HUMAN ENDOCRINE SYSTEM

Hypothalamus

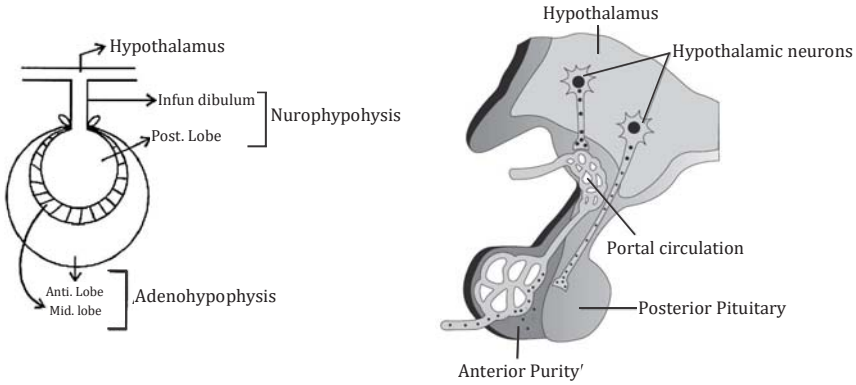
- The hypothalamus is the basal part of diencephalon (forebrain) and it regulates a wide spectrum of body functions.
- It contains several groups of neurosecretory cells called nuclei which produce hormones.
- These hormones regulate the synthesis and secretion of pituitary hormones.
- The hormones produced by hypothalamus are of two types –
- Releasing hormones (which stimulate secretion of pituitary hormones)
- Inhibiting hormones (which inhibit secretions of pituitary hormones).
- **Example –**
  - **(a)** A hypothalamic hormone called Gonadotrophin releasing hormone (GnRH) stimulates the pituitary synthesis and release of gonadotrophins (FSH and LH).
  - **(b)** On the other hand, somatostatin from the hypothalamus, inhibits the release of growth hormone (GH) from the pituitary.
- These hormones originating in the hypothalamic neurons, pass through axons and are released from their nerve endings.
- These hormones reach the pituitary gland through a portal circulatory system and regulate the functions of the anterior pituitary.
- The posterior pituitary is under the direct neural regulation of the hypothalamus.

Pituitary Gland (Hypothesis)

- It is situated in a bony case, sella–turcica of sphenoid bone.
- It is ectodermal in origin.
- This gland is attached to the hypothalamus through a stalk which is called as infundibulum.
- The lower terminal end of infundibulum is bulging type which is called as posterior lobe or pars nervosa.
- It is divided anatomically into two parts -
- Adenohypophysis (Includes anterior lobe and middle lobe)
- Neurohypophysis (Includes posterior lobe)

Adeno hypophysis (Anterior pituitary)	Neurohypophysis (Posterior Pituitary)
Contributes 75% part of total	Contributes 25% of total
Consists of pars distalis (Anterior lobe) and pars intermedia (middle lobe)	Consists of infundibulum and pars nervosa.
Developed from a pouch of foregut (Ectodermal)	Developed as an outgrowth of hypothalamus (Ectodermal)
Works under regulation of hypothalamus through portal circulation	Works direct under neural regulation of hypothalamus.
It secretes 6 trophic hormones	Stores and releases 2 hypothalamic hormones

- Hypophyseal portal vein collects the blood form hypothalamus and supplies to the anterior pituitary.



Hormones Secreted By Adenohypophysis

1. Growth Hormone Or Somatotrophic [G.H. Or S.T.H] :-

Effect on growth –

i. Promotes elongation of bones
ii. GH promotes mitosis & increases number of cells in many visceral organs e.g. liver
iii. GH stimulates growth of muscle and cartilage

Effect on metabolism

Fat:

Increases lipolysis. Under the influence of growth hormone fat is used for energy in preference to carbohydrate and protein.

Carbohydrate:

GH decreases uptake of glucose in the cells, so it is also called diabetogenic hormone.

Protein:

GH increases amino acid uptake by the cells of the liver & muscles & helps in protein synthesis.

Disorders of GH:

1. Hyposecretion:

- Deficiency of GH in childhood or adolescence, causes pituitary dwarfism (Ateliosis).
- Clowns of circus are such dwarfs, they are called midgets. This midget is physically & mentally Normal while sexual maturation is delayed.

2. Hypersecretion:

Gigantism:

- It is caused due to excess secretion of growth hormone during childhood.
- It is characterized by giant but proportionate and imbalanced body.

Acromegaly:

- It is caused the two excess secretion of growth hormone after adolescene.
- It is characterized by disproportionate increase in size of bones of face, hands and feet.

Thyrotrophic [T.T.H or T.S.H.] or Thyroid Stimulating Hormone :-

T.S.H stimulates thyroid gland to secrete thyroxine. TSH helps in almost all steps of the thyroid hormone synthesis & it causes growth of thyroid gland.

Secretion of TSH is stimulated by Thyrotropin releasing factor of hypothalamus.

Adreno Cortico Trophic Hormone or Corticotropin [ACTH]:

It accelerates the cortex part of adrenal gland to secrete hormones, mainly glucocorticoids.

