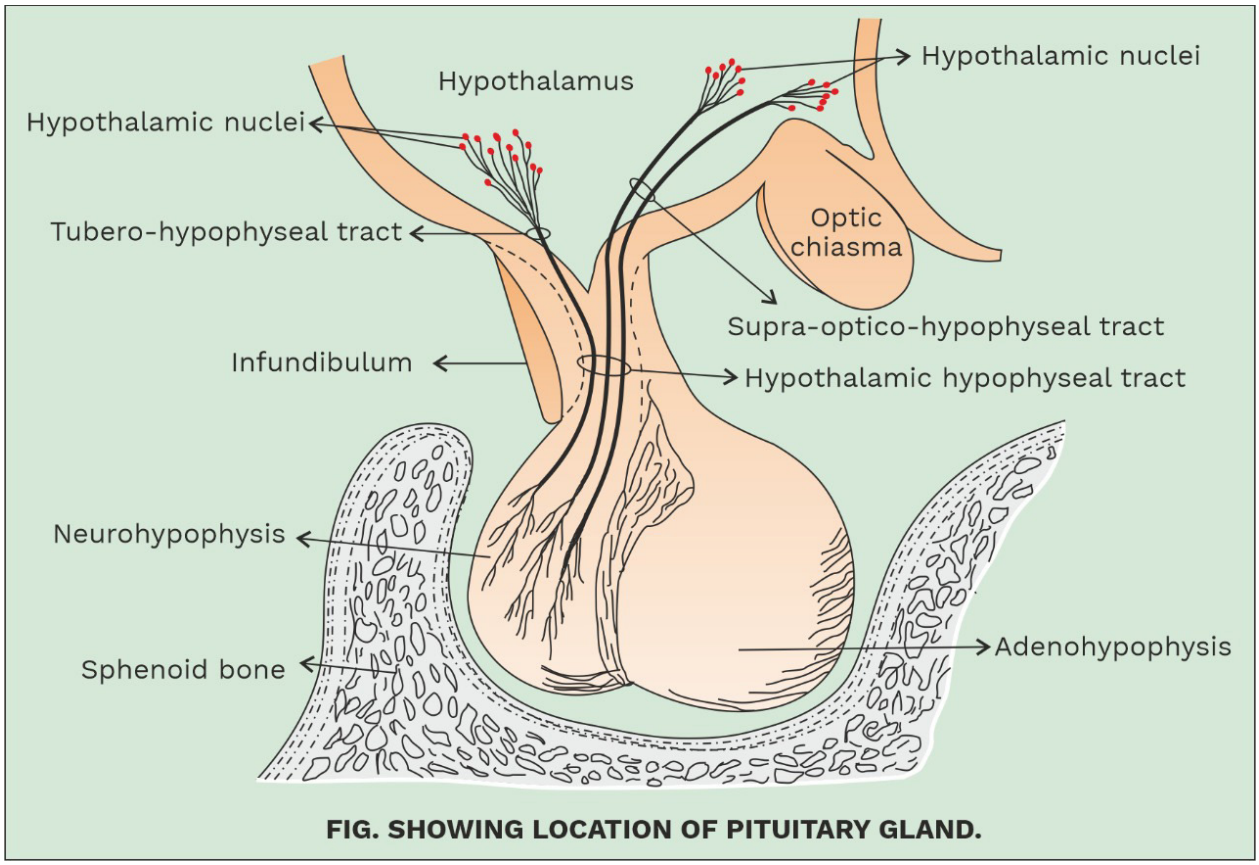


FIG. SHOWING LOCATION OF PITUITARY GLAND.

- The pituitary has three lobes viz., anterior lobe or adenohypophysis or epithelial hypophysis, the intermediate lobe and the posterior lobe.
- All lobes of pituitary are derived from ectoderm.

The Anterior Pituitary Lobe or Adenohypophysis

- It is compact and highly vascular part of pituitary which is 75 per cent of the total pituitary gland.
- It is connected with the hypothalamus by the portal blood vessels called hypophyseal portal vessels.

Previous Year's Question

Nonfunctional part of pituitary is
(1) anterior pituitary
(2) pars intermedia
(3) neurohypophysis
(4) pars nervosa

- The hormones of the anterior lobe of pituitary control all the endocrine glands of the human body.

Note: The anterior lobe consists of two types of cells-
Chromophobes, small cells without affinity for dyes.
Chromophils, large cells which stain readily.

Parts of Adenohypophysis

- Pars distalis (largest part)
- Pars tuberalis (smaller than pars distalis)
- Pars intermedia (poorly developed)

Hormones of the Anterior Lobe

- This part of pituitary secretes six hormones which are protein hormones.

Gray Matter Alert!!!

Pituitary gland is present in a saddle-like depression called sella turcica (hypophyseal fossa or Turkish saddle) of sphenoid bone of the cranium.

Rack Your Brain

Which gland acts as accumulation and release centre of neurohormones?

Gray Matter Alert!!!

The FSH stimulates both male and female gametes during puberty so is also called gametokinetic factor.

Hormone	Function
Adrenocorticotrophic hormone (ACTH)	It acts on the adrenal cortex and stimulates it to produce cortisol, glucocorticoid and mineralocorticoid hormones.
Follicle-stimulating hormone (FSH)	It stimulates the development of Graafian follicles in the ovary and the formation of spermatozoa in the testes.
Luteinising Hormone (LH) or interstitial cell stimulating hormone (ICSH)	It regulates the secretion of the estrogen and progesterone in the ovary and testosterone in the testes.
Prolactin	It controls the secretion of milk after pregnancy and maintains the existence of the corpus luteum during pregnancy.
Thyroid stimulating hormone (TSH)	It stimulates the thyroid gland to secrete thyroxine hormone.
Growth hormone (GH) or somatotropic hormone (STH)	It acts directly on the tissues (bones, muscles and viscera, etc.) of the body and controls the growth of the body.

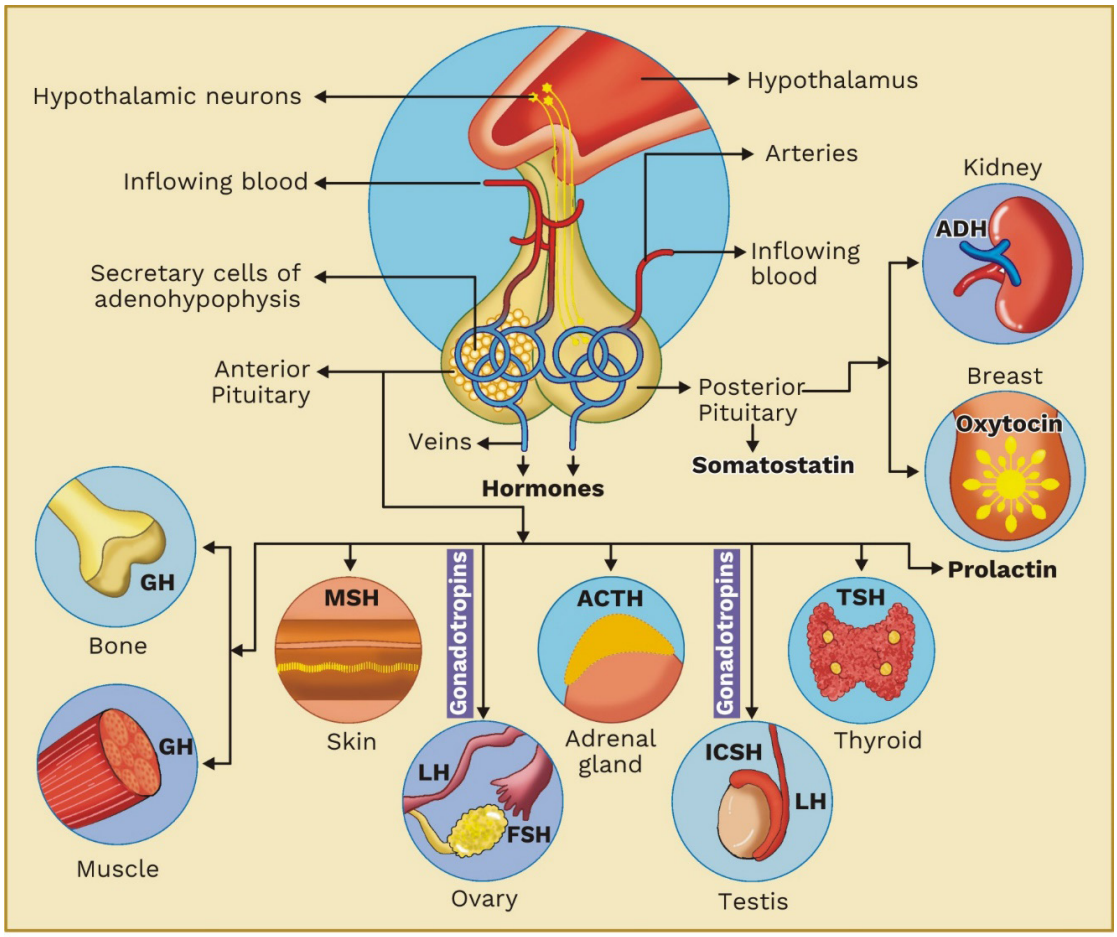


FIG. HORMONES SECRETED BY PITUITARY GLAND

Abnormal Secretion of Growth Hormone

- **Gigantism:** The excessive secretion of GH during the growth period leads to enormous growth of the body.
- **Dwarfism (Pituitary Nanism or Ateliosis):** Deficiency of GH during the growth period causes retarded growth.
- **Acromegaly:** Hypersecretion of GH during adulthood, body parts start growing disproportionately like hands and feet become large, over-growth of ear lobes, etc. Uncured acromegaly can be fatal.

Previous Year's Question

Gigantism and acromegaly are two defects produced due to improper functioning of-
(1) Thyroid, pituitary and thymus
(2) Pituitary
(3) Thyroid
(4) Thyroid and pituitary

Note: The FSH and LH hormones are called gonadotrophins (gonadotrophic hormones) as they influence the gonads (ovaries and testes).
LH causes ovulation in females and maintains corpus luteum if fertilisation occurs.
In males it stimulates Leydig cells to secrete testosterone hormone. In males, LH stimulates the synthesis and secretion of hormones called androgens from testis.

Intermediate lobe

- **Melanocyte stimulating hormone (MSH)** is a polypeptide hormone secreted by intermediate lobe of the pituitary.
- This hormone controls the colouration of the skin in many animals such as fishes and amphibians e.g., frog MSH stimulates the synthesis of the black pigment melanin in the skin and also a dispersal of melanin granules to the processes of skin cells. In man, it has no such role.

Gray Matter Alert!!!

MSH is also known as intermedin and is functional on the in cold blooded animal to make the skin darker or lighter during camouflage.

The Posterior Pituitary Lobe or Neurohypophysis

- It consists of non-medullated nerve fibres, neuroglia (pituicytes), blood vessels and non-secretory supporting cells. The nerve fibres come from the hypothalamus.
- The secretion of posterior lobe hormone is entirely under nervous control.
- This part stores the hormones which are released when required.

