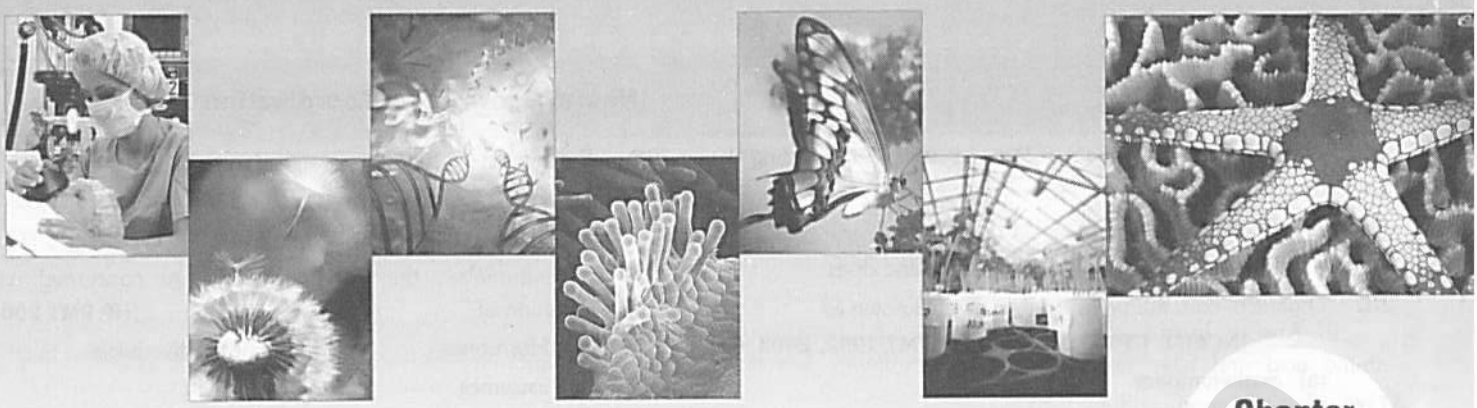


Chapter

5.7

Chemical Co-ordination and Integration

Endocrine system is formed of all endocrine glands of body. Though different endocrine glands are different in embryonic origin and are isolated from one another but these interact with one another so collectively form an endocrine system. Endocrine system along with nervous system, controls and coordinates the body functions and maintains a homeostasis. So both collectively form neuro-endocrine system. The study of these two systems is called neuro-endocrinology.

Glands of body : Animals have three types of glands.

(i) **Exocrine gland (Gr., *ex* = out + *krinein* = to secrete) :** These glands have ducts for discharging their secretions. Therefore, they are called as duct glands. *ex* – Liver, Sweat gland, Sebaceous gland, Gastric glands and some intestinal glands.

(ii) **Endocrine glands (Gr., *endo* = within + *krinein* = to secrete)** : These glands lack ducts and pass secretions into the surrounding blood directly. Therefore they are called as ductless glands. *ex* – Thyroid, parathyroid, adrenal, pituitary, pineal body and thymus.

(iii) **Heterocrine glands :** These glands consist of both exocrine and endocrine tissue. The exocrine discharge its secretion by a duct and the endocrine tissue discharges its secretion into the blood. Pancreas and gonads are heterocrine glands. These are also called mixed glands.

Hormones and their mechanism

Hormones are informational molecules secreted by the endocrine cells in one part of the body and carried by blood to another part where they stimulate or inhibit specific physiological process.

Discovery : First hormone discovered was secretin. It was discovered by two English physiologists : William M Bayliss and Ernest H. Starling in 1903.

Term hormone was coined by Starling (1905) from Greek word Homone means to excite. It is a misnomer because a number of hormones are known to have inhibitory effect (*e.g.*, Somatostatin).

General function of hormones

(1) Some hormones control Basal Metabolic Rate (BMR) *e.g.*, thyroxine of thyroid gland.

(2) Some hormones control the secretion of other endocrine glands, *e.g.*, Tropic hormones of Anterior pituitary control Thyroid, Adrenal cortex, gonads, etc.

(3) Some hormone control blood pressure *e.g.*, Aldosterone, Atrial Natriuretic Hormone (ANH) of heart, Vasopressin or ADH', oxytocin and Renin of kidney.

(4) Increase production of RBC *e.g.*, erythropoietin of kidney.

Properties of hormones

(1) These are secreted by endocrine gland (biogenic in origin).

(2) Their secretions is released directly into blood (except local hormones *e.g.*, gastrin).

(3) These are carried to distantly located specific organs, called target organ.

(4) These have specific physiological action (excitatory or inhibitory). These co-ordinate different physical, mental and metabolic activities and maintain homeostasis.

(5) The hormones have low molecular weight *e.g.*, ADH has a molecular weight of 600–2000 daltons.

(6) These act in very low concentration *e.g.*, around 10^{-10} molar.

(7) Hormones are non antigenic.

(8) These are mostly short-lived. So have a no cumulative effect.

(9) Some hormones are quick acting *e.g.*, adrenalin, while some acting slowly *e.g.*, oestrogen of ovary.

(10) Some hormones secreted in inactive form called Prohormone *e.g.*, Pro-insulin.

(11) Hormones are specific. They are carriers of specific information to their specific target organ. Only those target cell respond to a particular hormone for which they have receptors.

(12) Hormones after their action are destroyed in liver and kidney.

Classification of hormones

(1) **On the basis of chemical nature :** On the basis of chemical composition hormones are classified into three categories.

(i) **Amine hormones :** These are derived from tyrosine amino acid and have amino $(-NH_2)$ group *e.g.*, Thyroxine, Epinephrine, Nor-epinephrine.

(ii) **Steroids :** These are fat soluble and have sterol group. These are derived from cholesterol *e.g.*, hormones of adrenal cortex (cortisol, cortisone, corticosterone, aldosterone) testes (testosterone) and ovaries (oestrone, oestradiol, progesterone etc.)

(iii) **Proteinaceous and peptide hormones :** These are formed of 3 – 200 amino acids interlinked by peptide bonds and are water soluble *e.g.*,

(a) Proteinaceous hormones like STH, TSH, FSH, LH etc. Out of these FSH and LH are glycoproteins.

(b) Long peptide hormones like insulin and glucagon, ACTH, Paratharmone.

(c) Short peptide hormones like oxytocin, ADH, MSH. These hormones formed of a few amino acids.

(2) **On the basis of mode of action**

(i) **Quick acting hormones :** These hormones initiate immediate response from their target cells. There receptor is always located on the outer surface of plasma membrane of target cell because these are large sized. Hormone receptor complex activates a membrane enzyme adenyl cyclase which hydrolyse ATP into cyclic AMP. Which acts as secondary messenger, c-AMP activates an inactive enzyme system by cascade effect. So their mode of action is called second messenger hypothesis. *e.g.*, These includes proteinaceous, peptide and amine hormones.

(ii) **Delayed acting hormones :** These hormones initiate response after some time. These are small sized so are diffusable through the plasma membrane of their target cell. These bind their proteinaceous receptor present in the cytosol. These always operate through de-novo synthesis of m-RNA by activation of certain genes. So their mechanism of action is called m-RNA hypothesis. These include steroid hormones of testes, ovary and adrenal cortex.

Table : 5.7-1 Difference between hormone and enzymes

S.No.	Characters	Enzymes	Hormones
1.	Chemistry	Always proteinaceous	May be proteinaceous, or amine or steroids.
2.	Molecular weight	Macromolecules with high molecular weights.	Have low molecular weights.
3.	Diffusibility	Non-diffusible through cell membrane.	Diffusible through cell membrane.
4.	Site of action	Either act intracellularly or carried by some duct to another site.	Generally carried by blood to a target organ.
5.	Mode of action	Always act as biocatalysts and increase the rate of metabolic physiological process.	May be excitatory or inhibitatory in their physiological action.
6.	Reversibility	These catalyze reversible reactions.	Hormone controlled reactions are not reversible.
7.	Effect of concentration	Reaction rate increase with increase in their concentration upto a limit.	Deficiency or excess of hormone causes metabolic disorders and diseases.
8.	Speed	Act quickly	Some are quick acting, while some are slow acting with a lag period.
9.	Consumption	Not used in metabolic functions.	Used up in metabolic functions.

Table : 5.7-2 Difference between hormone and vitamin

S.No.	Characters	Hormones	Vitamins
1.	Source	Synthesized in the endocrine cells of body.	Taken along with food from outside.
2.	Chemistry	Steroids or proteinous or amino acid derivatives.	Simple organic compounds like amines, esters, organic acids etc.
3.	Action	Either excitatory or inhibatory. Do not act as co-enzymes.	These generally act as co-enzymes for enzyme activity.
4.	Cause of disorders	Both excess as well as deficiency of hormones.	Generally avitaminosis (deficiency of vitamins) leads to deficiency diseases.

Table : 5.7-3 Difference between Nervous and hormonal control

S.No.	Characters	Nervous control	Hormones control
1.	Speed of action	Always quick acting.	May be quick acting or acting with a long period.
2.	Mode of transmission of informations	As electrochemical nerve impulses.	As chemical messengers.
3.	Path of transmission	Through nerve fibres.	Through blood.
4.	Direction of the informations	Towards a specific direction (effector organ or CNS).	Released in general blood circulation from where taken by specific receptor.
5.	Suitability	For quick reactions like reflexes.	For long-term changes *e.g.* maintenance of pregnancy.
6.	Durability	Short time effect.	Long lasting.

Release of hormones : Hormones are released from endocrine glands by three types of stimuli.

(1) **Specific metabolites :** The presence of a specific metabolite in the blood elicits the hormone to deal with it.

For instance excess of glucose in the blood causes the release of insulin from the pancreas and decrease of glucose in blood causes the release of glucagon from pancreas.

(2) **Other hormone :** The presence of a specific hormone in the blood induces the release of another hormone. For example TSH stimulate thyroid gland to release thyroxine hormone and ACTH stimulate Adrenal cortex to release their hormones.

(3) **Neuronal impulse :** Neurons of autonomic system stimulate hormone release from some glands. For example adrenaline and nor-adrenaline are released from adrenal medulla on the arrival of nerve impulses during anxiety, stress and danger.

Mechanism of hormone action : The hormones act in two ways –

(1) **On cell surface :** The molecules of hormones that are amino acid derivatives, peptides or proteins are large and insoluble in lipid, and can not enter the target cell. Therefore they act at the cell surface. They bind to specific receptor molecules located on the surface of cell membrane. The hormone receptor complex may acts in one of the two ways –

(i) **Formation of cAMP :** Mechanism of formation of cAMP was discovered by E.W. Sutherland in 1950. The hormone receptor complex causes the release of an enzyme adenylcyclase from the receptor site. This enzyme hydrolyse the ATP into c-AMP. The c-AMP activates the existing enzyme system of the cell. This accelerates the metabolic reactions in cell. The hormone is called first messenger and the c-AMP is termed the second messenger. *e.g.*, Adrenaline causes the secretion of glucose from the liver cell from this mechanism.

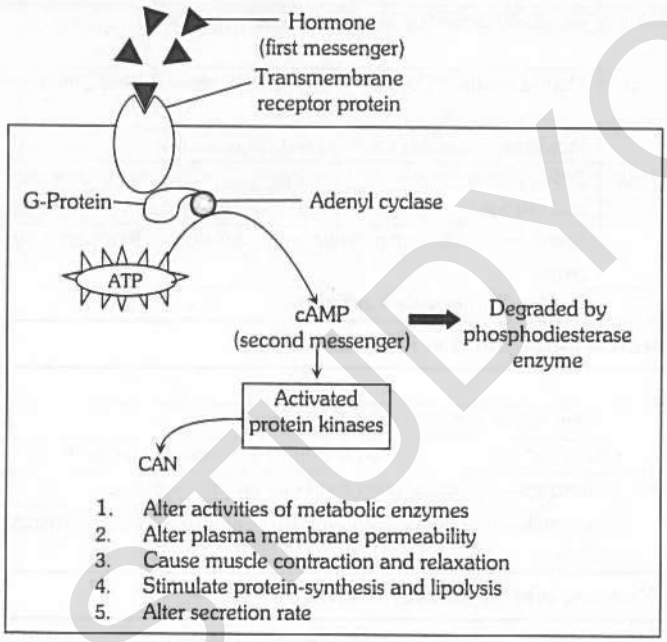


Fig : 5.7-1 Mechanism of Hormone action on cell surface

(ii) **Change in membrane permeability :** The receptor proteins of some hormones are large transmembrane intrinsic protein acting as ion channels for facilitated diffusion of Na^+, K^+, Ca^{2+} etc. On binding with specific hormone these receptor proteins undergo conformational changes, so that the membrane permeability for ions is altered, resulting into important changes in metabolism.

For example, insulin promotes the entry of glucose from blood into the muscle cells by increasing the permeability of sarcolemma to glucose.

(2) **Within a cell :** 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. The receptor molecules carry them into the nucleus. Here, the receptor hormone complex binds to a specific receptor site on the chromosome and activates certain genes that were previously repressed. The activated gene transcribe m-RNA which directs the synthesis of enzyme (protein molecule) in the cytoplasm. The enzyme molecule promote the metabolic reactions in the cell.

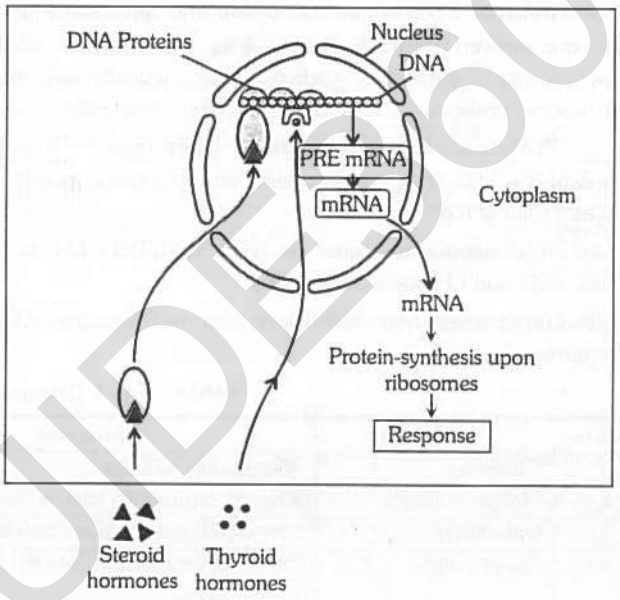


Fig : 5.7-2 Mechanism of cell surface within a cell

Feedback control of hormone secretion : The secretion of hormones depends on age, daily routine, health of body, physiological conditions of body etc. Besides the above factors hormone secretion also depends on its own amount circulating in the blood. Decrease and increase in the circulating amount of a hormone has a directly inverse effect on the secretion of hormone. This is known as the "pull and push" or "feed-back control" mechanism of hormonal secretion.

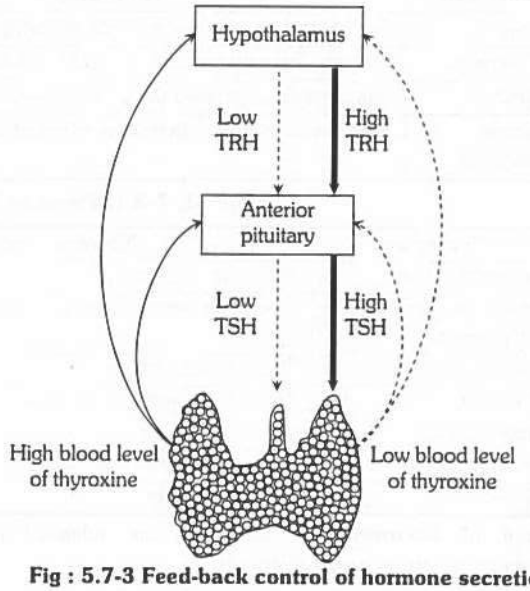


Fig : 5.7-3 Feed-back control of hormone secretion

(1) **Negative feedback control**

Direct feedback control : Thyroid stimulating hormone (T.S.H.) stimulates the thyroid gland to secrete thyroxine hormone. A high amount of thyroxine in the blood exerts an inhibitory effect on pituitary to secrete less T.S.H.. This eventually results in decrease in thyroxine. This is called "Direct feedback control".

(2) **Positive feedback control :** Oxytocin released by posterior pituitary gland stimulate contraction of uterus during child birth. As the contraction of uterus progresses, more and more of oxytocin is released. This is called positive feed back control.

Table : 5.7-4 Origin of different endocrine glands

Endocrine glands	Weight	Origin
Pituitary	0.5 gm	Ectoderm
Pineal	5.0 mg	Ectoderm
Thymus (upto 12 yrs.)	20.0 gm	Endoderm
Thyroid	25.0 gm	Endoderm
Parathyroid	20.0 mg	Endoderm
Adrenal cortex	4.0 gm	Mesoderm
Adrenal medulla	1.0 gm	Ectoderm
Testes	–	Mesoderm
Ovary	–	Mesoderm
Pancreas	60.0 gm	Endoderm

Table : 5.7-5 Number of hormones secreted by different endocrine glands

Endocrine-glands	Number of secreted hormones	
Pituitary – Anterior	–	7
Hypothalamus	–	2
Pineal body	–	2
Thymus	–	3
Thyroid	–	2
Parathyroid	–	1
Islets of Langerhans	–	3
Adrenal cortex	–	46
Adrenal medulla	–	2
Testes	–	1
Ovary	–	3
Placenta	–	2
Kidneys	–	2
Stomach	–	1
Duodenum	–	5
Ileum	–	2

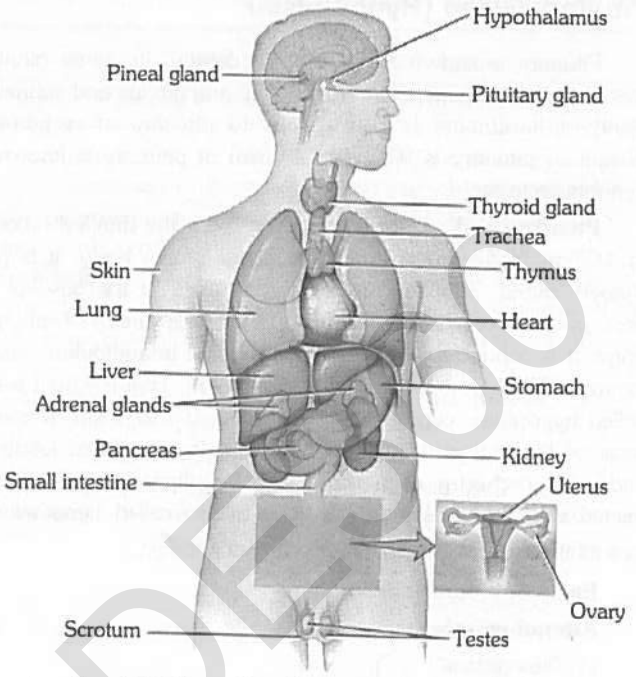


Fig : 5.7-4 Location of many endocrine glands

Discovery & Terms

(1) Term 'endocrine' was first used by Claude Bernard.

(2) Thomas Addison is called as father of endocrinology.

(3) Walter canon stated that the hormones maintain homeostasis in the body.

(4) Von Euler coined the term 'prostaglandin'

(5) Kendall for the first time prepared the crystals of thyroxine.

(6) Harrington and Barger studied the molecular structure of thyroxine.

(7) Term 'thyroxine' was coined by Whartson.

(8) Sutherland discovered cAMP.

(9) Parathormone was first isolated by Collip.

(10) Potts discovered the structure of PTH.

(11) Axelord studied the structure of epinephrin and nor-epinephrin.

(12) Endocrine structures of the pancreas were discovered by langerhans.

(13) Structure of insulin was studied by Sanger. He was given Nobel prize in 1958. He was rewarded Nobel prize in 1980 for gene structure.

(14) Human insulin was synthesized by Tsan.

(15) Glucagon was discovered by Kimball and Murlin.

(16) Term ' Secretin' was coined by Beylis and Starling.

(17) Adrenal gland was discovered by Eustachian.

Pituitary Gland (Hypophysis)

Pituitary is known as hypophysis cerebri, its name pituitary was given by Vesalius. Muller's gland of amphioxus and subneural gland of hardmania is homologous to pituitary of vertebrates. Weight of pituitary is 0.5 gm. Removal of pituitary is known as hypophysectomy.

Position and origin : Pituitary gland is the smallest (about 1 to 1½ cm in diameter) endocrine gland of the body. It is pea-shaped, ovoid, reddish brown gland situated at the base of the brain in a cavity, hypophyseal fossa of the sella turcica of sphenoid bone. It is connected by a short stalk called Infundibulum, to the ventral wall (Hypothalamus) of diencephalon. That is why it is also called hypophysis cerebri. It weight about 0.5 to 1 gm. It control most of the endocrine glands. Hence, it is also called leader of endocrine orchestra or master gland. Pituitary gland is closely related with hypothalamus, hence, it is also called hypothalamo-hypophyseal gland, pituitary is ectodermal in origin.

Parts and component

Adenohypophysis

(1) Pars distalis
(2) Pars tuberalis
(3) Pars intermedia
} Anterior lobe 75%

Neurohypophysis

(1) Pars nervosa
(2) Infundibulum
} Posterior lobe 25%

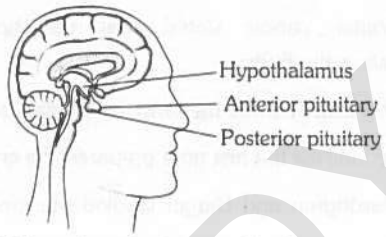


Fig : 5.7-5 Location of pituitary gland

Structure of pituitary gland : Pituitary gland is comprised of two main lobes – Adenohypophysis and Neurohypophysis. Adenohypophysis arises as hypophyseal or Rathke's pouch from dorsal wall of embyronic stomodeum. It is the anterior lobe of pituitary. The neurohypophysis (Pars nervosa or Posterior lobe) form as an outgrowth from the infundibulum of the floor of hypothalamus.

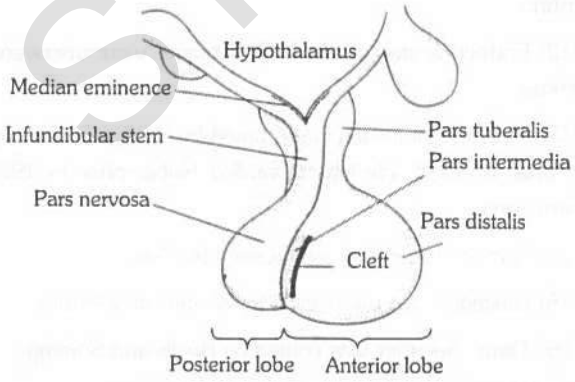


Fig : 5.7-6 Structure of pituitary gland

In pituitary following types of cells are found :

(1) **Chromophobes cells :** Found in adenohypophysis of pituitary. These are not stained by acid and base dye. Pigment granules are absent. These are colourless may change into chromophils.

(2) **Chromophil cells :** Found in adenohypophysis of pituitary. These are stained by acid and base dye. Pigment granules are filled in these cells. These may be two types :

(i) **Acidophils :** It is also known as α-cells synthesize and secretes growth hormone and prolactin.

(ii) **Basophils :** It is also known as cyanophils or β-cells synthesize and secretes TSH, ACTH, FSH, LH and MSH hormones.

(3) **Pituicyte cells :** These cells found in neurohypophysis of pituitary. These are supporting neuroglea cells and gives support to herring bodies.

(4) **Herring bodies :** Herring bodies are dilated terminal portion of Neurosecretory axon constituting hypothalamohypophyseal tract. They are hormone precursors for oxytocin and vasopressin.

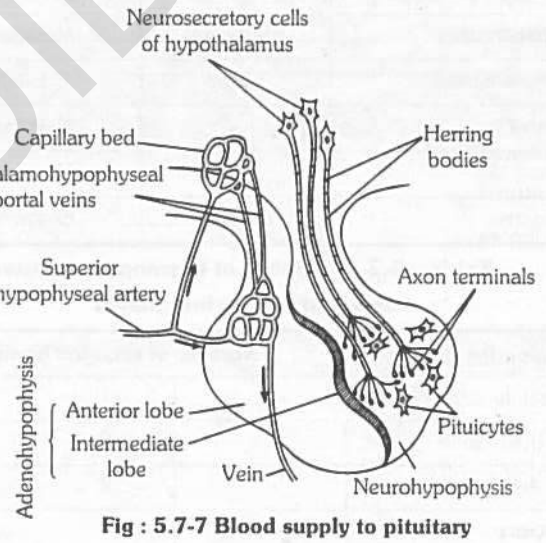


Fig : 5.7-7 Blood supply to pituitary

Blood supply to pituitary or Hypophyseal portal system : A pair of posterior hypophyseal arteries and a pair of anterior hypophyseal arteries provide blood to the pituitary gland. Posterior arteries supply blood to the pars nervosa, and anterior arteries supply blood to the hypothalamus and pars distalis. Adenohypophysis has dual blood supply by means of a "circle of willis". The anterior hypophyseal artery which bring blood into this circle big ureates into two branches outside the lobe. One branch supplies the adenohypophysis and other supplies the hypothalamus. The veins that drain the blood from hypothalamus. Then run into the pars distalis through pars tuberalis and divide into capillaries. Those veins are therefore, called portal hypophyseal veins. These constitute a hypothalamo hypophyseal portal system. Hypothalamic hormone reached anterior pituitary by portal system.

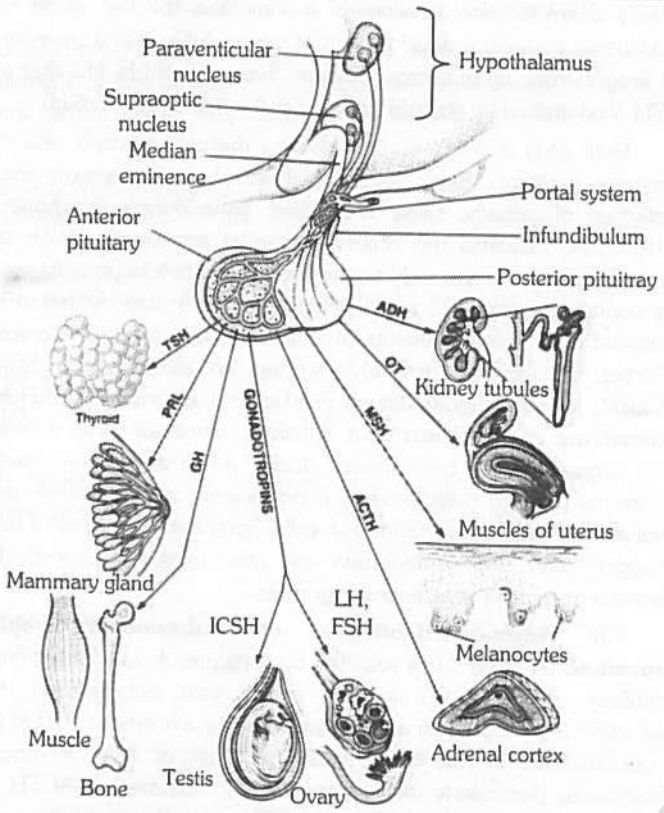


Fig : 5.7-8 Diagram to show the hormones of adenohypophysis and their target tissues and organs

Hormones of adenohypophysis

Adenohypophysis secretes seven hormones which are proteinacious in nature. These hormones are controlled by the controlling factors, secreted by the hypothalamus. There are 9 main controlling factors. Out of them 7 are releasing factors (RF) and 3 are inhibiting factor (IF). Complete failure of adenohypophysis (ant. pituitary) leads to simmonds syndrome. Hormones that influence another endocrine gland are called tropic or tropin hormones. The FSH/LH regulate testes and ovaries, thyrotropin stimulate thyroid, whereas corticotropin act on cortex of adrenal gland. Various hormones of adenohypophysis are as follows -

(1) Somatotropin (STH) or Growth Hormone (GH)

(i) **Functions of growth hormone :** Molecules of this hormone are polypeptides of 191 amino acid monomers. It is the major hormone in the secretion of anterior pituitary. It is the most important stimulant of proper normal growth of body. It promotes biosynthesis of DNA, RNA and proteins in all body cells. thus, it acts as an anabolic growth factor. Obviously, it stimulates cellular growth and proliferation, growth and repair of bones, muscles and connective tissue. In the liver cells it promotes, glycogenesis, deamination and gluconeogenesis.

According to modern scientists, the anabolic effects of growth hormone in man are indirect, instead of being direct. This hormone triggers synthesis of certain special, insulin-like growth factors (IGFs) in cells of many tissues, such as liver, muscles, cartilages, bones, etc. These growth factors are called somatomedins.

(ii) **Control of the secretion of growth hormone :** Secretion of growth hormone is controlled by two hormonal factors secreted by cells of hypothalamus. One of these factors, called GH-release hormone (GHRH) promotes secretion of growth hormone, while the other called GH-inhibitory hormone (GHIH) retards the secretion of growth hormone by the anterior pituitary. GHRH is also called somatocrinin and GHIH is called somatostatin.

