CHAPTER 10

Chemical Coordination and Integration

In this Chapter...

- Endocrine Glands and Hormones
- Human Endocrine System
- Structure and Functions of Major Endocrine Glands
- Mechanism of Hormone Action

The neural coordination is rapid, but short-lived in nature. However, the nerve cells do not reach to each and every cell of the body. So, a special kind of coordination and integration is provided to each cell for continuous cellular functions. This special function is performed by hormones.

Thus, the nervous system and endocrine system are intimately related to each other forming **neuroendocrine system** together that jointly coordinate together that regulates the physiological functions of the body.

Endocrine Glands and Hormones

The endocrine glands are **ductless glands**, i.e. lack ducts. They pour their secretion into the surrounding blood for transport to the site of action or distantly located target organ. Their secretions are called **hormones** or **internal secretion**.

Hormones

These are non-nutrient chemicals, which are produced in trace amounts and act as **intercellular messengers**. These are responsible for regulating the biological processes in the body. The organised endocrine glands also secrete a number of new molecules in addition to the hormones.

Vertebrates have large number of chemicals acting as hormones that provide coordination, while invertebrates possess very simple endocrine system with few hormones.

Note

- *The first hormone was discovered by **William M Bayliss** and **Ernest H Starling** in 1903.*
- ***Endocrinology** is the study of endocrine glands and hormones secreted by them.*

Human Endocrine System

The endocrine system in humans constitutes the **endocrine glands** and **hormone** producing diffused tissues/cells located in different parts of our body. In endocrine system, the hormone from one gland may stimulate or inhibit another endocrine gland. These can also vary in structure.

Types of Human Endocrine Glands

The endocrine glands are of following two types in humans

(i) Pure Endocrine Glands

These entirely work for the secretion of hormones. They include the hypothalamus, pituitary, pineal, thyroid, adrenal, pancreas, parathyroid, thymus glands and gonads (i.e. testes in males and ovaries in females).

(ii) Partial Endocrine Glands

These are partly endocrine and partly exocrine in function. They include kidneys, gastrointestinal tract, heart and placenta, etc.

Structure and Functions of Major Endocrine Glands

Hypothalamus

In humans, the complete endocrine system works more or less under the influence of hypothalamus.

Location

Hypothalamus is located in the basal part of diencephalon (forebrain) and it regulates a wide spectrum of functions in the body.

Origin

It develops from the ectoderm of embryo like other parts of brain.

Structure

It is composed of **nervous tissue**. It connects with the anterior lobe of pituitary by **hypophyseal portal** blood vessels and to the posterior lobe of pituitary by the **axons** of its neurons.

Hormones

Hypothalamus contains several groups of **neurosecretory cells**, known as nuclei, which produce hormones. The function of these hormones is to regulate the synthesis and secretion of pituitary hormones.

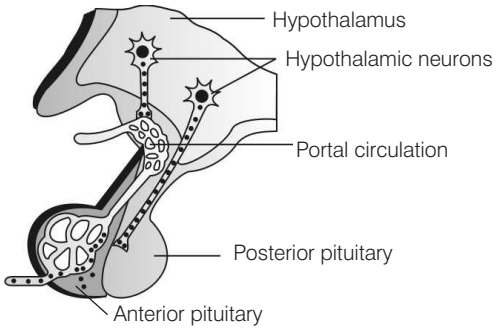
Hormones produced by hypothalamus are of following two types

(i) Releasing Hormones

These are the hormones that stimulate the secretion of pituitary hormones, e.g. **Gonadotropin Releasing Hormone** (GnRH), which stimulates the gonadotroph cells of anterior pituitary gland to release gonadotropins.

(ii) Inhibiting Hormones

These are the hormones that inhibit the release of pituitary hormones, e.g. **somatostatin**, which inhibits the secretion of growth hormone from anterior lobe of pituitary gland. All these hormones originating in the hypothalamic neurons, pass through the axons and are released from their nerve endings.



Diagrammatic representation of pituitary and its relationship with hypothalamus

These hormones finally reach the pituitary gland through a **portal circulatory system** (hypophyseal portal system) thereby, regulating the functions of anterior pituitary.

The posterior pituitary however, functions under the direct regulation of the hypothalamus.

Pituitary Gland (Hypophysis)

It is the smallest endocrine gland, but serves very important role in the human endocrine system. It directly or indirectly controls almost all other endocrine glands of the body. It is also known as **master gland**.

Origin

It originates from the ectoderm of the embryonic germ layers.

Location and Structure

It is **reddish grey** in colour and is roughly oval in shape. It is about a size of a pea seed. The pituitary gland is located in a small bony cavity of the brain called **sella turcica**.

Hormones

The pituitary gland has three major lobes, i.e. anterior, intermediate and posterior lobe. It is anatomically divided into two major portions.

Parts of Pituitary Gland	Hormones	Functions
1. **Adenohypophysis**		
Pars distalis	Growth Hormone (GH)	• Stimulates body growth. • Hyposecretion causes dwarfism, i.e. stunted growth. • Hypersecretion causes **gigantism**. • Excess secretion of GH in adults causes **acromegaly**.
	Prolactin (PRL)	Stimulates the growth of mammary glands, lactation and maintenance of corpus luteum.
	Thyroid Stimulating Hormone (TSH)	Synthesis and secretion of thyroid hormones $\mathbf{T_3}$ and $\mathbf{T_4}$ from thyroid gland.
	Adrenocorticotropic Hormone (ACTH)	Synthesis and secretion of **glucocorticoids** from the adrenal cortex.
	Luteinizing Hormone (LH)	• In males, stimulates the synthesis and secretion of **androgens** from testes. • In females, induces ovulation and maintains corpus luteum.

Parts of Pituitary Gland	Hormones	Functions
	Follicle Stimulating Hormone (FSH)	• In males, FSH and androgens regulate spermatogenesis. • In females, stimulates the growth and development of ovarian follicles.
Pars intermedia	Melanocyte Stimulating Hormone (MSH)	• Acts on melanocytes and regulates skin pigmentation. • Hypersecretion causes hyperpigmentation.
2. **Neurohypophysis** (Pars nervosa)	Oxytocin	• Acts on the smooth muscles and stimulates their contraction during childbirth. • Stimulates milk ejection from the mammary glands.
	Vasopressin (Anti-Diuretic Hormone or ADH)	• Acts mainly at kidneys and helps in $\mathbf{H_2O}$ and electrolytes resorption and prevents diuresis. • Hyposecretion causes **diabetes insipidus**.

Pineal Gland (Epiphysis)

It is a small gland in the brain derived from the embryonic ectoderm.

Location

It is located on the dorsal side of the forebrain between the cerebral hemispheres.

Structure

Pineal is a very small gland reddish grey in colour, vascular conical in shape and has solid body. It is composed of pineal cells and supporting glial cells.

Hormones

It secretes a hormone called **melatonin** that plays a very important role in the regulation of a 24 hrs (diurnal) rhythm of our body and melatonin also helps in maintaining the normal rhythms of sleep-wake cycle, body temperature. Metabolism, pigmentation, menstrual cycle as well as our defence capability is also influenced by this hormone.

Thyroid Gland

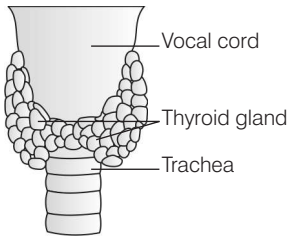
The thyroid gland is known to be the largest endocrine gland.

Origin

It is endodermal in origin, i.e. originates from the endoderm of the embryo. The thyroid gland is bilobed, highly vascular organ.

Location and Structure

It surrounds the front of the **larynx** and is composed of two lobes. Each of its lobe is located on either side of the trachea in the neck interconnected with each other through a thin flap of connective tissue called **isthmus**.



Diagrammatic view of the position of thyroid gland (ventral side)

It is composed of follicles (round in shape) held together by loose connective tissue called **stromal tissues**. Each thyroid follicle is composed of follicular cells, enclosing a cavity.

Hormones

The follicular cells synthesise following two hormones

(i) Tetraiodothyronine or thyroxine ($\mathbf{T_4}$) hormone

(ii) Triiodothyronine ($\mathbf{T_3}$) hormone

Both these hormones 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. Iodine (in diet) is essential for the synthesis of hormone at normal rate in thyroid.

Disorders

(i) Hypothyroidism

This disorder occurs due to the deficiency of iodine in our diet. It leads to the enlargement of thyroid gland commonly known as **goitre**.

(a) Hypothyroidism in women at the time of pregnancy affects the development and maturation of the growing baby and leads to stunted growth (cretinism), mental retardation, low intelligence quotient, abnormal skin, deaf-mutism, etc.

(b) Hypothyroidism in adult women may cause irregular menstrual cycle.