Previous Year's Question

Oxytocin helps in
(1) Ovulation
(2) Implantation
(3) Lactation
(4) Child birth

Parts of Posterior Pituitary

- Pars nervosa (neural lobe)
- Infundibular stem
- Median eminence

Gray Matter Alert!!!

Endocrine glands like anterior and middle lobes of pituitary, thyroid, parathyroid, thymus and pancreas are endodermal in origin.

Posterior lobe hormones and their Functions

- It secretes two protein hormones viz.-Antidiuretic hormone (ADH), and oxytocin.

Hormone	Function
Antidiuretic hormone (ADH) or Vasopressin or Pitressin	It controls the secretion of urine by the kidney and thus regulates the water and electrolyte balance of the body fluid.
Oxytocin hormone (Pitocin or birth hormone)	It helps in the expulsion or ejection of milk from the breast during lactation. It also effects the contraction of the uterus during the birth of the child.

Hyposecretion of antidiuretic hormones (ADH)

- **Diabetes insipidus,** a disorder which is characterised by excretion of large volume of hypotonic urine.

THE PINEAL GLAND (EPIPHYSIS CEREBRI)

- The pineal gland is situated in the mid brain.
- Its shape resembles with a pine cone giving it the name pineal.
- It secretes hormones which contain amino group (not protein) in their molecules and are called biogenic amines.

Hormones of Pineal Gland

- It secretes the two most important hormones- melatonin and serotonin.
- **Melatonin**
  - It is secreted at night.
  - It modulates sleep patterns (in both circadian and seasonal cycles).
  - It has an antigonadotropic effect as it reduces the quantity of follicle-stimulating hormone (FSH) and luteinising hormone (LH).
- **Serotonin**
  - It is a vasoconstrictor (decrease the diameter of the blood vessels).

Previous Year's Question

Diabetes insipidus is caused by the hyposecretion of-
(1) Thymosin
(2) Vasopressin
(3) Insulin
(4) Oxytocin

Gray Matter Alert!!!

Endocrine glands like pineal, adrenal medulla (adrenal gland) and posterior lobe of pituitary are ectodermal origin.

Previous Year's Question

Pineal gland produces-
(1) Cortisone
(2) Glucagon
(3) Aldosterone
(4) Melatonin

THE THYMUS

- The thymus is the major lymphoid organ at birth and is endodermal in origin.
- It is bilobed in structure.
- It is situated in the chest near to heart.
- The thymus is thought to be concerned with the production of antibodies. It starts shrinking after puberty and atropies at old age.

Hormones of Thymus

- Thymopoietin (formerly called thymin) and thymosin and are the two hormones secreted by thymus.
- **Thymopoietin**
  - It helps in the differentiation of thymocytes to lymphocytes inside the thymus.
- **Thymosin**
  - It stimulates precursor T-lymphocytes to develop into mature T-lymphocytes.
  - It helps in the development of sex glands but inhibits sexual maturity in early young age.

THYROID GLAND

- The thyroid gland is found in the neck region at the base of the larynx (voice box) on the ventral side.
- It consists of two lobes, placed one on each side of the trachea.
- The two lobes of the thyroid gland are connected together by a strip of thyroid tissue, known as **isthmus of the thyroid,** which lies across the trachea.

Structure of Thyroid Gland

- The thyroid gland is composed of number of vesicles lined with cuboidal epithelium, abundantly supplied with blood vessels, and held together by connective tissues.

Rack Your Brain

What will happen if thymus remains non-functional in an infant?

Previous Year's Question

Function of thymus is-
(1) Immunity
(2) Emergency hormone
(3) Growth
(4) Formation of RBCs

Previous Year's Question

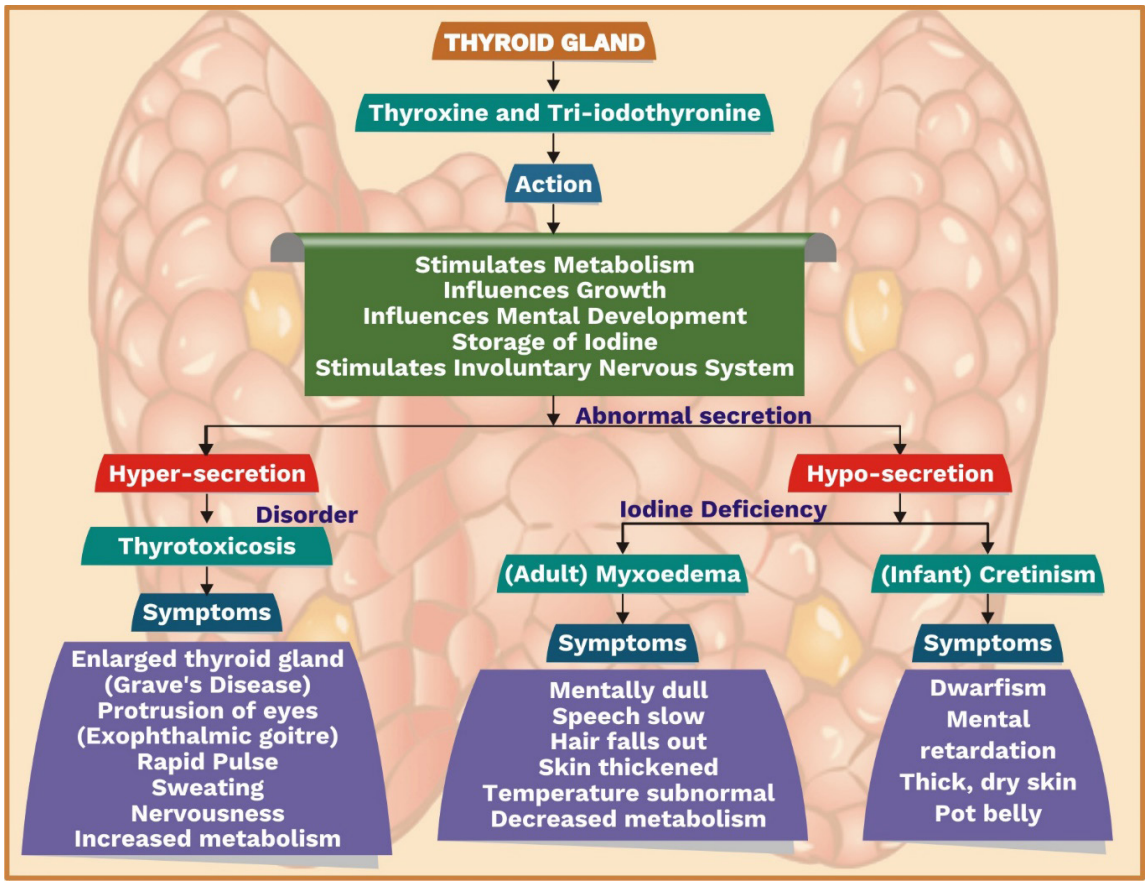
If thymus gland is removed from the newborn baby, the cells which will not be formed are
(1) Monocytes
(2) T-lymphocytes
(3) B-lymphocytes
(4) Eosinophils

Rack Your Brain

Name the bony cavity in which pituitary gland is lodged?

Previous Year's Question

Which of the following is due to abnormal secretion of thyroxine?
(1) Addison's disease
(2) Goitre
(3) Acromegaly
(4) Cretinism



Hormones of Thyroid Gland

- Thyroid gland produces two hormones thyroxine and calcitonin.
- A protein hormone called thyroxin. Thyroxine contains an iodine compound.
- Another hormone, calcitonin, is produced by the C-cells of the thyroid gland.

Thyroxine

- Hormone thyroxine is concerned with the metabolic activities and oxidation processes in the tissues.
- It controls the rate of cellular oxidation, the breakdown of sugar to produce energy, consumption of oxygen and consequently the output of carbon dioxide.

Previous Year's Question

Which of the following glands is associated with the consumption of iodised salts?
(1) Ovary
(2) Thymus
(3) Thyroid
(4) Pituitary

Calcitonin

- The C-cells are situated outside the follicles in the thyroid gland. Its secretion is under feedback mechanism.
- Calcitonin regulates the calcium phosphorus levels of the blood.
- Unlike parathormone, calcitonin is secreted when the concentration of Ca^{2+} rises in the blood plasma.
- The secreted calcitonin lowers the concentration of both Calcium and Phosphate ions in the plasma by reducing their mobilization from bones. It keeps the normal concentration of these ions in the blood.

Note: The plasma calcium level is very effectively maintained by a balance between the activities of parathormone and calcitonin.

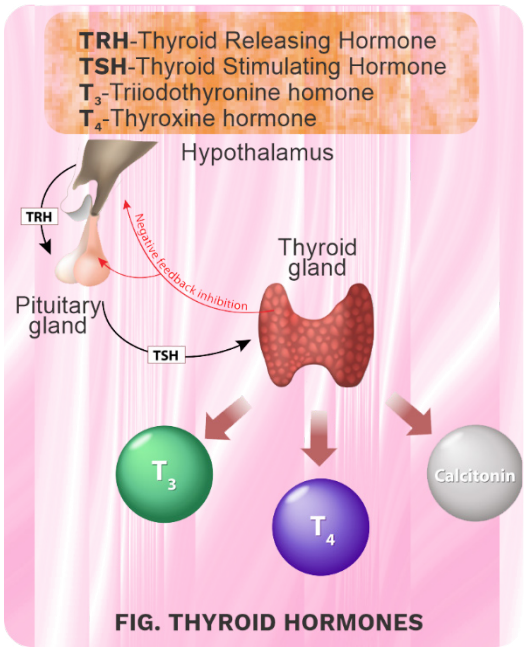


FIG. THYROID HORMONES

Abnormal Functioning of the Thyroid Gland

- Hyperactivity or hypoactivity reflects abnormal functioning of thyroid gland. In both the situations health is adversely affected.

Hyperactivity of the Thyroid Gland

- It causes increased secretion of thyroxine due to over activity of the thyroid cells or enlargement of the thyroid gland. This condition is called **hyperthyroidism.**
  - **Symptoms of Hyperthyroidism (Thyrotoxicosis)**
    - The basic metabolic rate is raised (hypermetabolism) and the body temperature may be higher than normal.
    - The patient loses weight. The food material is oxidized too rapidly.
    - The pulse rate is raised, the heart beats faster. The patient feels restlessness, nervousness, dizziness and difficulty in sleeping.

Previous Year's Question

Parathormone deficiency produces muscle cramp or tetany as a result of
(1) Enchanced blood glucose level
(2) Enchanced blood calcium level
(3) Lowered blood calcium level
(4) Enchanced blood sodium level

Rack Your Brain

Statement I: Iodine deficiency causes goitre.
Statement II: Goitre is curable.
Which of the above statement is correct?

- The eyeballs protrude out giving an angry look. This condition is called **exophthalmic goitre**.