(iii) **Effects of hyposecretion of growth hormone**

(a) **Nanism or ateliosis** : Hyposecretion (undersecretion) of growth hormone is childhood results into a blunted growth of body. Growth of all organs is retarded. Growth of bones at their epiphyseal ends stops. Hence, the bones do not grow in length, so that the body remains a dwarf. This pituitary dwarfism is called nanism or ateliosis.

(b) **Midgets :** Unlike the thyroid cretinism, the development of brain is normal in pituitary dwarfs, but like thyroid cretinism, the pituitary dwarfs are also infertile. The dwarfs of circuses are pituitary dwarfs. these are called midgets.

(c) **Pituitary myxoedema :** Undersecretion of growth hormone during adolescence (between 13 to 22 years of age) restricts body height, so that the person remains short-statured. Undersecretion after growth period (about the age of 22) causes pituitary myxoedema whose symptoms are almost similar to those of thyroid myxoedema. These include old age symptoms, such as reduced BMR and protein synthesis, greying and falling of hair, pallor and dryness of skin, reduced BP and low body temperature, insomnia, and weakness of muscles, vision and wisdom. Due to accumulation of mucus under the skin, the body becomes puffy, but weak. Genitalia weaken, causing sexual disability. Hence, the person becomes disheartened.

(iv) **Effects of hypersecretion of growth hormone**

(a) **Proportionate gigantism :** Hypersecretion (oversecretion of growth hormone during growth period (childhood and adolescence) causes excessive growth (hypergrowth) of all body parts, resulting into a symmetrically giant body. This is called proportionate gigantism.

(b) **Disproportionate gigantism or acromegaly :** The concerned person may attain a height of 8 feet or ever more. Oversecretion of growth hormone after growth period also causes gigantism, but in this the long bones do not grow in length due to closed epiphyseal plate at their ends, but the bones of hands, feet, lower jaw and rib cage thicken. Simultaneously, eyelids, lips, tongue, nose, chin, etc also enlarge. Soles, palms and forehead become wrinkled. Skin thickens and becomes wrinkled. Skin thickens and becomes coarse and fluffy (hirsutism).

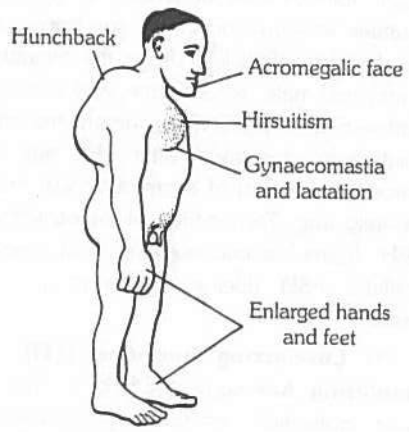


Fig : 5.7-9 A typical case of acromegaly

Consequently, the body becomes ugly like a gorilla. This is called disproportionate gigantism or acromegaly. It is common in men and rare in women.

(c) **Kyphosis :** In some cases, the backbone bends and thickens, causing hunchback condition (kyphosis). Breasts enlarge and mammary gland may yield milk. The patients often complain of headache, sexual disorders, muscular pain, and impaired vision and memory.

(d) **Diabetes mellitus :** Hypersecretion of growth hormone raises blood glucose level (*hyperglycemia*) which may cause diabetes mellitus.

(e) **Ketosis :** Increased breakdown of fat may release ketone bodies, mainly acetoacetic acid, in blood, causing ketosis.

(2) **Prolactin (PRL), Lactogenic, Luteotropic (LTH), or Mammotropic (MTH) Hormone :** It is secreted by the lactotroph cells of anterior pituitary. Its molecules are polypeptides of 198 amino acid monomers. Its secretion by anterior pituitary is enhanced by prolactin-release hormone (PRH) and suppressed by prolactin inhibitory hormone (PIH) of hypothalamus. PIH is also called dopamine. In humans, it may act as a mild growth hormone, but its main physiological effect is to activate growth of breasts during pregnancy and secretion of milk by mammary glands after childbirth. That is why, it is often referred to as "maternity hormone". In some other mammals, and probably in women also, it stimulates corpus luteum of ovaries to continue secreting progesterone, hormone during pregnancy. Prolactin levels rises during pregnancy due to PRH of hypothalamus.

Hypersecretion : (i) Prolactin hormone is secreted both in males as well females. In males it influence sexual behaviour. Its hypersecretion may hinder menstruation.

(ii) May cause impotency

(iii) In pigeons and doves, it stimulates the epithelial cells of crop in both males and females to secrete "pigeon milk" for nutrition of newly hatched infants.

(3) **Follicle-stimulating hormone (FSH) or Gametokinetic factor :** It is a glycoprotein whose molecules consists of a polypeptide of 204 amino acid residues. It stimulates growth of seminiferous tubules and spermatogenesis in men, and growth of ovarian follicles and oogenesis in women. In women, it also stimulates secretion of female sex hormones (oestrogens) by the cells of ovarian follicles. Under the negative feedback regulation, the principal male (testosterone) and female (oestradiol) hormones retard secretion of FSH. In women, the effect of FSH on ovaries considerably decreases after the age of 40. Consequently oogenesis, secretion of oestrogens and menstruation decline and ultimately stop. Termination of menstruation is called menopause. GnRH (gonadotropin-releasing hormones) from hypothalamus stimulates FSH release. There is no gonadotropin inhibiting hormone.

(4) **Luteinizing hormone (LH), or Interstitial cell-stimulating hormone (ICSH) :** This is also a glycoprotein whose molecules contain a polypeptide of 204 amino acid residues. In men it stimulates the growth and function of the interstitial cells of testes (cells of Leydig), which secrete the male hormones (androgens) to regulate the development of secondary sexual characteristics. In women, it stimulates the last stages of oogenesis, ovulation, development of corpus luteum and secretion of progesterone by the corpus luteum. Secretion of LH, like that of FSH is controlled by gonadotropin-releasing hormone (GnRH).

Both FSH and LH are secreted by the gonadotroph cells of anterior pituitary. Since both of these stimulate growth and activities of gonads, these are called gonadotropic hormones. These also activates the accessory genital organs. Secretion of these hormones begins only two to three years before puberty (age of sexual maturity – 12 to 14 years). Obviously their secretion is initiated by a "Genetic biological clock", located in hypothalamus. Further, the secretion of FSH in women are also regulated by a "Clock", located hypothalamus. Further, the secretion of FSH in women are also regulated by a "Clock of menstrual cycle". Under the regulation of both these clocks a gonadotropin-release hormone (GnRH) is secreted by hypothalamus and influences the activities of pituitary gonadotroph cells. Synthetic hormones of this category and their antagonists are now used to respectively activate or retard the activities of gonads.

(5) **Adrenocorticotropin or Adrenocorticotropic hormone (ACTH) :** It is secreted by corticotroph cells of anterior pituitary. Its molecules are 39 amino acid polypeptides. Its secretion is prompted by a corticotropin-release hormone (CRH) of hypothalamus. Its role is to intensify synthesis of adrenal cortical hormones, particularly the glucocorticoids. Secretion of ACTH is stimulated by low blood level of glucose, shock conditions and presence of a compound called interleukin-1 (IL-1) secreted by macrophages. Under a direct negative feedback regulation, the concentrations of glucocorticoids in blood affect the secretion of both ACTH and CRH. Hyposecretion of ACTH leads to rheumatic arthritis.

(6) **Thyrotropin or Thyroid-stimulating hormone (TSH) :** It is also a glycoprotein secreted by thyrotroph cells of anterior pituitary. The polypeptide of its molecule has 201 amino acid residues. Its secretion is stimulated by a hypothalamic thyrotropin-release hormone (TRH). It promotes growth and function of thyroid gland. Under the negative feedback regulation, the secretion rate of hypothalamic TRH depends on blood levels of TSH, thyroxine and glucose, and on metabolic rates of body cells. There is no thyrotropin-inhibiting hormone.

(7) **Melanocyte-stimulating hormone (MSH) or Melanotropin :** It was formerly called intermedin secreted by pars intermedia. This may be the condition in other vertebrates, but in humans, it is secreted by remnant cells of this lobe, which become a part of pars distalis. Its molecule is a small peptide of 13 amino acid residues. Its secretion is controlled by hypothalamic hormones, *viz* MRH (Melanocyte releasing hormone) and MIH (Possibly oxytocin is released at this time by posterior pituitary of both mother and the fetus. At actual Melanocyte inhibiting hormone). In lower vertebrates, the target cells of this hormone are the melanophores. Melatonin is antagonistic to melanocyte stimulating hormone MSH affects spreading of the melanin granules in these cells so that skin colour darkens in fish and amphibian but in birds and mammals of the role of MSH is uncertain. In man, presence of MSH receptor in brain suggests it may influence brain activity.

(8) **Metabolic hormone (MH) :** It influence carbohydrate and fat metabolism of body. The hormone which influence carbohydrate metabolism is known as diabetogenic hormone. The hormone which influence fat metabolism is known as ketogenic hormone.

Hormones of neurohypophysis and their functions

The herring bodies of neurohypophysis contain two hormones – vasopressin and oxytocin – which are released from axon terminals by exocytosis and diffuse into adjacent blood capillaries when needed. These are secreted by paraventricular nucleus and supra-optic nucleus respectively. Both vasopressin and oxytocin are proteinous in nature.

(1) **Vasopressin :** The principal role of this hormone is to promote reabsorption of water from the distal convoluted tubules of nephrons and collecting ducts reducing excretion of water in urine (diuresis). That is why, it is also called antidiuretic hormone (ADH). Its release into blood is controlled by an "osmoregulatory centre" located in hypothalamus. Another effect of vasopressin is to increase blood pressure by contracting blood vessels (vasoconstriction) in several tissues; hence the name vasopressin.

Effect of vasopressin

(i) Vasoconstriction of the blood vessels of skin by this hormone retards secretion of sweat glands.

(ii) It also stimulates contraction of intestinal smooth muscles.

(iii) When vasopressin is released in excessive amounts, the urine becomes concentrated and blood is diluted, increasing BP. The osmo-regulatory centre, then, issues motor impulses to check release of vasopressin.

(iv) When vasopressin is released in smaller amounts, diuresis increases; urine becomes diluted and blood becomes concentrate, amounts, diuresis increase; urine becomes diluted and blood becomes concentrated, decreasing BP.

(v) In acute diuresis, quantity of urine may increase to about 20 litres instead of normal 1 to 2 litres per day. This condition is called polyuria or diabetes insipidus (passing of watery; tasteless urine). It causes dehydration of body and thirst.

(2) **Oxytocin (Child birth hormone) :** This hormone stimulates contraction of uterine muscles, inducing labour pains for child birth (parturition) when secretion of progesterone hormone from the placenta declines, making the end of pregnancy. As the sensory impulse of increasing labour pain reaches hypothalamus, more and more oxytocin is released from posterior pituitary under a positive feedback regulation, it dilates the cervix (vaginal stretching). After childbirth, it helps in normalization of the uterus and contracts breast muscles and lactic ducts to facilitate release of milk (lactation) during sucking oxytocin stimulates milk ejection so has a galactogogic effect.

Master gland : As is clear from above account, the pituitary gland plays most important regulatory role in the body. Besides regulating growth, sex and general behaviour, it also regulates the secretory activities of other principal endocrine glands and cells. Most appropriately, therefore, pituitary has been referred to as "The Master Gland" of body, or the "Chief Executive of Endocrine System", or "The Leader of Endocrine Orchestra".

Table : 5.7-6 Summary of the Principal Action of Anterior Pituitary Hormones

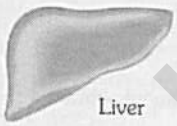
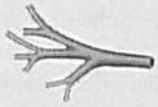
Hormone and Target Tissues	Principal Action	Hormone and Target Tissues	Principal Action
Human growth hormone (hGH) or somatotropin  Liver	Stimulates liver, muscle, cartilage, bone, and other tissues to synthesize and secrete insulin like growth factor of body cells, protein synthesis, tissue repair, glucose concentration.	Prolactin (PRL)  Mammary glands	Together with other hormones, promotes milk secretion by the mammary glands.
Thyroid-stimulating hormone (TSH) or thyrotropin  Thyroid gland	Stimulates synthesis and secretion of thyroid hormones by thyroid gland.	Adrenocorticotropic hormone (ACTH) or corticotropin  Adrenalcortex	Stimulates secretion of glucocorticoids (mainly cortisol) by adrenal cortex.
Follicle-stimulating hormone (FSH)   Ovaries Testes	In females, initiates development of oocytes and induces ovarian secretion of oestrogens. In males stimulates testes to produce sperm.	Melanocyte-stimulating hormone (MSH)	Exact role in humans is unknown but may influence brain activity, when present in excess, can cause darkening of skin.

Table : 5.7-7 Summary of Posterior Pituitary Hormones

Hormone and Target Tissues	Control of Secretion	Principal Actions
Oxytocin (OT)  Uterus  Mammary glands	Neurosecretory cells of hypothalamus secrete OT in response to uterine distention and stimulation of nipples.	Stimulates contraction of smooth muscle cells of uterus childbirth; stimulates contraction of myoepithelial cells in mammary glands to cause milk ejection.
Antidiuretic hormone (ADH) or vasopressin  Kidneys  Sudoriferous (sweat) glands  Arterioles	Neurosecretory cells of hypothalamus secrete ADH in response to elevated blood osmotic pressure, dehydration loss of blood volume, pain, or stress; low blood osmotic pressure, high blood volume, and alcohol inhibit ADH secretion.	Conserves body water by decreasing urine volume; decreases water loss through perspiration; raises blood pressure by constricting arterioles.

Hypothalamus

Position and Structure : Hypothalamus is the floor of diencephalon. It is formed of masses of grey matter, called hypothalmic nuclei, containing neurosecretory cells. It is connected with anterior pituitary lobe by blood capillaries of hypophyseal portal system and with the posterior pituitary lobe by axons of its neurons, both passing through the pituitary stalk.

Hormones of hypothalamus : Neurosecretory cells of hypothalamus secrete neurohormones called releasing factors (RF) or inhibiting factors (IF). These neurohormones are carried by hypophyseal portal system to adenohypophysis (primary target organ) and stimulate or inhibit the release of trophic hormones from adenohypophysis. These neurohormones are proteinaceous in nature and formed of 3 – 20 amino acids.

Table : 5.7-8 Neurohormones of Hypothalamus

S.No.	Neurohormones	Physiological effects
1.	TRH (Thyroid Releasing Hormone – Releasing Factor)	Increased TSH secretion from adenohypophysis.
2.	ACTH-RF (Adrenocorticotrophic Hormone-Releasing Factor)	Increased ACTH secretion from adenohypophysis.
3.	STH-RF (Somatotrophic Hormone-Releasing Factor)	Increased STH secretion from adenohypophysis
4.	SOMATOSTATIN (GROWTH INHIBITING HORMONE)	Decreased STH secretion from adenohypophysis.
5.	GTH-RF (Gonadotrophic Hormone-Releasing Factor) (i) FSH-RF (Follicular Stimulating Hormone-Releasing Factor) (ii) LH-RH (In female) (Luteinising Hormone – Releasing Factor) or ICSH-RF (In male) (Interstitial Cells stimulating Hormone-Releasing Factor)	Increased FSH secretion from adenohypophysis. Increased LH secretion from adenohypophysis.
6.	Prolactin-Releasing hormone (P-RH)	Increased secretion of prolactin or leuteotrophic hormone.
7.	Prolactin-Inhibiting hormone (P-IH)	Decreased secretion of prolactin or leuteotrophic hormone.
8.	MSH-RF (Melanophore Stimulating Hormone-Releasing Factor)	Increased MSH secretion from intermediate pituitary lobe.
9.	MIF (Melanophore Inhibiting Factor)	Decreased MSH secretion from intermediate pituitary lobe.

Hypothalamo – pituitary complex : Pituitary gland is closely related with hypothalamus. Both together form hypothalamo-pituitary complex.

The hypothalmic-pituitary (hypothalamo-hypophyseal) system is a direct proof of coordination between the hormonal and nervous system. It regulates most of the physiological activities of body and maintains homeostasis inside the body. These neurosecretory cells are known to synthesize two more hormones : Oxytocin and Vasopressin, which are stored in their axons extending in the posterior lobe of pituitary gland.

Thyroid gland

The name "thyroid" was introduced by Thomas Wharton (1656). It is derived from Greek "Thyreos" a shield.

Location : This is the largest endocrine gland of our body. It is located in our neck upon the ventral aspect of larynx (sound box or Adam's apple) and a few anteriomost tracheal rings. It is a dark brown and H-shaped/butterfly bilobed gland.

Origin : It is endodermal in origin and arises in the embryo as a midventral process from the floor of the tongue in pharyngeal region between the first and second pharyngeal pouches. Later, the duct-like connection (thyroglossal duct) of the process degenerates, so that the process is separated from the tongue and becomes endocrine. Probably, the gland is homologous to the endostyle of lower chordates.

Structure of thyroid gland : In adult human beings, thyroid gland measures about 5 cm in length and 3 cm in width. It's average weight is 30 grams. It is somewhat larger in women. In old age, it becomes somewhat smaller as age advances. Its two lobes are connected by a narrower isthmus formed of nonglandular connective tissue. A small, conical pyramidal lobe is often found extended forwards from the isthmus. The whole gland is enveloped by a fibrous capsule. Thin septa or trabeculae, extending inwards from the capsule, divide the gland into a number of lobules. Each lobule, in turn, consists of a large number of small and hollow, spherical follicles (acini) embedded in a small amount of a loose connective tissue that forms the stroma of the gland.

The wall of each thyroid consists of a single-layered cuboidal epithelium suspended from a basal lamina, while its cavity is filled with a yellowish, jelly-like and iodinated colloid glycoprotein substance, called iodothyroglobulin. Besides containing a dense network of blood capillaries, the stroma contains small clusters of specialized parafollicular or 'C' cells. The latter are remnants of ultimobranchial bodies derived from the fifth pharyngeal (branchial) pouches in the embryo.

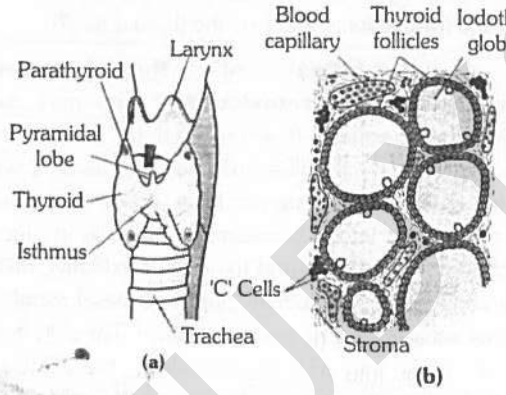


Fig : 5.7-10 (a) Thyroid gland, (b) Follicles suspended in stroma of a lobule

Synthesis and storage of iodothyroglobulin : Synthesis of a glycoprotein thyroglobulin (TGB) – occurs continuously in the follicular cells under genic control. The cells keep extruding thyroglobulin in follicular cavity by exocytosis. Each molecule of thyroglobulin contains about 500 amino acid monomers of which 123 monomers are of tyrosine at fixed places. Soon as the molecules of iodine and thyroglobulin come out of follicular cells, these interact in such a way that 15 tyrosine monomers of each thyroglubulin molecule at fixed places become iodinated. Certain tyrosine monomers bind with single atoms of iodine, forming monoiodotyrosine (MIT or T_1). Other tyrosine monomers bind with two atoms of iodine, forming diiodotyrosine (DIT or T_2). This is called organification of thyroglobulin. Molecules of iodothyroglobulin keep accumulating in follicular cavity, forming the jelly-like colloid. Within the colloid, molecules of iodothyroglobulin undergo conformational changes and may even interact with each other. This results in a coupling of most of the iodinated tyrosine monomers in pairs. This coupling may occur between the iodinated tyrosine monomers of the same or different molecules of iodothyroglobulin. It results in the formation of several groups of complexes of tetraiodothyronine (thyroxine – T_4) and some of triiodothyronine (T_3) in the colloid. Each T_4 complex obviously contains two tyrosine monomers and four atoms of iodine, whereas each triiodothyronine complex contain two tyrosine monomers and three atoms of iodine. T_4 and T_3 are actually the iodinated hormones secreted by thyroid. Obviously, the colloid acts as a reservoir of these hormones.

The daily output of thyroid glands is about 80µg (0.08mg) of T_4 and about 4µg of T_3. Since, however T_3 is several times more potent, most of the T_4 molecules also change into T_3 molecules by losing one iodine atom as these diffuse from blood into ECF. This deiodination of T_4 is maximum in the liver.

As described in a preceding account, the rate of thyroid secretion is controlled by pituitary gland and the hypothalamus of brain respectively under direct and indirect negative feedback regulation. Rate of thyroid secretion increases during winters and in pregnant women.

Synthesis and secretion of iodinated hormones

Iodides and Iodine : An adult human body contains about 5 to 6 milligram of iodine and most of it is found in thyroid gland. Thus, the thyroid is a reservoir of iodine. For secreting the iodinated hormones in normal amounts, the thyroid daily utilizes about 150 micrograms (0.15 milligram) of iodine. Obviously, a person must daily obtain 150µg of iodine from food. We can obtain this from dairy products, drinking water, seafood, *etc.* If obtained more than this, we excrete the excess iodine in urine.

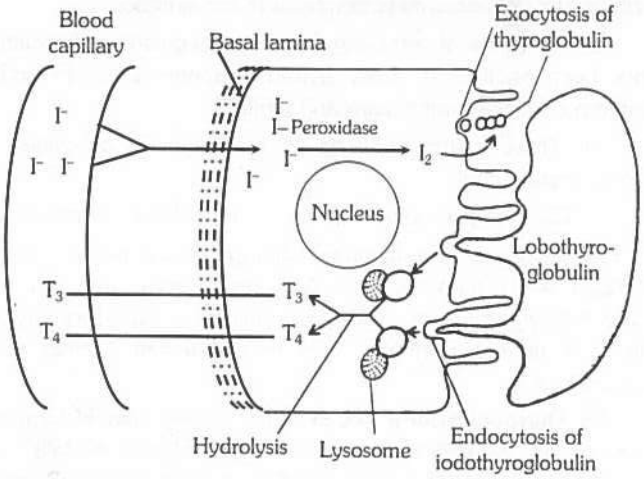


Fig : 5.7-11 Working mechanism of follicular cells of thyroid

Iodine of food is absorbed and circulated in blood in the form of iodide ions (I^-). Follicular cells of thyroid very actively obtain these ions from blood by active transport. That is why, the concentration of I^- in these cells normally remains about 50 to 250 times more than in blood. These cells possess peroxidase enzyme in abundance. Peroxidase continuosly oxidizes iodide ions into molecular iodine ($2I^- \rightarrow I_2$). Iodine is, then, released by follicular cells into follicular cavity.

Hormones of thyroid

Thyroid gland secretes two iodinated hormones. Thyroxine (T_4) and Tri iodothyronine (T_3) and one non iodinated hormone thyrocalcitonin. Secretion of thyroid gland is regulated by TSH of anterior pituitary lobe. Thyroxine was first isolated by Kocher (1914) but was first crystalized by Kendall (1919). Its molecular structure was given by Harrington and Berger (1927). They also synthesized thyroxine.

(1) **Thyroxine :** It is an iodine containing (6% iodine) amine hormone which is derived from tyrosine amino acid. Chemically thyroxine is tetraiodothyronine though also found as tri-iodothyronine. Secretion of thyroxine is inversely proportional to the blood level of thyroxine (feed back mechanism). These hormones perform following functions :

(i) These regulate Basal Metabolic Rate (BMR) of the body as control rate of cell respiration and energy production in mitochondria hence the "Tempo. of life". So these control physical, mental and sexual growth of body. It is called calorigenic effect.

(ii) In 1912 Gudernatsch discovered that metamorphosis in frog's tadpole begins only when adequate amount of thyroxine is secreted by the thyroid of the tadpole. It was also found that hyposecretion of thyroxine retards and hypersecretion enhances the rate of metamorphosis.

In the hilly tracts of North America from whose soil all iodine has been washed away by rain water, the tadpoles of *Ambystoma* probably never metamorphose. Therefore, these tadpoles grow to a large size and attain sexual maturity, *i.e.*, these become paedogenetic larvae. This phenomenon is called paedogenesis. The paedogenetic larvae of *Ambystoma* are called *Axolotl* larvae.

Addition of thyroxine or iodine in pond water naturally induces and enhances metamorphosis in the tadpoles.

(iii) Functions of osmo-regulation and regulation of moulting have been ascribed to these thyroid hormones in cold-blooded vertebrates (fishes, amphibians and reptiles).

(iv) These control working by renal tubules of kidney so control urine output.

(v) These help in homeothermy in warm blooded animals.

(vi) Synthesis of additional sodiumpotassium pump (Na^+/K^+ ATPase), which then use more ATP more heat is given off, and body temperature rises. This phenomenon is called calorigenic effect of thyroid hormone, and thus maintain normal body temperature.

(2) **Thyrocalcitonin (TCT) :** It is a long peptide hormone secreted by parafollicular cells of thyroid gland (C-cells). It's secretion is regulated by increased plasma level of calcium by feedback mechanism. TCT lowers calcium level in blood to normal by increasing calcium deposition in the bones, so checks osteoporosis and stimulates excretion of calcium in urine. It prevent hypercalcaemia. Decreasing reabsorption of calcium from urine, so increasing excretion of Ca^{2+}. So it prevents hypercalcaemia.

Irregularities of thyroid gland

(1) **Hypothyroidism :** (Decreased secretion of thyroxine from thyroid gland). It leads to the following diseases –

(i) **Cretinism :** It is disease of infants, called cretins. It is characterised by decreased BMR (50% than normal); stunted growth; retarded mental development so low I.Q., delayed puberty; decreased body temperature, heart rate, pulse rate, blood pressure and cardiac output; reduced urine output; decreased sugar level in blood, pigeon's chest (chest bulging forward in sternal region). Cretinism can be congenital (absence of thyroid due to genetic defect) or endemic (absence of iodine in diet). It can be corrected by thyroxin administration.

(ii) **Myxoedema :** It occurs due to deficiency of thyroxine in adults. Like cretinism, it also has low (BMR) (by 30 – 40%); low body temperature, reduced heart rate, pulse rate, blood pressure and cardiac output, low sugar and iodine level in blood etc. But the peculiar feature of myxoedema is that face and hands become swollen due to deposition of albuminous myxomatous tissue. It can also be corrected by thyroxine administration.

(iii) **Endemic or simple goitre or colloid goitre :** It occurs due to deficiency of iodine in drinking water. It is non-genetic (sporadic goitre is a genetic disease). It is characterized by enlargement of thyroid gland due to increase in number and size of acinal cells of thyroid gland. It is more common in people of hilly region. To prevent goitre, the table salt is being iodised these days.

(iv) **Hashimoto's disease :** It is called auto-immune thyroiditis and occurs due to age factor, injury-surgery, wrong treatment or infection of thyroid gland causing hyposecretion of thyroxine. When thyroxine secretion falls upto minimal limit, the antibodies are formed which destroy the thyroid gland.

(2) **Hypersecretion of thyroid hormones (Hyperthyroidism or thyrotoxicosis) :** This may also be a genetic defect, but usually it is provided by chronic infections (influenza, rheumatism, tonsilitis, tuberculosis, measles, whooping cough, etc.) pregnancy, intake of large doses of iodine, over-eating, etc. It results into a considerable increase in glucose and oxygen consumption by cells and the rate of oxidative metabolism in the mitochondria. Consequently, the BMR (basal metabolic rate) may increase several folds (hypermetabolism). The cells fail to store all catabolic energy into ATP. Consequently, the extra energy is liberated as heat. Instead of causing growth of body, this energy, thus, overheats the body, causing nervous tension and excitement, restlessness and anxiety, muscular weakness (thyrotoxic myopathy), fatigue and tremors, high temperature, palpitation of heart, copious sweating, diarrhoea, insomnia, trembling of limbs and body, weight loss, heat intolerance, warm and soft skin, increased appetite, etc.

Under his "Sodium pump theory of thermogenesis" Edelman has recently (1974) hypothesized that overheating of body in hyperthyroidism is not because cells fail to trap the excess catabolic energy in ATP, but because the excess ATP formed in this condition is utilized in considerably accelerating the Na^+–K^+ pump, releasing more heat that overheats the body.

(i) **Simple goitre :** Hyperthyroidism may be simply because of overactive cells of a normal gland, or because of an enlargement of the gland, causing goitre.

(ii) **Exophthalmic goitre :** Such a goitre is called exophthalmic goitre, because it is usually accompanied with some asymmetrical protrusion (Exophthalmos) of the eyeballs, imparting an angry, frightened, or staring look to the patient. Protrusion of eyeballs is due to accumulation of mucus in eye orbits.

(iii) **Grave's or Basedow's disease :** Enlargement of the gland is usually due to a diffused growth.

(iv) **Plummer's disease or Toxic Adenoma :** It is due to formation of one or more hypersecretory nodules.