(ii) Hyperthyroidism

- It is the condition during which rate of synthesis and secretion of thyroid hormones is increased to abnormal high levels. It may occur due to the cancer of the thyroid gland or due to development of nodules of the thyroid gland. It adversely affects the body physiology of an organism.
- **Exophthalmic Goitre** (Graves' disease) In this, enlargement of thyroid gland takes place. Thus, thyroid secretion increases. It leads to protrusion of the eyeballs, increased basal metabolic rate and weight loss.

- **Hashimoto disease** An autoimmune disorder in which the thyroid gland is destroyed by autoimmunity. All the functions of thyroid gland gets impaired during this disease.
- **Myxoedema** It is caused by deficiency of thyroid hormones in adults, it is more common in women and is characterised by puffy appearance due to the accumulation of fat in subcutaneous tissue because of low metabolic rate and retarded oxidation.

Functions of Thyroid Hormones

Thyroid hormones serves several functions in the body, such as

(i) These hormones regulate and maintain the **Basal Metabolic Rate** (BMR), i.e. both $\mathbf{T_3}$ and $\mathbf{T_4}$ hormones increase the overall metabolic rate of the body.

(ii) They support the process of formation of red blood cells. Also help in controlling the metabolism of carbohydrates, proteins and fats.

(iii) Influences the maintenance of water and electrolyte in our body. Apart from the hormone $\mathbf{T_3}$ and $\mathbf{T_4}$, thyroid gland also secretes a protein hormone called **Thyrocalcitonin** (TCT). Its main function is to regulate the level of calcium in blood.

Parathyroid Gland

These are small glands in the human neck that produces parathyroid hormone.

Origin

It is endodermal in origin.

Location

These glands are situated on the **posterior side** of the thyroid gland.

Structure

Parathyroid glands are **four** in number, i.e. each pair is situated in the two lobes of the thyroid gland on either side. These are small, flat and oval gland.

Hormones

Parathyroid glands secrete a single hormone known as **parathormone** or **Parathyroid Hormone** or PTH (functions opposite to the thyrocalcitonin hormone). The secretion of PTH is regulated by the circulating level of calcium ions in the blood.

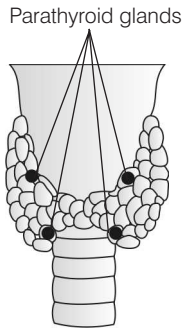
Functions of Parathyroid Hormone

Parathyroid hormone serves several functions in the body, such as

(i) It increases the level of $\mathbf{Ca^{2+}}$ in the blood.

(ii) It stimulates the process of bone reabsorption (i.e. dissolution/demineralisation) by acting on bones.

(iii) It also stimulates reabsorption of Ca^{2+} by the renal tubules and absorption of Ca^{2+} from the digested food.



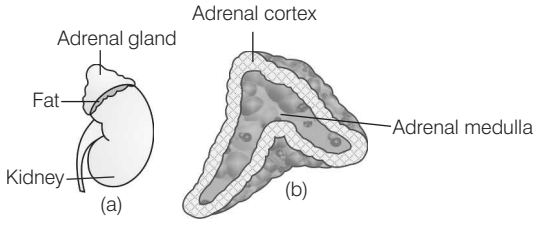
Diagrammatic view of the position of parathyroid gland (dorsal side)

By the above mentioned functions of parathyroid hormone, it is clear that PTH acts as a **hypercalcemic hormone** (increases the level of Ca^{2+} in the blood). Parathyroids are under the feedback control of blood calcium level. A fall in $\mathbf{Ca^{2+}}$ in blood stimulates them to secrete PTH. Thus, both the hormones (TCT and PTH) play a significant role to control and regulate the concentration of Ca^{2+} and phosphorus.

Adrenal Glands (Suprarenals)

Location

Our body has a pair of adrenal glands. Each located at the anterior part of each kidney.



Diagrammatic representation of adrenal gland

Structure

Adrenal glands are conical yellowish bodies composed of two types of tissues.

These are as follows

1. Adrenal Cortex

It is an external firm, pale-yellowish tissue derived from mesoderm of embryo.

It is further divided into three concentric layers

(i) **Zona Reticularis** It is the inner layer of the cortex whose cells are arranged in the net-like fashion.

(ii) **Zona Fasciculata** It is the middle layer of the cortex. It is the widest of all three layers.

(iii) **Zona Glomerulosa** It is the outermost layer. It is composed of five layers of compactly arranged cells.

Hormones secreted by these three layers of adrenal cortex are collectively known as **corticoids**.

Three groups of steroid hormones are secreted by adrenal cortex, such as

(a) Mineralocorticoids (Aldosterone)

They regulate the balance of water and electrolytes in our body. **Aldosterone** is the major mineralocorticoid found in our body. It mainly acts on renal tubules stimulating the reabsorption of Na^+ and water. Also stimulates the excretion of K^+ and phosphate ions from the body.

Functions of Mineralocorticoids

Its main function is in maintaining electrolytes, body fluid volume, osmotic pressure and blood pressure of the body.

(b) Glucocorticoids (Cortisol)

These are the hormones, which regulate the metabolism of carbohydrates, proteins and fats. **Cortisol** is the main glucocorticoid found in our body.

Functions of Glucocorticoids

(i) Cortisol stimulates the liver for the synthesis of carbohydrates from non-carbohydrate sources (like amino acids and glycerol). This process is known as **gluconeogenesis**. Hence, glucocorticoids stimulate gluconeogenesis, lipolysis and proteolysis.

(ii) Inhibition of cellular uptake and utilisation of amino acids.

(iii) Cortisol is involved in the maintenance of cardiovascular system and in proper functioning of kidney.

(iv) Cortisol produces anti-inflammatory reactions and also functions in suppression of immune response.

(v) It stimulates the production of RBC.

(c) Sexocorticoids (Androgen)

Adrenal cortex also produces a small quantity of androgenic steroids, i.e. **sex hormone** (androgens) both in males and females. These hormones are secreted as **DHEA** (Dehydroxy Epiandrosterone), which acts as a precursor of both testosterone and oestrogen.

Functions of Sexocorticoids

(i) It plays a major role in the growth of axial, pubic and facial hair during puberty in humans.

(ii) Development of acne are also due to these hormones in young girls.

(iii) It also plays an important role in the development of embryo (foetus).

- **Addison's disease** is caused by deficiency of mineralocorticoids.
- **Cushing's syndrome** is due to excess of cortisol, while an excess of aldosterone leads to aldosteronism.
- **Adrenal virilism** is caused by excess of sex corticoids in a female. In this, there is development of male secondary sexual characters such as beard, moustaches, etc., in females.

2. Adrenal Medulla

The adrenal medulla lies in the centre of the adrenal gland. It is an internal soft, dark reddish brown tissue derived from the ectoderm.

The adrenal medulla secretes two hormones

(i) Adrenaline (epinephrine)

(ii) Nor-adrenaline (nor-epinephrine)

Activation of Adrenaline and Nor-adrenaline

- Both hormones belong to the category of compounds known as **catecholamines** and are secreted in response to any kind of stress, danger and during emergency situations like increased respiratory rate, heartbeat, etc.
- The CNS at the time of stress or danger stimulates the adrenal medulla to release both these hormones. These are also known as **emergency hormones** or **hormones of fight** or **flight**.

Functions of Adrenaline and Nor-adrenaline

These hormones serve following purposes

(i) Increase alertness.

(ii) Dilation of pupil.

(iii) Piloerection (raising of hairs of hands and legs).

(iv) Increase in heartbeat and rate of respiration.

(v) They also stimulate the breakdown of glycogen due to which the concentration of glucose increases in the blood.

(vi) Stimulate breakdown of lipids and proteins.

Pancreas

It is a composite gland that acts as both exocrine and endocrine gland. Such glands are also called **heterocrine gland**.

Origin

It originates from the endoderm of the embryonic germ layers.

Location

It lies below the stomach, in the loop of duodenum.

Structure

- It is elongated yellowish gland that consists of large number of acini and ducts. Besides these, pancreas consists of 1-2 millions of small group of specialised cells, called **Islets of Langerhans** (after the name of their discoverer **Paul Langerhans** in 1869).
- In normal human pancreas, these cells represent only 1-2% of the pancreatic tissue.

Each islet consists of major two types of cells as

(i) **α-cells** (about 25%) It secretes a peptide hormone called **glucagon**.

(ii) **β-cells** (about 60%) It secretes another peptide hormone called **insulin**.

Note *Apart from α and β-cells, Islets of Langerhans consist of two or more types of cells called **delta cells** or **D-cells** (about 10%) which secrete somatostatin hormone and **PP-cells** or **F-cells** (which secrete Pancreatic Polypeptide-PP hormone).*

Hormones

Glucagon and insulin have antagonistic effect on blood glucose level. This can be cleared from the functioning given below

(i) Glucagon

This peptide hormone plays an important role in maintaining the normal blood glucose levels. It brings about change of liver glycogen to blood glucose.

Functions of Glucagon

This hormone serves following functions

(a) It acts mainly on liver cells (hepatocytes) and stimulates glycogenolysis, which results in an increased blood sugar known as **hyperglycemia**.