3. **Follicle Stimulating Hormone [FSH]:**
   - In males, it stimulates spermatogenesis in seminiferous tubulus of testes.
   - In females, it stimulates oogenesis and development of Graafian follicles in ovary.
   - Secretion of estrogen hormone from Graafian follicle is also regulated by FSH.
4. **Luteinizing Hormone (LH):**
   - It stimulates ovulation and formation of corpus luteum in females.
   - Hormone progesterone which is secreted by corpus luteum is also stimulated by L.H.
   - In men LH is called Interstitial Cell Stimulating Hormone (ICSH). It affects the Leydig's cells or Interstitial cells of testes and stimulates the secretion of male hormone "Testosterone".
   - FSH and LH both are collectively called gonadotrophic hormone (GTH).
   - Gonadotrophic hormones (FSH & LH) secretion starts during puberty. Their secretion is regulated by hypothalamus.

Lute trophic or Prolactin or Lactogenic or Mammotrophin Hormone (PRL):

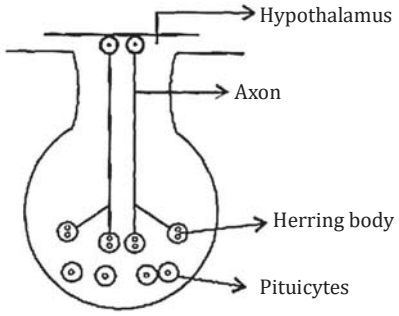
Lactation (Galactopoietic)

Prolactin is responsible for lactation (milk formation) in postpartum (after delivery) in women.

5. **Melanocyte Stimulating Hormone [MSH] :-**
   - It is secreted by middle lobe but in human the pars intermedia is almost merged with pars details.
   - In man, MSH is secreted by anterior lobe.
   - MSH is also called Intermedia.
   - It stimulates the melanocytes to synthesize melanin in mammals, but role of MSH in determining skin color in human is still doubtful.
   - MSH is produced in all vertebrate but it is more effective in lower vertebrates.
   - This hormone is related with change in the colour of skin in Amphibian and Reptiles. This phenomenon of colour changing is known as metachrosis.
   - It darkens the complexion of skin by distributing melanin pigment evenly under the skin.
   - Just opposite to it, melatonin secreted by pineal body, collects the melanin pigments at one place thus fairing the complexion of skin.

Neurohypophysis

It is just like nervous tissue, consists of supporting neuroglia cells (Pituicytes) and the axons of neurosecretory cells of hypothalamus. The swollen axon ends are called "Herring bodies". Hormones are released in these bodies.



Posterior pituitary hormones are not synthesised in the gland itself but they are synthesized in the neurosecretory cells (Nuclei) of hypothalamus.

(A) ADH or Vasopressin :-

- It acts mainly at the kidney and stimulates reabsorption of water and electrolytes in DCT and collecting duct of nephrons and thereby reduces loss of H_2O through urine (Diuresis), Hence, it is also called as "Anti-diuretic hormone(ADH)".
- Hyposecretion of ADH causes "Diabetes insipidus" (taste less urine or water drinker's disease), Which is characterised by polyuria, diluted urine, dehydration, excessive thirst (polydipsia) low BP (hypotension) etc.
- Intake of coffee, tea and excess alcohol etc. decreases the secretion of ADH .

(B) Oxytocin or Pitocin :-

It is the main parturition hormone. It stimulates the fast/ rapid contractions and expansions of non-striated muscles of the uterine wall at the last moment of gestation period (pregnancy). Due to this uterine constrictions, labour pains start just before child birth.

- This hormone is secreted by pituitary glands of mother at the time of parturition.
- Oxytocin hormone contracts the myoepithelial cells present at .all the sides of alveoli of mammary glands. Thus it helps in milk ejection so it is also called milk let down hormone.
- In female, this hormone related with emotion. Even thought, cry or sound of baby can bring about release of this hormone in lactating mother.
- Oxytocin acts on the smooth muscles of our body and stimulates their contraction. In females, it stimulates a vigorous contraction of uterus at the time of child birth, and milk ejection from the mammary gland.

Pineal Body (Epiphysis)

Position:-

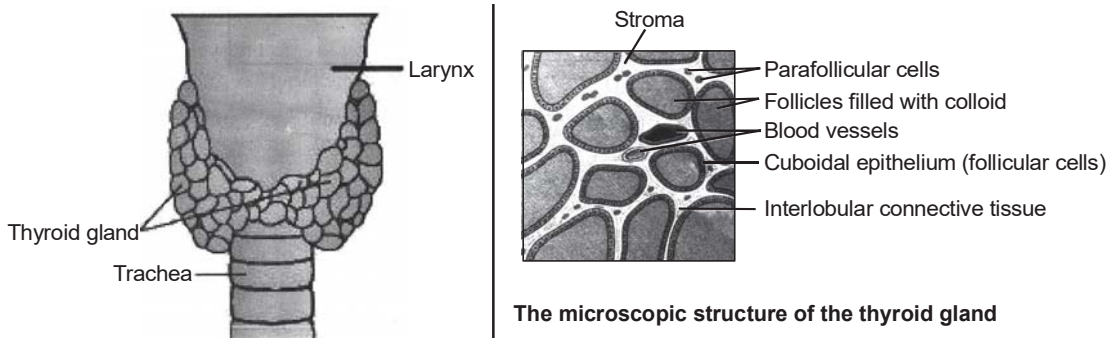
- It is situated at the dorsal side of diencephalon (Epithalamus) of anterior part of brain. It is also known as epiphysis cerebri. Pineal body is a part of brain. It is ectodermal in origin.
- There are found pinealocyte cells (formed by the modification of nerve cells) and supporting interstitial cells or neuroglial cells in pineal body.