Parathyroid gland

(1) **Position and structure :** These are four in number which are wholly or partially embedded in the dorsal surface of the thyroid gland two glands in each lobe of thyroid gland. Each is oval shaped, small sized (5×5 mm) and yellow coloured. Histologically, a parathyroid gland is formed of two masses of polygonal cell arranged in cords. Endocrine cell are of two types principal or chief and oxyphil cells. Parathyroid is endodermal in origin.

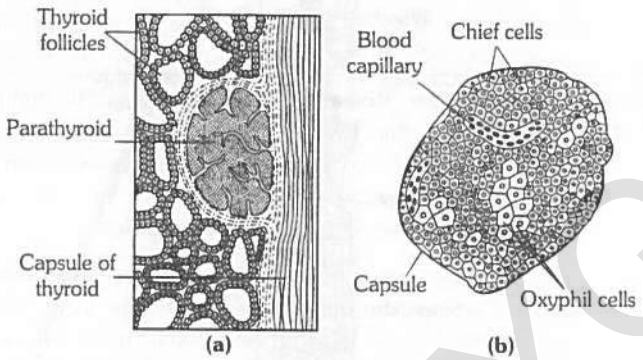


Fig : 5.7-12 (a) Parathyroid gland embedded in the surface of thyroid, (b) Ultrastructure of a parathyroid

(2) **Hormones of parathyroid :** Active hormone secreted by parathyroids is parathormone (PTH), also called Collip's Hormone (Phillips collip, 1925). It was discovered and purified by Collip in 1925. Its crystals were first prepared by Craig and Ras mussen in 1960. Its molecular structure was worked out by Potts and his associates in 1971. The latter is a protein of 84 amino acid monomer. It is a polypeptide hormone. Parathyroids are present in all vertebrates except fishes. Its secretion is stimulated by low level of calcium in blood than normal level through feedback control.

Functions of parathormone : Parathormone is essential for survival, because it significantly contributes to "homeostatis" by regulating the amount of calcium and phosphate ions in ECF. Parathormone maintains optimum level of plasma calcium by

(i) Mobilisation from bones

(ii) Reduced urinary excretion

(iii) Increased absorption from intestine.

The level of phosphorus is not allowed to remain high by stimulating its urinary excretion. Our body requires an optimum calcium level (10.0 to 11.5 mg per 100 mL.) in ECF (total 1000 to 1120 grams in a 70 kg man), because calcium is a key element in many physiological functions like proper permeability of cell membranes, muscular activities, nerve impulse conduction, heartbeat, blood coagulation, bone formation, fertilization of ova, etc. Calcium is most abundant of all minerals found in the body and about 99% of calcium and phosphorous are contained in the bones.

Maintenance of proper calcium level under 'homeostasis' is, in fact, a combined function of parathormone, thyrocalcitonin and vitamin D_3 (cholecalciferol). Parathormone promotes absorption of calcium from food in the intestine and its reabsoption from nephrons in the kidneys. Simultaneously, it accelerates elimination of phosphates in urine (phosphaturic action). Thus, calcium level tends to rise in the ECF due to the effect of parathormone. This calcium is, then, utilized by bone-forming cells – osteoblast – in bone formation under the influence of vitamin D_3. Bones are asymmetrical when first formed. Their unnecessary parts are, therefore, dissolved by bone-eating cells called osteoclasts. This process also proceeds under the influence of parathormone. It results in release of calcium and phosphate in blood.

Vitamin D_3, is a steroid hormone which is first synthesized in an inactive form in skin cells from 7-dehydrocholesterol under the influence of ultraviolet (UV) rays of sunlight. Skin cells release it in blood. Liver cells take it from blood, change in into 25-hydroxycholecalciferol and release back into blood. Finally, the cells of proximal convoluted tubules of nephrons in the kidneys change 25-hydroxycholecalciferol into 1-25-dihydroxycholecalciferol under the influence of parathormone. This last compound is released in blood as active vitamin D_3 named as cholecalciferol (calcitriol).

In addition to its role in bone-remodelling, D_3 also stimulates absorption of Ca^{2+} and Mg^{2+} in intestine. Similarly, parathormone also plays an additional role of stimulating excretion of Na^+, K^+ and HCO^-_3, but retarding the excretion of Mg^{2+}.

Irregularities of parathormones

(1) **Hypoparathyroidism (Hyposecretion of parathormone)**

(i) It is rare, however, in undersecretion of parathormone, the level of calcium in ECF falls (hypocalcemia), and that of phosphates rises (hyperphosphatemia). This causes neuromuscular hyperexcitability, excessive perspiration, gooseflesh (raising of hairs and prickly sensation in skin), cooling of hands and feet, painful muscular spasms and convulsions, and trembling.

(ii) Sometimes some skeletal muscles, usually of hands and feet, fail to relax after a contraction, and remain in "sustained contraction". This is called "Tetany". Tetany of laryngneal, thoracic, and phrenic muscles, which help in breathing, causes death, because the patient fails to breathe (asphyxia).

(iii) Childhood hypoparathyroidism retards growth, particularly of bones, teeth, hair and brain. Vitamin D is administered to such children.

(2) **Hyperparathyroidism (Hypersecretion of parathormone)**

(i) **Osteoporosis :** Oversecretion of parathormone is rare and occurs usually due to overgrowth of one or more parathyroid glands. It causes demineralization of bones which, therefore, become soft, weak, distorted and fragile. This is called osteoporosis.

(ii) **Hypercalcemia :** Simultaneously, due to a sharp rise in calcium level in blood and ECF (hypercalcemia) and a sharp fall in phosphate level (hypophosphatemia), muscles and nerves are weakened.

(iii) **Hypercalciurea :** Calcium is excreted in urine (hypercalciurea), thirst increases owing to copius urination, appetite is lost, constipation and headache become common, and often, kidney stones are formed. The only treatment so far known is removal of extra part of the glands by operation.

Feedback control of secretion of parathormone and thyrocalcitonin : Secretion of these two hormones is continuously regulated by a direct negative feedback. As Ca^{2+} levels tends to fall, secretion of parathormone increases, but that of thyrocalcitonin decreases. Contrarily, the secretion of parathormone decreases and that of thyrocalcitonin increases when Ca^{2+} level tends to rise in blood.

Adrenal gland

Adrenal gland was first reported by Eustachius.

Origin and position : The adrenals are paired glands placed on the top or superior of the kidneys as cap. Hence, they are also called suprarenal glands.

Adrenals have a dual origin, they are originated from ectoderm and mesoderm both. Like thyroid, adrenals are also highly vascular in nature.

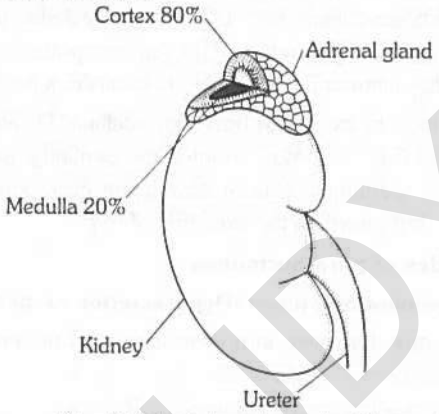


Fig : 5.7-13 Adrenal gland with a part cut to show cortex and medulla

Structure : Each adrenal is a small (5 cm long, 3 cm broad and 1 cm thick), triangular and yellowish cap like structure. Its weight in humans is about 3.5 to 5.09 gm. At birth adrenal glands are best developed. Each gland has two parts – outer cortex and inner medulla.

(1) **Outer cortex :** The cortex is derived from mesoderm and forms about 80% part of the gland. Cortex consists of fatty, cholesterol rich cells. These cells distinguish the cortex into three zones or regions.

(i) **Zona glomerulosa :** It is the outer part of the cortex (15% of the gland), which consists of small polyhedral cells. It secrets mineralocorticoids *e.g.*, Aldosterone.

(ii) **Zona fasciculata :** It is the middle part of the cortex (50% of the gland). Which consists of large polyhedral cells. This part secrets gluco-corticoids. *e.g.*, Cortison, Corticosterone.

(iii) **Zona Reticularis :** It is the inner part of the cortex (7% of the gland). In which the parallel cell cords of the zona fasciculata branched to form a loose anastomosing network. It secrets sex hormones.

(2) **Inner medulla :** The medulla is derived from ectoderm and forms about 20% part of the gland. Adrenal medulla is reddish brown in colour and colourless of rounded groups of short cords of relatively large and granular cells. These cells are modified postganglionic cells of sympathetic nervous system. These are called chromaffin cells or phaeochromocytes. Adrenal medulla secrets adrenalin and nor-adrenalin which are collectively called as catecholamines.

Hormones of adrenal cortex

About 20 steroids (steroidogenic) compounds are secreted from adrenal cortex. These are called adrenocorticoids (corticosteroids). Only few of them are biologically active as hormone. These hormones are steroid in nature. The later, however account about 80% of the secretion of adrenal cortex and are classified into three categories.

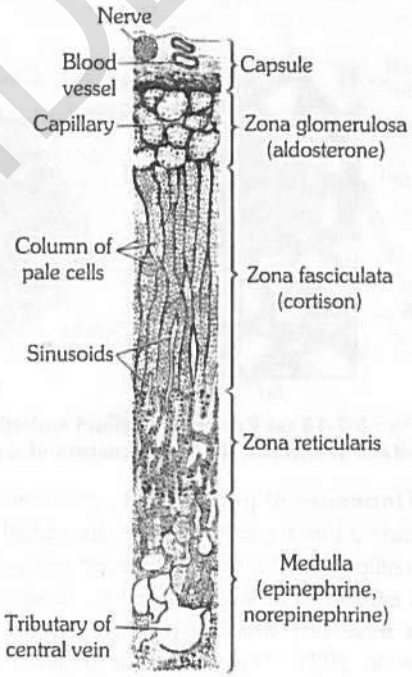


Fig : 5.7-14 Adrenal gland with a part cut to show cortex and medulla

(1) **Mineralo-corticoids :** The principal mineralocorticoid is aldosterone. It is also called salt-retaining hormone. It promotes reabsorption of sodium ions from kidney and excretion of potassium ions in urine. It also reabsorb Cl^- ions from kidney. Thus aldosterone has a important contribution in homeostasis by controling osmotic pressure of ECF (Extra cellular fluid).

Remember that doctors administer saline drip to the patients who lose excessive water and salts due to diarrhoea, cholera, etc. Aldosterone also helps in maintaining acid-base equilibrium and blood *pH* (7.35) by promoting reabsorption of HCO^-_3 and regulating excretion of H^+ by kidneys. It also promotes absorption of water and salt in intestine, mainly in colon. The Renin-angiotensin-aldosterone or RAA pathway controls secretion of Aldosterone.

(2) **Gluco-corticoids :** These include three main hormones – cortisol, corticosterone and cortisone. Cortisol is most abundant (about 95%) and most important. These hormones play an important role in carbodydrate, fat and protein metabolism as follows –

(i) Cortisol retards glucose consumption and protein synthesis, but promotes breakdown of proteins and fats in the cells.

(ii) Effects of glucocorticoids upon liver are anabolic. These promote intake of glucose, FFAs and amino acids by cells of liver. Then, these intensify deamination of amino acids, synthesis of urea, synthesis of glucose from fatty acids and amino acids (gluconeogenesis), and synthesis of glycogen from glucose (glycogenesis) in liver cells.

(iii) Cortisol is anti-inflammatory. It retards the migratory movements and phagocytic activities of white blood corpuscles (WBCs), suppressing "inflammation reactions" which constitute the normal defense mechanism of body against toxic substances. Simultaneously, it reduces the number of mast cells, reducing secretion of histamine. This is also an anti-inflammatory effect. It also denotes synthesis of collagen fibres which usually form at the sites of inflammation in normal defense. That is why, cortisol is usually injected as a drug for treatment of diseases that are caused by deposition of collagen fibres, such as arthritis or rheumatism.

(iv) Cortisol is also "immunosuppressive". It suppresses synthesis of antibodies, retarding the normal immune reactions of body against antigens and attack of micro-organisms. In fact, it induces atrophy of thymus gland and other lymphoid tissues, so that the productions of lymphocytes is inhibited. That is why, it is used for treatment of allergy. Also, it is used in transplantation surgery to suppress the formation of antibodies in the body of recipients so that the latter may accept the transplanted organs.

(v) Cortisol increases RBC count, but decreases the WBC count of blood. It also elevates blood pressure (BP).

(3) **Sex hormones :** The zona reticularis of adrenal cortex secrets androgen and estrogen in small quantity. These hormones regulates the development of sex organs, secondary sexual characters and promote growth and protein metabolism.

Role of adrenal cortex in stress reaction : Adrenal glands provide the body with an emergent "chemical defence mechanism" in stress conditions that threaten the physical integrity and chemical consistency of the body. After the "Fight or Flight" reaction, the body remains in a state of shock for some time just like a country after a war. Heartbeat, cardiac output, blood pressure and glucose and salt concentrations in ECF considerably go down in this "shock condition". For example, excessive bleeding in an accidental injury immediately sends the body into shock condition. the injured must be made to recline and his / her legs must be elevated by putting a few pillows under the feet and hips. This increases venous flow of blood towards the heart, so that the cardiac output is maintained.

Whereas the hormones of adrenal medulla elevate O_2-consumption, BMR, respiration and tension to increase alertness and responsivity to prepare the body for violent stress-reactions, those of adrenal cortex, particularly aldosterone and cortisol, serve to maintain the body in living condition and recoup it from the severe after-effects of stress reactions. An increased output of cortisol is actually "life-saving" in shock conditions. It inhibits the normal defence mechanisms and mobilises help from all parts of the body in order to keep the body alive.

Adrenal glands are large in fetus, but these mainly secrete sex hormones. By the time of child-birth, these become small and their secretions remain minimal for a few days after birth. Obviously, the "chemical defence system" is very weak in newly born infants. The latter can, therefore, easily succumb to stress conditions. That is why, infants are provided extra care in maternity homes.

As is clear from above account, adrenal cortex is very necessary for survival, but adrenal medulla is not so necessary, because its deficiency can be compensated by sympathetic nervous system.

Control of adrenal cortex secretions : Secretion of glucocorticoids and sex hormones by adrenal cortex is regulated by a hormone, corticotropin or adrenocorticotropic hormone (ACTH), secreted by the anterior lobe of pituitary gland. Secretion of ACTH from pituitary is, in turn, regulated by a "corticotropin-release hormone (ACTHRH)" of hypothalamus. A "feedback control mechanism" operates between hypothalamus, pituitary and adrenal cortex. A decrease in cortisol level in blood stimulates the hypothalamus and pituitary. Hence secretion of ACTHRH from hypothalamus and of ACTH from pituitary and, therefore, of glucocorticoids and sex hormones from adrenal cortex increases. When cortisol level in the blood rises, the control mechanism operates in reverse direction. This "feedback control" is very efficient and quick.

Secretion of mineralocorticoids is only nominally under the control of ACTH. Although adrenal glands themselves regulate secretion of mineralocorticoids according to Na^+, water and K^+ levels in ECF, by feedback, but this regulation is mainly provided by the kidneys. As the blood pressure goes down due to decreased amount of salt and water in blood, certain cells of afferent arterioles that supply glomeruli secrete an enzyme named renin.

Hormones of adrenal medulla

The chromaffin cells of adrenal medulla synthesize two hormones adrenalin or epinephrine (80%) and nor-adrenalin or nor-epinephrine (20%). These hormones are proteinaceous in nature and derived from amino acid tyrosine. Which is first hydroxylated and decarboxylated to form dopamine and than the latter is hydroxylated again to finally form norepinephrine. Epinephrine is derived by methylation of norepinephrine.

$$\text{Tyrosine} \xrightarrow[\text{Decarboxylation}]{\text{Hydroxylation}} \text{Dopamine} \xrightarrow{\text{Hydroxylation}}$$

$$\text{Nor epinephrine} \xrightarrow{\text{Methylation}} \text{Epinephrine}$$

Cortisol from adrenal cortex induce synthesis of enzymes needed to convert nor epinephrine to epinephrine. Norepinephrine lacks the converting enzymes. Because the ANS controls the chromaffin cells directly, hormones release can occur very quickly.

The molecular structure of dopamine, norepinephrine and epinephrine, includes a 6-carbon ring connected to two hydroxyl groups (– *OH*). This is called catechol ring, and these compounds are called catecholamines for this reason.

Epinephrine (adrenalin) was first extracted by Abel (1899) who coined this name for it. It was, however, extracted in pure form by Jokichi and Takamine (1900). Its molecular structure was worked out by Aldrich in 1901. Stolz (1904) and Dakin (1905) synthesized it in their laboratories. Norepinephrine was discovered by Ulf von Euler (1946). Effects of these hormones were studied by Axelrod (1965). For their discoveries Euler and Axelrod won Nobel Prize in 1970.

Function of epinephrine

(1) Epinephrine causes constriction of the blood vessels (vasoconstriction) which supply blood to those peripheral and abdominal organs (skin and organs of digestive, excretory and reproductive systems) that normally remain active while we are resting or sleeping. Obviously, the activities of these organs are retarded, but the blood pressure (BP) increases.

(2) Reduced supply of blood causes a pale skin (pallor), but arrector pilli muscles of skin contract, causing gooseflesh.

(3) Mouth becomes dry due to poor secretion of saliva.

(4) Food digestion is retarded because of reduced gut peristalsis due to relaxation of the smooth muscles of gut wall, as well as, because of poor secretion of digestive glands.

(5) Kidneys produce small volume of urine, and muscles or urinary bladder relax.

(6) In pregnant women, the muscles of uterus contract, increasing the possibility of abortion.

(7) Epinephrine causes dilation of blood vessels (vasodilation) which supply brain, skeletal muscles, heart, lungs, liver, adipose tissues, sensory organs, etc. Due to increased blood supply, these organs become very active, inducing alarm reaction. Obviously, the blood pressure, increased due to effect of norepinephrine, is reduced to some extent.

(8) Pupils dilate due to contraction of radial dilatory muscles of iris. Secretion of tear by lacrimal glands increases.

(9) Epinephrine causes relaxation of the smooth muscles of trachea, bronchi and bronchioles. These organs, therefore dilate, so that breathing becomes easier and faster. Remember that epinephrine is used in treatment of asthma for this reason.

(10) Contractions of cardiac muscles intensify, increasing both rate and force of heartbeat, pulse rate, arterial pressure and cardiac output.

(11) Due to an increase in adhesiveness of blood platelets, the time of blood clotting is considerably reduced.

(12) The spleen contracts, releasing its reserve of blood corpuscles whose number in blood, therefore, increases.

(13) In islets of Langerhans in pancreas, secretion of insulin hormone decreases, but that of glucagon increases. Glucagon causes glycogenolysis, *i.e.* breakdown of glycogen into glucose in liver and skeletal muscles.

(14) Because of an increase in blood levels of O_2 glucose, FFA, etc the basal metabolic rate of all body cells considerably increases and renders the whole body highly active and irritable.

(15) External genitalia become flaccid, but ejaculation becomes early and forceful.

Since the rate and force of the activities of most internal organs increase in a few seconds under the effects of epinephrine and norepinephrine, the various changes can be detected by a lie detector polygraph to ascertain the emotional state of a person.

Table : 5.7-9 Difference between Adrenal cortex and Adrenal medulla

S.No.	Adrenal cortex	Adrenal medulla
1.	It is external firm region of the adrenal gland.	It is central soft region of the adrenal gland.
2.	It is pale yellowish-pink in colour.	It is dark reddish-brown in colour.
3.	It is enclosed by a fibrous capsule.	It is not enclosed by a fibrous capsule.
4.	It forms about 80% of the adrenal gland.	It forms just 20% of the adrenal gland.
5.	It develops from the mesoderm.	It develops from the ectoderm (neural crests).
6.	It consists of 3 concentric regions : Outer zona glomerulosa, middle zona fasiculata and inner zona reticularis.	It is not differentiated into regions.
7.	It is essential for life, its destruction causes death.	It is not essential for life, its destruction does not cause death.
8.	It secretes 3 groups of hormones : mineralocorticoids, glucocorticoides and gonado corticoids	It secretes 2 similar hormones nor adrenaline and adrenaline.
9.	It is stimulated to release its hormones by the adrenocorticotrophic hormone from the anterior pituitray.	It is stimulated to secrete its hormones by nerve impulses reaching via sympathetic nerve fibres.
10.	There is no cooperation between adrenal cortex and sympathetic nervous system.	Adrenal medulla and sympathetic nervous system function as an integrated system called sympatheticoadrenal system.
11.	It causes many deficiency / excess disorders.	It is not known to cause any disorder.

Significance of adrenal medullary hormones

Relationship between adrenal medulla and sympathetic nervous system : Our routine in voluntary activities like food digestion, respiration, heartbeat and blood circulation, thermoregulation, peristalsis of tubular organs, secretion of glands, excretion, etc are continuously and automatically done by our internal (visceral) organs without the conscious control of our brain. These are, therefore, called involuntary activities, these activities occur under the control of autonomic nervous system and their co-ordinated regulation is controlled by the hypothalamus of brain. The autonomic nervous system controls these activities by affecting the activity levels of

cardiac muscles, smooth muscles of visceral organs and blood vessels, and the glands. The autonomic nervous system comprises two control systems, having antagonistic effects of these organs. These are sympathetic and parasympathetic systems. Obviously, the motor nerve fibres of both these systems, originating from central nervous system (CNS), innervate most of the internal organs. The motor fibres of parasympathetic system stimulate those organs which remain more active while we are at rest or sleeping. contrarily, the motor fibres of sympathetic system stimulate those organs which remain more active when we are awake and doing work.

The fibres of sympathetic system, innervating the organs, the postganglionic motor fibres. At their terminals, these release norepinephrine, a neurotransmitter which triggers an alteration in the activities of concerned organs. The adrenal medulla is also innervated by fibres of sympathetic system, but these are preganglionic fibres of this system. At their terminals these fibres release acetylcholine which stimulates chromaffin cells to release their hormones – epinephrine and norepinephrine. Circulating in blood, these hormones reach into the internal organs and not only increase the effects of sympathetic stimulation, but also prolong these effects about ten-fold. That is why, the sympathetic system and adrenal medulla are collectively considered as sympathoadrenal system, and the hormones of adrenal medulla are called sympathomimetic amines. Besides this, the medullary hormones, especially epinephrine, increase the basal metabolic rate (BMR) of all body cells, increasing the activity and irritability level of whole body. Since, however, the effects of sympathetic system and adrenal medullary hormones are complementary, a retarded efficiency of any one of these is compensated by the other.

Modern scientists have discovered that cells resembling chromaffin cells occur in small groups near the thoracic and abdominal ganglia of sympathetic system. These groups have been named paraganglia.

Alarm or stress reaction : Physico-chemical changes continuously occur in the external and internal environments of our body during our daily routine life, and our body keeps on maintaining homeostasis and functional equilibrium by counteracting the effects of these changes by alterations and co-ordinated regulations of the activities of various organs by sympathetic system under hypothalamic control. However, the emergency or stress conditions such as fear, anger, intense pain, accident and injury, burning, intense cooling or heating of body, sudden invasion of micro-organisms, poisoning, emotional upsets due to insult, restlessness, mental tension, anxiety, exertion, surgery, etc tend to disturb homeostasis and functional equilibrium to such an extent that the very survival of body in endangered.

As the sensory impulses of such strong stimuli called stressors, reach the brain, directly or through spinal cord, motor impulses or required responses are issued by hypothalamus to all organs, including adrenal medulla through the spinal cord. Consequently, norepinephrine is released simultaneously in all organs by sympathetic fibres, and a large amount of both epinephrine and norepinephrine is poured into blood by adrenal medulla. This "mass release" of these hormones prepares the whole body, within seconds, for a violent physical reaction called alarm or stress reaction, and often referred to as general adaptation syndrome (GAS). In this reaction, the concerned person either boldly faces the emergency, or tries somehow to escape from it. That is why, it is called "Fight or Flight reaction".

Effects of irregularities of adrenal secretion

(1) **Hyposecretion :** This may be a genetic defect. Undersecretion of adrenocorticoids (hypocorticism) causes Addison's disease which is relatively rare and occurs in both men and women between the ages of 20 to 40 years. This disease was first described by Thomas Addison in 1849, 1855. It is maintained in following symptoms :

(i) Owing to low aldosterone and gluco-corticoides level in blood, considerable amount of sodium ions and water is excreted in urine, leading to dehydration, low blood pressure, and weakness, all symptoms of a peculiar, Addinosonean anaemia which is different from common pernicious anaemia resulting from entirely different causes like diarrhoea, cholera, etc.

(ii) Owing to low cortisol level, glucose level also falls in blood (hypoglycemia). This sharply reduces BMR in body cells. Due to hypoglycemia and hyperkalemia (increased K^+ level in blood) efficiency of brain, liver, skeletal and cardiac muscles, etc declines. Body temperature also falls. Heartbeat may even stop, causing death.

(iii) Decreased cortisol level induces gastro-intestinal disorders, resulting in loss of appetite, nausea, vomiting, diarrhoea, abdominal pain and restlessness.

(iv) Due to a sharp decline in body's chemical defense and resistance, sensitivity to cold, heat, infection, poisoning and other adverse condition increases. Acute hypocorticism is catastrophic and threatens life. Complete destruction or removal of adrenals causes death in a short time, principally because of loss of excessive sodium in urine.

(v) Addison's disease also causes an increase in the number of WBCs, resulting into eosinophilia, lymphocytosis, leucocytosis, etc.

(vi) Undersecretion of sex hormones causes impotence in males and disorders of menstrual cycle in females.

(vii) Excessive deposists of melanin, particularly in the skin of open parts of body like face, hands, feet, neck, teats, etc cause deep bronzing of skin in these parts.

(viii) As increase in H^+ concentration in blood may cause acidosis.

(2) **Hypersecretion :** Oversecretion of adrenocorticoids (hypercorticism) causes following disorders and diseases –

(i) Glucose level rises in blood (hyperglycemia). This may lead to diabetes mellitus.

(ii) Irregular deposits of fat, particularly in thoracic parts and face, imparts asymmetrical shape to the body. the face becomes red and rounded (moon face), shoulders swell (buffalo humps) and abdomen dilates and often shows lines of stretching. All these are

symptoms of Cushing's disease (Cushing, 1932). Patients may die from brain haemorrhage, cardiac arrest, pneumonia, etc.

(iii) Retention of sodium and water is the ECF increases blood pressure, causing severe hypertension and associated symptoms like severe headache.

(iv) Excessive loss of potassium in urine causes potassium deficiency (hypokalemia). This leads to muscular weakness and convulsions and nervous disorders, and may even cause tetany and paralysis, copious and frequent urination (polyuria) and thirst, bed urination (nocturia), etc. Similarly, excessive loss of H^+ in urine may cause alkalosis.

Fig : 5.7-15 A girl showing pseudohermaphroditism

(v) Excessive mobilization of materials from all parts of body had widespread deteriorating effects. For instance, mobilization of proteins from all cells causes tissue wasting. similarly, mobilization from bones renders the bones weak and fragile (osteoporosis).

(3) Excessive secretion of male hormones (androgens) in a female fetus before complete formation of ovaries results into pseudohermaphroditism due to masculinization of external genitals, and causes abnormal development of muscles, hair on face (beard and moustache), early sexual maturation, hoarse voice and absence of menstruation. The clitoris grows to penis size, while vagina and uterus remain underdeveloped. This is known as adrenogenital syndrome. The resultant females are sterile. Oversecretion of androgens after complete formation of ovaries and fallopian tubes causes only a moderate enlargement of clitoris. Oversecretion of androgens in girls after birth causes a gradual masculinization manifested in overgrowth of clitoris, under development of mammary glands and uterus and disturbed menstruation. Oversecretion of androgens in male children causes excessive development of penis (marcogenitosomia) and other secondary sexual organs and characteristics, but atrophy of testes so that there is no spermatogenesis. Early erections are noted. Due to the anabolic effects of androgens, both in girls and boys, growth is accelerated, muscles are well-developed and strong, and bones mature early.

(4) Excessive secretion of female hormones in adult males cause enlarged mammary glands (gynaecomastia) and retards growth of beard. Contrarily, excessive secretion of androgens in females in masculinizing and causes hirsutism (increased facial and body hair and muscle growth, clitorial enlargement, etc.)

Pancreas

Location and origin : Pancreas (Gr. pankreas = sweet bread; Fr., pan = all + kreas = flesh) is a flattened and pinkish mixed gland (both exocrine and endocrine) situated in the concavity formed by duodenum just behind the stomach. It measures about 15 cm in length and 4 to 5 cm in breadth. It forms by fusion of two bilateral endodermal processes of embyronic intestine (duodenum of future adult).

Structure : About 99% part of the gland is exocrine and formed of hollow pancreatic acini or lobules embedded in a connective tissue stroma. In the stroma, there are numerous (approximately 1 to 2 million in human pancreas) small (0.1 to 0.2 mm in diameter) clusters of endocrine cells, called islets of Langerhans after the name of their discoverer, Paul Langerhans (1869).