(b) Apart from this, glucagon also stimulates the process of gluconeogenesis which also contributes to hyperglycemia. Glucagon is known as hyperglycemic hormone because it reduces the cellular glucose uptake and utilisation.

(c) It reduces glycogenesis and also enhances lipolysis.

Note *Glucagon also stimulates the secretion of insulin from beta cells by its paracrine effect.*

(ii) Insulin

- This peptide hormone plays a major role in regulation of glucose level in the blood. It mainly acts on **hepatocytes** and **adipocytes** (cells of adipose tissue), increasing the cellular glucose uptake and utilisation.
- As a result, the movement of glucose takes place rapidly from blood to liver cells and cells of adipose tissues by decreasing the blood glucose level (hypoglycemia).

Deficiency Disorder of Insulin

- Diabetes mellitus is the common complex disorder caused due to prolonged hyperglycemia.
- This is associated with the loss of glucose (when complete glucose cannot be reabsorbed by the kidneys) in the urine as pancreas fails to release adequate amount of insulin to lower the level of glucose in the body.
- During this disorder, cells fail to utilise glucose and other carbohydrate for production of energy instead start utilising proteins and fats for it (due to which person becomes weak). Diabetic patients are successfully treated with insulin therapy.

Functions of Insulin

This hormone serves following functions

(a) Insulin stimulates the conversion of glucose to glycogen (glycogenesis) in the target cells.

(b) Decreases gluconeogenesis.

(c) Decreases glycogenolysis.

(d) Also reduces the catabolism of proteins and fats.

(e) Increases synthesis of fat in the adipose tissue from fatty acids.

Testes

These are the **primary sex organ** of males. They perform dual role, i.e. function as endocrine gland apart from acting as male sex organ.

Location

A pair of testis is located in the **scrotal sac** (outside abdomen) of male individuals.

Structure

A testis is composed of many **seminiferous tubules** which are lined by germinal epithelium and stromal or interstitial tissue.

This epithelium consists of three types of cells

(i) **Follicular cells** give rise to sperms.

(ii) **Interstitial cells** or **Leydig cells** secrete group of hormones called **androgens** mainly testosterone.

(iii) **Sertoli cells** provide nourishment to sperms and also secrete hormone (inhibin).

Hormones

Interstitial cells present in the intertubular spaces produce a group of hormones, i.e. androgens. These include testosterone, dihydrotestosterone and androstenedione.But mainly secretes testosterone.

Functions

Androgen (mainly testosterone) performs a variety of functions given below

(a) It regulates the development, maturation and functions of **male accessory sex organs** like epididymis, vas deferens, seminal vesicles, prostate gland, urethra, etc.

(b) These hormones also stimulate changes associated with **puberty in males**, i.e. muscular growth, growth of facial and axillary hair, aggressiveness, low pitch of voice, etc.

(c) Also stimulates the process of **spermatogenesis**, i.e. formation of spermatozoa.

(d) Promotes the growth of body tissues such as bones and muscles and helps in the formation of musculine body.

(e) Also have **anabolic effects** (synthetic effects) on the metabolism of protein and carbohydrate.

Ovaries

These are the **primary sex organ** in females that serve to produce ova (female gametes) and female sex hormones.

Location

A pair of ovaries is located in the pelvic cavity (in the abdomen).

Structure

It is an almond-shaped structure. Internally, it is composed of **ovarian follicles** and **stromal tissues**.

Hormones

Ovary produces two groups of steroid hormones, i.e. **oestrogen** and **progesterone**. Oestrogens are secreted by granulosa cells of Graafian follicle. After ovulation, the ruptured follicle is converted to another structure called **corpus luteum**, responsible for secretion of progesterone.

Functions

Both oestrogen and progesterone play a vital role in various processes in female.

These are as follows

Oestrogen

(a) It helps in the growth of uterine endometrium layer during each menstrual cycle.

(b) It directly influences the development of mammary glands.

(c) Regulates female sexual behaviour and stimulates growth and activities of female secondary sex organs.

(d) Plays a role in the development of growing ovarian follicles.

(e) Appearance of female secondary sex characters (deposit of fat on thigh and hip region, high pitch, etc).

Progesterone

(a) It is secreted in very high amount continuously during pregnancy (i.e. supports pregnancy by forming placenta and preventing contractions in uterine wall).

(b) It also acts on mammary glands and stimulates the formation of alveoli (sac-like structures that store milk) and **milk secretion**.

(c) It also helps in forming a mucus plug at cervix.

Note ***Relaxin*** *is another hormone secreted by ovary in the later stages of pregnancy. Its main role is in softening ligament, widening pelvic cavity, also affects other ligaments such as of foot, etc. Due to which women may experience increase in their foot size during pregnancy.*

Mechanism of Hormone Action

Hormones are released from their respective gland in very small amount. They carryout widespread effects in the body of an individual. Their response is very specific and accurate. Their effects are produced on target tissues by binding to the specific proteins known as **hormone receptors**, located in the target tissues only.

Types of Hormones

On the basis of the chemical nature, hormones are divided into following four groups

(i) **Peptide, Polypeptide**, **Protein Hormones** (e.g. insulin, glucagon, pituitary hormones, hypothalamic hormones, etc).

(ii) **Steroids** (e.g. cortisol, testosterone, oestradiol and progesterone).

(iii) **Iodothyronines** (e.g. thyroid hormones).

(iv) **Amino acid derivatives** (e.g. epinephrine).

Types of Hormone Receptors

Hormone receptors are of following two types

(i) **Membrane Bound Receptors** Hormone receptors present on the cell membrane of the target cells.

(ii) **Intracellular Receptors** Hormone receptors present inside the target cell, e.g. nuclear receptor (present in the nucleus of a cell).

Hormone-Receptor Complex

Binding of a hormone to receptor leads to the formation of a hormone-receptor complex. Formation of this complex leads to certain biochemical reactions or changes in the respective target tissue. Metabolism of target tissue and their physiological function are thus, regulated by hormones.

Action of Hormone Through Extracellular Receptor

Hormones that interact with the membrane bound receptors do not enter their target cell in normal condition, but generate secondary messengers such as cyclic AMP (*c*AMP), IP_3, Ca^{2+}, etc., which regulate cellular metabolism of the body, e.g. protein or peptide hormone.

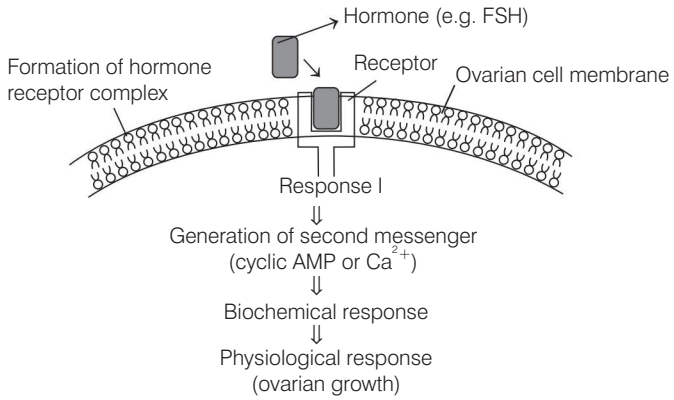
Note *Hormones do not participate in a metabolic reaction themselves, they instead act as messengers only, i.e. mainly primary messengers.*

Functioning of Peptide Hormone

Protein hormone is water soluble in nature, binds to the extrinsic receptors (present on cell surface) to form the **hormone-receptor complex**. The formation of this complex causes the release of enzyme, **adenylate cyclase**. This activated enzyme, thus leads to the formation of *c*AMP (i.e. cyclic adenosine monophosphate) from ATP in the cell from the receptor site.

$$\text{ATP} \xrightarrow[\text{adenyl cyclase} + \text{Mg}^{2+}]{\text{Activated}} \textbf{c}\text{AMP} + \text{PPi}$$

The hormone receptor complex changes the permeability of the cell membrane to facilitate the passage of materials through it (and thereby, regulates cellular activities of the cell causing specific response to occur).



Diagrammatic representation of the mechanism of hormone action of peptide or protein hormone

Action of Hormone Through Intracellular Receptors

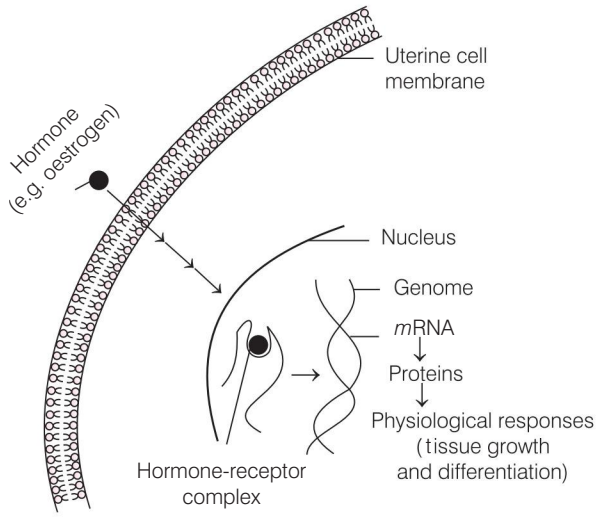
Hormones that interact with intracellular receptors are mostly involved in the regulation of gene expression or chromosome function by interaction of hormone-receptor complex with the genome, e.g. steroid hormone, iodothyronines, etc.