Hormone & Functions :-

- Pineal body secretes a hormone melatonin, which is an amino acid derivative.
- Melatonin plays a very important role in the regulating of a diurnal/ circadian rhythm, for example normal rhythm of sleep wake cycle, body temperature etc.
- It is proved that the level of melatonin rises during periods of darkness and falls during periods of light.
- Melatonin also influence metabolism, pigmentation, menstrual cycle & defense capability.
- In amphibians and reptiles, this hormone is related with metachrosis (change in the colour of skin). It affects the Melanophores of skin, thus acts antagonistically to the MSH of pituitary i.e. it fairs the complexion of skin.
- The hormone controls the sexual behavior in mammals. It inhibits the sexual irritation, and also inhibits the development of genitalia and their functions.
- Maximum development of pineal body up to 7year & then it undergoes involution & at the age of 14 year interstitial tissue and crystals of $CaCO_3$ or Ca_3PO_4 are deposited in it, these are called "Brain sand" or "Acervuli"

Thyroid Gland

It is the largest endocrine gland in the body.
It is situated at the ventro-lateral side of the joint of trachea and larynx in the neck region of man. If is bilobed and H shaped. Both of its lobes are connected by non-glandular flap of a connective tissue called isthmus.
It is endodermal in origin.
Each lobe of thyroid gland is made up of connective tissue. (Stroma) and many round follicles of glandular cells.



The microscopic structure of the thyroid gland

- A layer of cuboidal glandular cells is found in the wall of follicles. An iodised colloidal substance Thyroglobulin is filled in the cavity of these follicles. Thyroglobulin is glycoprotein in nature.
- Thyroid is the only endocrine gland in the body which stores its hormone in its inactive state. Para follicular cells are found in interstitial tissue in between the follicle & secrete calcitonin (TCT) hormone

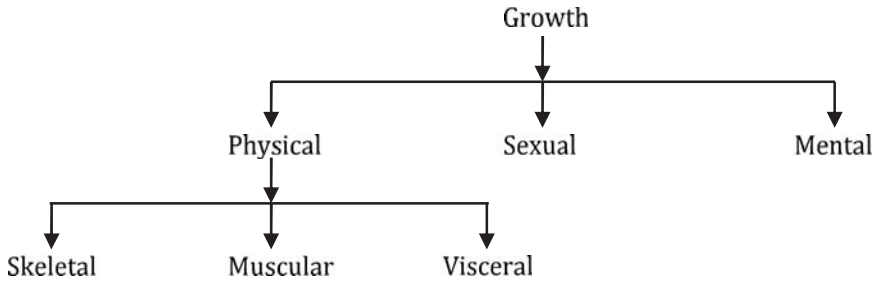
Production of hormones :-

T_3 = Tri Iodo thyronine (20%)
T_4 = Tetra Iodo thyronine (80%) or Thyroxine

- Secretion of T_4 is comparatively more than T_3, and T_3 hormone is four times more effective than T_4 hormone. T_4 changes into T_3 on reaching in the tissues.
- Thyroxine or Tetra- Iodo- Thyronin is a derivative of tyrosine amino acid.
- Thyroid hormones in the form of thyroglobulin are stored in the follicles in an amount sufficient to supply the body with its normal requirements of thyroid hormone for 3 months.
  Thyroid gland requires iodine "120 μg" every day for the production of thyroxine.

Functions of thyroxine :-

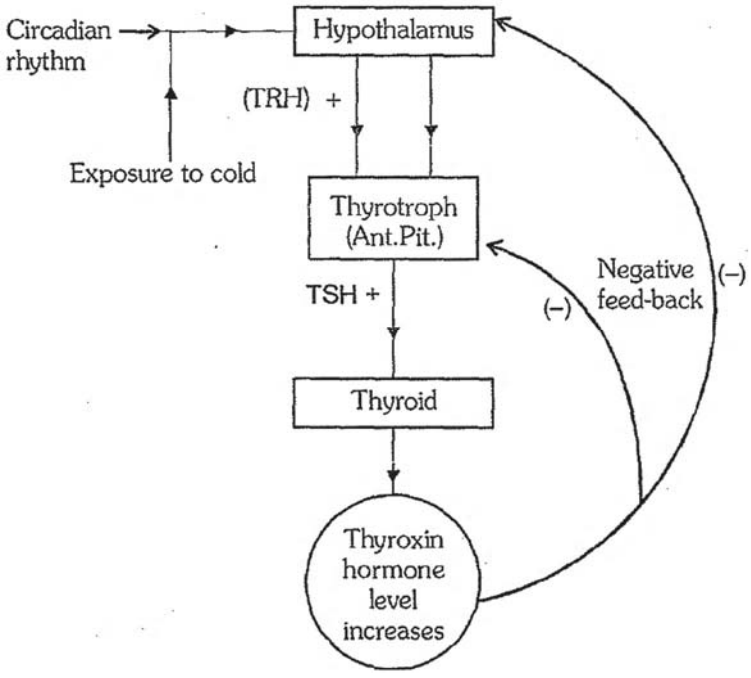
1. **Growth and Development :-**



2. **Basal metabolic rate :-**
   - Thyroxine regulates the Basal metabolic rate (BMR) in the body.