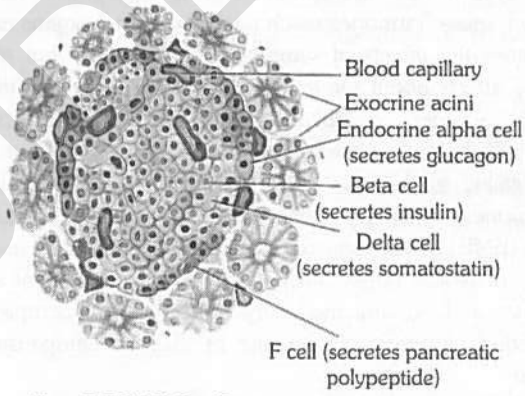


Fig : 5.7-16 T.S. of pancreas

Cells Types in the Pancreatic Islets

Each pancreatic islet includes four types of hormone-secreting cells :

(1) **Alpha or A cells** constitute about 15% of pancreatic islet cells and secrete glucagon.

(2) **Beta or B cells** constitute about 80% of pancreatic islet cells and secrete insulin.

(3) **Delta or D cells :** It's constitute about 5% of pancreatic islet cells and secrete somatostatin (identical to growth hormone-inhibiting hormone secreted by the hypothalamus).

(4) **F cells :** It's constitute the remainder of pancreatic islet cells and secrete **pancreatic polypeptide**.

Hormones of pancreas and their role

The β and α cells of islets of Langerhans respectively secrete insulin and glucagon hormones which are important regulation of carbohydrate, protein and fat metabolism in the body.

(1) **Insulin :** In 1889, Minkowski and Mehring discovered that pancreas is related with the disease of diabetes mellitus in humans. Normal concentration of glucose in blood is about 100 mg (0.1 gm) per 100 ml. It increases somewhat after a

carbohydrate rich food. Then, the secretion of insulin increases. It increases the permeability of all cells for glucose several times, except that of brain cells and red blood corpuscles (RBCs). The brain cells and RBCs are already highly permeable to glucose. After taking more glucose from blood, the cells utilize it for energy-production. Consequently, the basal metabolic rate (BMR) and RNA and protein synthesis increases in cells.

In 1923, two Canadian scientists, Banting and Best succeeded in preparing a pure extract of insulin from the pancreatic islets of a new born calf with the help of Macleod, Banting and Macleod won the 1923 Nobel prize for this work. Later, Abel (1926) succeeded in preparing pure crystals of insulin. F. Sanger (1955) worked out the molecular structure of bovine insulin and won the 1958 Nobel Prize. He discovered that insulin is a small protein whose molecule consists of two polypeptide chains, α and β, joined by disulphide linkages and respectively formed of 21 and 30 amino acid residues. Insulin is the first protein to be crystallized in pure form, first protein whose molecular structure was worked out, the first protein to be synthesized in laboratory in 1964, and also the first protein to be commercially manufactured by means of DNA recombinant technique. Even the human insulin was also synthesized by Tsan in 1965.

(i) **Hypoinsulinism :** In insulin deficiency, body cells fail to obtain glucose from blood. Hence, glucose level of blood rises, a condition called hyperglycemia. When glucose level rises further, glucose starts passing out in urine. This condition is called glycosuria. Ultimately, when glucose level in blood rises to more than 200 mg/100 ml blood the person concerned suffers from diabetes mellitus in which the urine becomes sweet.

Diabetes mellitus has been known to Greeks as a human disease since 1500 B.C. in England, it was known as a "pissing evil" due to copious urination in it. Modern scientists have discovered that diabetes mellitus is of two types – I and II. The type I diabetes is usually found in young people, in some of which it is hereditary. About 10% of diabetic patients suffer from this type. Other patients suffer from diabetes of type II, usually found in people of over 40 years of age or obese persons. Diabetics excrete large volumes of urine. This is called polyuria. It results into dehydration which, in turn, causes increased thirst (polydipsia) and hunger (polyphagia). Being unable to utilize glucose for energy-production ("starving in midst of plenty"), the cells utilize their proteins for it, causing "body wasting". The body, therefore, becomes very weak. Nervous system may be damaged and often cataract occurs. Lipolysis in adipose tissues increases, elevating blood level of free fatty acids (FFA). Accelerated, but incomplete, oxidation of fatty acids for energy, especially in liver, results into the formation of ketone bodies – acetone, acetoacetic acid and β-hydroxybutyrate– , causing ketosis. Since the ketone bodies are sweet, acidic and poisonous, their increased amount in blood causes acidosis. Hence, patients may anytime become unconscious (coma condition) and finally die.

Regular injections of insulin must be given to chronic patients of diabetes. Balanced diet, exercise, and regular intake of insulin tablets (*eg* dionyl) may keep diabetes in control. Certain drugs, like glyburide, which stimulate insulin secretion are now available.

(ii) **Hyperinsulinism :** Oversecretion of insulin enhances glucose intake by most body cells and glycogenesis in liver and muscles, causing a persistent decrease in blood glucose level (Hypoglycemia) since brain cells and cells of retina and germinal epithelium mainly depend on glucose for energy, nervous efficiency, fertility and vision sharply decline. Poor supply of glucose to the brain stimulates sympathetic nervous system, causing unnecessary excitement and feeling of anxiety, sweating, weakness, fatigue and muscular convulsions. Continued excess of insulin in blood causes "coma (insulin shock)" and death. Injections of cortisol, adrenaline, growth hormone and glucagon help in treatment of hyperinsulinism, because these hormones retard glucose utilization in cells and mobilize glucose and fatty acids respectively from liver and adipose tissues. Injections of glucose also give relief to the patients.

(2) **Glucagon :** This is secreted by the alpha cells of islets of Langerhans. It was discovered by Kimball and Murlin (1923). Like insulin, it is also a small protein. Its molecule consists of a single polypeptide chain of 29 amino acid residues. Its function is to elevate glucose level in blood when glucose is deficient. For this, glucagon intensifies glycogenolysis, deamination and gluconeogenesis, and inhibits glycogenesis in liver cells. It also intensifies lipolysis in adipose tissues. Thus, it is a promoter of catabolic metabolism. When, during excessive physical labour and stress, glucose consumption in the body increases and blood glucose level falls, glucagon is secreted to normalize the glucose level.

The secretion of insulin and glucagon is regulated by a "limit-control feedback" or "push and pull feedback" control system. When sugar level in blood increases, insulin is secreted and secretion of glucagon is inhibited. When, due to the effect of insulin, blood sugar level falls, secretion of insulin is inhibited and that of glucagon is stimulated.

(3) **Somatostatin and Pancreatic polypeptide :** Modern physiologists have postulated that the δ and F (PP) cells of pancreas respectively secrete somatostatin (SS) and pancreatic polypeptide (PP). Somatostatin resembles the growth hormone inhibitory hormone (GHIH) secreted by hypothalamus. Its molecule is a small peptide of 14 amino acid residues. Acting as a paracrine hormone, it serves to retard secretory activities of α and β cells. Besides this, it also slows down food digestion, absorption of digested nutrients and assimilation of nutrients in cells. Thus, it prolongs utilization of every feed. pancreatic polypeptide (PP) also acts as a local, paracrine hormone. It retards secretion of pancreatic enzymes and somatostatin. It also inhibits motility of stomach, duodenum and gall bladder.

Table : 5.7-10 Difference between diabetes mellitus and diabetes insipidus

S.No.	Diabetes mellitus	Diabetes insipidus
1.	It is due to deficiency of insulin.	It is due to deficiency of ADH.
2.	The blood sugar becomes high and glucose appears in urine.	The blood glucose is normal and glucose does not appear in urine.
3.	There is high blood cholesterol and ketone body formation.	There is no such phenomenon.

Thymus gland

Origin and position : The thymus is bilobed gland, is located in the upper part of the thorax near the heart in the mediastinum. It is endodermal in origin, arising in the embryo from the epithelium of outer part of third branchial pouches.

Structure : Structurally, it is like lymph gland enveloped by a thin, loose and fibrous connective tissue capsule. Septa, or trabeculae extending inwards from the capsule, divide the two lobes of the gland into a number of small lobules. Each lobule is distinguished into a cortical parenchyma containing numerous lymphocytes, and a medullary mass of large, irregularly branched and interconnected epithelial cells (reticular cells), a few lymphocytes and some phagocytic cells called macrophages or Hassal's corpuscles.

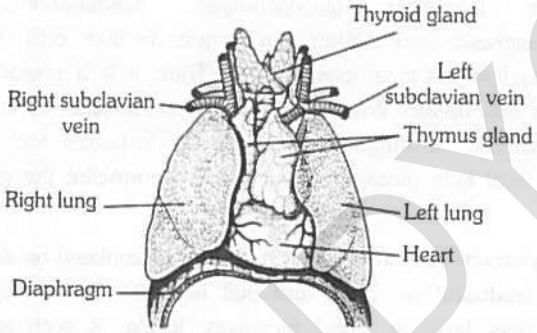


Fig : 5.7-17 Location of thymus gland

Function of thymus glands

(1) Thymus is haemopoietic, as well as, an endocrine gland. Thymus is the "seedbed" of "thymic lymphocytes (T-lymphocytes). Certain "stem cells", originating in yolk sac and liver in early embryo, but only in bone marrow in late embryo, migrate into the thymus and proliferate to form a large number of lymphocytes.

(2) The major function of thymus is to secrete thymosin hormone, thymic humoral factor (THF), thymic factor (TF), thymopoietin. These compounds induce, not only the proliferation of lymphocytes, but also their differentiation into a variety of clones differently specialized to destroy different specific categories of antigens and pathogens likely to get into the body. This is called maturation of lymphocytes.

(3) As is clear from above account, thymus is essential in neonatal (newly born) infant and postnatal child for normal development of lymphoid organs and cellular immunity. That is why, the thymus, small at birth, progressively grows in size about three or four-folds upto about the age of puberty. By this time lymphoid organs and tissues are well-developed. The thymus, therefore, starts gradually diminishing in size and its tissue is progressively infiltrated by yellowish adipose tissue. This is known as the "immunity theory of ageing". By the old age, the thymus is reduced to quite a thin, yet functional chord of tissue.

Pineal gland (Epiphysis)

Origin, position and structure : This is a small, whitish and somewhat flattened ectodermal gland situated at the tip of a small, fibrous stalk that arises from dorsal wall of diencephalon, *i.e.* the roof (epithalamus) of third ventricle of the brain. Due to its location, it is also called epiphysis cerebri. It is covered over by a thin capsule formed of the piamater of the brain. Septa from this membrane extend into the gland, dividing in into lobules having two types of branched cells, viz the large and modified nerve cells, called pinealocytes, and interstitial or neuroglial cells forming the supporting tissue. The pineal gland starts degenerating after the age of about 7 years because of deposition of granules of calcium salts (brain sand) in it.

Function of pineal body : Hormone, though the function of the gland is still the subject of current research, it is known to secrete one hormone, melatonin. Melatonin concentration in the blood appears to flow a diurnal (day-night) cycle as it arises in the evening and through the night and drops to a low around noon. Melatonin lightens skin colour in certain animals and regulates working of gonads (testes and ovaries). Light falling on the retina of the eye decreases melatonin production, darkness stimulates melatonin synthesis. Girls blind from birth attain puberty earlier than normal, apparently because there is no inhibitory effect of melatonin on ovarian function.

Serotonin, a neurotransmitter found in other locations in the brain, is also found in the pineal gland. Research evidence is accumulating to support the idea that the pineal gland may be involved in regulating cyclic phenomena in the body. Melatonin also is a potent antioxidant. Melatonin causes atrophy of gonads in several animals.

Gonads

The gonads are the sex glands, the testes and the ovary. Testes is the male gonad and ovary is the female gonads. Besides producing gametes, the gonads secrete sex hormones from the onset of puberty (sexual maturity) to control the reproductive organs and sexual behaviour.

The sex hormone were discovered by Adolf Butenononal in 1929 and 1931. He won the 1939 Nobel prize jointly with Leopold Ruzicka.

Testes

Location and structure : In testes between the siminiferous tubules, special types of cells are present called interstitial cells or cells of leydig. These cells secrete male hormones (androgens) derived from cholesterol. The main androgen is testosterone other less important androgens include androstenedione and

dehydroepiandrosterone (DHEA). It is a masculinizing hormone. From puberty to the age of about twenty year *i.e.* adolescence or the period of sexual maturation or attainment of adult hood.

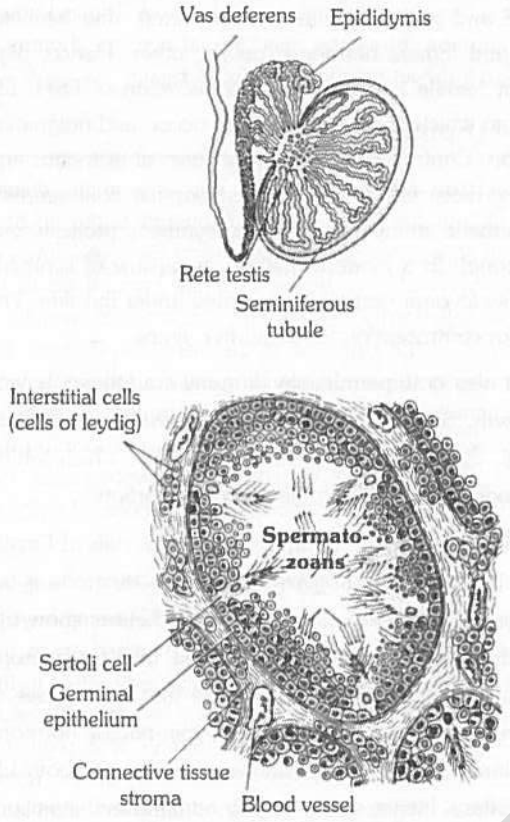


Fig : 5.7-18 Ultrastructure of testes

Function

(1) It stimulates the male reproductive system to grow to full size and become functional.

(2) It stimulates the formation of sperms (spermatogenesis) in the seminiferous tubules.

(3) It stimulates the development of male accessory sex characters such as hair on the face (beard and moustaches), growth and distribution of hair on the body, thickening of skin, deepening of voice, enlargement of larynx, broadening of shoulders, narrow lips enlarged and stronger bones and muscles. It also maintains these characters.

(4) It also determines the male sexual behaviour sexual urge, aggressive behaviour.

(5) Under its effect protein anabolism increases. (This function is obvious in the heavier muscle and bone mass of most men as compared to women).

(6) Grythropoisis in bone marrow increases.

(7) In brief, testosterone determines libido or sex drive. It is also required, together with the follicle stimulating hormone (FSH) of pituitary, for initiation and completion of spermatogenesis. All androgens are also secreted in traces from adrenal glands in both boys and girls.

(8) Increased sebaceous gland secretion.

Development of testis : Under the effect of chorionic gonadotropic hormone, secreted by placenta during pregnancy, the testes of eight to nine months old fetus start secreting testosterone. The latter regulates differentiation and development of urinogenital system, accessory genital organs and external genitalia in the embryo. During childhood *i.e.* from birth to puberty (age of 11 to 13 years), testes remain quiescent, so that androgens are not secreted. At puberty, the gonadotropic hormones (FSH and ICSH) of pituitary reactivate the testes which, therefore, start producing sperms and resume secreting androgens. Upto the age of about 40 years, androgens are secreted in sufficient amounts. thereafter, their secretion starts gradually declining, but the capability of reproduction still continues for many years.

Castration : Surgical removal of testes is called castration or orchidectomy. Castration, or deficient secretion of testosterone (hypogonadism) before puberty (due to congenital defects or injury to testes) retards growth of genitalia, muscles and bones, as well as, the development of sexual characteristics.

Castration or hypogonadism after puberty preserves the libido, but diminishes its overall efficiency (demasculinization). Muscular strength, hair growth, spermatogenesis, sex urge and potency sharply decline. Sometimes, the person becomes impotent.

Castration is widely used in animal husbandry and domestication. Castrated cattle, horses and fowls are respectively called steers, geldings and capons. Castration makes these docile.

Ovary

Primordial ovarian follicles are formed in the primitive ovaries of female fetuses as early as about 16 weeks of gestation, but these do not secrete hormones. Even in early childhood, upto the age of 7 or 8 years, ovaries remain quiescent. Thereafter, the pituitary starts secreting gonadotropins (FSH and LH) under whose influence puberty in girls sets in at about the age of 11 to 13 years; ovaries become active and menstrual cycle begins, so that the girls attain sexual maturity. Reproductive period, *i.e.*, ovarian function and menstrual cycles in women normally cease at about the age of 45 to 55 years. This is called menopause. It usually results in a rise in urinary excretion of gonadotropins of the pituitary gland.

Ovarian hormone : Under the influence of FSH and LH. They secretes three female sex hormone, estrogen, progesteron and relaxin. They are derived from cholesterol.

(1) **Oestrogen :** These are secreted by the cells of the Graffian (ovarian) follicle surrounding the maturing ovum in the ovary. They stimulate the female reproductive tract to grow to full size and become functional. They also stimulate the differentiation of ova (oogenesis) in the ovary. They also stimulate the development of accessory sex characters such as enlargement of breasts; broadening of pelvis; growth of pubic and axillary hair; deposition of fat in the thighs, and onset of menstruation cycle. Graffian follicle cells are stimulated to secrete oestrogens by luteinising hormone (LH) from the anterior lobe of the pituitary gland. Rise of blood-oestrogens level above normal inhibits the secretion of LH from the anterior pituitary. This negative feedback prevents the oversecretion of oestrogens.

(2) **Progesterone :** It is secreted by the corpus luteum. The latter is a yellowish body formed in the empty Graffian follicle after the release of the ovum. Its hormone suspends ovulation during pregnancy, fixes the foetus to the uterine wall, forms placenta, and controls the development of the foetus in the uterus. Progesterone is also called anti-abortion hormone. Ovulation, formation of corpus luteum and secretion of progesterone are sti: ıulated by the luteinising hormone (LH) from the anterior pituitary.

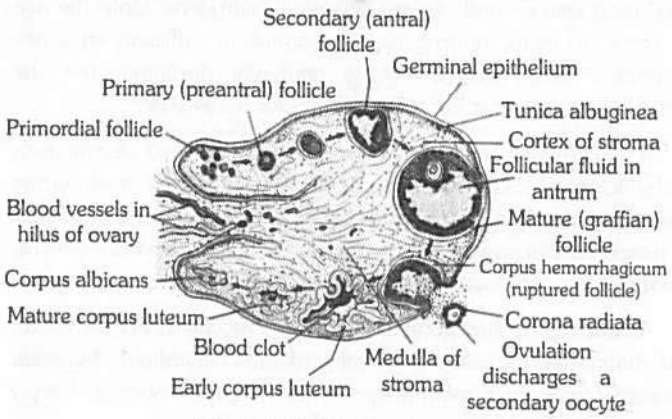


Fig : 5.7-19 V.L.S. of ovary

(3) **Relaxin :** It is produced by the corpus luteum at the end of the gestation period. It relaxes the cervix of the uterus and ligaments of the pelvic girdle for easy birth of the young one.

Regulation of ovarian hormone : Secretion of estrogens is regulated by the gonadotropins of pituitary. Undersecretion of estrogens (hypogonadism) before puberty due to congenital defects or damage to ovaries, causes female eunuchoidism. Accessory genitals and breasts remain underdeveloped, pelvis remains narrow and buttocks flat. Secondary sexual characteristics also do not develop. Hypogonadism in adulthood reduces fertility and disturbs menstrual cycles. Oversecretion (hypersecretion of hypergonadism) of estrogens also disturbs menstrual cycles and may even cause cancer.

Gravidex test : Involve testing of hcG of placenta in the urine to test the pregnancy.

Contraceptive pills : Contain less oestrogens and more progesterone so called combined pills. These check ovulation and so pregnancy in female.

Adiposogenital syndrome : Also called hypothalmic eunuchoidism characterized by hypogonadism in male caused by genetic inability of hypothalamus to secrete gonadotrophin releasing hormones.

Hormonal Contraception

Female contraception : As already described, gonads are stimulated to produces sex cells (gametes) and secrete sex hormones by the gonadotropic hormones (FSH and LH) of anterior pituitary. The anterior pituitary is, in turn, stimulated to secrete gonadotropins by the gonadotropin-releasing hormone (GnRH) of hypothalamus. In women, FSH promotes oogenesis and secretion of female hormones (estrogens). LH promotes ovulation, formation of corpus luteum and secretion of progesterone from it. A negative feedback regulation operates between GnRH and gonadotropins, on one hand, and between gonadotropins and female hormones on the other. Hence, high concentration of female hormones retards secretion of FSH, LH and GnRH due to which oogenesis does not occur, and pregnancy is out of question. Contraceptive pills of mixtures of estrogens and progesterone are more effective. The most popular contraceptive pills contain synthetic ethinyl estradiol and synthetic progesterone (*e.g.* norethindrone). In a modern method, a capsule of synthetic progesterone, like levonor gestrel, is implanted under the skin. The capsule serves for contraception for about five years.

Abortion is also now permissible in many countries to check population growth. Since progesterone is necessary to maintain early pregnancy, drugs, like mifepristone (RU-486), which inhibit the effects of progesterone are administered for abortion.

Male contraception : In men, LH stimulates cells of Leydig to secrete male hormones (androgens) of which testosterone is the principal hormone. Testosterone, in turn, inhibits LH secretion, but not FSH secretion by anterior pituitary. FSH and testosterone stimulate spermatogenesis. It has been found that large doses of testosterone can inhibit secretion of gonadotropin-release hormone (GnRH) by thalamic cells, thereby inhibiting secretion of both LH and FSH by pituitary. Hence systematically administered injections of testosterone have been suggested as a means of male contraception.

Recently, the cells of Sertoli in seminiferous have been found to secrete a protein factor named inhibin which directly inhibits secretion of FSH by pituitary. Hence, use of inhibin as a male contraceptive is now being explored.

Gastro-intestinal mucosa, placenta, skin, kidney and heart

(1) **Gastro-intestinal mucosa :** Inner most layer of the wall of the alimentary canal is called mucosa. Certain cell of the mucosa of the stomach and intestine secrete important hormones. Gastro-intestinal mucosa is endodermal in origin.

(i) **Stomach :** The mucosa of the pyloric stomach near the duodenum secretes a hormone called gastrin. Presence of food in the stomach provides a stimulus for gastrin secretion. Gastrin stimulates the gastric glands to produce the gastric juice. It also stimulates the stomach movements.

(ii) **Intestine :** The intestinal mucosa secretes six hormones : secretin, cholecystokinin, enterogastrone, enterocrinin, duocrinin and villikinin. Entry of acidic food from the stomach into the duodenum serves as a stimulus for the release of these hormones.

(a) **Secretin :** It is produced by the small intestinal mucosa. It causes the release of sodium bicarbonate solution from the pancreas for pancreatic juice and from the liver for bile. It also inhibits the secretion and movements of stomach.

(b) **Cholecystokinin-pancreozymin (CCK-PZ) :** This hormone is secreted by the mucosa of entire small intestine. The actions of cholecystokinin and pancreozymin were discovered independently. But it has been discovered that both hormones have similar effects and hence it is considered one hormone. As the name suggest CCK-PZ has two main functions. The word cholecystokinin is derived from three roots : Chol meaning bile, Cyst meaning bladder, and kinin meaning to remove. The word pancreozymin is derived from pancreas and Zymin, which means enzyme producer. This hormone stimulates the gall bladder to release the bile and also stimulates the pancreas to release its enzymes.

(c) **Enterogastrone :** It is secreted by the duodenal mucosa. It shows gastric contractions and stops the secretion of gastric juice.

(d) **Enterocrinin :** It is secreted by duodenal mucosa. It stimulates crypts of Lieberkuhn to secrete the enzymes in the intestinal juice.

(e) **Duocrinin :** It is secreted by the duodenal mucosa. It stimulates the release of viscous mucus from Brunner's glands into the intestinal juice.

(f) **Villikinin :** It is secreted by the mucosa of the entire small intestine. It accelerates the movements of villi to quicken absorption of food.

(2) **Placenta :** When the early embryo reaches into the uterus from fallopian tube, it becomes implanted with uterine wall by a placenta for support and nutrition. The cells of placenta secrete two steroid hormones (estradiol and progesterone) and two protein hormones (human chorionic gonadotropin-hcG and human chorionic somato mammotrophin-HCS). Early placenta secretes so much of chorionic gonadotropin that the latter starts being excreted in mother's urine just after about two weeks of pregnancy. Its presence in urine is used for pregnancy test. It serves to maintain the corpus luteum, and to stimulate it for secretion. Due to its effect, the corpus luteum continues secreting oestrogens, progesterone and relaxin. It also serves to maintain pregnancy by preventing contraction of uterine wall. After about three months of pregnancy, secretion of progesterone by the placenta increases. Hence, importance of corpus luteum decreases, and it starts degenerating. If therefore, ovaries are surgically removed at this stage, pregnancy remains unaffected, *i.e.* there is no abortion and the fetus grows and develops normally.

The chorionic somatomammotropin was formerly known as placental lactogen. Reaching into mother's body, its serves as a mid growth hormone and promote growth of milk glands.

Relaxin hormone : This hormone has been obtained from corpus luteum of ovaries and from the placenta. It is a polypeptide. During pregnancy it causes relaxation of the ligaments of pubic symphysis, and towards the termination of pregnancy, softens and widens the opening (cervix) of uterus for easy child birth (parturition). A temporary structure with endocrine function is placenta.

(3) **Skin :** Vitamins of *D* group are synthesized in skin cells under the effect of ultraviolet (UV) rays of sunlight from cholesterol-derived compounds. Cholecalciferol (D_3) is the main *D* vitamin. It circulates in blood. Liver cells convert it into hydroxycholecalciferol (calcidiol) by hydroxylation and release back into blood. Certain cells of proximal convoluted tubules of nephrons in the kidneys convert calcidiol into dihydroxycalciferol (calcitriol) by further hydroxylation and release back into blood. Calcitriol is an important regulator of Ca^{2+} homeostasis. It promotes absorption of Ca^{2+} and phosphorus in intestine and bone-formation. It is therefore, required for growth of body and bone healing. Its deficiency in childhood causes thin, weak and curved bones, a condition called rickets. Its deficiency after growth period, causes weak, porous and fragile bones. This is called osteomalacia.

(4) **Kidney :** Whenever the rate of ultrafiltration in kidneys decreases due to low blood pressure (BP), the cells of juxtamedullary complexes secrete into blood a compound named renin. The latter is a proteolytic enzyme. It acts upon a large plasma-protein formed in liver and called angiotensinogen, separating a small protein from it called angiotensin-I. Besides their function of excretion, the kidneys secrete three hormones, *viz* calcitriol, renin and erythropoietin. Calcitriol is the active form of vitamin D_3 as already described. While the blood flows in blood capillaries of liver, an angiotensin-converting enzyme (ACE) converts angiotensin-I into angiotensin-II which acts as a hormone. This hormone accelerates heartbeat and constricts arterioles increasing blood pressure. Consequently, the rate of ultrafiltration increases. Simultaneously, it stimulates adrenal cortex to secrete aldosterone, and enhances water and sodium reabsorption from nephrons. These factors also increase the volume of ECF, elevating blood pressure.

Erythropoietin (EPO) controls formation of erythrocytes (red blood corpuscles-RBC's) in red bone marrow. That is why, its secretion increases on decrease in blood volume, or RBC count, or haemoglobin deficiency (anaemia). Hence EPO is also called renal erythropoietic factor. Contrarily, its secretion decreases when RBC count tends to increase due to blood transfusion or other reasons.

(5) **Heart :** When volume of ECF and blood pressure (BP) increase due to retention of more *NaCl* in the body, certain cardiac muscle cells of the atria of heart secrete an atrial natriuretic peptide (ANP) which acts as a hormone. The effect of ANP is to promote copious urination (diuresis) and excretion of *NaCl* (natriuresis) to normalise ECF volume and BP. It also inhibits the effect of vasoconstrictor hormones and secretion of renin, aldosterone and vasopressin hormones.