Functioning of Steroid Hormone

Steroid hormones are lipid soluble in nature, so they can easily diffuse through the cell membrane and bind to receptor molecules present in the cytoplasm to form a hormone-receptor complex that enters the nucleus.

In nucleus, they bind to specific intracellular receptor site on chromosomes and regulate gene expression that results in physiological responses.

Thus, the cumulative biochemical actions result in physiological and developmental effects.



Mechanism of hormone action : Steroid hormone

Antagonistic and Synergistic Interactions of Hormones

- Hormones can show both antagonistic and synergistic interactions with each other. In antagonistic interactions, effects of two hormones are opposite to each other on the target cells. For example, **insulin** and **glucagon** hormones, act antagonistically on blood glucose level.
- In synergistic interaction, two or more hormones tend to complement each other for their effect on target cells. For example, oestrogen, progesterone, oxytocin, prolactin all acts synergistically for the secretion, production and ejection of milk in mammary glands.

Chapter Practice

PART 1
Objective Questions

• Multiple Choice Questions

1. Endocrine glands
(a) do not possess ducts
(b) sometimes do not have ducts
(c) pour their secretion into blood through ducts
(d) always have ducts
(***a***) The endocrine glands are ductless glands that secrete chemical messengers (called hormones).

2. Which of the following statements is correct in relation to the endocrine system?
(a) Organs in the body like gastrointestinal tract, heart, kidney and liver do not produce any hormones
(b) Non-nutrient chemicals produced by the body in trace amount that act as intercellular messenger are known as hormones
(c) Releasing and inhibitory hormones are produced by the pituitary gland
(d) Adenohypophysis is under direct neural regulation of the hypothalamus
(***b***) Statement in option (b) is correct in relation to the endocrine system whereas the other statements are incorrect.

3. GnRH, a hypothalamic hormone, needed in reproduction, acts on
(a) anterior pituitary gland and stimulates secretion of LH and oxytocin
(b) anterior pituitary gland and stimulates secretion of LH and FSH
(c) posterior pituitary gland and stimulates secretion of oxytocin and FSH
(d) posterior pituitary gland and stimulates secretion of LH and relaxin
(***b***) GnRH is a hypothalamic hormone. It stimulates the anterior lobe of pituitary gland to secrete LH and FSH, which in turn stimulates the gonadal activity.

4. Choose the correct statement about 'neurohypophysis'.
(a) It stores the hormones produced by adenohypophysis
(b) It is poorly developed and functionless in humans
(c) It stores and releases hormones secreted by hypothalamus
(d) It secretes its own hormones
(***c***) Statement in option (c) is correct.

5. Gigantism and dwarfism are the diseases related to
(a) prolactin hormone of mammary gland
(b) growth hormone of adenohypophysis
(c) luteinizing hormone of pituitary gland
(d) thyroid stimulating hormone of thyroid
(***b***) Gigantism and dwarfism are diseases related to growth hormone.

6. Select the incorrect statement.
(a) The thyroid gland plays a negligible role in the regulation of the basal metabolic rate
(b) The thyroid gland secretes thyroxine ($\mathbf{T_4}$) and triiodothyronine ($\mathbf{T_3}$)
(c) The lobes of thyroid gland are interconnected with a thin flap of connective tissue called isthmus
(d) The thyroid gland is composed of two lobes which are located on either side of the trachea
(***a***) Statement in option (a) is incorrect and can be corrected as
The thyroid gland plays an important role in the regulation of the basal metabolic rate.
Rest of the statements are correct.

7. Choose the statements which correctly indicates the functioning of thyroid hormones.
I. Regulation of the basal metabolic rate.
II. Stimulate the process of RBCs formation.
III. Regulating the blood phosphorus levels.
IV. Maintenance of pH and lipids balance.

The correct option is

(a) I, II and IV

(b) I and II

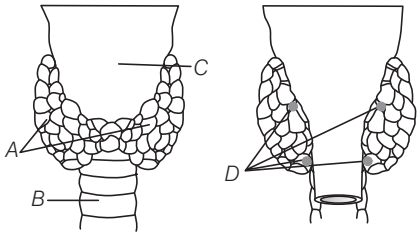
(c) I, II, III and IV

(d) III and IV

(***b***) Statements I and II are correctly indicate the functioning of thyroid hormones. Statements III and IV are incorrect and can be corrected as

- Thyroid hormone regulates the blood calcium levels.
- Thyroid hormone maintains the balance of water and electrolytes.

8. Identify *A, B, C* and *D* in the given diagrams and choose the correct combination.



(a) *A*–Thyroid, *B*–Trachea, *C*–Vocal cord, *D*–Parathyroid glands

(b) *A*–Trachea, *B*–Thyroid, *C*–Vocal cord, *D*–Parathyroid glands

(c) *A*–Trachea, *B*–Vocal cord, *C*–Thyroid, *D*–Parathyroid glands

(d) *A*–Parathyroid glands, *B*–Thyroid, *C*–Vocal cord, *D*–Trachea

(***a***) *A*–Thyroid, *B*–Trachea, *C*–Vocal cord, *D*–Parathyroid glands

9. Consider the following statements with respect to parathyroid gland.

I. It regulates calcium and phosphate level in blood.

II. It elevates blood calcium level in children.

III. It inhibits bone dissolution.

IV. It has no role in bone formation.

Choose the option containing incorrect statements.

(a) I and III

(b) II and V

(c) III and IV

(d) I and IV

(***c***) Statements III and IV are incorrect about parathyroid gland and can be corrected as

- It starts bone dissolution (osteoclastic action) and stimulates excretion of calcium in blood.
- It affects the formation and growth of bones, membrane permeability, nerve functioning and muscular activity of body.

Rest statements are correct.

10. Match the following columns.

	Column I (Hormones of adrenal gland)		**Column II** (Functions)
A.	Mineralocorticoids (Aldosterone)	1.	Suppresses immune response
B.	Cortisol	2.	Growth of pubic hair and axial hair during puberty
C.	Androgenic steroids of adrenal cortex	3.	Increased blood glucose concentration
D	Catecholamine	4.	Regulates balance of $\mathbf{H_2O}$ and electrolytes

Codes

	A	B	C	D
(a)	3	4	1	2
(b)	2	3	4	1
(c)	4	1	2	3
(d)	1	2	3	4

(***c***) A–4, B–1, C–2, D–3

11. Which of the following represents the action of insulin?

(a) Increases blood glucose levels by hydrolysis of glycogen

(b) Increases blood glucose levels by stimulating glucagon production

(c) Decreases blood glucose levels by forming glycogen

(d) Increases blood glucose level by promoting cellular uptake of glucose

(***c***) Insulin plays a major role in the regulation of glucose homeostasis. Insulin also stimulates conversion of glucose to glycogen (glycogenesis) in the target cells and thus, decreases blood glucose level.

12. Given below are endocrine glands and their characteristics.

I. Testes – Present in scrotal sac

II. Ovary – Present outside abdominal cavity

III. Placenta – Produce hormones during pregnancy

Choose the option containing incorrectly matched pairs.

(a) I and II (b) II and III (c) Only II (d) Only III

(***c***) Pair II in option (c) is incorrectly matched and can be corrected as

Females have a pair of ovaries located inside the abdomen. Ovary is the primary female sex organ.

Rest others are correctly matched endocrine glands and their characteristics.

13. The activity of formation of milk and the ejection of milk is controlled by

(a) oxytocin and prolactin, respectively

(b) prolactin and oxytocin, respectively

(c) prolactin and prolactin, respectively

(d) oxytocin and oxytocin, respectively

(***b***) Prolactin regulates the growth of the mammary glands and formation of milk. Oxytocin stimulates contraction of uterus and milk ejection.

14. Match the following columns.

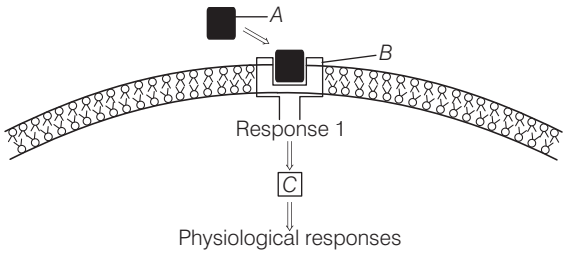
	Column I (Types)		Column II (Examples)
A.	Protein hormones	1.	Epinephrine
B.	Steroid hormones	2.	Testosterone, progesterone
C.	Iodothyronines hormones	3.	Thyroid hormone
D.	Amino acid derivative hormones	4.	Insulin and glucagon

Codes

	A	B	C	D
(a)	1	2	3	4
(b)	4	3	2	1
(c)	4	2	3	1
(d)	4	2	1	3

(*c*) A–4, B–2, C–3, D–1

15. Identify *A, B* and *C* in the diagrammatic representation of the mechanism of hormone action.



Select the correct option from the following.