- BMR : BMR refers to the minimum amount of energy in the form of calories that our body requires to complete its normal function.
- BMR increases Body Temperature increase loses weight.
- The hormone enhances the oxidative metabolism of body cells as a result of it energy production is also increased in the form of calories so this hormone is also called calorigenic hormone.
- Increase activity of Na^+ - K^+ ATPase. It increases the number of mitochondria in all the cells of body i.e. it increases metabolic rate of the body. It increases the consumption of oxygen by the cells of body.

3. **Metabolism :-**
   - **Fat**
     Enhances enzyme activity both synthesis & predominantly catabolism of cholesterol.
   - **Carbohydrate**
     Blood sugar increases, act as a diabetogenic hormone.
   - **Protein**
     Both catabolism & anabolism but at optimum concentration of thyroxine, anabolism is dominant.
4. **CNS**
   Development and maturation of CNS.
5. **Blood**
   Stimulate erythropoiesis.
6. **Maintenance of H_2O and electrolytes balance is also influenced by thyroid hormone.**
7. **Gonads**
   Regulates menstrual cycle.
   - Regulation of Thyroid Hormone Secretion :-



Thyroid Disorders:

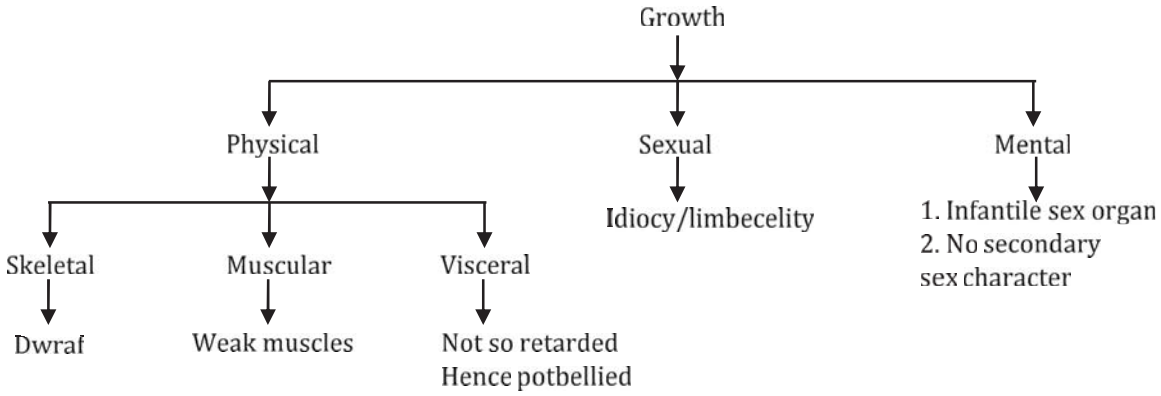
1. **Hypothyroidism :**

Simple/Colloid goitre: If there is deficiency of iodine in food then thyroid gland try to absorbs more and more iodine from blood and enlarges in size called simple goitre.

- Goitre is found more abundantly in the persons who live on mountain slopes, because iodine (at that place) flows along with water, therefore it is also called endemic goitre.
- Persons who take sea foods, are likely to show the symptoms of goiter as sea food is enriched in iodine.

Thyroid dwarfism or cretinism:

Hypothyroidism during pregnancy causes defective development and maturation of the growing baby. That leads to stunted growth, mental retardation, low intelligence quotient, abnormal skin, deaf-mutism, etc.



- Thyroid myxoedema (Gull's disease): In adults, hypothyroidism causes obesity, low HBR, lack of alertness and menstrual cycle becomes irregular in women.
- Hashimoto's disease: Autoimmune disorder of Thyroid gland

2. Hyperthyroidism:

- Due to cancer or development of nodules in thyroid glands the rate of synthesis and secretion of thyroid hormone is increased to abnormal high levels leading to a condition called hyperthyroidism which adversely effects the body physiology.
- Exophthalmic Goiter or (Grave's disease, or Basedow's disease):
  Exophthalmic goiter is a form of hyperthyroidism, characterized by enlargement of the thyroid gland, protrusion of the eyeballs, increased basal metabolic rate, and weight loss.
- Parafollicular cells or C-cells:
- These cells are scattered between thyroid follicles in stromal tissue and endocrine in nature.
- These cells secrete a protein hormone thyrocalcitonin or Calcitonin hormone (TCT).
- Thyrocalcitonin enhances the deposition of Ca^{++} in bones and increases the rate of excretion of Ca^{++} in urine, thus reduces Ca^{++} level in blood (Hypocalcemic Hormone)
- This hormone is antagonistic to parathormone (PTH).

Parathyroid Gland

- It is endodermal in origin.
- These glands remain embedded in the dorsal surface of thyroid gland. They are two pairs in number.
- These glands secrete only one hormone- parathormone or Collip's hormone or PTH. Its was obtained by Collip in its pure form.
- This hormone is proteinaceous in nature/Polypeptide hormone.
- Parathormone is essential for survival because it significantly contributes to "homeostasis" by regulating the amount of calcium and phosphate ions in ECF.