Graves' Disease

- it is an autoimmune disease that affects the thyroid. It is also known as **Basedow's disease** or **toxic diffuse goitre.** It frequently results in hyperthyroidism which often results in an enlarged thyroid.
- **Signs and symptoms of Graves' disease** may include-
  - irritability
  - muscle weakness
  - sleeping problems
  - a fast heartbeat
  - poor tolerance of heat
  - diarrhoea and unintentional weight loss.
  - Other symptoms may include thickening of the skin on the shins, known as pretibial myxoedema, and eye bulging.

Hypoactivity (Hyposecretion)

- Less secretion of the thyroxine hormone than the required amount.

Symptoms for hypothyroidism (Deficiency of the secretion):

Iodine Deficiency in Adults –

- The deficiency of thyroid hormone causes **myxoedema** in adults and the symptoms are-
  - Slowdown of the general metabolic processes; the body cells do not oxidise the food as fast as required.
  - A tendency to gain weight.
  - Slowness of mind and speech; skin becomes thickened and dry.
  - Subnormal body temperature and slow pulse rate.
  - Enlarged thyroid gland (Goitre) in order to produce more thyroxin.

Rack Your Brain

Statement I: TSH is smallest peptide hormone.
Statement II: It has feedback regulation.
Which of the above statement is correct?

Previous Year's Question

Which of the following disease is not related to thyroid gland?
(1) Myxoedema
(2) Acromegaly
(3) Cretinism
(4) Goitre

Rack Your Brain

Statement I: A tadpole kept in water containing a weak solution undergoes rapid metamorphosis.
Statement II: Metamorphosis is controlled by thyroxine hormone.
Which of the above statement is false?

Iodine Deficiency in Children –

- The deficiency causes Cretinism in infants and the symptoms are–
  - Retarded physical and mental growth.
  - Thick and dry skin.
  - Gaping mouth with thick lips and protruding tongue.

Rack Your Brain

A pregnant woman is suffering from hypothyroidism. Which disease is likely to occur in the newborn baby?

Note:

Simple Goitre

Goitre results due to the deficiency of iodine in one's diet. Iodine is rich constituent of thyroxine. The thyroid gland enlarges to produce required amount of thyroxine hormone. This disease is more common in the people residing in hilly areas where the soil and natural water is deficient in iodine.

The addition of iodine to the table salt or to the water supply prevents this disease.

Differences between simple goitre and exophthalmic goitre

Simple Goitre	Exophthalmic Goitre
Reason is hyposecretion of thyroxine due to iodine deficiency.	Reason is hypersecretion of thyroxine.
Thyroid gland enlarges to secrete required amount of thyroxine.	Thyroid gland enlarges due to hyperactivity of the gland.
Eyes remain normal.	Eyes bulge out.
Reduced basic metabolic rate, low body temperature, low blood pressure and lethargy.	High metabolic rate, weight loss, rise in body temperature, high blood pressure and nervousness.

Previous Year's Question

Calcitonin is a thyroid hormone which-

(1) has no effect on calcium

(2) elevates potassium

(3)

(4)

Previous Year's Question

Which gland plays a key role in metamorphosis of frog's tadpole

(1) Pancreas

(2) Adrenal

(3) Thymus

(4) Thyroid

Note:

Role of Thyroxine in Metamorphosis

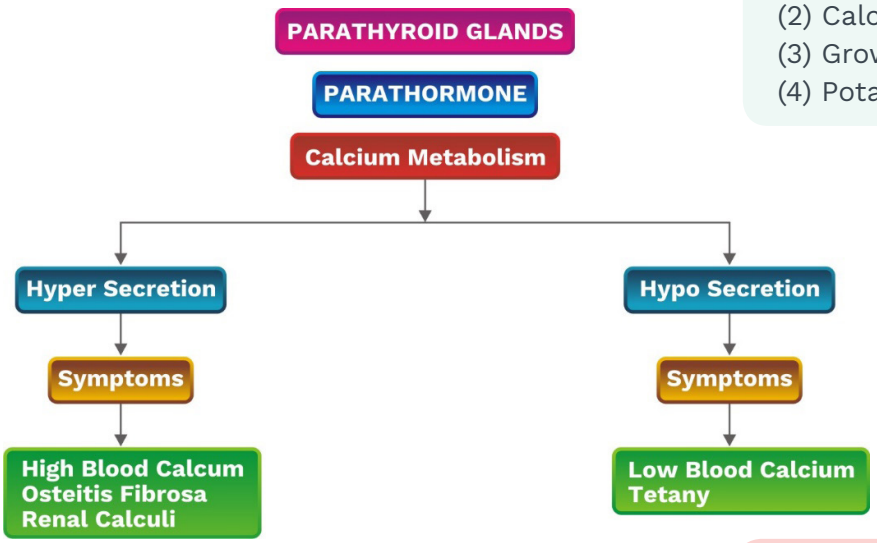
Thyroxine plays very vital role in the metamorphosis of tadpoles. If young tadpoles are supplied, thyroxine from outside, they metamorphose into frogs prematurely, before their body growth is complete. They are smaller than the normal metamorp hosed tadpole.

If tadpoles are administered antithyroid substances such as thiourea, their metamorphosis get delayed. Because they continue to grow without metamorphosis and become giant tadpoles.

Mexican *Axolotl* larva are amphibians which ordinarily exist and even reproduce in the aquatic larval form without undergoing metamorphosis. It happens because they are born deficient in thyroid hormones. If they are fed on thyroid hormones, they metamorphosis into the terrestrial adult form.

THE PARATHYROID GLANDS

- These are four small glands placed two on each side of the dorsal surface of the thyroid gland in the neck.
- Chief cells of parathyroid glands synthesise parathormone (PTH) or Collip's hormone.



Note: Parathyroids are under the direct feed-back regulation of blood-calcium level.

Previous Year's Question

If parathyroid gland degenerate which activity will be disturbed?
(1) Sodium concentration
(2) Calcium concentration
(3) Growth
(4) Potassium concentration

Rack Your Brain

Name the hormone which maintains calcium level in blood plasma.

Functions

- Parathormone (PTH) controls calcium metabolism.
- It promotes absorption and reabsorption of calcium from food in the intestine and nephrons respectively.
- It also regulates the amount of calcium in blood and bones and thereby affects the growth of bones, muscular contraction and activity of the nerves.

Previous Year's Question

Blood calcium level can be increased by the administration of-
(1) calcitonin (2) parathormone
(3) glucagon (4) progesterone

Hypoparathyroidism	Hyperparathyroidism
Hyposecretion of parathyroid hormone causes deficiency of blood calcium content and rise in phosphate level.	Over secretion of the parathormone causes rise of calcium level in blood.
Lack of calcium characterized by muscular twitching and convulsions, particularly of the hands and feet.	Decalcification of bones lead to bone deformities which are fracture prone.
Sustained contraction of muscles is called parathyroid tetany.	Formation of bone cysts and deposition of calcium in kidney (may result in formation of renal stones and kidney failure) take place.

Note: The administration of calcium quickly cure the patient.

Rack Your Brain

What stimulates the secretion of parathormone?

THE PANCREAS

- The pancreas is a heterocrine gland and is also the second largest gland of the human body.
- It is endodermal in origin.

Parts of Pancreas

- **Exocrine part:** It consists of acini cells with central lumen. These cells secretes digestive enzymes.
- **Endocrine part:** It consists of small groups of epithelial cells, found scattered between the alveoli of the pancreas, called **islets of Langerhans.**

Previous Year's Question

Which hormone possesses anti-insulin effect?
(1) Cortisol
(2) Calcitonin
(3) Oxytocin
(4) Aldosterone

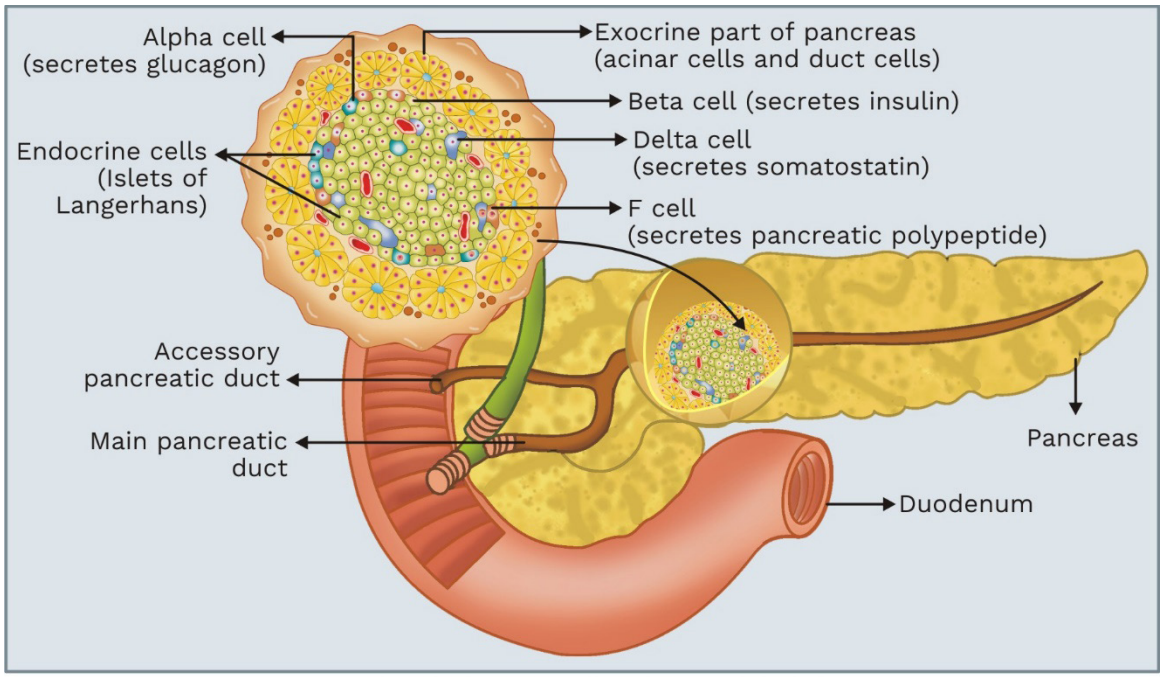


FIG. INNER STRUCTURE OF PANCREAS

- **Islets of Langerhans** consists of three types of cells-
  - **α cells**
  - **β cells**
  - **δ cells**

Functions

- Pancreas secretes three hormones: Insulin, glucagon and somatostatin.
- All these hormones are proteinaceous.
  - **Insulin**
    - Secreted by β cells
    - It regulates the amount of sugar in the blood.
    - It enables the body cells to absorb and use-glucose and fat.
  - **Glucagon**
    - Secreted by α cells
    - It helps to convert glycogen into glucose (glycogenolysis).

Note: Insulin and glucagon are antagonistic in action.