(a) *A*–Steroid hormone, *B*–Hormone-receptor complex, *C*–Protein

(b) *A*–Protein hormone, *B*–Receptor, *C*–Cyclic AMP

(c) *A*–Steroid hormone, *B*–Receptor, *C*–Second messenger

(d) *A* – Protein hormone, *B*–Cyclic AMP, *C*–Hormone-receptor complex

(*b*) *A*–Protein hormone, *B*–Receptor, *C*–Cyclic AMP

• Assertion-Reasoning MCQs

Direction (Q. Nos. 1-5) *Each of these questions contains two statements, Assertion (A) and Reason (R). Each of these questions also has four alternative choices, any one of which is the correct answer. You have to select one of the codes (a), (b), (c) and (d) given below.*

(a) Both A and R are true and R is the correct explanation of A

(b) Both A and R are true, but R is not the correct explanation of A

(c) A is true, but R is false

(d) A is false, but R is true

1. **Assertion** (A) GnRH stimulates the pituitary synthesis and release of gonadotropins.

Reason (R) Hypothalamic hormones regulate the synthesis and secretion of pituitary hormones.

(*a*) Both A and R are true and R is the correct explanation of A.

The hypothalamic hormones regulate the synthesis and secretion of pituitary hormones. Like GnRH (Gonadotropin Releasing Hormone) is released into the pituitary through a portal circulating system where it causes the anterior pituitary to release hormones like LH and FSH. These two hormones stimulate gonadal activity and hence called gonadotropins.

2. **Assertion** (A) In old persons, there is gradually weakening of immune system.

Reason (R) It is because of degeneration of thymus gland.

(*a*) Both A and R are true and R is the correct explanation of A.

In old persons, there is gradually weakening of immune system because of degeneration of thymus gland. Thymus secretes a hormone named thymosin which stimulates the development of certain kinds of WBCs involved in generating immunity. It is prominent at the time of birth, but it gradually atrophies in adults and its disappearance causes ageing.

3. **Assertion** (A) Our body secretes adrenaline in intense cold.

Reason (R) Adrenaline raises metabolic rate.

(*a*) Both A and R are true and R is the correct explanation of A.

Adrenaline is secreted in our body during cold, which raises metabolic rate. It causes vasoconstriction of essentially all the blood vessels of the body and increased activity of the heart which prevents heat loss. Shivering which is a rhythmic contraction of skeletal muscles produces heat. Adrenaline, nor-adrenaline, etc., increase the metabolic rate by stimulating the breakdown of fats.

4. **Assertion** (A) Glucagon is a steroid hormone.

Reason (R) Glucagon is hyperglycemic hormone.

(d) A is false, but R is true because

Glucagon is a peptide hormone, which plays an important role in maintaining the normal blood glucose level. This hormone stimulates the process of gluconeogenesis and reduces the cellular glucose uptake and utilisation.

Thus, glucagon is hyperglycemic hormone.

5. **Assertion** (A) Hormones interacting with membrane bound receptors normally do not enter the target cells.

Reason (R) They generate second messengers like cyclic AMP, IP_3 and Ca^{2+}.

(*a*) Both A and R are true and R is the correct explanation of A.

Hormones interacting with membrane bound receptors normally do not enter the target cells because they generate second messengers like cyclic AMP, IP_3, Ca^{2+}, etc. These are responsible for the amplification of signal. The hormone is called first messenger and *c*AMP is termed as second messenger.

• Case Based MCQ

1. Direction *Read the following passage and answer the questions that follows.*

At the age of 5, Kabir was diagnosed with an autoimmune disease, named diabetes mellitus. The doctors advised Kabir's parents to monitor Kabir's sugar level regularly and to give him insulin injections regularly. Doctor also counsel the parents about the importance of insulin in our body.

(i) Insulin is a ..... hormone.
(a) steroid
(b) proteinaceous
(c) amine
(d) amino acid derivative

(*b*) Insulin is a proteinaceous hormone. It is water soluble and binds to the surface receptors of the cell.

(ii) Insulin is secreted by
(a) pituitary gland (b) adrenal gland
(c) pancreas (d) thyroid gland

(*c*) Insulin is secreted by the β-cells of the islets of Langerhans (pancreas). It is a heterocrine gland.

(iii) Which hormone acts antagonistic to insulin?
(a) Oxytocin (b) Prolactin
(c) Vasopressin (d) Glucagon

(d) Glucagon acts antagonistic to insulin hormone. Insulin decreases sugar level whereas glucagon increases it.

(iv) In the absence of insulin in body,
(a) blood glucose level decreases
(b) bone dissolution increases
(c) blood glucose level increases
(d) growth is inhibited

(*c*) If the level of insulin hormone decreases in body the glucose would not be utilised by the cells and thus, its level would keep on increasing.

(v) The other hormone secreted by the structure which secrete insulin also, is
(a) somatostatin (b) cortisol
(c) prolactin (d) aldosterone

(*a*) Pancreas secretes insulin, glucagon and somatostatin. The secretion of insulin and glucagon is inhibited by somatostatin.

PART 2
Subjective Questions

• Short Answer (SA) Type Questions

1. Define the following
(i) Exocrine gland (ii) Endocrine gland
(iii) Hormones **(NCERT)**

(i) **Exocrine gland** is a gland that pours its secretion on the surface or into a particular region by means of ducts for performing a metabolic activity, e.g. sebaceous glands, sweat glands, salivary glands, etc.

(ii) **Endocrine gland** is a gland that pours its secretion into blood or lymph for reaching the target organ because the gland is not connected with the target organ by any duct. It is also known as ductless gland.

(iii) **Hormones** are non-nutrient chemicals which act as intercellular messengers and are produced in trace amount.

2. Why is chemical and hormonal coordination necessary?

The nerve fibres do not innervate all the cells of the body and cellular functions need to be regulated in a continuous manner. So, to regulate this coordination, endocrine system (chemical and hormonal coordination) is necessary.

3. Distinguish between endocrine and exocrine glands.

Differences between endocrine and exocrine glands are as follows

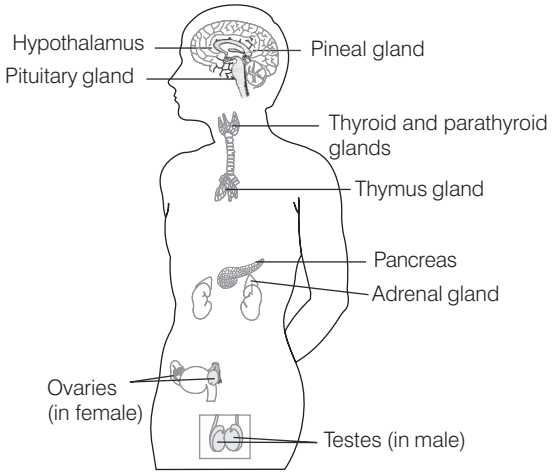
Endocrine Glands	Exocrine Glands
They do not have ducts.	They have ducts.
They secrete hormones directly into the blood.	They secrete their secretions into the ducts.
e.g. thyroid, hypothalamus, pituitary, etc.	e.g. sweat and oil glands (of skin) liver and salivary glands.

4. Comment 'hormones are called informational molecules'.

Hormones are known as informational molecules because their synthesis takes place in one part of the body, i.e. the endocrine cells and are carried by the blood to another part of the body, i.e. target organ or tissues where they stimulate or inhibit the specific physiological processes according to the need of the body.

5. Diagrammatically indicate the location of the various endocrine glands in our body. **(NCERT)**

Location of different endocrine glands

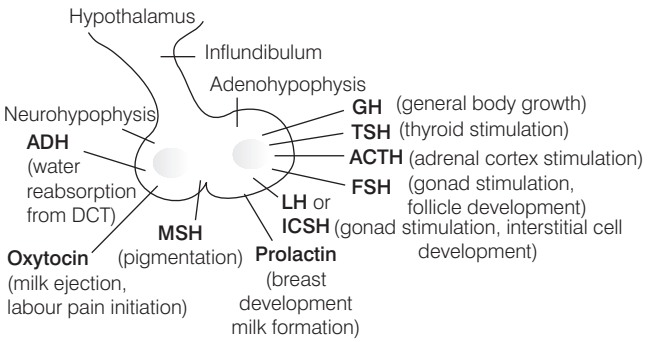


6. How are the hypothalamic hormones transported to target organs?

The hypothalamic hormones secreted by the neurosecretory cells called nuclei are transported through the hypothalamic axons and released from their nerve endings and mixed with blood of hypophyseal portal vein. These are then transported to anterior pituitary.

The posterior pituitary hormones pass through the axons that reach the posterior pituitary and remain stored in the axon terminals, till they are stimulated for release.