Table : 5.7-11 List of hormones, their chemical nature and functions

S.No.	Name of endocrine gland	Name of hormone and its chemical nature	Functions
1.	Neurosecretory cells of Hypothalamus (Supraoptic Nucleus and Paraventricular Nucleus)	Oxytocin and vasopressin monopeptide	Milk ejection and parturition (oxytocic effect). Vasoconstriction and antidiuretic (vasotocin) effects.
		Gonadotropin releasing hormones	Stimulates FSH and LH synthesis
		Other releasing hormones *e.g.* TSHRH, MSHRH, ACTHRH, GHRH etc. Proteinaceous	Stimulate TSH, MSH, ACTH GH secretions from pituitary.
2.	Pituitary (a) Neurohypophysis (Pars Nervosa) (b) Adenohypophysis (contains diverse cell types)	Store and release Oxytocin and Vasopressin. Proteinaceous or glycoprotein	Hormone release is related to physiological state and requirements. Affect growth, development differential pubertal changes and other metabolic mechanism.
3.	Pineal	Melatonin-derived from the amino acid tyrosine	Antagonist to FSH / LH Regulates biological / circadian rhythms.
4.	Thyroid gland (amine hormone) having – NH_2 group)	(a) Thyroxine, iodinated amino acid called tyrosine (T_2, T_3, T_4). (b) Thyrocalcitonin (Peptide)	(a) Controls basal metabolic rate (BMR). All organ / system of body responds to thyroxine. (b) Facilitates Ca^{+2} absorption
5.	Parathyroid gland	Parathormone, Peptide	Ca^{+2} and PO^{-}_4 metabolism.
6.	Thymus	Thymosine (polypeptide)	Anti-FSH and LH; delays puberty
7.	Islets of lengerhans (= Endocrine pancrease) (i) α-cells (ii) β-cells (iii) δ-cells	Glucagon, Insulin, Secretin } Isolated by Banting Polypeptide	(i) Gluconeogenesis / Glycogenolysis (ii) Glycogenesis (iii) Gastric functions
8.	Adrenal gland (a) Adrenal medulla (Amine hormone have – NH_2) (b) Adrenal cortex	(a) Catecholamines (epinephrine = adrenaline, and norepinephrine = noradrenaline (derived from tyrosine) (b) Mineralocorticoids and glucocorticoids and traces of androgen and oestrogen steroids derived from cholesterol	Stresses = emergency = Fright, Fight and Flight Hormone (3F) accelerates cardiac functions muscle activity etc. (b) Electrolyte and carbohydrate metabolism.
9.	Ovary (a) Granulosa cells steroid, fat soluble have sterol group derived from cholesterol (b) Corpus luteum Placenta temporary endocrine gland formed during pregnancy	Oestrogen (Steroid) oestrone, oestradiol Oestrogen and Progesterone (Steroid) (a) Steroid secreted are estrogen and progesterone (b) Relaxin-Polypeptide	(a) Secondary sex character primary action on uterine endometrium mitogenic. (a) Secreted during luteal phase of menstrual cycle in human female and oestrous cycle of other mammals. Prepares uterine endometrium for receiving blastocyst for implantation. Progesterone is also called pregnancy hormone and is anti-FSH and anti-LH/anti-LTH. (a) Maintenance of pregnant state, prevents lactogenesis folliculogenesis, and Ovulation. (b) Act on pubic symphysis and enlarges the birth canal to facilitate birth. Acts synergestically with oxytocin during this process (parturition)
10.	Testis (i) Sertoli cells (= sustentacular cells) (ii) Leydig cells (=Interstitial cells)	(i) Inhibin – Polypeptide (ii) Oestradiol-Steroid Androgens (*e.g.* Testosterone) Steroid androstenedione)	Inhibits FHS action and attenuates spermatogenesis decrementally (i) Pubertal changes in male, (ii) Secondary sex characters in male, (iii) Sex drives, (iv) Spermatogenesis
11.	Gastro-intestinal hormones (secreted by cells of mucosa of stomach and intestine) also called hormones (a) Pyloric stomach (Argentophil cells) Intestine	Gastrin (i) Secretin (ii) Cholecystokinin (CCK) (iii) Enterogastrone (iv) Duocrinin (v) Enterokinin (vi) Villikrinin	Stimulates gastric juices secretion from gastric gland, movement of sphincters of stomach and increased movement of stomach (i) Stimulates secretion of succus entericus, (ii) Bile released from gall bladder, (iii) Inhibits gastric secretion, (iv) Stimulates secretion of mucous from Brunner's gland, (v) Stimulate intestinal gland, (vi) Stimulate villi movement

Table : 5.7-12 Disease caused by hormonal irregularities

Disease	Hormone	Quantity	Gland
Dwarfism	GH	Deficiency	Pituitary
Gigantism	GH	Excess	Pituitary
Acromegaly	GH	Excess	Pituitary
Simmond's disease	GH	Deficiency	Pituitary
Diabetes incipidus	ADH	Deficiency	Pituitary
Cretinism	Thyroxine	Deficiency	Thyroid
Simple goitre	Thyroxine	Deficiency	Thyroid
Myxoedema	Thyroxine	Deficiency	Thyroid
Exophthalamic goitre	Thyroxine	Excess	Thyroid
Tetani	Parathormone	Deficiency	Parathyroid
Plummer's disease	Thyroxine	Excess	Thyroid
Addison's disease	Mineralocorticoids (Aldosterone) and Glucocorticoids (cortisol)	Deficiency	Adrenal cortex
Conn's disease	Mineralocorticoids	Excess	Adrenal cortex
Cushing's disease	Corticosteroid	Excess	Adrenal cortex

Local hormones, pheromones and insect endocrine glands

Local hormones

Hormones described so far are called circulating hormones, because these circulate in whole body with blood. When stimulated by physical or chemical stimuli, all body cells, except red blood corpuscles (RBCs), secrete certain such compounds which transmit coded informations of metabolic adjustments between neighbouring cells and hence remain ECF instead of diffusing into the blood. These compounds are called local tissue hormones or autocoids. These are short-lived, because various enzymes present in ECF continue degrading these at a fast rate.

Local hormones are of two main categories-paracrine and autocrine. Paracrine hormones affect metabolism of cells located in the neighbourhood of those which secrete them. Autocrine hormones affect metabolism of the every cells which secrete them. Most local hormones are paracrine. These belong to the following categories :

(1) **Eicosanoids :** These are a category of lipids derived from fatty acid, arachidonic acid, synthesized in the plasma membrane of cells, and released in ECF. These are of four categories, *viz.* Prostaglandins, prostacyclins, thromboxanes and leukotrienes.

(i) **Prostaglandins (PGs) :** In 1935, Ulf von Euler discovered that human semen contains a very active compound presumably secreted by prostate gland and, hence, named as such. He found that after the semen is discharged in woman's vagina, this compound contracts uterine muscles to facilitate the sperms to ascend into fallopian tubes and reach ova to fertilize these.

(ii) **Prostacyclins :** These are found in walls of blood vessels and induce vasodilation. These also facilitate flow of blood in vessels and prevent thrombosis by inhibiting aggregation of platelets.

(iii) **Thromboxanes :** These are secreted by blood platelets. These help in blood clotting by instigating aggregation of platelets at the place of injury. These also instigate vasoconstriction at places of injury to prevent excessive loss of blood.

(iv) **Leukotrienes :** These are secreted by eosinophils of blood and mast cells of connective tissues. These serve as mediators in inflammatory and allergic reactions, induce bronchoconstriction (constriction of bronchioles), constrict arterioles and induce migration of neutrophils and eosinophils towards the places of inflammation. These can cause asthma, arthritis, colitis, etc.

(2) **Neuroregulators :** These are a category of proteins which function as paracrine hormones in nervous tissues. These can be classified in three categories as follows :

(i) **Neurotransmitters :** These are synthesized in nerve cells and are secreted by exocytosis by axon terminals of these cells. These serve to transmit nerve impulses from one neuron to other neighbouring neuron, or muscles, or glands across synapses. About 60 of these have so far been discovered, but the most common of these are acetylcholine, norepinephrine, dopamine, serotonin and histamine.

(ii) **Neuromodulators :** In nervous tissues, the neurons secrete such paracrine hormones which modulate (increase or decrease) the excitability of other neighbouring neurons. These hormones are called neuromodulators. The main positive neuromodulators which increase the excitability of other neurons are the amino acids glutamate and aspartate, and polypeptide named '*P*' substance. Contrarily, the main negative modulators which decrease the excitability of neighbouring neurons are the amino acid glycine and gama aminobutyric acid (GABA), polypeptides named enkephalins, endorphins, dynorphins and tachychinins, and the nitric oxide (NO).

(iii) **Nerve growth factors :** The supporting glial cells of nervous tissues and cells of muscles, salivary glands and many other tissues secrete such polypeptide paracrine hormones which play important role in growth, development and survival of nerve cells. That is why, these hormones are collectively called neurotrophins.

Pheromones

These are defined as chemicals excreted or released by one animal to the exterior, but evoke a physiological or behavioral response in another animal of the same species. Some pheromones, release on body surface, evoke a response in the recipient when tasted by the latter by licking, but most pheromones are volatile and odorous fatty acids (hydrocarbons) whose air borne molecules are received by recipient animals through olfaction. Certain insect pheromones are well-known examples. For instance, certain insects secrete bombykol or gyplure to attract their mating partners. Some other insects release geranoil to transmit information of food, source of danger to their fellows.

In mammals, presumably including humans, certain volatile fatty acids secreted in vaginal fluid by females acts as pheromones. These may evoke sex drive in males, or affect menstrual cycle in other females. It has been observed that there is a tendency of synchronized menstrual cycles in female roommates. This "dormitory effect" must be due to pheromones.

Table : 5.7-13 Types of pheromones

S.No.	Type	Example
1.	Sex pheromones	Bombycol – Silkmoth (female) Queen substance – Honey bee (Queen) Civetone – Cat Muskone – Muskdeer
2.	Aggregation pheromones	Geradiol – Honey bee
3.	Alarm pheromones	Danger signals
4.	Marking pheromones	Mark the territory in wild animals

Insect endocrine glands

The endocrine system of cockroach comprises intercerebral gland cells, corpora cardiaca, corpora allata, and prothoracic glands.

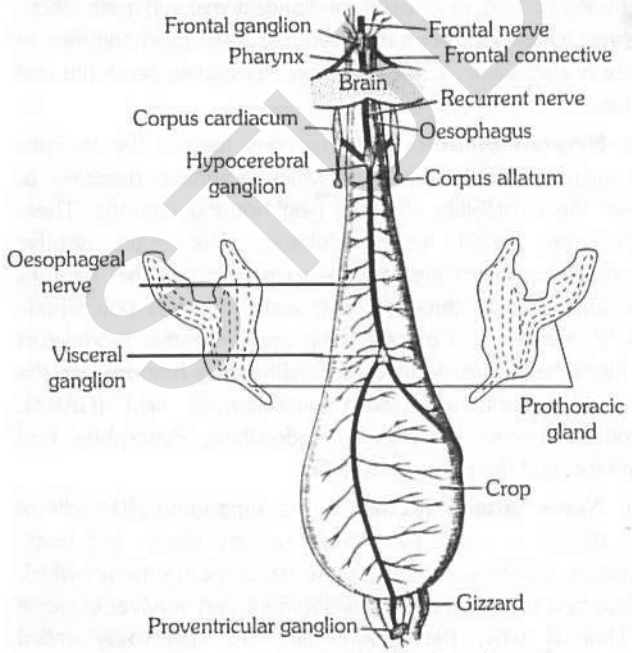


Fig : 5.7-20 Endocrine glands of cockroach

(1) **Intercerebral gland cells :** These cells lie in the brain between the two cerebral ganglia. They secrete a hormone called the brain hormone. This hormone activates the prothoracic glands to secrete their hormone.

(2) **Corpora cardiaca :** These are a pair of rod-like bodies situated on the sides of the oesophagus just behind the brain. They secrete a growth hormone.

(3) **Corpora Allata :** These are a pair of small, rounded bodies lying close behind the corpora cardiaca. They secrete a juvenile hormone in the nymphal stages. This hormone causes retention of the nymphal characters and checks the appearance of adult characters. In other words, it keep the insect young. In the last nymphal form, corpora allata become inactive, thereby resulting in the absence of juvenile hormone. The absence of this hormone permits the appearance of adult features. In the adult, the corpora allata again become active and secrete a gonadotropic hormone, which regulates egg production and development and functioning of the accessory sex glands.

(4) **Prothoracic glands :** These are fairly large, irregular glands situated in the prothorax. They secrete a hormone called ecdyson, which controls moulting of the nymphs. The prothoracic glands degenerate after metamorphosis.

Tips & Tricks

- The word 'endocrine' is derived from a Greek word meaning 'I separate within'.
- The word 'hormone' was first used in reference to secretin.
- The father of endocrinolgy is Thomas Addison. The first endocrine disease reported was Addison's disease (1855) caused by the destruction of adrenal cortex or glucocorticoids.
- When two hormones work against each other to control a process, this is called antagonism, e.g., Insulin and Glucagon, Calcitonin and Parathormone.
- There are some hormone – like substances, but not the products of endocrine glands. They are parahormones, e.g., Prostaglandins and Pheromones.
- Hormones are not present in food but are synthesized in body.
- Protein hormones act at membrane level and change the permeability of plasma membrane.
- Steroid hormones enter nucleus and inactivate or activate the function of some gene.
- Although thyroxine is not a steroid hormone but it is lipid soluble and acts at gene level like steroid hormones.
- Water soluble hormones act through extracellular receptors.

- Lipid soluble hormones act through intracellular receptors.
- Insulin receptor is a heterotetrameric protein consisting of 2α subunits and 2 β subunits.
- One signaling molecules activates many mediators and one molecule of mediator activates hundreds of other molecules. In this way a signal is amplified hundred folds.
- Hormones secreted at nerve endings are called neurohormones or neurohumors.
- Sutherland received Noble prize in 1971 for his contribution in field of understanding of mechanism of hormone action.
- Secondary messengers are intermediate compounds that amplify a hormonal signal.
- By using two opposite signals within a cell sympathetic and parasympathetic nervous system achieve opposite actions.
- Cells have receptors for insulin and glucagons which also have antagonistic effects.
- Although thyroxine is not a steroid hormone but it is lipid soluble and acts at gene level like steroid hormones.
- Endocrine glands with ducts are pancreas, ovaries and testes.
- Primary target organ of hypothalamus is pituitary gland.
- In amphibians and reptiles pineal gland is considered third vestigeal eye.
- In human pituitary, the intermediate lobe is functional in embryo but is rudimentary in adult.
- One neuron-one hormone hypothesis is followed by pituicytes.
- Growth hormone is the only hormone of anterior pituitary that has direct effect on body cells.
- Median eminence is a part of posterior pituitary.
- Myesthenia gravis : Abnormal neuromuscular excitation due to hypersecretion of thymosine.
- Hormones are also called autocoids or chemical messengers or information molecules.
- Local hormones are also called para-hormones or tissue hormones.
- First discovered hormone was secretin but first isolated hormone was insulin and was isolated from pancreas of dogs by Banting and McLeod.
- Thyroxine hormone is derived from tyrosine amino acid while oxytocin and ADH are short chain peptide hormones.
- Pheromones : These are intra-specific chemical messengers released by an animal into air to initiate specific response in another animal of same species. These may be signals of food, mate etc. These are also called ectohormones. Term pheromone was coined by Karlson and Butendant (1959).
- **Feedback inhibition :** In this, end product sends certain inhibitory signals (called negative feedback) when end product is at required level.
- **Endocrinologist :** Scientist involved in the study of endocrine glands.
- **Ecdysone :** A steroid hormone secreted by prothoracic glands present in the prothorax of insects the cockroach and controls moulting or ecdysis.
- **Corpora cardiaca :** A part of rod-like endocrine glands found in insects on the sides of oesophagus and secrete growth hormone which controls the growth of nymphs.
- **Juvenile hormone :** Secreted by a pair of rounded endocrine glands called corpora allata, present just behind corpora cardiaca. These secrete juvenile hormone in the nymphal stage and checks the appearance of adult characters.
- Level of hormones in our blood can be measured by Radio Immune Assay (RIA).
- Hormone receptors are always proteinous and are located either on cell membrane of target cells or in cytosol.
- Spleen does not secrete any hormone.
- Basal metabolic rate (BMR) – minimum energy required during rest or sleep (160 Kcal/day).
- Thyroid gland is only endocrine gland that stores its secretory product.
- During continuous stress size of adrenal gland (mainly adrenal cortex) increases.
- Human insulin was prepared for the first time byTsan in 1965.
- Insulin is effective only when it is given by injection.
- If insulin is taken orally, it is digested.
- Chemicals, alloxan and streptozotocin selectively destroy beta cells of islets of Langerhans.
- Cobalt chloride selectively destroys alpha cells of islets of Langerhans.
- **Humulin :** Genetically engineered human insulin is called humulin.
- **Acidosis :** Decrease in pH of blood e.g. in diabetes mellitus.
- The seminal vesicles are the chief source of prostaglandins in semen.
- The commonest prostaglandins are PGA_1, PGA_2, PGE_1, PGE_2 PGF.

Ordinary Thinking

Objective Questions

Hormones and their mechanism

1. The name second messenger is given to **[NCERT; MP PMT 2002]**

Or

In the mechanism of action of a protein hormone, one of the second messengers is **[NCERT]**

(a) ATP (b) Cyclic AMP
(c) GTP (d) Both ATP and AMP

2. In mechanism of hormone action, which of the following is not a second messenger **[MHCET 2015]**

(a) Cyclic AMP (b) IP_3
(c) Ca^{++} (d) Mg^{++}

3. What is hormone **[MP PMT 1998]**

(a) Glandular secretion
(b) Enzyme
(c) Chemical messenger
(d) Organic complex substance

4. .....shows anti-allergic and anti-inflammatory effect **[GUJCET 2015]**

(a) Mineralocorticoids (b) Glucocorticoids
(c) Sexcorticoids (d) Noradrenaline

5. Which is the inhibitory hormone of GH **[GUJCET 2015]**

(a) Insulin (b) Parathormone
(c) Somatostatin (d) Testosterone

6. The chemical nature of hormones secreted by α & β cells of pancreas is **[WB JEE 2009]**

(a) Glycolipid (b) Glycoprotein
(c) Steroid (d) Polypeptide

7. Which of the following cell does not secrete hormone **[MP PMT 2000]**

(a) Kupffer cell
(b) Leydig cell
(c) Lutein cell
(d) Parafollicular cells of thyroid

8. Which of the following hormones are produced in the hypothalamus and stored in the posterior pituitary **[KCET 2006]**

(a) FSH and LH (b) ADH and oxytocin
(c) TSH and STH (d) ACTH and MSH

9. Which of the following is not necessarily a property of all hormones **[AIIMS 1993]**

(a) Information carrying (b) Secreted in low amounts
(c) Short half-life (d) Protein in nature

10. The feed back control mechanism is related with **[CBSE PMT 2000; BHU 2002]**

(a) Bile secretion (b) *HCl* secretion
(c) Hormonal secretion (d) Hering breuer reflex

11. Pheromone is **[MP PMT 2000]**

(a) A product of endocrine gland
(b) Used for animal communication
(c) Messenger RNA
(d) Always protein

12. Consider the given diagrammatic representation of the mechanism of action for 2 categories of hormones. In which of the following option correct answers for blanks A to I are indicated **[NCERT]**

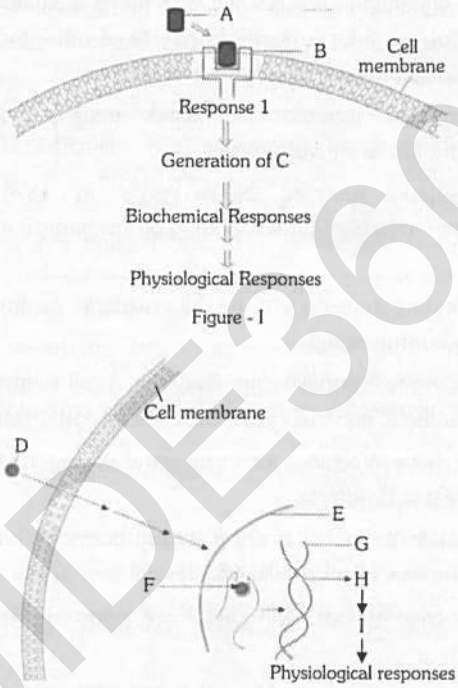


Figure - I

Figure - II

(a) A - Steroid hormone, B - Enzyme, C - Secondary messenger, D - Non- steroid hormone, E - Nucleus, F – Hormone - enzyme complex, G - Genome, H - mRNA, I - protein

(b) A - Steroid hormone, B - Receptor, C - Primary messenger, D - Non- steroid hormone, E - Nucleus, F - Hormone- receptor complex, G - Genome, H - mRNA, I - protein

(c) A - Non -Steroid hormone, B - Receptor, C - Secondary messenger, D - Steroid hormone, E - Nucleus, F - Hormone receptor complex, G - Genome, H - mRNA, I - Protein

(d) A - Steroid hormone, B - Receptor, C - Secondary messenger, D - Non- steroid hormone, E - Nucleus, F - Hormone - receptor complex, G - Genome, H - mRNA, I – protein

13. Who is the "Father of Endocrinology" **[CPMT 2000; BHU 2006]**

(a) Whittaker (b) Einthoven
(c) Pasteur (d) T. Addison

14. Term '*hormone*' was coined by **[CPMT 1994]**

(a) W. M. Bayliss (b) E. H. Schally
(c) E. H. Starling (d) G. W. Harris

15. Receptors for protein hormones are located
(a) In cytoplasm (b) On cell surface
(c) In nucleus (d) On endoplasmic reticulum

16. Which one of the following flows directly into blood from the seat of its production to act on an organ away from it
(a) Enzyme (b) Hormone (Renin)
(c) Blood (d) Lymph

17. Which is not involved as 2nd messenger in Ca^{+2} mediated hormone **[NCERT; DPMT 2007]**
(a) c-AMP (b) DAG
(c) Phospholipase (d) IP_3

18. Hormones may be **[BVP 2003; CBSE PMT 2004]**
(a) Amino acid derivatives (b) Peptides
(c) Steroids (d) All the above

19. Which of the following statements is **correct** in relation to the endocrine system **[NEET 2013]**
(a) Releasing and inhibitory hormones are produced by the pituitary gland
(b) Adenohypophysis is under direct neural regulation of the hypothalamus
(c) Organs in the body like gastrointestinal tract, heart, kidney and liver do not produce any hormones
(d) Non-nutrient chemicals produced by the body in trace amount that act as intercellular messenger are known as hormones

20. Endocrine glands **[NCERT; J & K CET 2002; Odisha JEE 2012]**
(a) Do not possess ducts
(b) Sometimes do not have ducts
(c) Pour their secretion into blood through ducts
(d) Always have ducts

21. According to the accepted concept of hormone action, if receptor molecules are removed from target organs **[CBSE PMT 1995; AFMC 1999]**
(a) The target organ will continue to respond to the hormone without any difference
(b) The target organ will continue to respond to the hormone but will require higher concentration
(c) The target organ will not respond to the hormone
(d) The target organ will continue to respond to the hormone but in the opposite way

22. All functions of the body are regulated and integrated by **[MP PMT 1994, 96]**
(a) Respiratory system (b) Digestive system
(c) Neuroendocrine system (d) Excretory system

Different glands and their hormones

1. Select the mismatch pair from the following **[KCET 2015]**
(a) Oxytocin – Contraction of uterine muscles
(b) Insulin – Gluconeogenesis
(c) Prolactin – Milk production in mammary glands
(d) Glucagon – Glycogenolysis

2. Inadequate production of STH in early life may result in
(a) Gigantism (b) Acromegaly
(c) Sterility (d) Dwarfism

3. What is correct to say about the hormone action in humans **[CBSE PMT (Pre.) 2012]**
(a) Glucagon is secreted by β-cells of Islets of Langerhans and stimulates glycogenolysis
(b) Secretion of thymosins is stimulated with aging
(c) In females, FSH first binds with specific receptors on ovarian cell membrane
(d) FSH stimulates the secretion of estrogen and progesterone

4. Which is a 32 amino acid water soluble peptide hormone **[AMU (Med.) 2010]**
(a) Gastrin (b) Calcitonin
(c) Glucagon (d) Insulin

5. A health disorder that results from the deficiency of thyroxine in adults and characterized by (i) a low metabolic rate, (ii) increase in body weight and (iii) tendency to retain water in tissues is **[CBSE PMT 2009]**

Or

Man with thick lips, dirt deposited on tongue, low heart beating rate, with excess amount of cholesterol in blood, is supposed to be suffering from which abnormality **[CPMT 1996]**
(a) Hypothyroidism (b) Simple goitre
(c) Myxoedema (d) Cretinism

6. One of the following cells secretes a hormone **[MHCET 2015]**
(a) Cells of Leydig (b) Cells of Sertoli
(c) Primary spermatocyte (d) Secondary spermatocyte

7. Which one of the following hormones is not involved in sugar metabolism **[AIPMT 2015]**
(a) Aldosterone (b) Insulin
(c) Glucagon (d) Cortisone

8. The hormones of posterior pituitary are oxytocin and vasopressin; but later is better known as **[CPMT 2009]**
(a) Antidiuretic hormone (b) Growth hormone
(c) Corticotrophic hormone (d) Neurohypophyseal

9. Which one of the following four glands is correctly matched with the accompanying description **[AIIMS 2008]**
(a) Thyroid – Hyperactivity in young children causes cretinism
(b) Thymus – Starts undergoing atrophy after puberty
(c) Parathyroid – Secretes parathormone, which promotes move–ment of calcium ions from blood into bones during classification
(d) Pancreas – Delta cells of the islets of Langerhans secrete a hormone, which stimulates glycolysis in liver

10. The hormone that maintains the secretory activity of the corpus luteum as well as the increase in the size of the mammary glands is
(a) Estrogen (b) Luteinizing
(c) Luteotrophin (d) Gonadotrophin

11. Which one of the following pairs of organs includes only the endocrine glands **[CBSE PMT 2008]**
(a) Thymus and Testes (b) Adrenal and Ovary
(c) Parathyroid and Adrenal (d) Pancreas and parathyroid

12. Secretion of the androgen by Leydig cells of testis is under the regulatory influence of **[KCET 2004]**
(a) LTH (b) FSH
(c) STH (d) ICSH

13. The process of spermatogenesis and sperm formation is under the regulatory influence of **[CPMT 1994]**
(a) FSH (b) ADH
(c) LH (d) LTH

14. In human adult females oxytocin **[MH CET 2005; CBSE PMT 2008]**
(a) Stimulates pituitary to secrete vasopressin
(b) Causes strong uterine contractions during parturition
(c) Is secreted by anterior pituitary
(d) Stimulates growth of mammary glands

15. Which hormone stops the release of FSH from the pituitary after fertilization **[CMC Vellore 1993; MP PMT 2009]**
(a) Placental hormone (b) Fertilizin
(c) Estradiol (d) Luteinizing hormone

16. Diabetes insipidus is caused due to the deficiency of **[AIIMS 1993; MP PMT 1997, 2003; CPMT 1999]**
(a) Oxytocin (b) Insulin
(c) Vasopressin (d) Glucagon

17. A person suffering from diabetes insipidus will pass what amount of urine per day **[MP PMT 1993]**
(a) 1 litre (b) $\frac{1}{2}$ litre
(c) 3 litres (d) 1.5 litres

18. Which one of the following hormones through synthesized elsewhere is stored and released by the master gland **[AIPMT 2015]**
(a) Luteinizing hormone
(b) Prolactin
(c) Melanocyte stimulating hormone
(d) Antidiuretic hormone

19. The blood calcium level is lowered by the deficiency of **[CBSE PMT 2008]**

Or

The harmone that increases the blood calcium level and decreases its excretion by kidney is **[DUMET 2009; WB JEE 2011]**

Or

Tetany (Irregular muscle contraction) and osteoporosis are caused due to the deficiency of **[MP PMT 1999, 2001; JIPMER 2002; WB JEE 2011; Kerala PMT 2012]**
(a) Both calcitonin and parathormone
(b) Calcitonin
(c) Parathormone
(d) Thyroxine

20. The activity of adrenal cortex is governed by a pituitary hormone abbreviated as **[DPMT 1993]**

Or

Addison's disease is caused by under secretion of **[DPMT 1993]**
(a) HCG (b) FSH
(c) ACTH (d) TSH

21. Which one of the following pairs of hormones are the examples of those that can easily pass through the cell membrane of the target cell and bind to a receptor inside it (Mostly in the nucleus) **[CBSE PMT (Pre.) 2012]**
(a) Insulin, glucagon (b) Thyroxin, insulin
(c) Somatostatin, oxytocin (d) Cortisol, testosterone

22. The intermediate lobe of the pituitary gland produces a secretion which causes a dramatic darkening of the skin of many fishes, amphibians and reptiles. It is **[CBSE PMT 1993; Pb. PMT 1999]**

Or

Which of the following pituitary hormone is a direct action hormone **[MP PMT 2003]**
(a) Adrenocorticotropic hormone (ACTH)
(b) Follicle stimulating hormone (FSH)
(c) Melanocyte stimulating hormone (MSH)
(d) Luteinizing hormone (LH)

23. The Leydig cells as found in the human body are the secretory source of **[NCERT; MH CET 2007; CBSE PMT (Pre.) 2012]**
(a) Progesterone (b) Intestinal mucus
(c) Glucagon (d) Androgens

24. Serotonin and Melatonin are hormones, secreted by **[MHCET 2015]**
(a) Pancreas (b) Pineal body
(c) Pituitary gland (d) Thymus

25. Select the correct matching of a hormone, its source and function **[CBSE PMT (Mains) 2010]**

	Hormone	Source	Function
(a)	Vasopressin	Posterior Pituitary	Increases loss of water through urine
(b)	Norepinephrine	Adrenal medulla	Increases heart beat, rate of respiration and alertness
(c)	Glucagon	Beta-cells of Islets of langerhans	Stimulates glycogenolysis
(d)	Prolactin	Posterior Pituitary	Regulates growth of mammary glands and milk formation in females

26. Pineal gland of human brain secretes melatonin concerned with **[RPMT 2005; MP PMT 2012; PET (Pharmacy) 2013]**
(a) Anger (b) Body temperature
(c) Colouration of skin (d) Sleep