Previous Year's Question

Glucagon produced by α cells of islets of Langerhans-
(1) Decrease concentration of glucose in blood
(2) Converts glycogen to glucose
(3) Converts glucose to glycogen
(4) None of these

Previous Year's Question

Find out the correct matching pair from the following-
(1) Hyperglycemia – glucagon
(2) Calcitonin – parathyroid
(4) Vitamin D - Cretinism
(4) Thyroxine – rickets

Somatostatin

- The delta cells of islets of Langerhans secrete somatostatin hormone.
- Somatostatin inhibits secretion of insulin and glucagon.

Rack Your Brain

Why insulin and glucagon are known as antagonistic hormones.

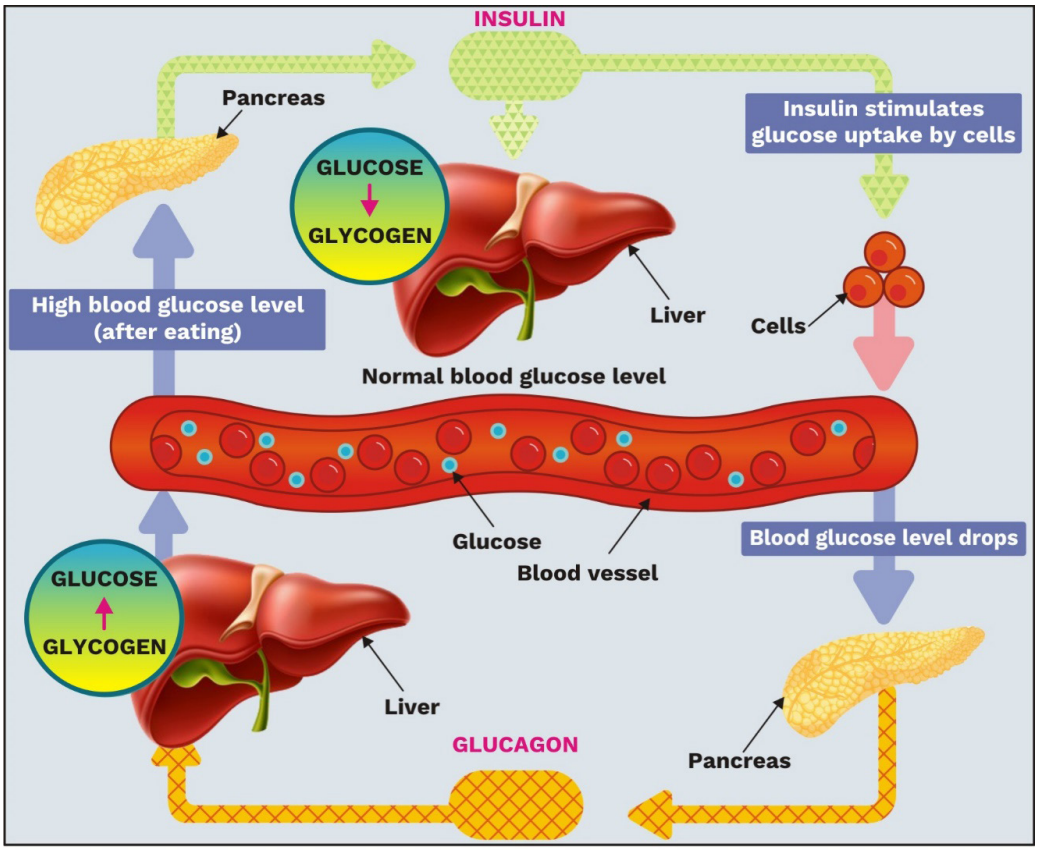


FIG. ROLE OF INSULIN AND GLUCAGON

Hypoactivity of the β cells

- It results in hyperglycaemia (deficiency of insulin),

Symptoms

- High blood sugar, loss of weight, fatigue and polyuria, presence of sugar in urine.
- In the deficiency of insulin, the liver and muscles are unable to convert the excess of glucose into glycogen (glycogenesis). As a result, amount of glucose in the blood stream increases.

Previous Year's Question

Pancreatic secretion is stimulated by
(1) enterogastrone
(2) cholicystokin-pancreozymin
(3) secretin
(4) duocrinin

- Kidney filters excess of the glucose along with urine. This disease is called diabetes mellitus.

Corrective Measures

- Diabetes patients are given insulin injection. Insulin is obtained from the pancreas of slaughtered animals.
- Human insulin is produced by recombinant technology using *Escherichia coli* and *Saccharomyces cerevisiae* for therapeutic use.

Caution: Insulin is never given orally because insulin is hormone and it will be converted into amino acids in the digestive tract.

Previous Year's Question

Diabetes is due to
(1) Hormonal deficiency
(2) Sodium deficiency
(3) Iodine deficiency
(4) Enzyme deficiency

Previous Year's Question

Diabetes is a disease in which urine contains?
(1) Protein (2) Sugar
(3) Salt (4) Fat

Comparision between Hyperglycemia and Hypoglycemia

Hyperglycemia	Hypoglycemia
Blood glucose level rises above the normal level.	Blood glucose level falls below the normal.
It is caused by deficiency of insulin.	It is caused by oversecretion of insulin.
Glucose is excreted in urine.	Glucose is not found in urine.
Excessive urination and dehydration is frequent.	Weakness, sweating, irritability, convulsions, etc. are predominant.
More intake of water is required.	Intake of glucose or sugar is required.

RENIN-ANGIOTENSIN SYSTEM

- Certain cells near the glomerular region of the kidney secrete a hormone renin under the influence of nervous stimuli.

- **Renin-hormone** stimulates liver to produce a hormone angiotensin.
- The hormone **angiotensin,** in its turn, stimulates adrenal cortex to secrete another hormone **aldosterone** (mineralocorticoid).
- Aldosterone regulates the excretion of sodium ions by the kidney tubules.

THE ADRENAL GLAND

- The adrenal glands are also known as **suprarenal** glands because of their location. There are two adrenal glands, each one lies on the top of the either side of kidney.
- Each adrenal gland consists of an outer yellowish part known as **cortex** and an inner portion called **medulla.**
- The adrenal cortex secretes several steroid hormones such as–
  - **Hydrocortisone,**
  - **Aldosterone**
  - **Corticosterone**

Hormones of Adrenal Cortex

- Cortical hormones can be classified into three groups:

Mineralocorticoids

- They are secreted by zona glomerulosa (outer layer).
- Regulate electrolyte or mineral and water balance in the body fluids e.g., aldosterone.
- **Aldosterone**
  - Its secretion is under the control of renin-angiotensin system.
  - Production of the hormone is stimulated by fall in plasma Na^+, rise in plasma K^+ or fall in blood volume.
  - Aldosterone reduces the elimination of Na^+ and Cl^- through their active reabsorption from glomerular filtrate and other excretory fluids. In exchange of reabsorbed

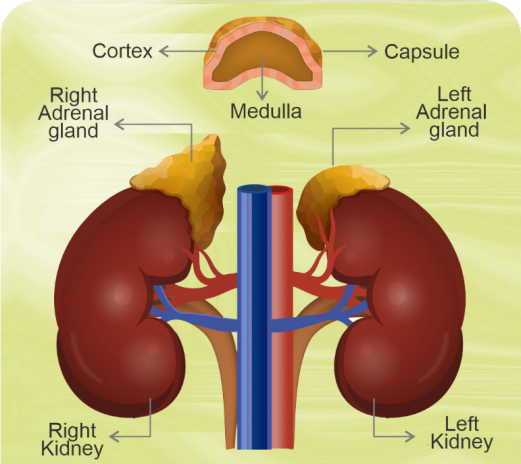


FIG. KIDNEYS AND ANDRENAL GLANDS

Previous Year's Question

Blood pressure is controlled by
(1) Hormones secreted by anterior pituitary gland
(2) Hormones secreted by mid pituitary gland
(3) Hormones secreted by posterior pituitary gland
(4) Adrenaline

Rack Your Brain

A sample of urine was diagnosed to contain a high content of glucose and ketone bodies. Based on this observation, answer the following:
(a) Which endocrine gland and hormone is related to this condition?
(b) Name the cells on which this hormone acts.
(c) What is the condition called and how can it be rectified?

Na^+, aldosterone promotes the elimination of K^+. Reabsorbed Na also brings out a lot of water from glomerular filtrate due to osmotic effect. This concentrate urine and increases the volume of blood.

- **Deficiency of aldosterone causes Addison's disease.**
- **Over secretion of aldosterone causes Conn's syndrome (aldosteronism).**

Glucocorticoids

- They are secreted by the middle layer or zona fasciculata (middle layer) of adrenal cortex under the stimulation of corticotropin (corticotrophin) hormone of anterior pituitary.
- Glucocorticoids include **cortisol, cortisone** and **corticosterone.**
- Cortisone, which is converted to **cortisol** is the main glucocorticoid.

Functions of Glucocorticoids

- Regulate metabolism of carbohydrates, fats and protein.
- Increase blood glucose by conversion of proteins into amino acids and deamination of amino acids, breakdown of fats and hydrolysis of glycogen.
- Cortisol has powerful anti-inflammatory properties.

Note: Excess production of glucocorticoids give rise to Cushing's syndrome.

Sex Corticoids

- They are hormones secreted by middle layer (zona fasciculata) and inner layer (zona reticularis) of adrenal cortex probably under the stimulation of corticotrophin (–corticotropin) hormone of anterior pituitary.
- Sex corticoids are connected with the development and maintenance of external sex characteristics, especially of the male type, e.g., androstenedione, dehydroepiandrosterone.

Previous Year's Question

Which of the following glands secrete life saving hormones?
(1) Thyroid
(2) Adrenal
(3) Pituitary
(4) Hypothalamus

Previous Year's Question

Androgens are secreted by
(1) Thyroid
(2) Parathyroids
(3) Pituitary
(4) Adrenals

Previous Year's Question

Hormone having stimulatory effect on heart is-
(1) Glucagon
(2) Thyroxine
(3) Gastrin
(4) Adrenaline

Previous Year's Question

Which hormone controls water and mineral metabolism?
(1) Glucagon
(2) Insulin
(3) Progesterone
(4) Deoxycorticosterone

- **Excess secretion sex corticoids cause adrenal virilism or male type of external characteristics in females.**

Note: In adrenal cortex inefficiency, kidney fails to conserve sodium, which therefore, is excreted in large amount. This disease is treated with cortisone hormone.

Hormones of Adrenal Medulla

- The adrenal medulla secretes two hormones commonly called as catecholamines. viz **adrenalin (epinephrine)** and **noradrenaline (norepinephrine).**
- These hormones are biogenic amines.
- The adrenal medulla produces these hormones under the influence of sympathetic nervous system.

Comparison between Adrenalin and Noradrenaline

Adrenalin	Noradrenaline
It is the hormone which acts during emergency situation and contributes to **fright, fight** and **flight** (triple F) reactions.	It also operates during emergency situations but bring all body activities to normal level after the excited state.
It is a **vasodilator** (increase the diameter of blood vessels). Thus, increases cardiac output as well as heart rate.	It is a **vasoconstrictor** (decreases the diameter of the blood vessels). Thus, reduces cardiac output as well as heart rate.
It has hyperglycemic effect by increasing in the output of glucose from the liver in order to combat the shock produced by the emotional stress.	It has hypoglycemic effect and thus reduces conversion of glycogen to glucose at the end of emergency situations.