7. Draw a neat and labelled diagram of the pituitary gland with hypothalamus connection also showing its various hormones.



Pituitary hormones and their major hormones

8. Why the pituitary gland is called 'master gland of endocrine orchestra'?

Pituitary gland secretes several hormones, e.g. TSH, ACTH, etc., which in turn regulate the functioning of other endocrine gland. That is why it is called master gland of endocrine orchestra. But pituitary gland itself is being controlled by the hormones released by the hypothalamus of the brain.

9. Briefly mention the mechanism of action of FSH. **(NCERT)**

In males, FSH and androgens regulate spermatogenesis. In females, FSH stimulates growth and development of the ovarian follicles. It stimulates the secretion of oestrogen in ovaries.

10. A milkman is very upset one morning as his cow refuses to give any milk. The milkman's wife gets the calf from the shed. On fondling by the calf, the cow gave sufficient milk.
Describe the role of endocrine gland and pathway associated with this response. **(NCERT Exemplar)**

The fondling by the calf stimulates the release of oxytocin from the posterior pituitary. Oxytocin brings about contraction of the smooth muscles of the mammary glands that causes ejection of milk.

11. Which hormones are secreted by the posterior pituitary gland? What function does each serve? Where are these hormones actually produced? How are these hormones transported to the region from where they are released?

Oxytocin and vasopressin are secreted by the posterior pituitary gland.

(i) **Oxytocin** is released into the blood when hypothalamic neurons are stimulated by the widening of uterus at the time of delivery or by the sucking of breasts by an infant. It induces contraction of smooth muscles of the uterus during the birth of a youngone and myoepithelial cells of mammary glands to cause release of milk during sucking by an infant. Therefore, it is also known as 'birth hormone'.

(ii) **Vasopressin** is also called Antidiuretic Hormone (ADH). It decreases the loss of water in urine by increasing reabsorption of water in distal convoluted tubules, collecting tubules and collecting ducts of kidneys.

12. Which hormone is responsible for maintenance of diurnal rhythm of our body? Mention its source.

The hormone responsible for diurnal rhythm of our body is melatonin. The source of its secretion is pineal gland.

13. George comes on a vacation to India from US. The long journey disturbs his biological clock and he suffers from jet lag. What is the cause of his discomfort?

Jet lag is caused by the disruption of the body clock as it is out of synchronisation with the unfamiliar time zone of the two different parts of the world. The body experiences different patterns of light and dark then it is normally used to which disrupts the natural sleep-wake cycle.

Melatonin is a hormone that plays a key role in body rhythms and jet lag. After the sun sets, the eyes perceive

darkness and alert the hypothalamus to begin releasing melatonin, which promotes sleep. Conversely, when the eyes perceive sunlight, they tell the hypothalamus to with-hold melatonin production. However, the hypothalamus cannot read just its schedule instantly, it takes several days.

14. Which endocrine gland is called the 'biological clock' and why?

Pineal gland may be called as the 'biological clock.' Its secretion is melatonin which has antigonadotrophic effect. The gland receives photoperiod information *via* neural circuit from the eyes. Pineal gland also controls annual rhythm of reproduction. The seasonal changes in photoperiod may be translated into physiological effect *via* the pineal and its endocrine products.

15. Give the name of the endocrine gland that produces calcitonin and also mention the role played by this hormone.

Calcitonin (CT) or thyrocalcitonin hormone is produced by thyroid glands.

It is hypocalcemic and hypophosphatemic peptide hormones, which check excess plasma Ca^{2+} and phosphate by decrease mobilisation from bones.

16. Write short notes on the functions of the following hormones

(i) Parathyroid hormone (PTH)

(ii) Thyroid Hormones

(iii) Thymosins **(NCERT)**

(i) Functions of PTH are as follows

- It increases the level of $\mathbf{Ca^{2+}}$ in the blood.
- It stimulates the process of bone reabsorption (i.e. dissolution/demineralisation) by acting on bones.

(ii) Functions of thyroid hormones are as follows

- These hormones regulate and maintain the Basal Metabolic Rate (BMR), i.e. both $\mathbf{T_3}$ and $\mathbf{T_4}$ hormones increase, the overall metabolic rate of the body.
- These support the process of formation of red blood cells and also help in controlling the metaboilsm of carbohydrates, proteins and fats.

(iii) Functions of thymosins are as follows

Thymosins, when released in the blood has a stimulating effect on the entire immune system. Apart from this, thymosin also promotes the production of antibodies to the provide humoral immunity.

17. In countries where dietary intake of iodine is low, goitres, enlargement of the thyroid are common. What would you say about the chain of events leading to the formation of goitre?

In the absence of iodine, neither **thyroxine** nor **triiodothyronine** hormone is produced, due to which their concentration in the blood decreases. To compensate this, the anterior pituitary secretes large amounts of TSH, which stimulates the growth of the thyroid gland, sometimes to gigantic proportions, thus leading to the formation of goitre.

However, enlargement of the gland cannot increase production of the hormones, because of the deficiency of the of main ingredient, i.e. thyroxine hormone.

18. Differentiate between insulin and glucagon.

Differences between insulin and glucagon are as follows

Insulin	**Glucagon**
It is a hormone secreted by beta cells of pancreas.	It is a hormone secreted by alpha cells of the pancreas.
It is secreted in response to high blood sugar level.	It is secreted in response to low blood glucose level.
It makes muscle, red blood cells and fat cells to take up glucose in from the blood.	If functions to cause the liver to release stored glucose from its cells into the blood.

19. Mention the difference between hypothyroidism and hyperthyroidism. **(NCERT Exemplar)**

Hypothyroidism is low secretion of thyroxine hormone.

Hyperthyroidism is oversecretion of thyroid hormone. It occurs due to low or hyperactivity of the thyroid gland.

20. What are the effects of hypothyroidism (observed during pregnancy) on the development and maturation of a growing baby? **(NCERT Exemplar)**

Hypothyroidism during pregnancy causes defective development and maturation of the growing baby leading to stunted growth (cretinism), mental retardation, low intelligence, abnormal skin, deaf-mutism, etc.

21. On an educational trip to Uttarakhand, Ketki and her friends observed that many local people were having swollen necks. Please help Ketki and her friends to find out the solutions to the following questions.

(i) Which probable disease are these people suffering from?

(ii) How is it caused?

(iii) What effect does this condition have on pregnancy? **(NCERT Exemplar)**

(i) The people are suffering from the goitre disease.

(ii) Goitre is caused by deficiency of iodine which leads to the hypothyroidism.

(iii) It leads to defective development of foetus and birth of child with cretinism.

22. Calcium plays a very important role in the formation of bones. Write about the role of endocrine glands and hormones responsible for maintaining calcium homeostasis. **(NCERT Exemplar)**

The secretion of Parathyroid Hormone (PTH) regulates the concentration of calcium ions (Ca^{2+}).

Parathyroid hormone increases the Ca^{2+} levels in the blood, It acts on bones and stimulates the process of bone resorption (dissolution/ demineralisation). It also

stimulates reabsorption of Ca^{2+} by the renal tubules and increases Ca^{2+} absorption from the digested food. It is thus, clear that PTH is a hypercalcemic hormone, i.e. it increases the blood Ca^{2+} levels. Along with TCT, it plays a significant role in calcium balance in the body.

23. When does the secretion of adrenocorticotropin take place in the body? What is the purpose of its secretion?

Adrenocorticotropin is secreted when Adrenocorticotropin Releasing Hormone (ACRH) stimulates the corticotroph cells of the anterior lobe of pituitary gland.

It is released because its stimulation is responsible for the synthesis and secretion of glucocorticoid steroid hormone from the adrenal cortex of adrenal gland.

24. How do you justify the statement that hormones of adrenal medulla are emergency hormones?

Hormones of adrenal medulla, i.e. adrenaline and nor-adrenaline (belong to the category of compounds called catecholamines) are secreted in response to any kind of stress, danger and during emergency situations like fall in blood pressure or sugar, increase respiratory rate and heartbeat. CNS at the time of stress or danger stimulates adrenal medulla to release these hormones. All these conditions need more energy for their action. As these hormones prepare the body to face stress or danger hence, these are called emergency hormones.

25. Inflammatory responses can be controlled by a certain steroid. Name the steroid, its source and also its other important functions. **(NCERT Exemplar)**

Inflammatory responses are controlled by steroid hormones called glucocorticoids, which are secreted by adrenal cortex. Its other functions are to stimulate gluconeogenesis, lipolysis and proteolysis and inhibit cellular uptake and utilisation of amino acids.

26. Differentiate between hyperglycemia and hypoglycemia.

Differences between hyperglycemia and hypoglycemia are as follows

Hyperglycemia	**Hypoglycemia**
It results from hyposecretion of insulin.	It results from hypersecretion of insulin.
Its symptoms include high blood glucose level, breakdown of muscles, tissues, loss of weight and tiredness.	Its symptoms include low blood glucose level, hunger, sweating, irritability, double vision.