- Calcium is key element in many physiological functions like proper permeability of cell membranes, muscular activities, nerve impulse conduction, heart beat, blood coagulation, bone formation, fertilization of ova.
- Calcium is most abundant of all minerals found in the body and about 99% of calcium and phosphorus are contained in the bones. (1% Ca^{+2} found in ECF).
- Maintenance of proper calcium level under "homeostasis" is in fact, a combined function of parathormone, thyrocalcitonin and vitamin D_3 (cholecalciferol).

Parathormone is a hypercalcemic hormone that increases blood Ca^{+2} level by :-

- Stimulating the process of bone resorption/dissolution/ demineralization.
- Promoting the absorbtion of Ca^{+2} from food in the intestine.
- Promoting the 'reabsorbtion from the nephrons in the kidneys.

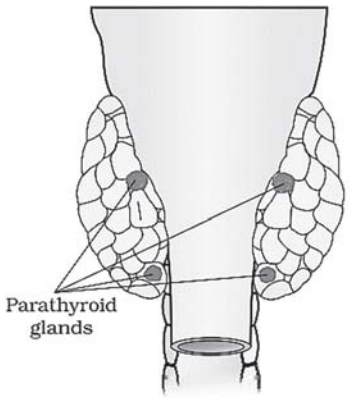


Fig. Diagrammatic view of the position of Thyroid and Parathyroid

- This calcium is then utilized by bone-forming cells, (Osteoblast) in bone formation under the influence of vitamin D_3.
- Parathormone stimulates the osteoclast cells to feed upon bones, these cells remove unnecessary parts of bones by dissolving and phagocytosis thus change asymmetrical bone into symmetrical bone. The remoulding of bone is done by these cells life long. As a result of this, amount of Ca^{+2} remains constant in blood in normal conditions.
  Each 100 ml of blood contains 12 mg of Ca^{++}.
- Parathormone maintains the activity of muscles.
- Just opposite to it, thyrocalcitonin (TCT) hormone works antagonistically to oppose the parathormone. Thyrocalcitonin reduces the amount of Ca^{++} in blood by increasing the excretion of Ca^{++} in urine and by reducing destruction of bone.

1. **Hyposecretion:** Due to hyposecretion of parathormone or PTH, the amount of Ca^{++} decreases in blood. It is known as hypocalcaemia.

Parathyroid tetany

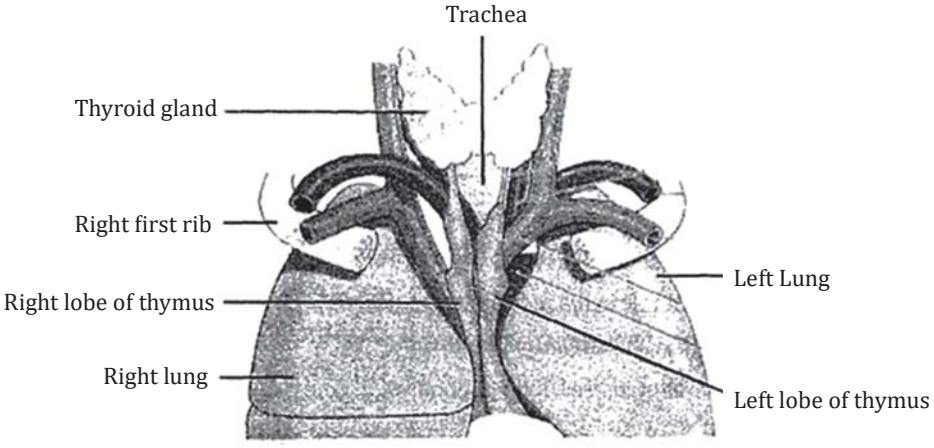
- Due to the deficiency of Ca^{++} in blood, muscles and nerves get unnecessarily irritated and start convulsion and cramping. Sometimes voluntary muscles remain contracted for a long time, it is known as Tetany disease.
- If this tetany happens in intercostal muscles and diaphragm, then animal dies due to Asphyxia.

2. Hypersecretion

Due to hypersecretion of PTH, osteoclast cells feed excess amount of bone unnecessarily. As a result of this, bones become fragile, porous and weak. This condition is called as Osteoporosis.

- When quantity of Ca^{++} increases in blood plasma and level of PO_4^{-3} is reduced, this condition is known as hypercalcaemia and hypophosphatemia respectively.
- Excess deposition of Ca^{++} in kidneys and gallbladder, may lead to stone formation.

Thymus Gland



- It is endodermal in origin.
- Thymus is a bilobed gland located between lungs (mediastinal space) behind sternum on the ventral side of heart and aorta.
- It plays a major role in development of immune system.
- It is quite large at the time of birth but keep reducing in size with age and by the time puberty is attained, it reduces to a very small size. As a result with the increase in age the immune response gradually become weak.
- Its structure is just like a lymph gland. It is covered by connective tissue coat capsule and intermally both the lobes are redividing in to small lobules.