Previous Year's Question

Water reabsorption in kidney is controlled by
(1) Oxytocin
(2) Aldosterone
(3) ADH
(4) GH

Rack Your Brain

Name the salt balancing hormone in human body.

Rack Your Brain

Name a steroid hormone which regulates glucose metabolism.

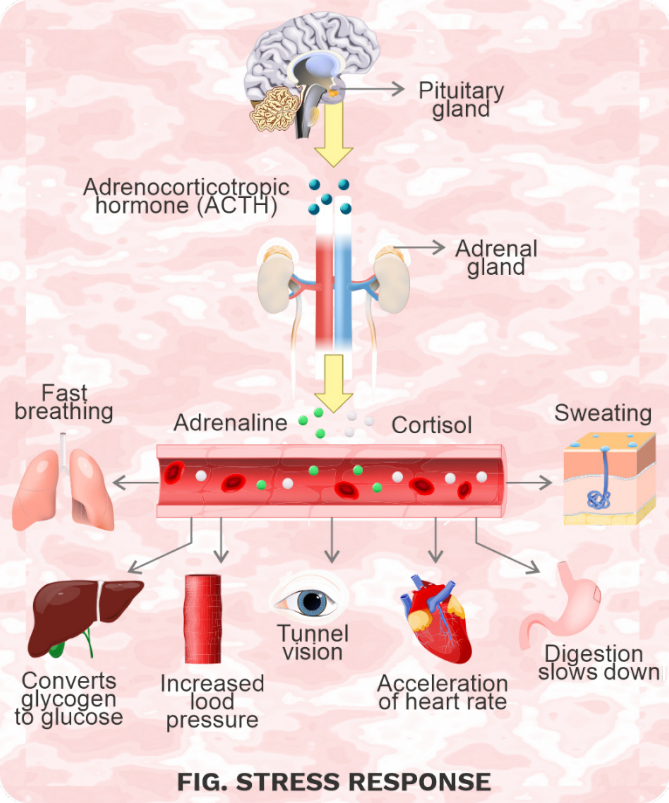


FIG. STRESS RESPONSE

Note: Adrenalin and noradrenaline increase alertness, pupilatory dilation, piloerection (raising of hair), sweating, etc.

Adrenal Disorders

Adrenogenital Syndrome

- The term was first used by Gallais in 1912.
- It is due to excess secretion of androgenic hormones.
- It is limited to females. The over secretion of androgens inhibits the secretion of gonadotropins from pituitary gland, thus results in failure of follicle development and of ovulation.
- It is characterised by enlarged clitoris and increased masculinity.

Previous Year's Question

Which hormone causes anti-insulin effect?
(1) Aldosterone
(2) Calcitonin
(3) Cortisol
(4) Oxytocin

Rack Your Brain

Name two hormones which are derived from tyrosine?

Previous Year's Question

Adrenal cortex produces-
(1) Calcitonin
(2) Adrenalin
(3) Aldosterone
(4) Ephinephrine

Rack Your Brain

Write on the role of endocrine glands and hormones responsible for maintaining calcium homeostasis.

Virilism (Hirsutism)

- It is caused due to over secretion of androgens by adrenal cortex.
- It is a tendency to develop male characters in a female like masculine in appearance, growth of beard, deep voice, baldness, thick neck, menstruation becomes irregular and disappears later on, small uterus and external genitalia normal with enlarged clitoris.

Gynecomastia

- Excessive secretion of estrogens due to adrenal cortex.
- It occurs in males where enlarged mammary glands, retards growth of beard, atrophy of testes and a feminine distribution of fat is observed.

Cushing's Syndrome (Hypercorticism)

- It is caused by excess of corticosteroids or adrenocorticoids which may be due to a tumour of the adrenal cortex.
- The main symptoms are:
  - High blood sugar and appearance of sugar in urine.
  - Rise in plasma Na^+ and fall in plasma K^+.
  - Rise in blood volume and high blood pressure.
  - Obesity and fat pads result into Buffalo hump and impart asymmetrical shape to the body.
  - Wasting of muscles of thigh, pectoral and pelvic girdles.
  - Red cheeks and moon face are the main clinical symptoms.
  - Excessive mobilization of materials from bone renders the bones weak and fragile (osteoporosis).
  - Excessive loss of potassium in urine causes potassium deficiency (hypokalemia). This leads to muscular weakness and nervous disorders, and may cause tetany and paralysis, frequent urination (polyuria) thirst and bed urination (nocturia), etc.

Previous Year's Question

In emergency, blood pressure is controlled by-
(1) Adrenaline
(2) Prolactin
(3) ACTH
(4) Thyroxine

Rack Your Brain

Inflammatory responses can be controlled by a certain steroid. Name the steroid, its source and also its other important functions.

Previous Year's Question

Cushing's disease caused by hyperactivity of
(1) insulin
(2) GH
(3) thyroxine
(4) glucocorticoid

Rack Your Brain

Statement I: Excess of cortisol causes Cushing's syndrome.
Statement II: High BP, sugar in urine, wasting of limb muscles.
How are these two statements complementing each other?

Addison's disease (Hypocorticism)

- Hyposecretion of adrenocorticoids cause Addison's disease.
- This disease was first described by Thomas Addison (Father of Endocrinology) in 1855. This condition may be caused due to tuberculosis or atrophy of the adrenal cortex.
- It is characterized by–
  - Brownish pigmentation or bronze like skin on the exposed parts of the body like face and hands due to deposition of melanin.
  - Considerable amount of Na+ ions and water is excreted in urine, leading to dehydration, low blood pressure, hypotension and weakness.
  - Due to low cortisol level, glucose level also falls in blood (hypoglycemia). It greatly reduces BMR, efficiency of brain, skeletal and cardiac muscles and body temperature also falls.
  - Loss of appetite, abdominal pain, restlessness and loss of weight.

Aldosteronism (Conn's Syndrome)

- A syndrome produced by hypersecretion of aldosterone from an adrenal cortical tumour.
- Its symptoms include:
  - High plasma Na^+ ions
  - Low plasma K^+ (hypokalemia)
  - alkaline urine
  - Sensation of thirst
  - Hypertension, frequent urination periodic paralysis (polyuria)
  - Periodic paralysis and tetany
- This condition may occur at any age, normally above twelve and in either sex.

ENDOCRINE FUNCTIONS OF GONADS

- The gonads-ovaries and testes produce gametes eggs and sperms respectively and also produce sex hormones.

Rack Your Brain

Hypoactivity of adrenal cortex alters carbohydrate metabolism which results into _____ and Graves' disease is caused by _____.

Previous Year's Question

Which one does not match with regard to biological activity?
(1) Creatinine
(2) Oxytocin
(3) Renin
(4) Gastrin

Rack Your Brain

Besides growth hormone of pituitary, hormones of which other gland act as mild growth hormone?

Previous Year's Question

Endocrine gland for combating emergency is-
(1) Parathyroid
(2) Adrenal medulla
(3) Adrenal cortex
(4) Pancreas

Ovaries (Female reproductive organ)

- There are two ovaries found in a female in the lower part of the abdomen.
- Ovary is composed of ovarian follicles and stroma tissues.
- The stroma tissues and the Graafian follicle cells produce hormones known as estrogens the most important of which is estradiol (steroid).

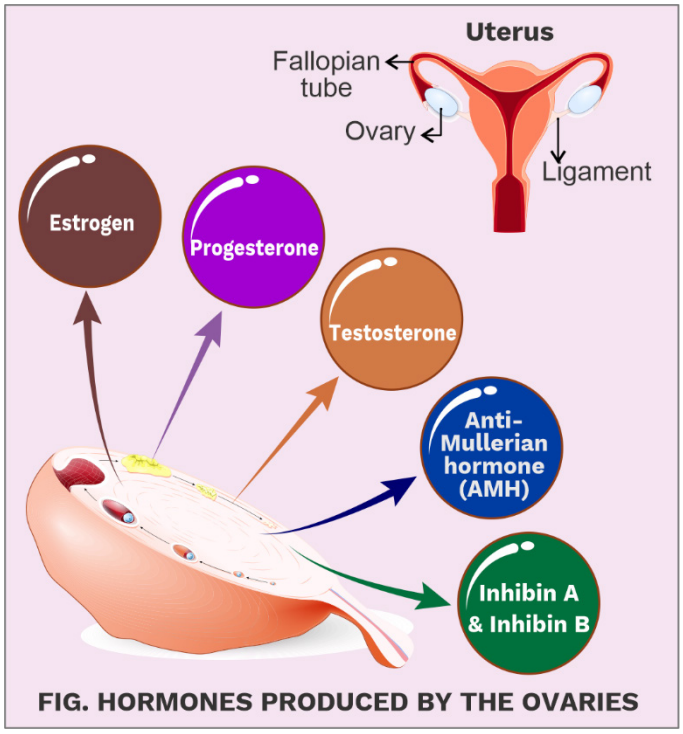


FIG. HORMONES PRODUCED BY THE OVARIES

Estrogen Hormone

- It is synthesised mainly by growing ovarian follicles.
- It helps in producing secondary female characters in female (at puberty):
  - Development of breast
  - Development of pubic hair
  - Deposition of fat on the thighs
  - Enlargement of uterus and vagina
  - Periodic bleeding (menstruation)

Previous Year's Question

Which of the hormone is secreted by Graafian follicle of the ovary?
(1) Relaxin
(2) Progesterone
(3) Estrogen
(4) Cortisone

Rack Your Brain

There are many endocrine glands in the human body. Name the glands which are absent in male and the one absent in the female.

Previous Year's Question

FSH plays an important role in
(1) Ovulation
(2) Spermatogenesis
(3) Control of blood sugar
(4) None

Previous Year's Question

Female sex hormone is-
(1) Insulin
(2) Estrogen
(3) Androgen
(4) Adrenalin

- It is produced in great quantity before ovulation so as to prepare the uterine wall for the possible reception of the fertilised egg.

Progesterone

- It is secreted by corpus luteum (leftover follicular cells after ovulation).
- Progesterone avoids the menstruation.
- The mammary glands enlarge (formation of alveoli) and other necessary changes associated with pregnancy and milk secretion.
- **Medical Value of Progesterone.** It is injected to prevent threatened abortion.

Previous Year's Question

The temporary endocrine structure after ovulation is
(1) Corpus callosum
(2) Corpus albicans
(3) Corpus luteum
(4) Corpus uteri

Note:

Corpus luteum (Temporary Endocrine Gland)

After ovulation, the ruptured follicle shrinks and becomes a small body, the corpus luteum (yellow in colour). It secretes another female hormone, progesterone which continues to prepare the uterus to receive the egg.

If the egg is not fertilised, the corpus luteum begins to degenerate and monthly bleeding (menstruation) occurs.