27. Endemic goiter is a state of **[WB JEE 2010]**
(a) Increased thyroid function
(b) Normal thyroid function
(c) Decreased thyroid function
(d) Moderate thyroid function

28. The anterior lobe of pituitary affects
(a) Protein metabolism
(b) Fat metabolism
(c) Carbohydrate metabolism
(d) All of the above

29. Complete failure of adenohypophysis of pituitary causes
(a) Addison's disease (b) Cushing's disease
(c) Dwarfism (d) Simmond's disease

30. A chemical signal that has both endocrine and neural roles is **[AIPMT (Cancelled) 2015]**
(a) Calcitonin (b) Epinephrine
(c) Cortisol (d) Melatonin

31. A substance called ADH is **[CBSE PMT 1991]**
(a) A hormone that promotes glycogenesis in liver cells
(b) An enzyme secreted by cell of intestinal wall; hydrolyses dipeptides into amino acids
(c) A pituitary secretion which promotes reabsorption of water from glomerular filtrate
(d) A high energy compound involved in muscle contraction

32. The co-ordinator between Nervous and endocrine system is **[MHCET 2015]**

Or

Oxytocin is synthesized in **[WB JEE 2016]**
(a) Thalamus (b) Hypothalamus
(c) Epithalamus (d) Colliculus

33. Growth hormone activity **[CPMT 1993]**
(a) Decreases with thyroxine (b) Increases with thyroxine
(c) Remains same (d) None of these

34. Pituitary gland is found in **[MP PMT 1994, 98]**
(a) Brain (b) Trachea
(c) Gonads (d) Pancreas

35. A person entering an empty room suddenly finds a snake right in front on opening the door. Which one of the following is likely to happen in his neuro-hormonal control system **[CBSE PMT (Pre.) 2012]**
(a) Sympathetic nervous system is activated releasing epinephrin and norepinephrin from adrenal medulla
(b) Neurotransmitters diffuse rapidly across the cleft and transmit a nerve impulse
(c) Hypothalamus activates the parasympathetic division of brain
(d) Sympathetic nervous system is activated releasing epinephrin and norepinephrin from adrenal cortex

36. FSH is a **[RPMT 2000]**
(a) Catecholamine (b) Glycoprotein
(c) Polypeptide (d) Steroid

37. Match List I with List II and select the correct option

List I		List II	
A.	Adrenalin	1.	Myxoedema
B.	Hyperparathyroidism	2.	Accelerates heart beat
C.	Oxytocin	3.	Salt-water balance
D.	Hypothyroidism	4.	Childbirth
E.	Aldosterone	5.	Demineralisation

[DPMT 2006; Kerala PMT 2008; CPMT 2010]
(a) A – 2, B – 5, C – 4, D – 1, E – 3
(b) A – 3, B – 4, C – 5, D – 3, E – 2
(c) A – 5, B – 3, C – 2, D – 4, E – 1
(d) A – 2, B – 3, C – 4, D – 5, E – 1
(e) A – 5, B – 3, C – 4, D – 2, E – 1

38. Gonadotrophic hormones are produced in the **[MP PMT 1995; CBSE PMT 1999; CPMT 2010]**
(a) Posterior part of thyroid
(b) Adrenal cortex
(c) Adenohypophysis of pituitary
(d) Interstitial cells of testis

39. Injury localized to the hypothalamus would most likely disrupt **[CBSE PMT 2014]**
(a) Executive function, such as decision making
(b) Regulation of body temperature
(c) Short term memory
(d) Co-ordination during locomotion

40. Adrenaline is equivalent to which neurotransmitter **[Odisha JEE 2009]**
(a) GABA (b) Serotonin
(c) Epinephrine (d) Norepinephrine

41. Steroid hormones easily pass through the plasma membrane by simple diffusion because they **[DUMET 2009]**
(a) Are water soluble
(b) Contain carbon and hydrogen
(c) Enter through pores
(d) Are lipid soluble

42. If the pituitary gland of an adult rat is surgically removed, which of the following endocrine gland will be less affected **[DUMET 2009]**
(a) Adrenal cortex (b) Adrenal medulla
(c) Thyroid (d) Gonads

43. Select the correct option describing gonadotropin activity in a normal pregnant female **[CBSE PMT 2014]**
(a) High level of hCG stimulates the synthesis of estrogen and progesterone
(b) High level of hCG stimulates the thickening of endometrium
(c) High level of FSH and LH stimulates the thickening of endometrium
(d) High level of FSH and LH facilitate implantation of the embryo

44. Estrogen and testosterone are steroid hormones, and are most likely bind to **[Odisha JEE 2009; DUMET 2009; KCET 2011]**

(a) Membrane ions channels
(b) Enzyme-linked membrane receptors
(c) G-protein linked membrane receptors
(d) Cytoplasmic receptors

45. Which of the following secretes leutenizing hormone **[CPMT 1995]**

(a) Pituitary (b) Thyroid
(c) Parathyroid (d) Adrenal

46. Pitressin is also called as **[CPMT 1995]**

(a) ADH (b) LH
(c) NADH (d) FSH

47. Which of the following hormones regulates growth and metamorphosis in insects **[DUMET 2009]**

(a) Juvenile hormone
(b) Brain hormone
(c) Ecdyson
(d) Prothoracicotropic hormone

48. Depict the correct site of hormone **[NCERT; RPMT 1995; DPMT 2007]**

(a) α – glucagon, β – insulin, δ – somatostatin
(b) α – insulin, β – glucagon, δ – somatostatin
(c) δ – insulin, α – somatostatin, β – glucagon
(d) α – somatostatin, β – insulin, δ – glucagon

49. Glycosuria is the condition, where a man **[DUMET 2009; WB JEE 2010]**

(a) Eats more sugar
(b) Excretes sugar in urine
(c) Sugar is excreted in faeces
(d) Has low sugar level in blood

50. Cortisol is secreted by the adrenal cortex in response to stress. In addition to its function in a stress response, it functions in negative feedback by **[J & K CET 2012]**

(a) Inhibiting the hypothalamus so that corticotropin releasing hormone (CRH) secretion is reduced
(b) Inhibiting the anterior pituitary's ability to respond to CRH by reducing the pituitary's sensitivity to CRH
(c) Both (a) and (b) are correct
(d) None of these

51. RAAS secretes which of the following hormone **[NCERT; DPMT 2007]**

(a) Mineralocorticoids (b) Glucocorticoids
(c) Both (a) and (b) (d) None of these

52. Which one controls the secretion of oestrogen **[MP PMT 1997]**

(a) hCG (b) Progesteron
(c) LH (d) FSH

53. Which one of the following is not a second messenger in hormone action **[CBSE PMT 2006; WB JEE 2011]**

(a) Sodium (b) cAMP
(c) cGMP (d) Calcium

54. Fight-or-flight reactions cause activation of **[NCERT; CBSE PMT 2014]**

(a) The adrenal medulla, leading to increased secretion of epinephrine and norepinephrine
(b) The pancreas leading to a reduction in the blood sugar levels
(c) The parathyroid glands, leading to increased metabolic rate
(d) The kidney, leading to suppression of reninangiotensin-aldosterone pathway

55. At cellular level GH affects growth by controlling the production of **[MP PMT 2000, 06]**

(a) *r*-RNA (b) *t*-RNA
(c) *m*-RNA (d) None of the above

56. The synthesis of vasopressin is done by **[RPMT 2001]**

(a) Hypothalamus (b) Kidney
(c) Anterior pituitary (d) Posterior pituitary

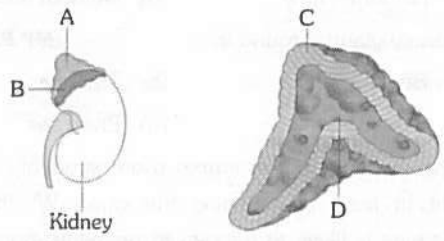
57. A person passes much urine and drinks much water but his blood glucose level is normal. This condition may be the result of **[AIIMS 2003]**

(a) A reduction in insulin secretion from pancreas
(b) A reduction in vasopressin secretion from posterior pituitary
(c) A fall in the glucose concentration in urine
(d) An increase in secretion of glucagon

58. A man is admitted to a hospital. He is suffering from an abnormally low body temperature, loss of appetite and extreme thirst. His brain scan would probably show a tumor in **[KCET 2009]**

(a) Medulla oblongata (b) Pons
(c) Cerebellum (d) Hypothalamus

59. See the following figures and identify it **[NCERT]**



(a) A - Adrenal gland, B - Fat, C - Pars distalis, D - Pars intermedia
(b) A - Adrenal gland, B - Fat, C - Medulla, D - Cortex
(c) A - JGA, B - Fat, C - Cortex, D - Medulla
(d) A - Adrenal gland, B - Fat, C - Cortex, D - Medulla

60. Thyrotropin-Releasing Factor (TRF) is produced by **[MP PMT 2002]**

(a) Cerebrum (b) Optic lobe
(c) Cerebellum (d) Hypothalamus

61. Similarity between the secretion of thyroid and adrenal is that both the secretions **[AIIMS 1992]**

(a) Are proteins
(b) Are steroid
(c) Increase glucose metabolism
(d) Control mineral metabolism

62. Calcitonin lowers the calcium level in the blood. This is secreted by **[CBSE PMT 1992; CPMT 1998; MP PMT 2013]**
(a) Parathyroid (b) Hypothalamus
(c) Adrenal (d) Thyroid

63. Select the incorrect statement **[NEET (Phase-I) 2016]**
(a) FSH stimulates the sertoli cells which help in spermiogenesis
(b) LH triggers ovulation in ovary
(c) LH and FSH decrease gradually during the follicular phase
(d) LH triggers secretion of androgens from the leydig cells

64. Disease caused by deficiency of iodine is **[CBSE PMT 1993; MP PMT 1999; HP PMT 2005; MH CET 2007]**
(a) Goitre (b) Myxodema
(c) Cretinism (d) Tetany

65. Which disease is caused by the deficiency of thyroxin in the adults **[Pb. PMT 2000; MP PMT 2000]**
(a) Diabetes incipidus (b) Diabetes mellitus
(c) Myxoedema (d) Exopthalmic goitre

66. Acromegaly results after adolescence due to excess production of one of the following hormones **[MP PMT 2001; AIIMS 2001; CBSE PMT 2002; Kerala CET 2002]**
(a) Prolactin (b) Thyroxin
(c) Insulin (d) STH

67. An organ X has a large blood supply. It produces a hormone lack of which causes a disease called as cretenism. The cause is **[NCERT]**

Or

Cretinism is due to **[CPMT 1992, 93, 2004; MP PMT 1993, 99; 2013; CMC Vellore 1993; WB JEE 2011]**
(a) Excess growth hormone
(b) Absence of insulin
(c) Excess adrenalin
(d) Hyposecretion of thyroid in childhood (Thyroxin)

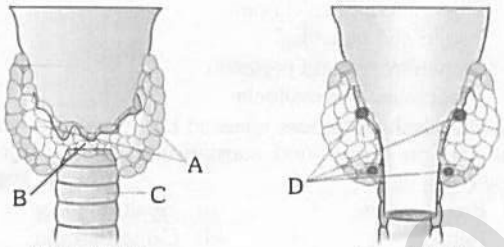
68. '*Exophthalmic goitre*' (Grave's disease) is caused due to **[NEET (Phase-II) 2016]**
(a) Hypofunction of the thyroid
(b) Hyperfunction of the thyroid
(c) Hypofunction of the parathyroid
(d) Hyperfunction of the parathyroid

69. Which of the following hormones does not contain a polypeptide **[KCET 2009]**
(a) Prostaglandin (b) Oxytocin
(c) Insulin (d) Antidiuretic hormone

70. Damage to thymus in a child may lead to **[AIIMS 2007; KCET 2009]**
(a) Loss of cell mediated immunity
(b) A reduction in the haemoglobin content in blood
(c) A reduction in the amount of plasma proteins
(d) Loss of antibody mediated immunity

71. Which hormone causes dilation of blood vessels, increased oxygen consumption and glucogenesis **[CBSE PMT 2006]**
(a) Adrenalin (b) Glucagon
(c) ACTH (d) Insulin

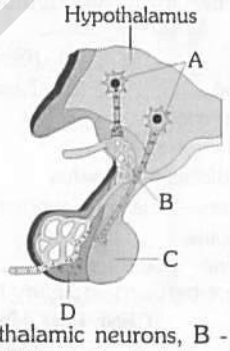
72. Consider the following figures. Identify A to D **[NCERT]**



(a) A - Thyroid, B - Corpus luteum, C - Trachea, D - Parathyroid gland
(b) A - Thyroid, B - Isthmus, C - Larynx, D - Parathyroid gland
(c) A - Thyroid, B - Isthmus, C - Trachea, D - Parathyroid gland
(d) A - Parathyroid gland, B - Isthmus, C - Trachea, D - Thyroid

73. Which of the following hormone is not involved in tyrosine metabolism **[CPMT 2010]**
(a) Calcitonin (b) Melanin
(c) Thyroxine (d) Epinephrine

74. See the given diagrammatic representation. Identify A, B, C and D **[NCERT]**



(a) A - Hypothalamic neurons, B - Portal circulation, C - Posterior pituitary, D - Anterior pituitary
(b) A - Hypothalamic neurons, B - Portal circulation, C - Anterior pituitary, D - Posterior pituitary
(c) A - Epithalamic neurons, B - Hypothalamic vein, C - Pars distalis, D - Pars intermedia
(d) A - Hypothalamic neurons, B - Hypothalamic artery, C - Posterior pituitary, D - Anterior pituitary

75. An adenohypophysis hormone which is regulated by feedback mechanism is **[Kerala PMT 2009]**
(a) Oxytocin (b) TSH
(c) Vasopressin (d) Cortisone
(e) Calcitonin

76. Match the hormones with its source of secretion

(A)	Somatostatin	(1)	Pineal gland
(B)	Melatonin	(2)	Corpus luteum
(C)	Aldosterone	(3)	Placenta
(D)	Progesterone	(4)	Adrenal cortex
(E)	HCG	(5)	Islet of Langerhans
		(6)	Adenohypophysis

[Kerala PMT 2009; CPMT 2010]
(a) (A) — (5), (B) — (1), (C) — (6), (D) — (3), (E) — (2)
(b) (A) — (1), (B) — (2), (C) — (4), (D) — (3), (E) — (5)
(c) (A) — (2), (B) — (6), (C) — (4), (D) — (5), (E) — (3)
(d) (A) — (5), (B) — (1), (C) — (4), (D) — (2), (E) — (3)
(e) (A) — (1), (B) — (3), (C) — (4), (D) — (2), (E) — (5)

77. The source of somatostatin is same as that of **[AIIMS 2003]**
(a) Thyroxine and calcitonin
(b) Insulin and glucagon
(c) Somatotropin and prolactin
(d) Vasopresin and oxytocin

78. The chemical substances released by activated spermatozoa that acts on the ground substances of the follicle cells is known as **[Kerala PMT 2009]**
(a) Progesterone (b) Hyaluronidase
(c) Relaxin (d) Gonadotropin
(e) Teratogen

79. Match list I with list II and choose the correct answer

List I		List II	
(A)	Hypothalamus	(1)	Sperm lysins
(B)	Acrosome	(2)	Estrogen
(C)	Graafian follicle	(3)	Relaxin
(D)	Leydig cells	(4)	GnRH
(E)	Parturition	(5)	Testosterone

[Kerala PMT 2009]
(a) (A) — (4), (B) — (1), (C) — (2), (D) — (3), (E) — (5)
(b) (A) — (2), (B) — (1), (C) — (4), (D) — (3), (E) — (5)
(c) (A) — (2), (B) — (1), (C) — (5), (D) — (4), (E) — (3)
(d) (A) — (4), (B) — (1), (C) — (2), (D) — (5), (E) — (3)
(e) (A) — (5), (B) — (1), (C) — (3), (D) — (2), (E) — (4)

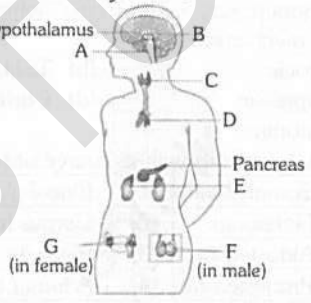
80. Which one of the following hormone never reaches to cytoplasm **[BHU 2008]**
(a) Estrogen (b) FSH
(c) Progesterone (d) Testosterone

81. Find the odd one out **[BHU 2008]**
(a) Parathyroid – tetany
(b) Pancreas – diabetes insipidus
(c) Adrenal cortex – Cushing's syndrome
(d) Thyroid – goitre

82. Which endocrine gland stores its secretion in the extracellular space before discharging it into the blood **[CBSE PMT 1995; Odisha JEE 2005]**
(a) Adrenal (b) Pancreas
(c) Testis (d) Thyroid

83. Which of the following radioactive isotopes is used in the detection of thyroid cancer **[CBSE PMT 1995]**
(a) Iodine–131 (b) Carbon–14
(c) Uranium–238 (d) Phosphorus–32

84. See the given figure which related with principal endocrine glands in human. Identify A to G **[NCERT]**



(a) A - Pituitary, B - Pineal, C - Thyroid and parathyroid, D - Thymus, E - Adrenal, F - Testis, G - Ovary
(b) A - Pituitary, B - Pineal, C - Thyroid and parathyroid, D - Thymus, E - Kidney, F - Testis, G - Ovary
(c) A - Pituitary, B - Pineal, C - Thyroid and parathyroid, D - Thymus, E - Adrenal, F - Ovary, G - Testis
(d) A - Pineal, B - Pituitary, C - Thyroid and parathyroid, D - Thymus, E - Adrenal, F - Testis, G - Ovary

85. Adrenal gland is derived from **[MP PMT 2007]**
(a) Ectoderm (b) Mesoderm
(c) Ectoderm and mesoderm (d) Ectoderm and endoderm

86. Which of the following is not an endocrine gland **[Odisha JEE 2010]**

Or

Which of the following does not secrete any hormones
(a) Liver/spleen (b) Pancreas
(c) Testes (d) Thymus

87. Melanin is secreted by **[MP PMT 2013]**
(a) Erythroblasts of blood
(b) Chromatophores of skin
(c) Cells of stratum compactum
(d) Ganglia of sensory nerves

88. Which of the following hormones has no effect on heart beat **[AFMC 2012]**
(a) Thyroxine (b) Oxytocin
(c) Adrenaline (d) Noradrenaline

89. Which of the following glands is associated with the consumption of iodized salt **[RPMT 1995; CPMT 1999; JIPMER 2001]**

Or

Thyroxine is secreted by **[RPMT 1999]**
(a) Thyroid (b) Thymus
(c) Pituitary (d) Ovary

90. The hormone which regulates the basal metabolism in our body, is secreted from **[CPMT 1998]**
(a) Pituitary (b) Thyroid
(c) Adrenal cortex (d) Pancreas

91. Hormones thyroxin, adrenaline and the pigment melanin are formed from **[CBSE PMT 1997]**
(a) Tryptophan (b) Glycine
(c) Tyrosine (d) Proline

92. Iodine is associated with **[CBSE PMT 1997; BHU 2001; WB JEE 2016]**
(a) Thyroxin (b) Calcitonin
(c) Oxytocin (d) Secretin

93. _____ is a globular protein of ~6 *kDa* consisting of 51 amino acids, arranged in 2 polypeptide chains held together by disulphide bridge **[AMU (Med.) 2012]**
(a) Insulin (b) Keratin
(c) Glucagon (d) Fibrinogen

94. Which of the following gland plays a key role in metamorphosis of frog's tadpole **[AIIMS 1999; CPMT 2003]**
(a) Adrenal (b) Thymus
(c) Pancreas (d) Thyroid

95. Goitre affects **[MP PMT 2000]**
(a) Metabolism (b) Vision
(c) Excretion (d) Speech

96. Why thyroxine is a hormone not an enzyme **[RPMT 2001]**
(a) It is secreted in small quantity
(b) It is not a polypeptide
(c) It has no special effect
(d) It is directly poured into blood

97. The other name for autoimmune thyroiditis is **[RPMT 1995; MP PMT 2001; BHU 2002; JIPMER 2002]**

Or

An autoimmune disease where the body's own antibodies attack the cells of thyroid is **[MP PMT 2007]**

(a) Addison's disease (b) Simmond's disease
(c) Hashimoto's disease (d) Cushing's disease

98. Toxic agents present in food which interfere with thyroxine synthesis lead to the development of **[CBSE PMT (Pre.) 2010]**

Or

Disease related to thyroxin hormone **[CPMT 2003]**

(a) Thyrotoxicosis (b) Toxic goitre
(c) Cretinism (d) Simple goitre

99. 'Royal jelly' is secreted from **[WB JEE 2008]**

(a) Hypopharyngeal gland (b) Salivary gland
(c) Milk gland (d) Integumentary gland

100. Hypoparathyroidism results to

(a) Upset in metabolism
(b) Improper gonodial function
(c) Convulsions and tetany
(d) Nervousness and wasting

101. Parathormone induces **[CPMT 1991, 92, 93; MP PMT 1996, 97, 2002; Pb. PMT 1999; RPMT 2000; BHU 2000; AMU (Med.) 2006]**

(a) Increase in serum calcium level
(b) Decrease in serum potassium level
(c) Increase in blood sugar level
(d) Decrease in blood sugar level

102. If parathyroid gland of a child is removed, which activity is disturbed **[CPMT 1993; AIIMS 2013]**

(a) Growth (b) Calcium concentration
(c) Potassium concentration (d) None of these

103. Diabetes mellitus is caused due to **[Odisha JEE 2012]**

(a) Underproduction of insulin
(b) Underproduction of glycogen
(c) Overproduction of insulin
(d) Overproduction of glycogen

104. In case the islets of Langerhans stop functioning which hormone will be in short supply and what will be its effect **[MP PMT 2006]**

(a) Insulin–Blood glucose level will rise
(b) Adrenaline–Heart beat will increase
(c) Thyroxin–Growth will be retarded
(d) Cortine–Tetany will develop

105. Hypokalaemia means **[MP PMT 2011]**

(a) High level of potassium in blood
(b) High level of sodium in blood
(c) Low level of potassium in blood
(d) Low level of sodium in blood

106. Most of the contraceptive pills contain **[CBSE PMT 1998, 99; BVP 2002; AFMC 2009; WB JEE 2012]**

(a) Estrogen + FSH (b) Progesterone + LH
(c) FSH + LH (d) Oestrogen + progesterone

107. Insulin increases glucose uptake in all the following structures except **[CBSE PMT 2001]**

(a) Cardiac muscle (b) Skeletal muscle
(c) Adipose tissue (d) Intestinal mucosa

108. Parathormone is secreted during **[J & K CET 2002; RPMT 2005]**

(a) Increased blood calcium level
(b) Decreased blood calcium level
(c) Increased blood sugar level
(d) Decreased blood sugar level

109. Which of the following pairs of hormones are **not** antagonistic (having opposite effects) to each other **[NEET (Phase-I) 2016]**

(a) Parathormone – Calcitonin
(b) Insulin - Glucagon
(c) Aldosterone - Atrial Natriuretic Factor
(d) Relaxin - Inhibin

110. Angiotensin is derived from plasma protein "angiotensinogen" by the action of renin and other nervous stimuli. Angiotensin stimulates the following **[CBSE PMT 1992]**

(a) Thyroid (b) Adrenal
(c) Ovary (d) Thymus

111. The hormones that initiate ejection of milk, stimulates milk production and growth of ovarian follicles are respectively known as **[Kerala PMT 2006]**

(a) PRL, OT and LH (b) OT, PRL and FSH
(c) LH, PRL and FSH (d) PRH, OT and LH
(e) PRH, OT and FSH

112. The mineralocorticoid hormone of the adrenal cortex which causes the *Na* retention and *K* excretion is **[NCERT; CMC Vellore 1993; Kerala PMT 2010; WB JEE 2011]**

Or

Conn's disease is caused by the over-secretion of **[AIIMS 1999]**

(a) Corticosol (b) Corticosterone
(c) Progesterone (d) Aldosterone

113. Which one of the following cells, found in testes of rabbit secretes male hormone **[CBSE PMT 1998]**

(a) Leydig's cell (b) Sertoli cells
(c) Epithelial cells (d) Spermatocytes

114. Which one of the following hormone controls the water and mineral metabolism

(a) Progesterone (b) Insulin
(c) Succus entericus (d) Deoxycorticosterone

115. If a human female starts developing male characteristics like beared, degeneration of uterus and ovaries, enlargement of clitoris etc. It may be due to

(a) Over production oestrogen and testosterone
(b) Damage to posterior pituitary
(c) Over production of adrenal androgens
(d) Surgical removal of mammary gland

116. Which is not a gonadal hormone **[MP PMT 1993]**

(a) Progesterone (b) Testosterone
(c) Adrenalin (d) Oestrogen

117. Goitre can occur as a consequence of all the following except **[WB JEE 2009]**

(a) Iodine deficiency
(b) Pituitary adenoma
(c) Grave's disease
(d) Excessive intake of exogenous thyroxine

118. Cushing's syndrome and myxoedema are associated with these glands respectively **[CBSE PMT 1993]**
(a) Thyroid, adrenal (b) Adrenal, thyroid
(c) Parathyroid, thyroid (d) Adrenal, pituitary

119. Cholecystokinin and secretin are **[CBSE PMT 1990; JIPMER 1993; MP PMT 1994, 95]**
(a) Hormones liberated by mucosa of duodenum and stimulate gall bladder and pancreas respectively
(b) Hormones stimulating liver
(c) Hormones stimulating pancreas
(d) Enzymes

120. Deficiency in the activity of adrenal cortex leads to **[MP PMT 2002, 06]**
(a) Addison's disease (b) Simmond's disease
(c) Cohn's syndrome (d) Cushing's disease

121. Which of the following hormone governs the metabolism of carbohydrates **[CBSE PMT 1993]**
(a) Corticoids (b) Glucagon
(c) Insulin (d) Glucagon and insulin

122. Which one of the following is both hormone and enzyme **[RPMT 2000]**
(a) ADH hormone (b) Acetylcholinesterase
(c) Angiotensinogen (d) Renin

123. Blood pressure is controlled by **[NCERT; MP PMT 2004]**
(a) Adrenal (b) Thyroid
(c) Thymus (d) Corpus luteum

124. Which of the following endocrine glands functions under nervous control
(a) Cortex of adrenal glands (b) Medulla of adrenal glands
(c) Anterior pituitary glands (d) Posterior pituitary gland

125. Insulin is secreted by **[BVP 2001; Odisha PMT 2002; CPMT 2003]**
(a) Pituitary (b) Pancreas
(c) Gonads (d) Thymus

126. Adrenal cortex secretes androgen, it is **[CPMT 1992, 93]**
(a) Testosterone (b) Androsterone
(c) Progesterone (d) Aldosterone

127. Adrenal glands are found located in abdominal cavity in close association with **[MP PMT 1994; AFMC 2003; Odisha JEE 2012]**
Or
Which one of the following is not a gland **[AFMC 2003]**
(a) Testes (b) Spleen
(c) Liver (d) Kidneys

128. The genetic deficiency of ADH-receptor leads to **[MP PMT 2001; WB JEE 2008, 09]**
(a) Diabetes mellitus (b) Glycosuria
(c) Diabetes insipidus (d) Nephrogenic diabetes

129. Which of the following is correctly matched **[AFMC 2009, 10]**
(a) Thyroxine - tetanus (b) Insulin - diabetes insipidus
(c) Adrenaline – hepatitis (d) Parathyroid - tetany

130. Catecholamine in a normal person induces **[AIIMS 2012]**
(a) Intense salivation (b) Alertness
(c) Decrease in heart beat (d) Excessive urination

131. Hormone involved in the discharge of pancreatic juice in mammals is
(a) Secretin (b) Gastrin
(c) Cholecytokinin (d) Enterogasterone

132. Hypothyroidism in adults and hyperparathyroidism will respectively lead to **[Kerala PMT 2006]**
(a) Myxoderma and Cretinism
(b) Grave's disease and Hashimoto's disease
(c) Myxoedema and Osteitis fibrosa cystica
(d) Addison's disease and Cretinism
(e) Cretinism and Osteitis fibrosa cystica

133. Which one of the following pairs is incorrectly matched **[CBSE PMT (Pre.) 2010]**
(a) Insulin-Diabetes mellitus (Disease)
(b) Glucagon-Beta cells (Source)
(c) Somatostatin-Delta cells (Source)
(d) Corpusluteum-Relaxin (Secretion)

134. The main function of nor-adrenaline is **[CPMT 1995]**
(a) Contraction of arteries
(b) To stop contraction of arteries
(c) Relaxation
(d) None of the above

135. Cause of Addison's disease is **[CPMT 1996, 99; AIIMS 1998; MP PMT 2003]**
(a) Hyposecretion of aldosterone hormone
(b) Hypersecretion of aldosterone hormone
(c) Hyposecretion of cortisone hormone
(d) Hypersecretion of cortisone hormone

136. Life saving hormone is secreted by which gland **[MP PMT 1999]**
(a) Adrenal gland (b) Hypothalamus gland
(c) Pituitary gland (d) Thyroid gland