- Outer part consists of densely packed lymphocytes while the inner part consists of reticular epithelial cell, a few lymphocytes and the Hassal's corpuscles which are phagocytic in nature.
- Thymus gland secretes a peptide hormone called thymosin or thymin hormone.
- After the birth, T-Cells or T-lymphocytes are matured in thymus gland and get stored in secondary lymphatic organs like spleen, payer's patches, lymph nodes, MALT etc.
- Thymosin hormone stimulates the maturation of lymphocytes to destroy the antigens produced by bacteria or pathogen.
- According to one of the theories of Ageing the decline or disappearance of Thymus gland by middle age is the primary cause of ageing.

Adrenal Or Supra Renal Gland

- It is found on the head (anterior most part) of both the kidneys.
- Adrenal gland is ecto mesodermal in origin.

It is divided into 2 parts:

Adrenal Cortex	Adrenal Medulla
Outer thick part (80 – 90%)	Inner thin part (10 – 20%)
Mesodermal origin	Made up of nervous tissue (Ectodermal)
Secretes steroid hormones (corticoids)	Secrets 2 proteinaceous hormones
Works under regulation of pituitary gland (ACTH)	Works direct under neural regulation

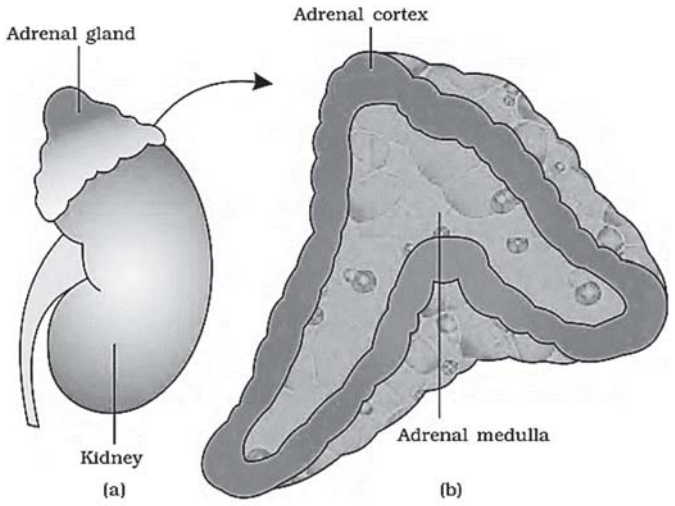
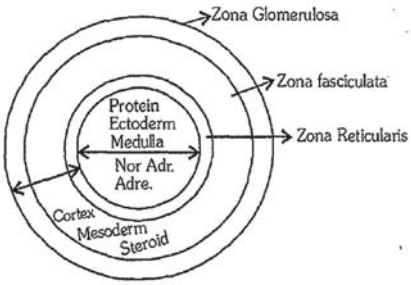


Fig. Diagrammatic representation of:
(a) Adrenal gland above kidney (b) Section showing two parts of adrenal gland

Adrenal Cortex :-

Most of the cells of this part are fatty. This portion is divided into three regions from periphery to centre.

- Outer zone or Zona glomerulosa :-
- Mineralocorticoid hormones are secreted by this zone.
- Middle zone or Zona fasciculate :-
- This zone secretes glucocorticoid hormones. In this region polyangular cells are arranged in the layers.
- Inner zone or Zona reticular is :- Cells of this region are spread in the form of a network, these are arranged in layers. This zone secretes a small amount of sex hormones.



About 40-50 hormones are synthesized in adrenal cortex. All these hormones are of steroid nature. Their basic constituent is cholesterol these are also called corticoids. Out of these 40-50 hormones, only 7-8 hormones are active.

1. **Mineralocorticoids :-**

   These corticoids related with water and electrolyte (Na, K, Cl etc.)

   Main hormone fall under this category is Aldosterone.

   Aldosterone:

   (salt retaining hormone) : Mainly act on DCT and collecting duct of uriniferous tubule by activating Na^+ K^+ pump it stimulates reabsorption of Na^+ and water and excretion of K^+ and phosphate ions. Thus aldosterone help in maintanance of electrolyte; body fluid volume, osmotic pressure of blood and blood pressure. Hyposecretion of aldosterone hormone causes loss of Na^+, Cl^- and water by the urine increase K^+ ions in blood and reduced blood pressure (Hypotension).

2. **Glucocorticoids :- (Secretion control by ACTH) :-**

   Main hormone comes under this category is Cortisol. (Life saving hormome).

   Metabolic Effect :

   - On carbohydrate metabolism :
     Stimulate gluconeogenesis and increases sugar in blood (hyperglycemic hormone)
   - Fat metabolism :- Stimulates lipolysis in adipose tissue.
   - Protein metabolism : Stimulates proteolysis and inhibits cellular up take and utilisation of amino acids.
   - This hormone is "anti - inflammatory. This prevent the actions of WBC and collagen fibres in tissues, so used in diseases like oedema, arthritis/Rheumatism.
   - This hormone is Immuno-suppressive, because it check the immune reactions by antibodies. So it is also used in the treatment of allergy. Now a days, cortisols are used in transplantation of organs.
   - Cortisol is also involved in maintaining the cardio-vascular system as well as the kidney functions.
   - Cortisol stimulates the RBC production.