27. State whether True or False.

(i) Pars distalis produces six trophic hormones.

(ii) B-lymphocytes provide cell-mediated immunity.

(iii) Insulin resistance results in a disease called diabetes mellitus. **(NCERT Exemplar)**

(i) True (ii) False (iii) True

28. Give examples of

(i) hyperglycemic hormone and hypoglycemic hormone

(ii) hypercalcemic hormone

(iii) gonadotropic hormone

(iv) progestational hormone

(v) blood pressure lowering hormone

(vi) androgens and oestrogens **(NCERT)**

(i) Glucagon and insulin, respectively

(ii) Parathyroid hormone

(iii) Follicle Stimulating Hormone (FSH) and Luteinizing Hormone (LH)

(iv) Progesterone

(v) Atrial Natriuretic Factor (ANF)

(vi) Androgens are mainly testosterone and oestrogens include oestriol, oestradiol and oestrone.

29. Correct the following statements by replacing the term underlined.

(i) Insulin is a <u>steroid</u> hormone.

(ii) TSH is secreted from the <u>corpus luteum</u>.

(iii) <u>Tetraiodothyronine</u> is an emergency hormone.

(iv) The pineal gland is located on the <u>anterior part</u> of the kidney. **(NCERT Exemplar)**

(i) Insulin is a proteinaceous hormone.

(ii) TSH is secreted from the thyroid glands.

(iii) Adrenaline is an emergency hormone.

(iv) The pineal gland is located on the dorsal side of the forebrain.

30. Fill up the blank spaces (i)-(vi) in the table given below.

Names of Endocrine Gland	**Secreted Hormones**	**Functions of the Hormone**
Pituitary	(i)	Reabsorption of water and electrolytes in kidney.
(ii)	Insulin	(iii).....
Thymus	Thymosins	(iv).....
Ovary	(v) ..... and (vi)	Development of growing ovarian follicles controls metabolism of proteins, fats and carbohydrates.

(i) Vasopressin

(ii) Pancreas

(iii) Reduces blood glucose level

(iv) Differentiation of T-lymphocytes

(v) Oestrogen

(vi) Progesterone

31. Mention the major classes of hormones being in humans. Give examples of each.

Although hormones are chemically diverse, they generally belong to one of four different chemical groups

(i) **Steroid Hormones** These hormones are manufactured by endocrine cells from cholesterol, an important type of lipid in the human body. Examples include cortisol, aldosterone, oestrogen, progesterone and testosterone.

(ii) **Amino Acid Derivatives** The thyroid hormones (T_3 and T_4) are synthesised from the amino acid tyrosine and iodide, respectively. Adrenaline (also known as epinephrine) and nor-adrenaline (also known as nor-epinephrine) are produced by the medulla of the adrenal gland and these are also derived from tyrosine.
Melatonin is synthesised from the amino acid tryptophan.

(iii) **Protein Hormones** These hormones are long, folded chains of amino acids. Included among these hormones are insulin, glucagons, parathyroid hormone, growth hormone, prolactin, etc.

(iv) **Peptide Hormones** Hormones such as oxytocin and antidiuretic hormone are smaller than protein hormone. They are made up of a short chain of amino acids.

32. (i) What is termed as first messenger and second messenger in the target cells.

(ii) How do protein hormones act on target cells?

(i) Hormone is called first messenger and *c*AMP is called second messenger.

(ii) Protein hormone is water soluble, it binds to the extrinsic receptor present on the cell surface of the plasma membrane. Hormones when bind to them activate a membrane bound enzyme adenyl cyclase, which catalyses the conversion of ATP to *c*AMP.

The *c*AMP then activates one more enzymes known as protein kinases. After phosphorylation of protien, alteration of its function occurs which thereby, leads to some metabolic effect.

33. What is the role of second messenger in protein hormone action? **(NCERT Exemplar)**

Hormones which do not enter the target cells, interact with specific receptors located on the surface of the target cell membranes and generates second messengers (e.g. *c*AMP) on the inner side of the plasma membrane. The second messenger, in turn, carries out all the hormonal functions.

34. Explain amplification of a signal in hormone action. What is its role?

Although hormones are present in very small amounts, they effectively regulate many physiological processes. This is the result of signal amplification, an increase in signal strength. For example, a single hormone receptor complex can stimulate the production of many *c*AMP molecules. In turn, each *c*AMP can activate a protein kinase that phosphorylates many protein molecules. In this way, a single hormone molecule can activate many proteins.

35. What is meant by 'antagonistic effect'? Illustrate your answer with an example.

It refers to the effect of a hormones that are countered by an antagonistic (opposing) signal, often another hormone. For example, the sympathetic and parasympathetic nervous systems achieve antagonistic effect on heartbeat.

This mechanism involves the use of more than one second messenger. In heart cells cyclic form of Adenosine Monophosphate (*c*AMP), serves as a second messenger, speeding up muscle cell contraction in response to adrenaline, while cyclic Guanosine Monophosphate (*c*GMP) serves as another second messenger, slowing muscle contraction in response to acetylcholine.

36. Write short note on feedback mechanism of hormone action.

The regulation of hormonal secretion in the body of an organism is called feedback control. This helps to maintain a homeostasis within the endocrine system.

Feedback control is of two types

(i) **Negative feedback** where the end product of a biochemical process inhibits its own production, e.g. regulation of release of thyroxine hormone.

(ii) **Positive feedback**, where hormones released by one gland stimulates other gland which further lead to even more significant changes in the same direction.

37. Write a note on hormone receptors.

Hormones are released from their respective gland in very small amount. They carry out widespread effects in the body of an individual. Their response is very specific and accurate. Their effects are produced on target tissues by binding to the specific proteins known as hormone receptors, located in the target tissues only.

Hormone receptors are of following two types

(i) **Membrane Bound Receptors** Hormone receptors present on the cell membrane of the target cells.

(ii) **Intracellular Receptors** Hormone receptors present inside the target cell, e.g. nuclear receptor (present in the nucleus of a cell).

• Long Answer (LA) Type Questions

1. Hypothalamus is a super master endocrine gland. Elaborate. **(NCERT Exemplar)**

Hypothalamus regulates a wide spectrum of body functions. It contains several groups of neurosecretory cells called nuclei, which produce hormones. These hormones regulate the synthesis and secretion of pituitary hormones. However, the hormones produced by hypothalamus are of two types, the releasing hormones (which stimulate secretion of pituitary hormones) and the inhibiting hormones (which inhibit secretions of pituitary hormones).

The hormones reach the pituitary gland through a portal circulatory system and regulate the functions of the anterior pituitary. The posterior pituitary is under the direct regulation of hypothalamus.

The oxytocin and vasopressin are the two hormones synthesised by hypothalamus that are transported to posterior pituitary.

2. Explain the following by giving scientific reasons.

(i) Hypothalamus and pituitary function as an integrated and coordinated system.

(ii) Body growth is greatly accelerated at puberty in males.

(i) The hypothalamus and pituitary function as an integrated and coordinated system because both of them are connected at the base of the brain. They interact to each other in two ways

(a) By the hypophyseal portal system, which is a system of blood vessels that connect part of hypothalamus to the anterior lobe of pituitary gland. Hypothalamus secretes hormones into this portal system and the hormones act on the anterior pituitary, triggering the synthesis/ secretion of pituitary hormone.

(b) The other is that they have direct anatomical connection between the hypothalamus and the posterior lobe of pituitary (posterior pituitary is actually are extension of hypothalamus).

(ii) Puberty is the phenomenon of physical changes by which child's body matures into an adult male, capable of sexual reproduction to enable fertilisation. It is initiated by the hormonal signals from the brain to the gonads, i.e. testes in a male. In response to the signals, gonads produce hormones that in turn stimulates the growth, function and transformation of the brain, muscles, blood, hair, sexual organs, etc. An androgen called as testosterone in males, functions as principal sex hormone, producing all changes in male related to growth and development at puberty.

3. List the hormones secreted by the following.

(i) Hypothalamus (ii) Pituitary
(iii) Thyroid (iv) Parathyroid
(v) Adrenal (vi) Pancreas **(NCERT)**

Hormones secreted by the following glands are

(i) **Hypothalamus** secretes thyrotropin releasing hormone, adrenocorticotropin releasing hormone, gonadotropin releasing hormone, somatotropin releasing hormone, prolactin releasing hormone, melanocyte stimulating hormone, releasing hormone.

(ii) (a) Pars distalis part of pituitary (anterior pituitary) secretes Growth Hormone (GH), Prolactin (PRL), Thyroid Stimulating Hormone (TSH), Adrenocorticotropic Hormone (ACTH), Luteinizing Hormone (LH), Follicle Stimulating Hormone (FSH).

(b) Pars intermedia secretes Melanocyte Stimulating Hormone (MSH).

(c) Pars nervosa secretes oxytocin and vasopressin.

(iii) Thyroid secretes thyroxine (T_4) and triiodothyronine (T_3).