Testes (Male Reproductive Organ)

- The testes are two oval glandular organs suspended in a cutaneous pouch called the scrotal sac (outside abdomen).
- Testes perform dual functions as a primary sex organ as well as an endocrine gland.
- The temperature of the scrotal sac remains 2°C lower than the body temperature. This lower temperature is necessary for testicular functions i.e., production of sperms and male androgens hormone.
- The interstitial cells **(Leydig cells)** of the testis produce the male hormones androgens (steroids) the most important of which is testosterone.

Previous Year's Question

If ovaries of a lady are removed in the fourth month of pregnancy, the result will be
(1) Embryo will develop normally till birth
(2) Abortion will occur after some time
(3) Development of embryo becomes abnormal
(4) None of these

Testosterone

- This hormone brings about the secondary masculine (male) sex characters such as–
  - Enlargement of the scrotum and penis
  - Broadening of the shoulders
  - Deepening of the voice
  - Growth of the pubic hair, growth of moustache and beard etc.

PLACENTAL HORMONES

- The human placenta acts as a temporary endocrine gland.
- Placental hormones: **Estrogen, progesterone, human placental lactogen (hPL)** and **human chorionic gonadotropin (hCG).**

Functions

- Human Chorionic Gonadotropin (hCG) enlarges the corpus luteum in the ovary and stimulates it to secrete progesterone to support necessary changes during pregnancy.

HORMONES SECRETED FROM NON-ENDOCRINE GLAND (TISSUES)

Hormones from Heart

Antinatriuretic Factor (ANF)

- ANF is a peptide hormone.
- It is secreted from the atrial wall of heart when the blood volume or pressure in the atria increases. It dilates the blood vessels and helps in reducing the blood pressure.

Hormones from Kidneys

- **Erythropoietin (EPO)** is a peptide hormone secreted from the cells of juxtaglomerular apparatus.
- It stimulates erythropoiesis (formation of erythrocytes in the bone marrow).

Previous Year's Question

Which of the following hormones is not a secretion of human placenta?

(1) Prolactin (2) Estrogen
(3) Progesterone (4) HCG

Rack Your Brain

Testicular hormones are usually _____ hormones.

Previous Year's Question

Uterine contraction at child birth is stimulated by-

(1) Adrenaline
(2) Prolactin
(3) Progesterone
(4) Oxytocin

Rack Your Brain

Alcohol inhibits secretion of which of the following hormones?

(a) ADH
(b) Insulin
(c) Mineralocorticoids

Gastrointestinal Hormones

- These are peptide hormones, secreted by the gastrointestinal mucosa.
- They mainly regulate the secretions and movement of the alimentary system.

Previous Year's Question

The hormone that stimulates the stomach to secrete gastric juice is
(1) Gastrin (2) Enterogastrone
(3) Enterokinase (4) Renin

Examples of Gastrointestinal Hormones

Hormone	Description
Gastrin	It is secreted from near the junction of the stomach and duodenum. Its function is to stimulate the secretion of gastric juice and movement of the stomach.
Enterogastrone	It retards the secretion of gastric juice.
Secretin	It is secreted by the intestinal mucosa. It stimulates the secretion of water and bicarbonates in the pancreas and bile juice. It inhibits the secretion and movements of the stomach.
Cholecystokinin (CCK)	It is also secreted by the small intestinal mucosa. It stimulates the secretion of enzymes in the pancreatic juice and the contraction of gall bladder to release bile into duodenum.
Gastric Inhibitory Peptide (GIP)	It is secreted by the mucosa of duodenum. It inhibits gastric secretion and mobility.

Note:
Growth Factors
Hormones secreted from non-endocrine tissues which are essential for normal growth of tissues and their repairing or regeneration.

Previous Year's Question

Which of the following is a gastro-intestinal hormone?
(1) Cholinesterase (2) Enterokinase
(3) Secretin (4) Prolactin

INTEGRATED ROLE OF HORMONES IN HOMEOSTASIS

- Hormones set up a communication between one part of the body and another. Though different hormones regulate or carry out a number of metabolic functions yet all the hormones work together in order to achieve metabolic harmony or maintenance of steady state control (homeostasis) of the body.
- Feedback mechanism of the endocrine glands is an effective mechanism in maintenance of steady state control (homeostasis) of the body.

FEEDBACK CONTROL OF THE ENDOCRINE

- The secretion of all the anterior pituitary hormones is governed by the different releasing hormones (RH), produced by the hypothalamus. In turn, anterior pituitary hormones govern the production of hormones by the respective endocrine glands.
- The release of hormone less or more than normal required amount by the endocrine glands affect the hypothalamus and pituitary gland so that they produce less or more endocrine regulating hormone to maintain the balance of hormone level in the blood.
- This mechanism is known as feedback control.

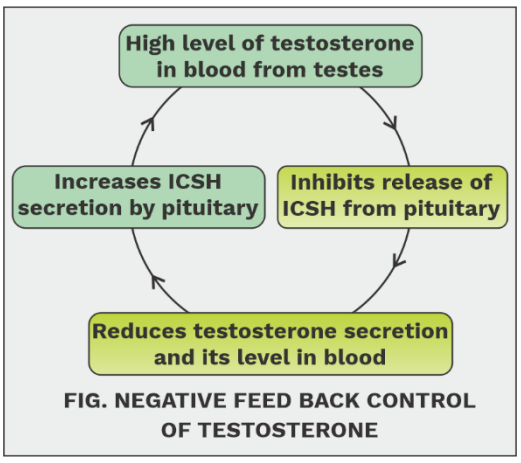


FIG. NEGATIVE FEED BACK CONTROL OF TESTOSTERONE

Definition

Homeostasis: It refers to steady internal state of a living organism by self-regulating life processes best suited for its survival and hormones play important role.

Gray Matter Alert!!!

The term homeostasis is coined by Walter D. Cannon in 1930.

Rack Your Brain

What is erythropoiesis? Which hormone stimulates it?

Previous Year's Question

Testosterone is produced by-
(1) Pituitary gland
(2) Leydig cells
(3) Sertoli cells
(4) Oxyntic cells

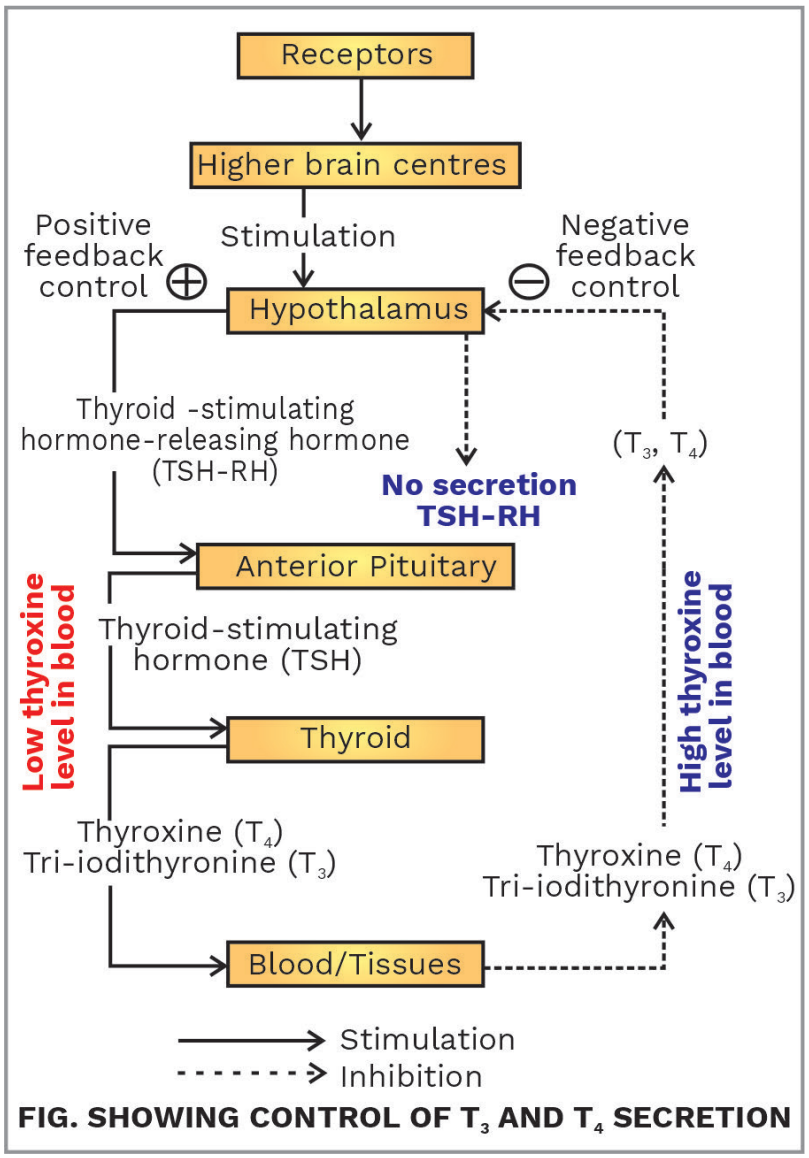


FIG. SHOWING CONTROL OF T_3 AND T_4 SECRETION

Note: Suppose, level of thyroxine in the blood is high. This will affect the hypothalamus to release less TSH-RH. As a result, anterior pituitary lobe will produce less TSH. Consequently, production of thyroxine by the thyroid gland will be reduced to maintain the normal level of thyroxine in the blood. This type of feedback control is known as negative feedback effect.

Previous Year's Question

Which hormone promotes cell division, protein synthesis and bone growth?

(1) GH (2) ADH
(3) ACTH (4) PTH

*This type of feedback mechanism is called positive feedback effect.

Feedback Control by Metabolites

- The level of certain metabolites also effects the secretion of certain hormones bound to act on these metabolites.
- For example, after a meal, glucose level of the blood rises which evokes the secretion of insulin to act on it. Within the fall in glucose level in blood a decrease in release of the insulin is signalled.

Feedback Control by Nerves

- The secretion of adrenal medullary hormones (adrenaline and noradrenaline) is controlled by the nerves of the sympathetic nervous system is well known.
- An emotional stress stimulates the sympathetic nervous system. In turn, sympathetic nerves of adrenal gland stimulate adrenal medulla to produce adrenalin hormone.
- Consequently, there is increase in blood pressure, heartbeat, rate of respiration etc.
- When the emotional stress is over, sympathetic nerve signals shutting off the release of adrenaline.