3. **Sex - Honnones/Sex corticoids/Gonadocorticoids :-**

   - Sex hormones secreted by adrenals are called gonadocorticoids.
   - They are secreted in very small amount by zona reticularis.
   - Male hormones are called androgens and female hormones are called oestrogens.
   - Both the hormones are secreted by men & women both, but sex hormones secreted by gonads inactivate the sex hormone of opposite sex secreted by adrenal gland.
   - These hormones stimulate the muscles, external genitalia and sexual behaviour.
   - Male hormone secreted by adrenal gland is mainly dehydroepiandrosterone [DHEA].
   - Female sex hormones, progesterone and estrogens are secreted in minute quantities.

Adrenal Medulla

Origin

The adrenal medulla develops from the neuroectodenn of the embryo.

Structure

The adrenal medulla consists of rounded groups of relatively large and granular cells. These cells are modified of sympathetic nervous system which have lost normal processes and have acquired a glandular function. These cells are called chromaffin cells or phaeochromocytes. These cells are connected with the preganglionic motor fibres of sympathetic nervous system, therefore, these are discussed together as sympatheticoadrenal system.

Honnones of Adrenal medulla

Two hormones are secreted by this part. These collectively are called catecholamine. Catecholamines stimulate the breakdown of glycogen resulting in an increased concentration of glucose in blood. In addition, they also stimulate the breakdown of lipids and proteins.

(A) Adrenaline or Epinephrine (Emergency hormone):-

- This hormone is 80% part of the total hormones secreted by Adrenal medulla
- This hormone prepares the body to face unavoidable emergency situations.

Functions of Adrenaline :-

1. It increases alertness and pupilary dilation. It constricts the erecter pilli muscle of hair, and hair are raised (Piloerecton) and increases sweating by stimulating sweat glands.
2. Increases the heart beat, the strength of heart contraction and thus circulation of blood becomes faster.
3. The hormone stimulates the trachea and bronchi muscles to relax, as a result of it, rate of breathing is increased. So adrenaline hormone is used to cure asthma.
4. The hormone enhances the flow of blood by vasodilation of blood vessels of brain, heart, liver and skeletal muscles.
5. It constricts the blood vessels of skin (Vasoconstriction).
6. It also stimulates the breakdown of glycogen resulting in an increased concentration of glucose in blood. It also stimuilate the breakdown of lipids and proteins.
7. The hormone stimulates contraction in spleen, as a result of it, spleen pours its stored blood into blood stream.
8. It checks the secretion of saliva and reduces the peristaltic movements in alimentary canal.
9. Due to the effect of this hormone, clotting period of blood is reduced.

Adrenaline provides the body with an emergent chemical defense mechanism in stress conditions that threaten the physical integrity and chemical consistancy of the body e.g. accident, restlessness, fear anger, mental tension, pain etc. It immediately prepares the body to face the emergency by a violent stress or alarm reaction.

(B) Noradrenaline or Norepinephrine hormone :-

- It is only 20% part of total hormones secreted by adrenal medulla.
- It acts as vasoconstrictor, thus increases the blood pressure.
  Exception - It does not constrict coronary artery of heart.

Control of adrenal Secretion :-

- Adrenocorticotropic hormone (ACTH) of anterior lobe of pituitary gland controls the hormones secreted by adrenal cortex.
- ACTH controls very little or even does not control the secretion of mineralocorticoids. These are controlled by Renin hormone secreted by kidneys.

- Pituitary gland does not control the secretion of adrenal medulla hormones, the adrenal medulla hormones secretion is controlled by nervous system.

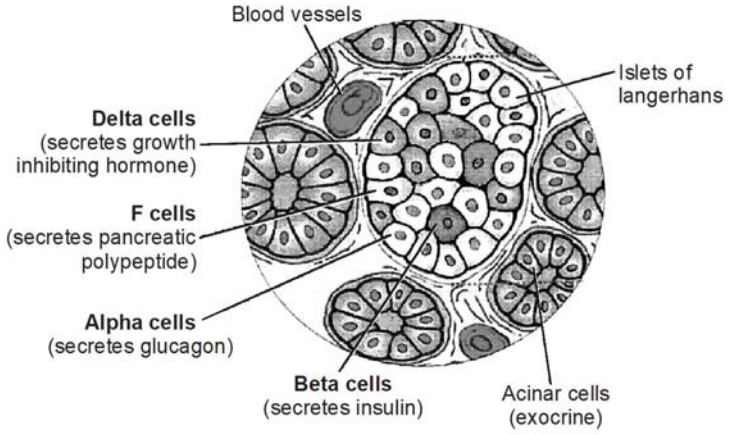
Irregular Secretion Of Adrenal Hormone :-

1. **Hyposecretion :-**
   Addison's disease
   It is characterized by hypoglycemia, acute weakness, increased susceptibility to stress and fatigue. It is also characterized by the hyperpigmentation/bronzing of skin.

2. **Hypersecretion :-**
   Cushing's syndrome (disease)
   Over secretion of cortisol leads to the excess break down of body fat (lipolysis). The fat is deposited in unusual body areas like face and upper abdominal region which is characterized by - moon face, fish mouth, buffalo hump.