(iv) Parathyroid secretes Parathyroid Hormone (PTH).

(v) Adrenal

(a) secretes adrenaline, nor-adrenaline from adrenal medulla.

(b) also secretes corticoids (glucocorticoid and mineralocorticoid) and sexocorticoids from adrenal cortex.

(vi) α-cells of pancreas secrete glucagon, while the β-cells secrete insulin. The delta cells (δ) secrete somatostatins.

4. What are the hormones of adenohypophysis and also write their target organs? **(NCERT Exemplar)**

The anterior lobe of pituitary is called adenohypophysis. It secretes various hormones. These are as follows

(i) Somatotropic Hormone (STH) or Growth Hormone (GH) target the cells which undergo growth.

(ii) Thyroid Stimulating Hormone (TSH) or Thyrotropin influence the cells of thyroid gland.

(iii) Prolactin Hormone (PRL) or Mammotrophin Hormone (MTH) or Luteotrophin Hormone (LTH) called the 'hormone of maternity' activates mammary glands during pregnancy and after childbirth.

(iv) Adrenocorticotropic Hormone (ACTH) stimulates cortex of adrenal gland.

(v) Gonadotropic hormones are of two types

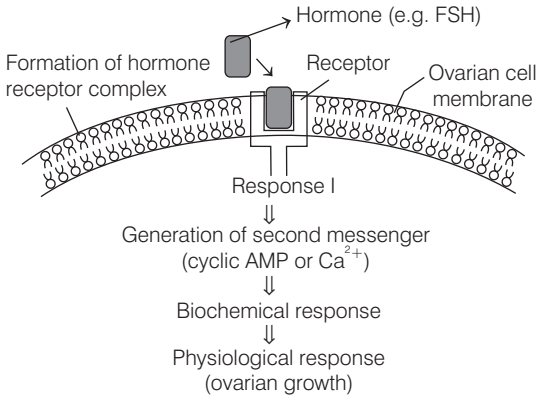
(a) Follicle Stimulating Hormone (FSH) stimulates the growth of ovarian follicles.

(b) Luteinizing Hormone (LH) acts on corpus luteum to secrete progesterone but in males it activates cells of Leydig to secrete androgens.

5. (i) Give a diagrammatic representation of the mechanism of protein hormone (e.g. FSH) action.

(ii) Illustrate the differences between the mechanism of action of a protein and a steroid hormone. **(NCERT Exemplar)**

(i) Diagrammatic representation of the mechanism of hormone action of peptide or protein hormone

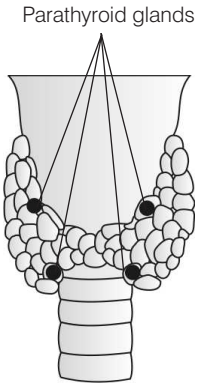


(ii) Differences between mechanism of action of a protein and a steroid hormone are as follows

Protein Hormones	Steroid Hormones
They interact with membrane bound receptors.	They interact with intracellular receptors.
They generate second messengers (cyclic AMP, IP_3, Ca^{2+}, etc).	They regulate gene expression or chromosome function by the interaction of hormone receptor complex with the genome.
The second messengers regulate cellular metabolism.	Cumulative biochemical action of hormone receptor complex results in physiological and developmental effects.

• Case Based Questions

1. Refer to the diagram given below and answer the following questions.



(i) What is the relation of parathyroid gland and thyroid gland?

Parathyroid glands are small glands in the human neck that produces parathyroid hormone. These glands are situated on the posterior side of the thyroid gland.

(ii) Why is parathyroid hormone called a hypercalcemic hormone?

Parathyroid hormone increases the level of Ca^{2+} in the blood. It stimulates the process of bone reabsorption (i.e. dissolution/demineralisation) by the action on bones.

It also stimulates reabsorption of Ca^{2+} by the renal tubules and absorption of Ca^{2+} from the digested food. By the above mentioned functions of parathyiond hormone, it is clear that PTH acts as a hypercalcemic hormone (increases the level of Ca^{2+} in the blood).

(iii) Mention the structural characteristic of parathyroid gland.

Parathyroid glands are **four** in number, i.e. each pair is situated in the two lobes of the thyroid gland on either side. These are small, flat and oval gland.

(iv) What does the hormone of parathyroid gland called? Which ion regulate the level of these hormones?

Parathyroid glands secrete a single hormone known as **parathormone** or **Parathyroid Hormone**, i.e. PTH (functions opposite to the thyrocalcitonin hormone). The secretion of PTH is regulated by the circulating level of calcium ions in the blood.

2. Direction *Read the following passage and answer the questions that follows.*

Lakshita was studying endocrine system for her unit test. She was confused how hormones produce their effects on the target tissue. She read many times, but still did not understand the process. She asked the same to her neighbour Stuti, a biology teacher in a school. Stuti explained her about the hormone receptor complex through diagrams and flowcharts.

(i) Name the two types of receptors.

Two types of receptors are

(a) membrane bound extracellular receptors,

(b) intracellular receptors.

(ii) Why do different hormones use different types of receptors?

The hormones which cannot enter the target cell, need membrane bound (extracellular) receptors and the hormones which can enter the target cell, need intracellular (mostly nuclear) receptors.

(iii) What are second messengers? Give two examples?

Second messengers are those chemicals, which are generated in the target cells, by those hormones which cannot enter the cells, to bring about the biochemical changes, e.g. Inositol Triphosphate (IP_3) cyclic Adenosine Monophosphate (*c*AMP).

(iv) Mention the role of second messenger in the mechanism of protein hormone action.

Second messenger regulate the metabolism of a cell, which results in many physiological effects.

(v) Give the name of the major classes of hormones.

The major classes of hormones are

(a) Steroid hormones, (b) Amino acid derivatives,
(c) Protein hormones, (d) Peptide hormones

Chapter Test

Multiple Choice Questions

1. The posterior pituitary gland is not a 'true' endocrine gland because
(a) it is provided with a duct
(b) it only stores and releases hormones
(c) it is under the regulation of hypothalamus
(d) it secretes enzymes

2. Identify the hormone with its correct matching of source and function.
(a) Oxytocin–Posterior pituitary, growth and maintenance of mammary glands
(b) Melatonin–Pineal gland, regulates the normal rhythm of sleep-wake cycle
(c) Progesterone–Corpus luteum, stimulation of growth and activities of female secondary sex organs
(d) Atrial natriuretic factor–Ventricular wall increases the blood pressure

3. Which of the following is true for 'parathormone'?
(a) It increases blood calcium level and decreases calcium store of the bone
(b) It decreases blood calcium level and increases calcium store of the bone
(c) It increases blood glucose level and decreases calcium store of the bone
(d) It decreases blood glucose level and increases calcium store of the bone

4. The layer of adrenal cortex from outer to inner region are
(a) zona glomerulosa, zona fasciculata, zona reticularis
(b) zona reticularis, zona glomerulosa, zona fasciculata
(c) zona fasciculata, zona reticularis, zona glomerulosa
(d) zona reticularis, zona fasciculata, zona glomerulosa

5. Hormones that interact with membrane bound receptors normally
(a) enters into the cell membrane
(b) do not enter into the cell
(c) generate secondary messenger
(d) Both (b) and (c)

Assertion-Reasoning MCQs

Direction (Q. Nos. 1-3) *Each of these questions contains two statements, Assertion (A) and Reason (R). Each of these questions also has four alternative choices, any one of which is the correct answer. You have to select one of the codes (a), (b), (c) and (d) given below.*
(a) Both A and R are true and R is the correct explanation of A
(b) Both A and R are true, but R is not the correct explanation of A
(c) A is true, but R is false
(d) A is false, but R is true

1. **Assertion** (A) Endocrine glands are called ductless glands.
Reason (R) Hormones produced by endocrine glands are released into the blood and transported to distant target organs.

2. **Assertion** (A) Pineal gland secretes two biogenic hormones.
Reason (R) Serotonin is secreted by pituitary gland.

3. **Assertion** (A) Pancreas is a composite gland.
Reason (R) It acts both as an exocrine and an endocrine gland.

Short Answer Type Questions

1. Name the T_3 and T_4 components of thyroid hormones. Explain their specification.

2. Which hormonal deficiency is responsible for the following?
(i) Diabetes mellitus (ii) Goitre (iii) Cretinism
(**NCERT**)

3. Enlist the functions of glucagon in human body.

4. How does progesterone function in a human female?

5. What is meant by synergistic effect? Explain with an example.

Long Answer Type Questions

1. 'Adrenal cortex releases variety of hormones which have different regulatory effects in human body'. Justify this statement by explaining different hormones secreted by adrenal cortex and their functions.

2. Explain the structure of pancreas and also mention the role of the hormone secreted by it.

Answers

Multiple Choice Questions

1. *(b)* ***2.*** *(b)* ***3.*** *(a)* ***4.*** *(a)* ***5.*** *(d)*

Assertion-Reasoning MCQs

1. *(a)* ***2.*** *(c)* ***3.*** *(a)*