The Pheromones

- Pheromones are the chemical substances which act as chemical signals. Pheromones or chemical signals are produced by exocrine glands and released in the external environment. Pheromones are used between members of the same species.
- For example, honey bees in a food-rich area secrete pheromones that attract other bees to the locations.
- Similarly, under stress conditions many types of ants release alarming pheromones that induce fellow ants to become aggressive.
- **Juvenile Hormone** is the hormone produce by **corpus allatum** (pl.corpora allata), a type of gland in the insects. Its presence prevents imaginal

Hypothalamus produces thyroid stimulating hormone-releasing hormone (TSH-RH)

↓

Which stimulates anterior pituitary lobe to secrete thyroid stimulating hormone (TSH)

↓

In turn, TSH stimulates thyroid gland to secrete thyroxine hormone

↓

If level of thyroxine is less than normal, it will affect hypothalamus to produce more TSH-RH

↓

More production TSH-RH will cause release of more TSH by the anterior pituitary lobe

↓

In turn, TSH stimulates thyroid gland to secrete thyroxine hormone

If level of thyroxine is less than normal, it will affect hypothalamus to produce more TSH-RH

↓

More production of TSH-RH will cause release of more TSH by the anterior pituitary lobe

↓

In turn, TSH will excite thyroid to produce more thyroxine so that its level in the blood is maintained

Rack Your Brain

Which is the most essential unit for a living cell to sustain limited life span?

moult (the stage in which an insect attains maturity).

MECHANISM OF HORMONE

Mechanism of a Steroid Hormone

- The hormones when released into the blood enters into the specific cells which make up that hormone's target tissue.
- The hormones form two major groups like steroid and proteinous. They effect the cell in two different ways:
  - The steroid hormones act within the cell. Their small, lipid-soluble molecules pass through the cell membrane and bind to specific receptor molecules present in the cytoplasm forming a complex.
  - The complex moves to the nucleus of the cell where hormone molecule binds to the chromosome (DNA) and activates the gene.
  - The activated gene results in the production of specific protein inside the cell.

Mechanism of Proteinous Hormone Action

- The proteinous hormone molecules are large and cannot enter the cell. Therefore, they bind with specific receptor molecules on the cell membrane and form complex.
- The hormone-receptor complex enters into the cell and acts in two different ways:
  - **Formation of cAMP**
    - The hormone receptor complex releases an enzyme adenyl cyclase from the inner surface of the membrane.
    - This enzyme combines with ATP and forms cyclic adenosine monophate (cAMP).
    - The cAMP activates the intracellular enzymes which control the metabolic activities of the cell.
    - The conversion of glycogen to glucose occurs in the liver by this mechanism.

Previous Year's Question

Secretin stimulates secretion of
(1) Stomach
(2) Liver
(3) Pancreas
(4) Gall Bladder

Previous Year's Question

The hormone that stimulates the stomach to secrete gastric juice is
(1) Gastrin
(2) Renin
(3) Enterokinase
(4) Enterogastrone

Rack Your Brain

The _____ gland gradually atrophies at the age of 14 – 16 years due to the activity of sex glands.

Previous Year's Question

Which of the following is not a secondary messenger in hormone action?
(1) CAMP
(2) cGMP
(3) Calcium
(4) Sodium

- The hormone-receptor complex acts as first messenger and the cAMP as second messenger.
- This mechanism is also known as second messenger hypothesis which was described by Earl W. Sutherland in 1950.
- The formation of cyclic AMP occurs in certain hormones like epinephrine, norepinephrine, glucagon, vasopressin, thyroxine, etc. These hormones show their effect on target tissues immediately after their release, as such called quick-acting hormones.

Permeability of Membrane

- The hormone-receptor complex modifies the molecular structure of the membrane and changes its permeability to inorganic ions, sugars, amino acids and water. For example, excess of glucose causes the release of insulin from the pancreas.
- Insulin increases the permeability of the plasma membrane for the transfer of blood glucose into the muscle cells.

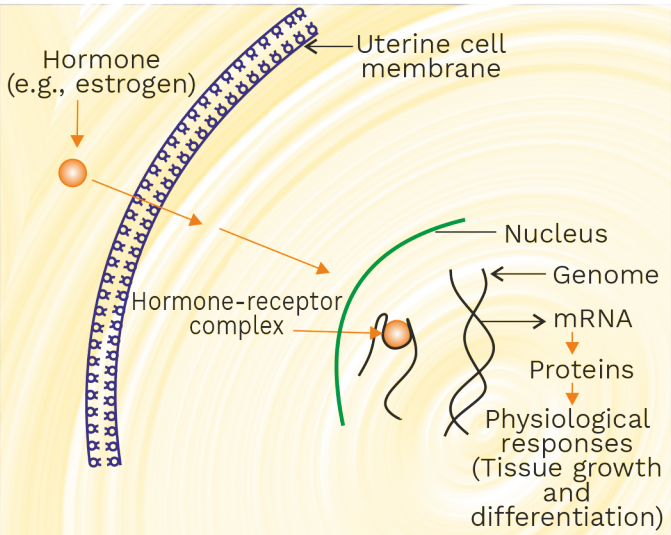


FIG. MECHANISM OF STEROID HORMONE ACTION

Gray Matter Alert!!!

Cyclic AMP (cAMP) is destroyed by phosphodiesterases enzymes once it has served its function.

Rack Your Brain

Which gland atrophies with advancing age?

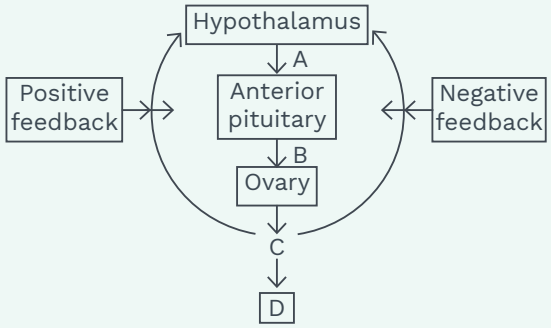
Previous Year's Question

Receptors for protein hormones are located
(1) In cytoplasm
(2) On cell surface
(3) In the nucleus
(4) On the endoplasmic reticulum

- The antidiuretic hormone (ADH) or vasopressin hormone produced by the posterior pituitary gland increases the permeability of the walls of the renal collecting tubules to water.
- Those hormones which form complex on the cell membrane often produce their effect faster than those hormones which form complex in the cytoplasm.
- Surface-acting hormones (proteinous hormones) are called quick-acting hormones and those which act in the cytoplasm like steroid hormones take some time for the appearance of their effect and thus, called slow-acting hormones or hormones acting with a lag period.

Previous Year's Question

Choose the correct combination of labelling the hormonal control of female reproductive system.

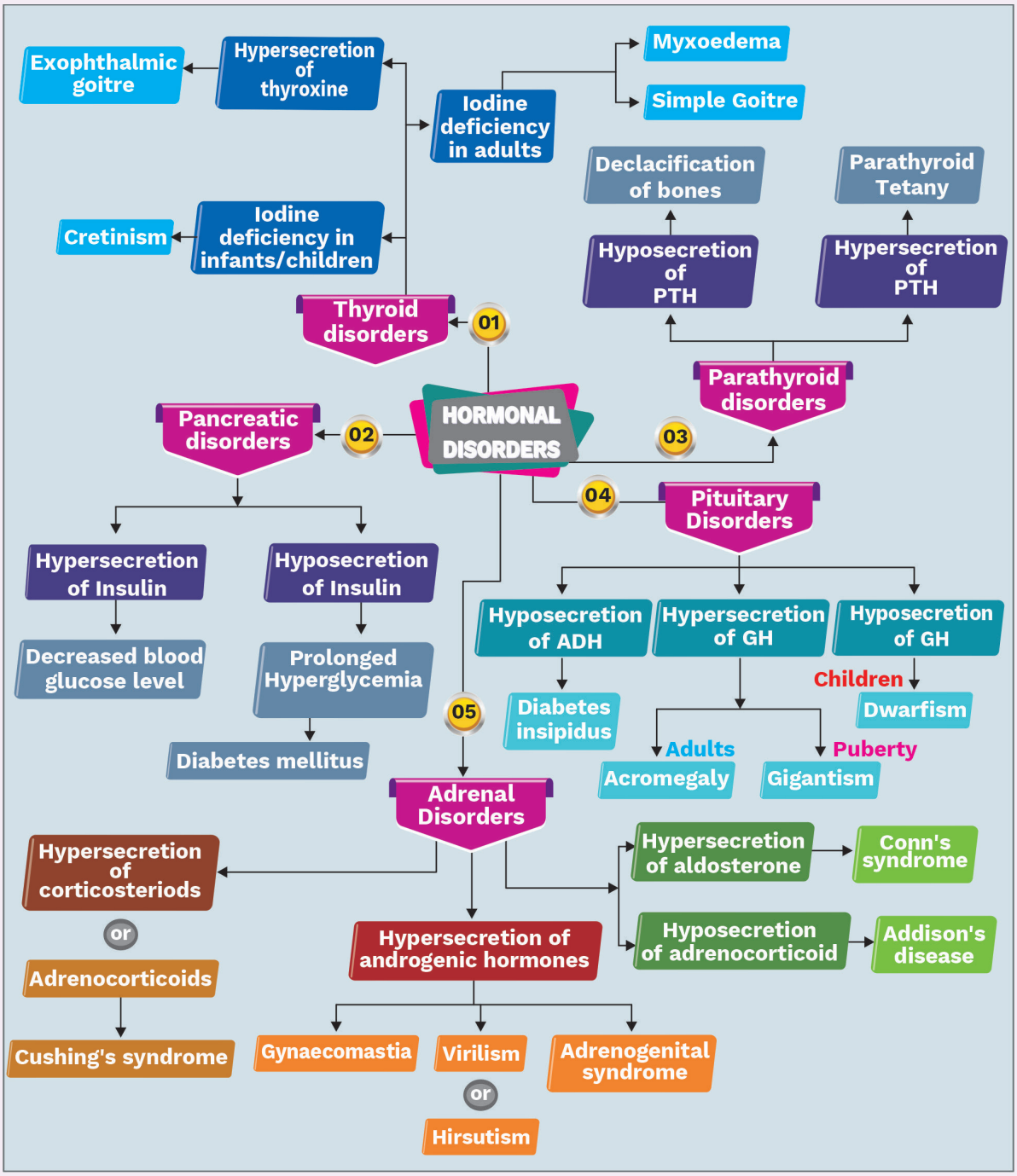


(1) A-GnRH, B-TSH, C-LTH, D-uterus
(2) A-GnRH, B-LH/FSH, C-estrogen or progesterone, D-uterus
(3) A-GnRH, B-STH, C-LH, D-uterus
(4) A-GnRH, B-ACTH, C-LH, D-uterus
(5) A-GnRH, B-LTH, C-estrogen, D-uterus