Pancreas

- It is endodermal in origin.
- Position : Pancreas is a pink coloured mixed gland (heterocrine) situated in the loop of deodenum in abdominal cavity.
- It consists of numerous spherical units called acini.
- Acini form 99% part of pancreas gland. These are exocrine in nature and secretes digestive enzymes.
- There are found numerous small endocrine glands scattered between the acini, which are called Islets of Langerhans (1 to 2 million cell). They form only 1% part of the gland. These were discovered by Langerhans.



Pancreatic islet with surrounding acine showing different cells

Each islet of Langerhans has 3-4 types of cells

(A) Alfa cells (α - cells)
These are the largest cells present in peripheral region (25%). They secrete glucagon hormone.

(B) Beta cells (β - cells)
These are the small cells present in central region (60-65%). They secrete Insulin hormone.

(C) Delta cells (δ - cells) or Gamma cells (γ - cells)
These cells are found in middle region (10%). They secrete somatostatin hormone which regulates the activities of α - cells and β - cells.

1. Insulin:

- It plays a major role in the regulation of glucose homeostasis. Normal concentration of sugar in blood is 90 – 110 mg. per 100 ml. of blood.
- Insulin acts mainly on hepatocytes and adipocytes (cells of adipose tissue).

Effect on Metabolism (BMR)

1) **Carbohydrate** : Reduces blood glucose level (Hypoglycemic)
   Except brain cells, R.B.Cs, retina and genital epithelium, insulin stimulates the permeability and consumption of glucose in all somatic cells.
   Insulin inhibits gluconeogenesis.
   Promotes glycogenesis in liver and the muscles and inhibits glycogenolysis
   It enhences cellular glucose uptake and utilisation.
2) **Fat** : Insulin promotes fat synthesis called lipogenesis and inhibits lipolysis.
3) **Protein** : Insulin promotes protein synthesis by promoting uptake of amino acid by liver and muscle cell.
   It also promotes synthesis of nucleic acids.

Hyposecretion of Insulin

(a) Diabetes mellitus or sugar disease

- Due to hyposecretion of insulin, body cells can not use the sugar stored in blood. So amount of sugar increases in blood and this is called Hyperglycemia.
- Glucose is excreted through urine, if amount of glucose exceeds from 180 mg/dl in the blood, this is known as "Glycosuria".

Type - I diabetes or Insulin-dependent diabetes mellitus (IDDM)

- Caused by deficiency of insulin.
- Can be treated by insulin-therapy.
- It is an example of auto immune disorder.

Type - II diabetes or non-insulin-dependent diabetes mellitus (NIDDM)

- It is initially caused by decreased sensitivity of receptors of target tissue to the metabolic effect of insulin. This reduced sensitivity to insulin is often called insulin resistance.

Glucagon

- This is secreted by α-cells.
- Glucagon acts mainly on the liver cells (hepatocytes). It is antagonistic to insulin.
- Glucagon is a hyperglycemic factor. It reduces cellular consumption of glucose and increases the amount of sugar (glucose) in blood.
- It stimulates gluconeogenesis in liver, as a result of that amount of glucose in the blood increased.
- It decomposes the glycogen into glucose in liver. (stimulates glycogenolysis).
- It stimulates lipolysis of fats in fatty tissues.
- The secretion of insulin and glucagon is controlled by a negative feed back. When amount of sugar is increased in blood, then insulin is secreted by β-cells. As a result of it, when amount of glucose is reduced in blood, then glucagon is secreted by α-cells.

Gonads And Other Organs Which Secrete Hormones

1. Testis

A pair of testis is present in the scrotal sac (outside abdomen) of male individuals. Testis performs dual functions as a primary sex organ as well as an endocrine gland. Testis is composed of seminiferous tubules and stromal or interstitial tissue. The Leydig cells or interstitial cells, which are present in the intertubular spaces produce a group of hormones called androgens mainly testosterone.

Androgens regulate the development, maturation and functions of the male accessory sex organs like epididymis, vas deferens, seminal vesicles, prostate gland, urethra etc.

These hormones stimulate muscular growth, growth of facial and axillary hair, aggressiveness, low pitch of voice etc.

Androgens play a major stimulatory role in the process of spermatogenesis (formation of spermatozoa). Androgens act on the central neural system and influence the male sexual behaviour (libido). These hormones produce anabolic (synthetic) effects on protein and carbohydrate metabolism.

2. Ovary :

Females have a pair of ovaries located in the abdomen. Ovary is the primary female sex organ which produces one ovum during each menstrual cycle.

In addition. ovary also produces two groups of steroid hormones called estrogen and progesterone.

Ovary is composed of ovarian follicles and stromal tissues. The estrogen is synthesised and secreted mainly by the growing ovarian follicles.

After ovulation the ruptured follicle is converted to a structure called corpus luteum. which secretes mainly progesterone.

Estrogens produce wide ranging actions such as stimulation of growth and activities of female secondary sex organs, development of growing ovarian follicles, appearance of female secondary sex characters (e.g. high pitch of voice. etc.l. mammary gland development. Estrogens also regulate female sexual behaviour. Progesterone supports pregnancy.

Progesterone also acts on the mammary glands and stimulates the formation of alveoli (sac-like structures which store milk) and milk secretion.

Actually progesterone promotes alveolar growth in pregancy and increases secretory surface of alveoli, thus it supports milk secretion in lactating mother.