137. Which hormone can increase rate of formation of glycogen, volume of blood in vessel and rate of heart beat **[KCET 1994; CPMT 1998]**
(a) Insulin (b) Glucagon
(c) Adrenalin (d) FSH

138. Which of the following hormones is a derivative of amino acid **[AIIMS 1999; MP PMT 2010; Kerala PMT 2010, 11]**
(a) Oestrogen (b) Epinephrine
(c) Progesterone (d) Prostaglandin

139. Glucagon hormone is secreted by **[CBSE PMT 1993]**
(a) Pituitary
(b) Adrenal
(c) Beta cells of islets of Langerhans
(d) Alpha cells of islets of Langerhans

140. Nor epinephrine is secreted from **[RPMT 2000]**
(a) Zona glomerulosa (b) Zona fasciculata
(c) Zona reticularis (d) Medulla of adrenal

141. Which gland is concerned with salt equilibrium in body **[RPMT 2001]**
(a) Anterior pituitary (b) Pancreas
(c) Adrenal (d) Thyroid

142. Which one affects liver, muscle and adipose tissue **[BHU 2003]**

Or

Name a peptide hormone which acts mainly on hepatocytes, adipocytes and enhances cellular glucose uptake and utilization **[NEET (Phase-II) 2016]**

(a) Androgen (b) Insulin
(c) Progesterone (d) Glucagon

143. Hassal's bodies/corpuscles **[DPMT 2006]**

(a) Adrenal medula (b) Thyroid
(c) Thymus (d) Parathyroid

144. Norepinephrine **[RPMT 2006; NEET (Karnataka) 2013]**

(A) Is released by sympathetic fibers
(B) Is released by parasympathetic fibers
(C) Increases the heart rate
(D) Decreases blood pressure

Which of the above said statements are correct

(a) (A) and (C) (b) (B) and (C)
(c) (B) and (D) (d) (A) and (D)

145. Pineal body originates from **[MP PMT 2003]**

(a) Dorsal part of diencephalon
(b) Ventral part of diencephalon
(c) Ventral part of cerebellum
(d) Dorsal part of cerebellum

146. According to recent knowledge, the pineal body is considered as

(a) A vestigeal organ
(b) An organ of intelligence
(c) An endocrine gland
(d) An organ of involuntary action

147. Identify the hormone with its correct matching of source and function **[CBSE PMT 2014]**

(a) Progesterone – corpus-luteum, stimulation of growth and activities of female secondary sex organs
(b) Atrial natriuretic factor – ventricular wall increases the blood pressure
(c) Oxytocin – posterior pituitary, growth and maintenance of mammary glands
(d) Melatonin – pineal gland, regulates the normal rhythm of sleepwake cycle

148. Daily rythms are usually associated with **[CPMT 1999; JIPMER 2001]**

Or

One of the following endocrine gland functions as a biological clock and a neurosecretory transducer **[Kerala PMT 2006]**

(a) Pineal (b) Pituitary
(c) Thymus (d) Hypothalamus

149. In a pregnant woman having prolonged labour pains, if child birth has to be hastened *i.e* to aid parturition, it is advisable to administer a hormone that can **[DPMT 1993]**

(a) Activate the smooth muscles
(b) Increase the metabolic rate
(c) Release glucose into the blood
(d) Stimulate the ovary

150. Which one of the following statement about sex hormones is correct **[MP PMT 1992]**

(a) Testosterone is produced by Leydig cells under the influence of luteinizing hormone (LH)
(b) Progesterone is secreted by corpus luteum and soften ligaments during child birth
(c) Estrogen is secreted by both Sertoli cells and corpus luteum
(d) The progesterone produced by corpus luteum is biologically different from the one produced by placenta

151. Luteinizing hormone **[KCET 1994]**

(a) Stimulates ovulation
(b) Stimulates the egg mother cell to undergo completion of meiotic cycle
(c) Stimulates the corpus luteum to secrete progesterone
(d) All of the above

152. Testosterone, a hormone responsible for the development of secondary sexual characteristics in male is produced by the **[AIIMS 1992]**

(a) Spermatogonia
(b) Seminiferous tubules
(c) Anterior lobe of the pituitary
(d) Cells that lie between seminiferous tubules

153. Parathormone influences calcium absorption in the small intestine by regulating the metabolism of **[AMU (Med.) 2010; DUMET 2010]**

(a) Vitamin *C* (b) Vitamin *D*
(c) Vitamin B_6 (d) Enterogasterone

154. Continued secretion of milk is maintained by **[MP PMT 1993; CPMT 2001, 03; MH CET 2006]**

Or

Which of the following is a lactogenic hormone **[MP PMT 2013]**

(a) Prolactin (b) Progesterone
(c) Estrogen (d) Relaxin

155. Signal from fully developed foetus and placenta ultimately lead to parturition(child birth) which requires the release of **[NCERT; DPMT 1993; CBSE PMT 1999; CPMT 2001; CBSE PMT (Mains) 2010; NEET (Karnataka) 2013]**

(a) Estrogen from placenta
(b) Oxytocin from maternal pituitary
(c) Oxytocin from foetal pituitary
(d) Relaxin from placenta

156. Progesterone hormone is secreted by **[NCERT; CPMT 2001; MP PMT 1994, 96, 2009; BHU 2003; CBSE PMT 2014]**

(a) Corpus luteum (b) Corpus callosum
(c) Corpus uteri (d) Corpus albicans

157. Diabetes is due to **[CBSE PMT 1999]**

(a) Na^+ deficiency (b) Hormonal deficiency
(c) Enzyme deficiency (d) Iodine deficiency

158. Hormone responsible for the implantation of embryo in uterus and formation of placenta is **[BHU 1999]**

Or

Pregnancy hormone is **[CPMT 1994]**

(a) Adrenalin (b) Progesterone
(c) Estradiol (d) FSH

159. Graafian follicles are formed by the active division of
(a) Peritoneum
(b) Generative epithelium
(c) Columnar epithelium (sensory)
(d) Corpus cavernosa

160. Insulin receptors are **[DPMT 2007]**
(a) Extrinsic protein (b) Intrinsic protein
(c) G-protein (d) Trimeric protein

161. The 24 hour (diurnal) rhythm of our body such as the sleep-wake cycle is regulated by the hormone **[NCERT; Kerala PMT 2010; MP PMT 2011; CBSE PMT (Mains) 2011]**

Or

Which hormone is secreted more in dark condition **[MP PMT 2000]**
(a) Adrenaline (b) Melatonin
(c) Calcitonin (d) Prolactin

162. Which one of the following is temporary endocrine gland **[NEET 2017]**
(a) Pineal (b) Pancreas
(c) Placenta (corpus luteum) (d) Parathyroid

163. Female sex hormone is **[MP PMT 1993]**

Or

Which of the following hormone is not chemically glycoprotein **[WB JEE 2016]**
(a) Androgen (b) Adrenalin
(c) Insulin (d) Estrogen

164. Which hormone is secreted at the time of parturition **[MP PMT 1993]**
(a) Progesterone (b) Thyroxin
(c) Relaxin (d) Glucocorticoid

165. Match the items in Column – I with Column – II and choose the correct alternative

	Column – I		Column – II
A.	Calcitonin	1.	Treatment of viral infections
B.	Gonadotropin	2.	Treatment of rickets
C.	Erythropoietin	3.	Enhancement of immune action
D.	Interferon	4.	Formation of erythrocytes
E.	Interleukin	5.	treatment of infertility

[Kerala PMT 2007]
(a) A – 3, B – 1, C – 4, D – 2, E – 5
(b) A – 3, B – 2, C – 1, D – 5, E – 4
(c) A – 4, B – 3, C – 2, D – 1, E – 5
(d) A – 2, B – 3, C – 4, D – 5, E – 1
(e) A – 2, B – 5, C – 4, D – 1, E – 3

166. The effect of prolactin will be marked in **[MP PMT 1993]**
(a) Bones (b) Pancreas
(c) Mammary gland (d) Liver

167. "*Islets of Langerhans*" are found in **[MP PMT 1994, 98; JIPMER 2002; BHU 2006; WB JEE 2010]**
(a) Pancreas (b) Pituitary
(c) Stomach (d) Spleen

168. Cholesterol is necessary for the synthesis of
(a) Vitamin C (b) Vitamin B
(c) Oestradiol (d) Insulin

169. Which one of the following statements is incorrect **[WB JEE 2012]**
(a) Glucagon is secreted by pancreas
(b) Androgen is produced by ovary
(c) Thyroxine is secreted by thyroid
(d) Oxytocin is secreted by pituitary

170. Which of the following is known as master endocrine gland **[Odisha JEE 2012]**
(a) Adrenal gland (b) Thyroid gland
(c) Pituitary gland (d) Pineal gland

171. The rise of blood sugar above the normal level is known as **[DPMT 1993]**
(a) Hyperglycemia (b) Hypoglycemia
(c) Glucosuria (d) Glycolysis

172. A disease characterised by raised levels of blood glucose as well as increased fat and protein metabolism is **[CBSE PMT 1993]**
(a) Diabetes (b) Cancer
(c) Ulcer (d) Enlargement of pancreas

173. Steroid hormones regulate gene activity through **[AFMC 1993]**
(a) Transcription
(b) Binding with specific DNA sites
(c) Removing the repressor molecules
(d) The formation of a receptor complex

174. A polypeptide secreted into the blood by the cells in the stomach wall, stimulates the production of *HCl* by the parietal cells of the stomach is **[CBSE PMT 1993]**
(a) Gastrin (b) Secretin
(c) Pancreozymin (d) Renin

175. Function of relaxin hormone is
(a) Relax pubic symphysis (b) Relax ovaries
(c) Relax uterus (d) Relax fallopian tubule

176. Insulin was isolated from dog by
(a) M. Bayliss (b) E.H. Sterling
(c) Banting and Best (d) Von Mering

177. Given below is an incomplete table about certain hormones, their source glands and one major effect of each on the body in humans. Identify the correct option for the three blanks A, B and C

Glands	Secretion	Effect on body
A	Oestrogen	Maintenance of secondary sexual character
Alpha cells of Islets of Langerhans	B	Raises blood sugar level
Anterior pituitary	C	Over secretion leads to gigantism

Options **[NCERT; CBSE PMT (Pre.) 2011]**

	A	B	C
(a)	Placenta	Glucagon	Calcitonin
(b)	Ovary	Glucagon	Growth hormone
(c)	Placenta	Insulin	Vasopressin
(d)	Ovary	Insulin	Calcitonisn

178. Which hormone stimulates the secretion of milk during sucking of milk by baby **[CBSE PMT 1996]**

Or

Which hormone is responsible for milk ejection after the birth of the baby **[MP PMT 2007; WB JEE 2010]**

(a) Oxytocin (b) Relaxin
(c) Prolactin (d) Progesteron

179. Which hormone among these is not secreted by an endocrine gland **[Kerala PMT 2012]**

(a) ADH (b) ANF
(c) T_4 (d) PTH
(e) MSH

180. Choose the mismatched pair from the following **[KCET 2012]**

(a) Insulin – Gluconeogenesis
(b) Glucagon – Glycogenolysis
(c) Oxytocin – Contraction of uterine muscles
(d) Prolactin – Milk production in mammary glands

181. Match the source gland with its respectively hormone as well as the function **[NCERT; CBSE PMT (Pre.) 2011; NEET 2013]**

	Source gland	Hormone	Function
(a)	Thyroid	Thyroxine	Regulates blood calcium level
(b)	Anterior pituitary	Oxytocin	Contraction of uterus muscles during child birth
(c)	Posterior pituitary	Vasopressin	Stimulates reabsorption of water in the distal tubules in the nephron
(d)	Corpus luteum	Estrogen	Supports pregnancy

182. Match the column I with column II and select the correct option

Column I		Column II	
A.	ANF	1.	Regulates blood calcium levels
B.	MSH	2.	Decreases blood pressure
C.	GIP	3.	Pigmentation
D.	TCT	4.	Inhibits gastric secretion

[Kerala PMT 2011; MH CET 2015]

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

183. During menstruation the level of progesterone in blood is **[DPMT 2003]**

(a) Low (b) High
(c) Normal (d) Very high

184. Hormone prolactin was discovered by

(a) Riddle (b) Hisaw
(c) Leonard (d) Hisaw and Leonard

185. During pregnancy which of the following is secreted through urine of mother **[NCERT; CPMT 1993; AIEEE Pharmacy 2003; MP PMT 2009, 11; WB JEE 2012]**

Or

The persistance of corpus luteum during pregnancy is due to a hormone known as **[MP PMT 2001]**

(a) Progestron (b) Luteinizing hormone
(c) FSH (d) Chorionic gonadotropin

186. When mammary glands of male develop similar to that of female, then this condition is known as **[Odisha JEE 2005; J & K CET 2010]**

(a) Gonochorism (b) Gynaecomastia
(c) Feminism (d) Gynaecism

187. Select the correct matched pair **[Kerala PMT 2011]**

(a)	Pineal gland	–	Does not influence menstrual cycle
(b)	Corpus luteum	–	Secretes oxytocin
(c)	Interstitial cells	–	Erythropoietic
(d)	Cholecystokinin	–	Stimulates pancreatic enzyme secretions
(e)	Thyroxine	–	Triiodothyronine

188. Diabetes mellitus is caused due to the deficiency of insulin which is secreted by **[MP PMT 1992, 95, 98, 2001; CPMT 1996; RPMT 2001; Odisha JEE 2012]**

(a) Alpha cells (b) Beta cells
(c) Pituitary (d) Thyroid

189. Which of the following statements are false/true

A. Calcitonin regulates the metabolism of calcium
B. Oxytocin stimulates contraction of uterine muscles during birth
C. Grave's disease is caused by malfunctioning of adrenal gland
D. *ADH* stimulates absorption of water and increase the urine productions **[Kerala PMT 2007]**

(a) *A* and *C* are true ; *B* and *D* are false
(b) *A* and *B* are true ; *C* and *D* are false
(c) *A* and *D* are false ; *B* and *C* are true
(d) *A*, *B* and *C* are true ; *D* only false
(e) *A* only true ; *B*, *C* and *D* are false

190. Match the columns

	Column-I		Column-II
A.	Adrenaline	1.	Anger, fear, danger, pain
B.	Oestrogen	2.	Attracting partners through sense of smell
C.	Insulin	3.	Females
D.	Pheromones	4.	Glucose

[Kerala CET 2003; AIIMS 2010]

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

191. The function of glucagon hormone is **[MP PMT 2003]**

(a) To increase glycogenesis
(b) To decrease blood sugar level
(c) To release glucose from liver cells and glycogenolysis promotion
(d) To increase the absorption of glucose and fatty acids through cell

192. Glucagon and insulin are **[Bihar MDAT 1995; AIEEE Pharmacy 2003]**

(a) Antagonistic secretions
(b) Secreted by same cells and perform similar function
(c) Secreted by different cells and perform antagonistic function
(d) Secreted by same cells and perform antagonistic functions
(e) None of the above

193. Which one of the following hormone is antiinflamatory **[MP PMT 1992]**
(a) Secretin (b) Epinephrin
(c) Glucoprotein (d) Glucocorticoid

194. An overdose of intravenous insulin may lead to the death of an individual due to **[MP PMT 1992]**
(a) An excessive increase of blood glucose
(b) An excessive decrease of blood glucose
(c) An inhibition of glucagon secretion
(d) An over production of histamine

195. Pancreas secretes **[RPMT 1995]**
(a) Digestive enzymes (b) Insulin
(c) Glucagon (d) All the above

196. Gluconeogenesis is controlled by **[CPMT 1994]**
(a) Cortisol (b) Corticosterone
(c) Thyroxine (d) All the above

197. 'Mammalian thymus' is mainly concerned with **[BHU 2006]**
(a) Regulation of body temperature
(b) Regulation of body growth
(c) Immunological functions
(d) Secretion of thyrotropin

198. The structure of insulin consists of two polypeptide chains *A* and *B*. These two polypeptide chains
(a) Have equal number of amino acids
(b) Chain *A* has 21 amino acids, while chain *B* has 30 amino acids
(c) Chain *A* has 30 amino acids, while chain *B* has 21 amino acids
(d) Chain *A* has 11 amino acids, while chain *B* has 40 amino acids

199. Match column I (hormone) with column II (endocrine gland) and column III (function)

	Column I		Column II		Column III
1.	Melatonin	A.	Thyroid	i.	Acts on the renal tubules
2.	MSH	B.	Adrenal	ii.	Regulates blood calcium levels
3.	Aldosterone	C.	Pituitary	iii.	Maintains diurnal rhythm of our body
4.	TCT	D.	Pineal	iv.	Acts on the melanocytes

[Kerala PMT 2012]
(a) 4-A-iv; 3-D-iii; 1-B-ii;; 2-C-i
(b) 1-D-iii; 2-C-iv; 3-B-i; 4-A-ii
(c) 1-B-i; 4-A-iii; 3-C-ii; 2-D-iv
(d) 2-D-ii; 1-B-I; 4-C-iv; 3-C-iii
(e) 2-C-iv; 3-A-ii; 1-D-iii; 4-B-i

200. Which of the following hormones is responsible for hoarseness in voice, beard, moustaches *etc.* in males **[CPMT 1995]**
(a) Gonadotropic hormone (b) Adrenaline
(c) Thyroid (d) All the above

201. Which hormone(s) of the following endocrine glands lacks peptides, amines and sulphur **[AFMC 1995]**
(a) Hormone of anterior pituitary
(b) Hormone of posterior pituitary and pancreas
(c) Hormone of thyroid and adrenal gland
(d) Hormone of testes and ovary

202. With reference to the pituitary, which of the following statements is true **[KCET 2011]**
(a) Neurohypophysis secretes vasopressin and oxytocin
(b) Neurohypophysis secretes TSH and STH
(c) Neurohypophysis collects and stores vasopressin and oxytocin
(d) Adenohypophysis secretes vasopressin and oxytocin

203. Progesterone is a **[RPMT 1995]**
(a) Carbohydrate (b) Steroid
(c) Protein (d) Sterol

204. Low Ca^{++} in the body fluid may be the cause of **[CBSE PMT (Pre.) 2010]**
(a) Gout (b) Tetany
(c) Anaemia (d) Angina pectoris

205. Gorilla like man with large head and hands and protruding jaws, is produced due to **[MP PMT 1997]**
(a) Over secretion of thyroxin
(b) Over secretion of growth hormone since maturity
(c) Excess of vitamin '*C*' in diet
(d) Excess secretion of TSH

206. In males, the essential hormone for secondary sexual characteristics is **[MP PMT 1999]**

Or

The hormone which brings about characteristic changes in the male at puberty is called
(a) Testosterone (b) Progesterone
(c) Estrogen (d) Relaxin

207. The adrenal cortex synthesizes only **[WB JEE 2016]**
(a) Steroid hormones (b) Peptide hormones
(c) Glycopeptide hormones (d) Catecholamines

208. The posterior pituitary gland is **not** a 'true' endocrine gland because **[NEET (Phase-II) 2016]**
(a) It secretes enzymes
(b) It is provided with a duct
(c) It only stores and releases hormones
(d) It is under the regulation of hypothalamus

209. GnRH, a hypothalamic hormone, needed in reproduction, acts on **[NEET 2017]**
(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

NCERT Exemplar Questions

1. Select the right match of endocrine gland and their hormones among the options given below

A. Pineal	i. Epinephrine
B. Thyroid	ii. Melatonin
C. Ovary	iii. Estrogen
D. Adrenal medulla	iv. Tetraiodothyronine

Options **[NCERT]**
(a) A-iv, B-ii, C-iii, D-i (b) A-ii, B-iv, C-i, D-iii
(c) A-iv, B-ii, C-i, D-iii (d) A-ii, B-iv, C-iii, D-i

2. Listed below are the hormones of anterior pituitary origin. Tick the wrong entry **[NCERT]**
(a) Growth hormone
(b) Follicle stimulating hormone
(c) Oxytocin
(d) Adrenocorticotrophic hormone

3. Mary is about to face an interview. But during the first five minutes before the interview she experiences sweating, increased rate of heart beat, respiration etc. Which hormone is responsible for her restlessness **[NCERT]**
(a) Estrogen and progesterone
(b) Oxytocin and vasopressin
(c) Adrenaline and noradrenaline
(d) Insulin and glucagons

4. The steroid responsible for balance of water and electrolytes in our body is **[NCERT]**
(a) Insulin (b) Melatonin
(c) Testosterone (d) Aldosterone

5. Thymosin is responsible for **[NCERT]**
(a) Raising the blood sugar level
(b) Raising the blood calcium level
(c) Increased production of T lymphocytes
(d) Decrease in blood RBC

6. One of the following conditions is not linked to deficiency of thyroid hormones **[NCERT]**
(a) Cretinism (b) Goitre
(c) Myxoedema (d) Exophthalmosis

7. Cortisol is secreted from **[NCERT]**
(a) Pancrease (b) Thyroid
(c) Adrenal (d) Thymus

8. Hormones are called chemical signals that stimulate specific target tissues. Their specificity is due to the presence of signal receiving 'receptors' only in the respective target tissues. Where are these receptors present in case of hormones of protein nature **[NCERT]**
(a) Extra cellular matrix (b) Blood
(c) Plasma membrane (d) Nucleus

9. Choose the correct answer among the following options

A. Epinephrine	i. Increase in muscle growth
B. Testosterone	ii. Decrease in blood pressure
C. Glucagon	iii. Decrease in liver glycogen content
D. Atrial natriuretic factor	iv. Increase heart beat

Options: **[NCERT]**
(a) A-ii, B-i, C-iii, D-iv (b) A-iv, B-i, C-iii, D-ii
(c) A-i, B-ii, C-iii, D-iv (d) A-i, B-iv, C-ii, D-iii

10. Blood calcium level is a resultant of how much dietary calcium is absorbed, how much calcium is lost in the urine, how much bone dissolves releasing calcium into the blood and how much calcium from blood enters tissues. A number of factors play an important role in these processes. Mark the one which has no role **[NCERT]**
(a) Vitamin D (b) Parathyroid hormone
(c) Thyrocalcitonin (d) Thymosin

11. All the following tissues in mammals except one consists of a central 'medullary' region surrounded by a cortical region. Mark the wrong entry **[NCERT]**
(a) Ovary (b) Adrenal
(c) Liver (d) Kidney

Critical Thinking

Objective Questions

1. In an accident the anterior pituitary of a four year old boy was severely damaged but the boy survived. What is likely to happen **[MP PMT 1992]**
(a) High levels of thyroxin will be released
(b) Spermatogenesis will be stimulated
(c) The boy will not grow much in height
(d) The growth of mammary glands will be stimulated

2. Which one of the following hormones inhibits gastric secretion **[CPMT 1992, 93]**
(a) Gastrin (b) Secretin
(c) Enterogastrone (d) Cholecystokinin

3. 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 **[CBSE PMT 2007]**

Or

Injury to adrenal cortex is not likely to affect the secretion of which one of the following **[CBSE PMT (Pre.) 2010]**
(a) Thyroxin (b) Adrenaline
(c) Glucagon (d) Gastrin

4. The correct set of a single endocrine gland hormone is
(a) Oxytocin, prolactin, ACTH
(b) Oxytocin, vasopressin, ADH
(c) Thyroxin, secretin, ACTH
(d) Epinephrin, cortisol, ICSH

5. Which of the following is an emergency hormone **[NCERT; CPMT 1995, 2000; AIIMS 2000; AFMC 2001; MH CET 2003; BHU 2006; MP PMT 2013]**

Or

When an animal is angry and wants to fight, the hormone that is secreted is
(a) Pituitary (b) Prolactin
(c) Progesterone (d) Adrenalin

6. Appearance of facial hairs in a woman may be due to the effect of **[MP PMT 1992]**
(a) Temperature (b) Ultraviolet radiation
(c) Hormone (d) Pollution

7. Thyroxine is **[MP PMT 1998; BVP 2000]**
(a) An enzyme (b) A hormone
(c) A vitamin (d) An excretory product

8. If thyroid gland is completely removed from a tadpole, it will **[MP PMT 2001]**
(a) Die immediately
(b) Turn into a giant frog
(c) Turn into a dwarf frog
(d) Remain tadpole throughout its life

9. Which one of the following is an example of negative feedback loop in humans **[CBSE PMT 2007]**
(a) Constriction of skin blood vessels and contraction of skeletal muscles when it is too cold
(b) Secretion of tears after falling of sand particles into the eye
(c) Salivation of mouth at the sight of delicious food
(d) Secretion of sweat glands and constriction of skin blood vessels when it is too hot

10. In the homeostatic control of blood sugar level, which organs function respectively as modulator and effector **[KCET 2006]**
(a) Liver and islets of langerhans
(b) Hypothalamus and liver
(c) Hypothalamus and islets of langerhans
(d) Islets of langerhans and hypothalamus

11. The urine of a man is very dilute and the quantity of urine is too much and dehydration has started in his body and he is very thirsty by the cause of **[CPMT 1994]**
(a) Hypersecretion of ADH (b) Hyposecretion of ADH
(c) Both (a) and (b) (d) None of the above

12. Which of the following pair of hormones is responsible for the growth and maturation of the graafian follicle **[MP PMT 1995; BHU 2006]**
(a) GH–ADH (b) ACTH–LH
(c) FSH–LH (d) FSH–LTH

13. FSH and LH hormones together are called **[MP PMT 1997, 2002; CPMT 2000; HPMT 2005]**
(a) Emergency hormones (b) Gonadotropic hormones
(c) Neurohormones (d) Outstress hormones

14. Secretion of progesterone by corpus luteum is initiated by **[CBSE PMT 1999]**
(a) MSH (b) LH
(c) Testosterone (d) Thyroxine

15. Which hormone promotes cell division, protein synthesis and bone growth **[AFMC 1999; BVP 2000; RPMT 2002]**
(a) GH (STH) (b) PTH
(c) ADH (d) ACTH

16. Function of hypothalamus is **[RPMT 1995]**
(a) Helps in sleeping (b) Related to hunger and thirst
(c) Temperature regulation (d) All the above

17. Which of the following is both (mixed) exo and endocrine gland **[AFMC 2000; RPMT 2001; MP PMT 2002; Odisha JEE 2012]**
(a) Thyroid (b) Pancreas
(c) Payer's patches (d) Thymus

18. Which endocrine gland becomes inactive in old age **[MP PMT 1999; DPMT 2006]**
(a) Adrenal (b) Pineal
(c) Thymus (d) Pituitary

19. Which of the following is an accumulation and release centre of neurohormones **[CBSE PMT 2006]**
(a) Hypothalamus
(b) Anterior pituitary lobe
(c) Posterior pituitary lobe
(d) Intermediate lobe of the pituitary

20. Which of the following is not secreted by pituitary gland **[RPMT 1995]**
(a) ACTH (b) GH
(c) FSH (d) Thyroxine

21. A man has an I.Q. equivalent to that of a boy 5 years old, this is due to deficiency of which hormone **[CPMT 1996]**
(a) Thyroxin (b) Adrenaline
(c) Aldosterone (d) Somatotropin

22. Hypersecretion of Growth Hormone in adults does not cause further increase in height, because **[NEET 2017]**
(a) Growth Hormone becomes inactive in adults
(b) Epiphyseal plates close after adolescence
(c) Bones loose their sensitivity of Growth Hormone in adults
(d) Muscle fibres do not grow in size after birth

AR Assertion & Reason

Read the assertion and reason carefully to mark the correct option out of the options given below :

(a) If both the assertion and the reason are true and the reason is a correct explanation of the assertion
(b) If both the assertion and reason are true but the reason is not a correct explanation of the assertion
(c) If the assertion is true but the reason is false
(d) If both the assertion and reason are false
(e) If the assertion is false but reason is true

1. Assertion : Diabetes insipidus is marked by excessive urination and too much thirst of water.
Reason : Anti–diuretic hormone (ADH) is secreted by the posterior lobe of pituitary. **[AIIMS 2008]**

2. Assertion : Adrenal cortex can be removed without causing death.
Reason : Adrenal cortex is not vital for survival.

3. Assertion : Adrenal cortex is called the gland for 'fight, fright and flight'.
Reason : The hormones adrenaline and noradrenaline help the body to combat against stress and emergency conditions.

4. Assertion : FSH is also known as interstitial cell stimulating hormone.
Reason : It is because of the fact that FSH stimulates the interstitial cells of testis.

5. Assertion : Failure of secretion of somatotropin from an early age causes dwarfism in the patient.
Reason : Somatotropin hormone stimulates the body growth and elongation of long bones.

6. Assertion : A tumor of adrenal cortex may cause addison's disease.
Reason : This happens due to over secretion of cortisol by the tumor.

7. Assertion : Oxytocin is also known as Anti Diuretic hormone (ADH).
Reason : Oxytocin can cause an increase in the renal reabsorption of water.

8. Assertion : Prolactin is also called the 'Milk ejection hormone'.
Reason : Prolactin stimulates the smooth muscle contractions of the mammary glands.

9. Assertion : The tadpoles become giant tadpoles when fed on thiourea.
Reason : Thiourea is an antithyroid substance.

10. Assertion : Females have less stature than males after puberty.
Reason : This happens because of the presence of HCG in the blood of females.