Summary


Releasing hormones
Hypothalamus
Inhibiting hormones
GH (STH), TSH, ACTH, FSH or ICSH LH, PRL, MSH
Adenohypophysis
Pituitary
Vasopressin (or ADH) Oxytocin, Somatostatin
Neurohypophysis
Melatonin
Pineal
Tri-idothyronine (T_3)
Thyroxine (T_4)
Thyroid
Thyrocalcitonin (TCT)
Parathormone (PTH)
Parathyroid
Thymosins
Thymus
Mineralocorticoids Glucocorticoids Gonadocorticoids
Adrenal cortex
Adrenal
Adrenaline Noradrenaline
Adrenal medulla
Gastrin, Gastric Inhibitory Peptide, Secretin, Cholecystokinin, Duocrinin, Villikinin, Enterocrinin
Hormones of Gastrointestinal Tract
Hormone of Kidney
Erythropoietin
Hormone of Heart
Atrial Natriuretic Factor (ANF)
HUMAN ENDOCRINE SYSTEM
Enzymes, mucus, wax, oil, sweat, etc.
Secrete
Exocrine Glands (with ducts)
Glands
Endocrine Glands (without ducts)
Heterocrine Glands (Partly endocrine and partly exocrine)
Secrete
Hormones
Pancreas
Ovaries
Testes
Beta cells
Alpha cells
Estrogen Progesterone
Insulin
Glucagon
Testosterone
D cells
F cells
Somatostatin
Pancreatic Polypeptide

Summary


HORMONAL DISORDERS
01
Thyroid disorders
Exophthalmic goitre
Hypersecretion of thyroxine
Iodine deficiency in adults
Myxoedema
Simple Goitre
Cretinism
Iodine deficiency in infants/children
02
Pancreatic disorders
Hypersecretion of Insulin
Decreased blood glucose level
Hyposecretion of Insulin
Prolonged Hyperglycemia
Diabetes mellitus
03
Parathyroid disorders
Declacification of bones
Hyposecretion of PTH
Parathyroid Tetany
Hypersecretion of PTH
04
Pituitary Disorders
Hyposecretion of ADH
Diabetes insipidus
Hypersecretion of GH
Adults
Acromegaly
Puberty
Gigantism
Hyposecretion of GH
Children
Dwarfism
05
Adrenal Disorders
Hypersecretion of corticosteriods
or
Adrenocorticoids
Cushing's syndrome
Hypersecretion of androgenic hormones
Gynaecomastia
Virilism
or
Hirsutism
Adrenogenital syndrome
Hypersecretion of aldosterone
Conn's syndrome
Hyposecretion of adrenocorticoid
Addison's disease

Summary

Source, chemical nature and functions of various hormones

S.No.	Gland	Hormones	Chemical Nature	Chief Function & Regulation	Disorder	
1.	Pineal	Melatonin	Biogenic amine	Sleep-wake cycle, body temp., metabolism, pigmentation, menstrual cycle, defense capability	Disturbed sleep-wake cycle, Reproductive impairment etc.	
2.	Thyroid	Thyroxine	Protein	Basic metabolic rate (BMR)	Simple goitre, cretinism(children) (hyposecretion)	Exophthalmic goitre or Grave's disease (hypersecretion)
3.	Parathyroid	Parathormone (Hypercalcemic)	Protein	Calcium metabolism, stimulates bone resorption	Nerve and muscle abnormality, tetanus etc. (hyposecretion)	Hypercalcemia, bone weakening (hypersecretion)
4.	Pancreas (i) β cells	Insulin	Proteins	Blood sugar conversion of glucose to glycogen	Hyperglycemia (hyposecretion)	Diabetes mellitus (Prolonged hyperglycemia)
	(ii) α cells	Glucagon		Conversion of glycogen to glucose	–	–
5.	Adrenal Cortex	Mineralo-corticoids (Aldosterone)	Steroids	Salt and water balance	Loss of sodium	Impaired salt balance
		Glucocorticoids (Cortisol)		Glucose level; carbohydrate metabolism	More oxidation of glucose less gluconeogenesis, (hyposecretion)	Impaired carbo. metabolism (hypersecretion)
6.	Adrenal medulla	Catecholamines Adrenalin	Biogenic amines	Alterness, pupilary dialation, piloerection, sweating,blood pressure, heart beat, respiration and glucose metabolism (response to stress)	Increased vasodilation	Impaired glucose metabolism and blood pressure (hyposecretion)
		Non-adrenalin			Increased vasoconstriction	
7.	Testis	Testosterone and other androgens	Steroid	Primary and secondary male sex characters	Hirsutism (hypersecretion) in females	Feminisation (hyposecretion in males)
8.	Ovary (I) Graafian follicle	Estrogen & Estradiol	Steroid	Primary and secondary male sex characters	Carcinogenic (hypersecretion)	Impaired reproduction
	(ii) Corpus luteum	Progesterone	Steroid	Uterus growth in pregnancy, milk secretion		Abortion during pregnancy (hyposecretion)
9.	Anterior lobe Pituitary	TSH	Proteins	Stimulates thyroid	Various diseases	Various diseases
		ACTH		Stimulates adrenal cortex		
		FSH/ISCH		Simulates ovary follicle/interstitial cells		
		LH		Simulates luteum		
		Prolaction		Simulates milk secretion		
		GH		Simulates tissue growth	Gigantism (hypersecretion)	Dwarfism (hyposecretion)
10.	Intermediate lobe Pituitary	Melanocyte stimulating hormone (MSH)	Protein	Coloration of skin	Various diseases	
11.	Posterior lobe pituitary	Vasopressin or ADH	Protein	Controls the water and salt absorption from kidney	Diabetes insipidus (hyposecretion)	
		Oxytocin	Protein	Contraction of uterus and expulsion of milk.	–	

Solved Exercise

Q1 **Which one of the following pair of organs includes only the endocrine glands?**
(1) Thymus and testes
(2) Adrenal and ovary
(3) Parathyroid and adrenal
(4) Pancreas and parathyroid

A2 **(3)**
Parathyroid and adrenal glands are the endocrine glands because they manufacture hormones and secrete them directly into the blood stream to act at distant sites in the body. Thyroid and pituitary are its other examples.

Q2 **The blood calcium level is lowered by the deficiency of**
(1) parathormone
(2) calcitonin
(3) both calcitonin and parathormone
(4) thyroxine

A2 **(1)**
Parathormone is secreted by chief cells of the parathyroid that regulates the metabolism of calcium and phosphate. It increases calcium absorption from the intestine and also increases calcium resorption from the nephrons of the kidneys. So its deficiency leads to low blood calcium level.

Q3 **Feeling the tremors of an earthquake a scared resident of seventh floor of a multistoryed building starts climbing down the stairs rapidly. Which hormone initiated this action?**
(1) Adrenaline
(2) Glucagon
(3) Gastrin
(4) Thyroxine

A3 **(1)**
Adrenaline (epinephrine), also called emergency hormone, is a hormone, produced by the medulla of the adrenal glands, that increases heart activity, improves the power and prolongs the action of muscles, and increases the rate

and depth of breathing to prepare the body for 'fright, flight, or fight'. At the same time it inhibits digestion and excretion. Similar effects are produced by stimulation of the sympathetic nervous system.

Q4 **Which hormone causes dilation of blood vessels, increased oxygen consumption and glucogenesis?**
(1) Glucagon
(2) ACTH
(3) Insulin
(4) Adrenaline

A4 **(4)**
Adrenaline is the hormone secreted by adrenal medulla. It prepares the animal to face special conditions created by physical stress. All these conditions require more energy which is provided by increasing heart beat, blood pressure, respiratory rate, sugar level of blood, blood supply of heart and skeletal muscles and brain through dilation of their small arteries, and oxidative metabolism. It also stimulates the breakdown of liver and muscle glycogen (glucogenesis) to provide glucose for respiration.

Q5 **Which of the following is an accumulation and release centre of neurohormones?**
(1) Anterior pituitary lobe
(2) Posterior pituitary lobe
(3) Intermediate lobe of the pituitary
(4) Hypothalamus

A5 **(4)**
Releasing and inhibiting factors are released by hypothalamus. The hypothalamus is connected to adenohypophysis by hypophysial portal vein and is connected to the neurohypophysis by axons of neurosecretory cells. Hence, neurohypophysis is directly under the neural control. The cardiocytes of atria of the heart secrete peptide hormone, called atrial natriuretic factor (ANF) in response to an increased return of the deoxygenated (venous) blood. The liver produces angiotensinogen which is changed to angiotensin II by an enzyme renin secreted by juxtaglomerular apparatus (JGA)

Q6 **Which one of the following is not a secondary messenger in hormone action?**
(1) cAMP
(2) cGMP
(3) Calcium
(4) Sodium

A6 **(4)**
Secondary messengers are low-weight diffusible molecules that are used to relay signals within a cell. They are synthesized or released by specific enzymatic reactions, usually as a result of an external signal that is received by a transmembrane receptor. cAMP, cGMP and Ca^{2+} act as secondary messengers and are located within the cytoplasm. Sodium is an essential nutrient which helps to maintain blood volume and keeps nerves functioning.

Q7 **Which one of the following statements is correct?**
(1) Endocrine glands regulate neural activity, but not vice versa.
(2) Neurons regulate endocrine activity, but not vice versa.
(3) Endocrine glands regulate neural activity, and nervous system regulates endocrine glands.
(4) Neither hormones control neural activity nor the neurons control endocrine activity.

A7 **(3)**
The endocrine system links the brain to the organs that control body metabolism, growth and development, and reproduction. The endocrine system is regulated by feedback. For example, the hormones that are regulated by the pituitary gland, a signal is sent from the hypothalamus to the pituitary gland in the form of a “releasing hormone,” which stimulates the pituitary to secrete a “stimulating hormone” into the circulation. The stimulating hormone then signals the target gland to secrete its hormone. As the level of this hormone rises in the circulation, the hypothalamus and the pituitary gland shut down secretion of the releasing hormone and the stimulating hormone, which in turn slows the secretion by the target gland. This system results in stable blood concentrations of the hormones that are regulated by the pituitary gland.

Q8 **Which one of the following hormones is modified amino acid?**
(1) Epinephrine
(2) Progesterone
(3) Prostaglandin
(4) Estrogen

A8 **(1)**
Epinephrine is synthesized from tyrosine which is a non-essential amino acid possessing cyclic structure with a straight side chain bearing carboxylic and amino group. The conversion of tyrosine to epinephrine involves 4 steps – (i) ring hydroxylation (ii) decarboxylation, (iii) side¬-chain hydroxylation (iv) N-¬methylation.

Q9 **Which one of the following endocrine glands stores its secretion in the extra-cellular space before discharging it into the blood?**
(1) Testis
(2) Thyroid
(3) Pancreas
(4) Adrenal

A9 **(2)**
The thyroid gland secretes three hormones: thyroxine or tetraiodothyronine (T_4), triiodothyronine (T_3) and calcitonin. Thyroxine and Triiodothyronine are iodinated forms of the amino acid tyrosine. They are stored in the colloid that fills the follicles, and are released to the blood when needed. The storage occurs in an unusual place, the extracellular colloid.

Q10 **Low Ca^+ + in the body fluid may be the cause of -**
(1) tetany
(2) anaemia
(3) angina pectoris
(4) gout

A10 **(1)**
Tetany is a spasm and twitching of the muscles, particularly those of the face, hands, and feet. Tetany is usually caused by a reduction in the blood calcium level, which may be due to underactive parathyroid glands, rickets, or alkalosis.