Answers

Hormones and their mechanism

1	b	2	d	3	c	4	b	5	c
6	d	7	a	8	b	9	d	10	c
11	b	12	c	13	d	14	c	15	b
16	b	17	c	18	d	19	d	20	a
21	c	22	c						

Different glands and their hormones

1	b	2	d	3	d	4	b	5	c
6	a	7	a	8	a	9	b	10	b
11	c	12	d	13	a	14	b	15	a
16	c	17	c	18	d	19	c	20	c
21	d	22	c	23	d	24	b	25	b
26	c	27	c	28	d	29	d	30	b
31	c	32	b	33	b	34	a	35	a
36	b	37	a	38	c	39	b	40	c
41	d	42	b	43	a	44	d	45	a
46	a	47	a	48	a	49	b	50	c
51	a	52	d	53	a	54	a	55	c
56	a	57	b	58	d	59	d	60	d
61	c	62	d	63	c	64	a	65	c
66	d	67	d	68	b	69	a	70	a
71	a	72	c	73	a	74	a	75	b
76	d	77	b	78	b	79	d	80	b
81	b	82	d	83	a	84	a	85	c
86	a	87	b	88	b	89	a	90	b
91	c	92	a	93	a	94	d	95	a
96	d	97	c	98	d	99	a	100	c
101	a	102	b	103	a	104	a	105	c
106	d	107	d	108	b	109	d	110	b
111	b	112	d	113	a	114	d	115	c
116	c	117	d	118	b	119	a	120	a
121	d	122	d	123	a	124	b	125	b
126	b	127	d	128	c	129	d	130	b
131	a	132	c	133	b	134	a	135	a
136	a	137	c	138	b	139	d	140	d
141	c	142	b	143	c	144	a	145	a
146	c	147	d	148	a	149	a	150	a
151	d	152	d	153	b	154	a	155	b
156	a	157	b	158	b	159	b	160	a
161	b	162	c	163	d	164	c	165	e
166	c	167	a	168	c	169	b	170	c
171	a	172	a	173	a	174	a	175	a
176	c	177	b	178	a	179	b	180	a
181	c	182	e	183	a	184	d	185	d
186	b	187	d	188	b	189	b	190	c
191	c	192	c	193	d	194	b	195	d
196	d	197	c	198	b	199	b	200	a
201	d	202	c	203	b	204	b	205	b
206	a	207	a	208	c	209	b		

NCERT Exemplar Questions

1	d	2	c	3	c	4	d	5	c
6	d	7	c	8	c	9	b	10	d
11	a								

Critical Thinking Questions

1	c	2	c	3	b	4	b	5	d
6	c	7	b	8	d	9	d	10	c
11	b	12	c	13	b	14	b	15	a
16	d	17	b	18	c	19	a	20	d
21	a	22	b						

Assertion and Reason

1	b	2	d	3	e	4	d	5	a
6	d	7	d	8	d	9	a	10	c

AS Answers and Solutions

Hormones and their mechanism

1. (b) Cyclic AMP and GMP act as intracellular mediators and affect the cell metabolism in various ways. According to the second messenger theory given by *Sutherland* the 1st messenger is hormone itself and the 2nd messenger is cyclic AMP.

3. (c) Hormone is a chemical messenger produced by endocrine glands and secreted directly into the blood stream to exert a specific effect on a distant part of the body.

7. (a) Kupffer's cells occur in the lining of liver sinusoids and help in phagocytosis.

9. (d) Hormone do not belong to a single chemical group but are varied in their composition is polypeptide, proteins, amines or steroid.

11. (b) Pheromones serve to conduct messages by smell and taste and affect the mutual behaviour of members of a species.

13. (d) The father of endocrinology is Thomas Addison. The first endocrine disease reported was Addison's disease caused by destruction of adrenal cortex.

14. (c) Starling (1905) first used the term hormone for internal secretion.

15. (b) The molecules of amino acid derivatives, peptides or polypeptide (protein) hormones bind to specific receptor molecules located on the plasma membrane of target cells.

17. (c) Ionositoltriphosphate (IP_3) & diacylglycerol (DAG) act as intracellular secondary messengers responsible for amplification of signal. IP_3, being water soluble, diffuses in the cytoplasm to stimulate the release of Ca^{+2} from endoplasmic reticulum of target cells. The latter activate many Ca^{+2} mediated reactions. DAG remains in the cell membrane to activate the enzyme protein kinase – C. Certain body cells use more than one secondary messenger, e.g. in heart cells, c-AMP acts as a secondary messenger to stimulate the release of Ca^{2+} from sarcoplasmic reticulum of muscle fibre resulting in muscle contraction.

Phospholipase is any of various enzymes that cleave particular bonds in the polar phosphate 'heads' of glyerophospholipids.

18. (d) Hormones composition can be polypeptide proteins, amines or steroid.

20. (a) Endocrine glands are ductless gland their secretion flows directly into the blood stream.

Different glands and their hormones

2. (d) Deficiency of somatotrophic hormone (STH) from early age result in growth of long bones and of the body stops prematurely making the patient Dwarf.

5. (c) Myxoedema occurs due to deficiency of thyroxine is adults. It is characterized by low BMR, low body temperature, reduced heart rate, pulse rate, cardiac output. Face and hands become swollen.

7. (a) Aldosterone is secreted by adrenal cortex and is responsible for regulation of Na^+ and K^+ levels in body.

8. (a) Both are neurohypophyseal hormones and ADH is the only other name for vasopressin.

12. (d) In the male, ICSH stimulates the interstitial cells of leydig in testis to develop and secrete large amount of testosterone.

13. (a) In male, FSH stimulates the testis to initiate sperm production.

16. (c) Failure of secretion of vasopressin leads to a reduced renal reabsorption of water and a consequent elimination of a large volume of very dilute urine this disorder is known as diabetes incipidus.

18. (d) ADH and oxytocin are secreted by hypothalamus and stored in posterior pituitary.

19. (c) Hypoparathyroidism results in hypocalcemia. Skeletal muscles fail to relax causing tetany and hyperparathyroidism result in osteoporosis i.e. dissolution of bone and hypercalcemia.

21. (d) Cortisol and testosterone are steroid group of hormones which bind to intracellular receptor.

22. (c) MSH increases skin pigmentation by stimulating the dispersion of melanin granules in melanocytes. Since it affects the target cells directly i.e. it affect the distribution of melanin granules in the chromatophores/melanocytes directly.

25. (b) Vasopressin decreases loss of water through urine. Glucagon is released from α – cells. Prolactin is released from anterior pituitary.

27. (c) Endemic goitre is due to low iodine in soil and water in hilly areas.

29. (d) The hyposecretion of GH in the adult life lead to a rare condition called "simmond's disease" The patient becomes quite thin and shows signs of premature ageing.

34. (a) At the dorsal surface of diencephalon.

36. (b) Follicular stimulating hormone (FSH) is glycoprotein in nature.

38. (c) The gonadotrophic hormones (FSH and ICSH (= LH) are secreted by anterior lobe of the pituitary (adenohypophysis).

39. (b) Hypothalamus regulates body temperature.

43. (a) In pregnant female, hCG maintains the corpus luteum which secretes estrogen and progesterone.

45. (a) Basophil cells of *pars distalis* or anterior pituitary secrete luteinizing hormone which is responsible for maintenance of corpus luteum.

46. (a) Pitressin is also called as ADH or vasopressin.

54. (a) In fight or flight reactions, emergency hormones are secreted by adrenal medulla.

56. (a) Hypothalamus cells are also known to synthesize two more hormones : oxytocin and vasopressin which are stored in their axons extending in the posterior lobe of pituitary gland.

57. (b) Vasopressin reduces the excretion of water in urine by promoting its reabsorption from DCT. When vasopressin is released in lesser amounts, diuresis increases.

60. (d) Neurosecretory cells of hypothalamus secrete neurohormones called thyrotrophic releasing factors (TRF) or inhibiting factor (IF).

62. (d) Calcitonin is a noniodinized hormone secreted by the parafollicular cells (clear or cells) of thyroid stroma.

64. (a) Simple goitre is caused by lower intake of iodine through diet, goitre is the swelling of neck due to enlargement of thyroid.

65. (c) Myxoedema occurs due to deficiency of thyroxine in adult. The peculiar feature of myxoedema is that face and hand become swollen due to deposition of albuminous myxomatous tissue.

66. (d) Acromegaly characterised by abnormal elongation of limbs and lower jaw, giving gorilla like appearance and kyphosis protruding bony ridge over the eyes. It occurs due to oversecretion of STH in adult.

67. (d) Hyposecretion of thyroxine during the growing years of birth is called childhood hypothyroidism or cretinism. Two important symptoms are dwarfism and mental retardation also.

68. (b) Exophthalmic goitre (Grave's disease) is hyperthyroidism. Eye balls protrude due to accumulation of mucus in eye orbits metabolic rate is abnormally high.

82. (d) Thyroid gland is made up of tiny follicles (hollow spheres whose wall is singly layered cuboidal epithelium). In these follicles, thyroid hormones are stored, and bound to a protein called thyroglobulin formed by the follicle. To release the hormones into the blood, the epithelial cells take up thyroglobulin by pinocytosis and remove the active hormone from thyroglobulin.

83. (a) Iodine is used by thyroid gland for the synthesis of thyroid hormone. Thus radio active isotope iodine – 131 is used as radioactive material for detection of thyroid cancer.

89. (a) Iodine is essential for the synthesis of thyroid hormones. An adult human body contains about 5 to 6mg of iodine and most of it is found in thyroid gland. Thyroxine is iodine containing amine hormone which is derived from tyrosine amino acid and secreted by thyroid gland.

90. (b) The most important function of thyroid hormone is to enhance the basal metabolic rate in our body. They are secreted by thyroid gland.

94. (d) Thyroid initiate, regulates and plays a key role in the metamorphosis of frog's tadpole. The changes that takes place during transformation of larva into adult are called as metamorphosis.

101. (a) Parathormone is secreted by parathyroid gland. It is also called as parathymin. it controls calcium levels in blood plasma and metabolism.

106. (d) Contraceptive pills for women contain female sex hormones oestrogen and progesterone. These prevent development of eggs and ovulation by inhibiting secretion of FSH some pills contain progesterone only in such cases ovulation may occur but cervical mucus is thickened preventing the entry of sperm.

112. (d) Mineralocorticoids hormones are 21-carbon steroids secreted by the cells of zona glomerulosa of adrenal cortex. The principal mineralcorticoid is aldosterone. It is a salt retaining hormone". It upgrades sodium ion concentration in the ECF by promoting reabsorption of sodium ions from renal tubules and excretion of potassium ions in urine. Conn's disease is characterised by rise in blood volume and pressure and is caused due to over secretion of aldosterone.

113. (a) The endocrine part of testes is formed of groups of cells, called interstitial cell or leydig's cells. Leydig's cells of testes are stimulated to secrete male sex hormones called, androgen.

116. (c) Progesterone, Testosterone and Oestrogen these are the hormones of gonads. But the adrenalin is the hormone of adrenal medulla.

120. (a) Hyposecretion of glucocorticoids which are a hormone of adrenal cortex results in addison's disease.

124. (b) Because adrenal medulla is a modified sympathetic ganglion of autonomic nervous system. It develops from same embryonic tissue as all other sympathetic ganglia develop.

127. (d) Adrenal glands are paired endocrine glands located superior to kidney, hence called 'suprarenals'.

133. (b) Glucagon is secreted by α-cells of pancreatic islets.

136. (a) Life-saving hormones are secreted by adrenals. An increased output of cortisol is actually "life saving in shock condition".

137. (c) Adrenalin increases the rate of heart beat and cardiac out put, so increases blood pressure.

138. (b) Epinephrine hormones are amine hormones and are derivatives of catechol, so collectively called catecholamines.

139. (d) Glucagon is a hyperglycaemic or diabetogenic polypetide hormone secreted by α-cells of islets of langerhans. Its secretion is stimulated by low blood sugar level.

140. (d) Medulla of adrenal secrets nor-epinephrin/adrenalin hormone which is sympathomimetic.

141. (c) Aldosterone hormone of the adrenal cortex is also called salt retaining hormone. Increased sodium concentration increases salt concentration of interstitial fluid which increases water reabsorption.

143. (c) Hassal's corpuscles are spherical or oval bodies present in the thymus. They are phagocytic in function.

145. (a) Pineal gland is an endocrine organ, it is located on the roof of diencephalon.

146. (c) Pineal body was considered vestigeal of 3rd eye earlier but now has been confirmed to be endocrine gland.

147. (d) Pineal gland secretes three hormones namely melatonin, serotonin and adrenoglomerulotropin.

149. (a) The hormone oxytocin is sometimes used to hasten the child birth. It contracts the involuntary smooth muscles of the uterus to expel the child.

152. (d) Called *Sertoli cells*.

154. (a) Sucking at nipple causes reflexes to release oxytocin hormone from the posterior pituitary gland which in turn causes the contraction of breast alveoli and secretion of milk.
Prolactin another hormone is responsible for production of milk not its secretion.

155. (b) Oxytocin causes contraction of the smooth muscles of myometrium forcing the foetus out of the uterus. Oxytocin is also involved in ejection of milk, but not lactation (actual production of milk) for milk to be produced, prolactin must be present.

156. (a) Progesterone is a principal female sex hormones. It is a steroid. It is secreted during the later half of the menstrual cycle in human female by temporary endocrine tissue, the corpus luteum. The luteinizing hormone (LH) of anterior pituitary brings about a rupture of the graafian follicle to release the ovum, and changes the ruptured follicle into a yellow structure called corpus luteum, which secrets progesterone.

158. (b) Progesterone a hormone produced by mammalian corpus luteum maintains pregnancy. It is responsible for the implantation of embryo and formation of uterine bed and placenta, as well as for inhibiting of ovulation and action of oxytocin on uterus during pregnancy.

160. (a) The molecules of hormones that are amino acid derivatives, peptides or proteins are large and insoluble in lipids, and cannot enter the target cell. Therefore, they act at the cell surface. They bind to specific receptor molecules located on the surface of the cell membrane. Insulin is a polypeptide hormone, so it operates through extracellular membrane bound receptor, a heterotetrameric protein (extrinsic protein) on the target cell.

161. (b) Melatonin, secreted by the pineal gland, stimulates the concentration of pigment granules in the melanocytes, lightening the skin colour.

162. (c) A temporary structure with endocrine function is placenta.

164. (c) It increases width of vaginal passage by relaxing pelvic ligaments there by helps in parturition *i.e.* child birth.

166. (c) It increases synthesis and secretion of milk.

167. (a) Pancreas is a hetrocrine gland. The endocrine part is formed of about 1 to 2 million groups of epithelial cells, called islets of langerhans.

171. (a) High sugar level in blood is called hyperglycemia.

175. (a) Relaxin is a proteinous hormone secreted by the corpus albicans formed from the corpus luteum at the end of gestation period. It softens the public symphysis so help in parturition (child birth).

176. (c) Banting and Best (1921) extracted insulin from pancreas and showed that it reduces blood sugar in dogs.

177. (b) *A.* Ovary secretes oestrogen for maintenance of secondary sexual characters.
B. Alpha cells of Islets of Langerhans secrete glucagon which raises blood sugar level.
C. Anterior lobe of pituitary secretes growth hormone. Its over secretion leads to gigantism.

181. (c) Vasopressin (ADH) is synthesised in hypothalamus but released into the blood from posterior lobe of pituitary, so it is called as a hormone of posterior lobe. It stimulates reabsorption of water in distal tubules in the nephron.

185. (d) Its presence in urine confirms pregnancy, therefore used for pregnancy test.

186. (b) Excessive secretion of female hormones in adult males may cause enlarged mammary gland (Gynaecomastia) and retards growth of breast.

188. (b) Beta cells of islets of Langerhans.

192. (c) Glucagon is antagonistic to insulin. Antagonistic hormones are those which work against each others. Glucagon increases sugar level in blood and insulin decreases glucose level in blood.

193. (d) Glucocorticoids include three main hormones : cortisol, corticosterone and cortisone. Cortisone has anti insulin effect. It also helps in reducing pain cortisol is anti-in flammatory.

194. (b) Oral dose of insulin is degenerated by the hydrolysing action of enzymes in the stomach.

195. (d) Pancreas is a heterocrine gland which secrets both enzyme and hormone.

197. (c) 'Mammalian thymus' is a bilobed lymphoid organ situated in front of the heart in the upper part of sternum.

198. (b) Chemically insulin is a protein (large polypeptide) Insulin contains 51 amino acid arranged in two chain, an acidic A chain containing 21 amino acid residues and a basic B-chain containing 30 residue.

201. (d) Hormones produced by gonads *i.e.* testis and ovary are steroid in chemical nature *i.e.* they are derived from fats.

203. (b) Chemical nature of progesterone is steroid (cholesterol) *i.e.* derived from fats.

205. (b) The hypersecretion during adulthood is called acromegaly (after the closure of the epiphyseal plates at the ends of the bones) Acromegaly patient has a gorilla-like appearance with huge hand and legs.

206. (a) Testosterone stimulates the development of male secondary sexual charcters like-beard, moustaches, deepening of voice, broadening of shoulders, increased height due to elongation of bones and increased development of limbs.

207. (a) All hormones of adrenal cortex are steroid in nature and are derived from cholesterol.

Critical Thinking Questions

2. (c) Enterogasterone is secreted by the epithelium which inhibits gastric secretion and motality.

4. (b) Oxytocin and ADH is secreted from posterior pituitary, vasopressin is another name of ADH.

5. (d) Adrenaline whip up metabolism to prepare animal to face special physical or mental stress. This cause contraction of spleen to squeeze out the reserve blood as well as stimulate the breakdown of liver and muscle glycogen to provide more glucose for respiration.

8. (d) Because thyroid gland helps in tissue differentiation and hence, in metamorphosis.

11. (b) Due to deficiency of ADH water absorption by kidney tubules is decreased leading to excessive urine formation *i.e.* diuresis, so the person feels thirsty due to dehydration.

13. (b) FSH and LH are collectively known as gonadotropic hormone because they regulate the growth and functioning of gonads.

15. (a) The chief function of STH (GH) is to promote synthesis and secretion of small protein hormone called insulin like growth factors (IGFs).

17. (b) Pancreas is a mixed gland (heterocrine gland) with both exocrine and endocrine portion.

18. (c) Thymus is well developed in new born child and grows upto the age of puberty after that it starts shrinking and almost disappears in old age.

20. (d) Thyroxine is secreted by thyroid gland.

21. (a) Thyroxine causes the development and differentiation of brain.

Assertion and Reason

1. (b)

2. (d) Adrenals or suprarenals are two conical pyramid shaped glands, one immediately above each kidney. Each adrenal is made up of an outer layer called adrenal cortex and a central portion called adrenal medulla. The cortex and the medulla secrete different hormones and are regulated in different ways. Adrenal cortex is vitally important for life because it secretes a number of steroid hormones belonging to three broad groups viz. glucocorticoids, mineralocorticoids and sex corticoids. Hence its destruction or removal kills the animal. On the other hand, Adrenal medulla is not vital for surrival and may be removed without causing death. Adrenal medulla helps the body to combat against stress or emergency conditions by secreting two hormones viz. adrenaline and noradrenaline.

3. (e) It is not the adrenal cortex but the adrenal medulla which is also called the gland for 'fight, fright and flight', because the hormones secreted by adrenal medulla viz. adrenaline and noradrenaline helps the body to combat against stress or emergency conditions. Adrenaline or epinephrine dilates (widens) arterioles in the skeletal muscles and constricts (narrows) those in the skin and abdominal viscera. It increases the rate and force of heart beats and arterial blood pressure by enhancing the cardiac output. Adrenaline relaxes the smooth muscles of gastro-intestinal tract, and urinary bladder and bronchioles and contracts the sphincters of gastrointestinal tract and bladder.

increases blood sugar and blood lactic acid levels and also increases heat production, metabolic rate and body temperature. Noradrenaline or norepinephrine constricts arterioles in general or increase the total peripheral resistance against the flow of blood. The coordinated actions of both adrenaline and noradrenaline, thus help the body to react under stress conditions.

4. (d) It is not FSH (follicle stimulating hormone), but the LH (luteinizing hormone) which is also known as Interstitial Cell Stimulating Hormone (ICSH). It stimulates the interstitial cells of leydig, of testis to secrete the male sex hormone testosterone and other androgen to regulate the secondary sexual characteristics.

The follicle stimulating hormone (FSH) is secreted by anterior pituitary. It stimulates the testes in the males to produce sperms and the ovaries in the female to produce ova. It also stimulates ovaries to secrete female sex hormones called oestrogens.

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

6. (d) A destruction of adrenal cortex by diseases like tuberculosis produces Addison's disease, due to the deficiency of glucocorticoids and mineralocorticoids which are secreted by the adrenal cortex region zona fasciculata and zona glomerulosa respectively. Symptoms of Addison's disease include a bronze-like pigmentation of skin, low blood sugar, low plasma Na^+, high plasma K^+, increased urinary Na^+, nausea, vomiting and diarrhoea.

Cortisol is a glucocorticoid which regulates the metabolisms of carbohydrates, fats and proteins. A tumor of the adrenal cortex may secret too much cortisol to produce Cushing's syndrome.

High blood sugar, appearance of sugar in the urine, obesity, wasting of limb muscles, rise in plasma Na^+, fall in plasma K^+, rise in blood volume and high blood pressure are observed in the patient suffering from Cushing's syndrome.

7. (d) It is not oxytocin, but the hormone vasopressin (also known as antidiuretic hormone, ADH) because it reduces the volume of urine by increasing the reabsorption of water from the urine in the distal convoluted tubules, collecting tubules and collecting ducts in the kidney.

It does so by rendering the walls of those tubules permeable to water. Failure of secretion of vasopressin leads to a reduced renal reabsorption of water and a consequent elimination of a large volume of very dilute (hypotonic) urine. Oxytocin is another hormone released by the posterior lobe of pituitary gland. Oxytocin contracts the mammary glands, smooth muscles of uterus. Uterine contractions, stimulated by oxytocin at the end of pregnancy, help in the child-birth or parturition, hence also called birth hormone.

8. (d) It is not prolactin but oxytocin hormone also known as 'milk ejection hormone' because the oxytocin induces contractions of the mammary gland muscles help in the flow of stored milk from the mammary glands to the mouth of the suckling infant. Oxytocin contracts the smooth muscles of uterus and mammary glands. Uterine contractions, stimulated by oxytocin at the end of pregnancy, help in the child-birth. That is why, it is also called 'Birth hormone'.

Prolactin or lactogenic hormone or luteotrophic hormone (LTH) is secreted by the anterior pituitary which helps in the growth of mammary glands during pregnancy and initiates the secretion of milk after child-birth.

9. (a) The thyroid gland secretes thyroxine and triiodothyronine hormone. One of their function is stimulation of tissue differentiation. Because of this action, they promote metamorphosis of tadpoles into adult frogs. Feeding of anti-thyroid substances like thiourea to tadpoles, delays their metamorphosis. As they continue to grow without metamorphosis, they become giant tadpoles.

10. (c) Males have more stature than females because of the action of male sex hormone-testosterone which is secreted by testis in males. Body starts secreting testosterone from the age of puberty. Its secretion is under the influence of Luteinising Hormone (LH) of the anterior lobe of pituitary gland. Testosterone controls the development of secondary sexual characters in males like hoarseness of voice, development of facial hairs, bone growth, calcium retention, closing of epiphysial cartilage. The total quantity of bone matrix increases. The pelvic outlet is narrowed and lengthened. The strength of the pelvic bones increases to carry more loads. That is why males have more stature than females after puberty when this hormone is present in the blood.

HCG (Human Chorionic Gonadotropin) is the hormone secreted by human placenta during pregnancy. HCG enlarges the corpus luteum in the mother's ovary and stimulates it to secrete progesterone.

Chemical Co-ordination and Integration

SET Self Evaluation Test

1. The secretion of following anterior pituitary hormones is controlled by hypothalamus **[MP PMT 1992]**
   (a) Thyrotropin (TSH) and cortisol
   (b) Follicle stimulating hormone (FSH) and progesterone
   (c) Corticotropin (ACTH), growth hormone and vasopressin
   (d) Luteinizing hormone (LH), corticotropin (ACTH) and thyrotropin (TSH)
2. Which of the following hormone is not steroid **[CPMT 2009]**
   (a) Androgen (b) Aldosterone
   (c) Testosterone (d) Vasopressin
3. Hypersecretion of GH from pituitary in the adult causes a disease called **[CPMT 2004; MH CET 2005; MP PMT 2009]**
   (a) Gigantism (b) Acromegaly
   (c) Cushing's disease (d) Addison's disease
4. The nervous control of pituitary secretion lies in
   (a) Infundibulum (b) Pituitary centre
   (c) Hypothalamus (d) Medulla oblongata
5. The hormone responsible for the regulation of metabolism of calcium and phosphorus is secreted by **[RPMT 1995]**
   (a) Thyroid
   (b) Parathyroid and thyroid both
   (c) Thymus
   (d) Pancreas
6. The hormone which controls the rate of body metabolism is **[CBSE PMT 1993; RPMT 2006]**
   (a) Thyroxin (b) Insulin
   (c) ACTH (d) HGH
7. Hypothyroidism causes **[DPMT 2007]**
   (a) Myxodema (b) Cretinism
   (c) Both (a) and (b) (d) Exophthalmic goitre
8. A person is having problems with calcium and phosphorus metabolism in his body. Which one of the following glands may not be functioning properly **[CBSE PMT 2007]**
   (a) Parathyroid (b) Parotid
   (c) Pancreas (d) Thyroid
9. Epinepherine is
   (a) Nephrostomal part of mesoderm
   (b) Clusters of glomeruli in mammalian kidney
   (c) Hormone of the adrenal gland
   (d) Frontal lobe of nephridia
10. A steroid hormone which regulates glucose metabolism is **[CBSE PMT 2006]**

    Or

    Excess of which of the following hormones causes Cushing's syndrome **[AFMC 2009]**
    (a) 11-deoxycorticosterone (b) Cortisone
    (c) Cortisol (d) Corticosterone
11. Prostaglandins are **[CPMT 2009]**
    (a) Amino acid (b) Steroid
    (c) Fatty acid (d) Carbohydrate
12. Which of the endocrine gland is mainly concerned with immunity in man **[CPMT 1994; MP PMT 1994, 99; Odisha JEE 2010]**
    (a) Parathyroid gland (b) Adrenal gland
    (c) Thymus gland (d) Posterior pituitary gland
13. The pancreas secretes **[MP PMT 2013]**
    (a) Pancreozymin (b) Angiotensin I
    (c) Somatostatin (d) Angiotensin II
14. Column I lists the endocrine structure and column II lists the corresponding hormones. Match the two columns. Identify the correct option from those given

Column I		Column II
A.	Hypothalamus	p. Relaxin
B.	Anterior pituitary	q. Estrogen
C.	Testis	r. FSH and LH
D.	Ovary	s. Androgens
		t. Gonadotropin releasing hormone

[Pb PMT 2000; KCET 2000, 06; JIPMER 2001; BHU 2005; MP PMT 2012]
(a) A=t, B=r, C=s, D=q (b) A=t, B=r, C=q, D=s
(c) A=p, B=q, C=s, D=r (d) A=r, B=t, C=s, D=q

15. Match the hormone in column I with their function in column II

Column I		Column II
A.	FSH	1. Prepare endometrium for implantation
B.	LH	2. Develops female secondary sexual characters
C.	Progesterone	3. Contraction of uterine wall
D.	Estrogen	4. Development of corpus luteum
		5. Maturation of graffian follicle

[Kerala PMT 2006]
(a) A–5, B–4, C–1, D–2 (b) A–4, B–5, C–2, D–1
(c) A–4, B–3, C–2, D–5 (d) A–5, B–1, C–2, D–4
(e) A–4, B–2, C–3, D–5

AS Answers and Solutions

1	d	2	d	3	b	4	c	5	b
6	a	7	c	8	a	9	c	10	c
11	c	12	c	13	c	14	a	15	a

1. (d) Hypothalamus secretes both releasing and inhibitory hormones controlling the secretion of some anterior pituitary hormones (LH, ACTH, and TSH etc.)
3. (b) Hypersecretion of growth hormones or somatotrophic hormone during adulthood causes acromegaly. Acromegaly patient has a gorilla like appearance with huge hands and legs.
4. (c) Hypothalamus synthesizes and secretes certain specific chemicals called factors which pass to adenohypophysis to control secretion of its hormones, thereby called master of masterglands.
5. (b) Parathyroid and thyroid hormones regulates the amount of calcium and phosphate in extra cellular fluid. It promotes the absorption of calcium from food in intestine, it accelerates elimination of phosphates in urine.
6. (a) Thyroxine's main function is to control the BMR-metabolism. These help in homeothermy in warm blooded animals.
9. (c) The chromaffin cells of adrenal medulla synthesize two hormones adrenaline or epinephrine (80%) and noradrenaline or norepinephrine (20%).
12. (c) Thymus is the site of differentiation of T-lymphocytes of immunity system.

* * *