Chemical Coordination & Integration

22

INTRODUCTION

- The endocrine glands and the hormones producing defused tissues/cells in different part of our body constitute the endocrine system.
- The neural system and the endrocrine system jointly co-ordinate & regulate the physiological function in body.
- Pituitary, pineal, adrenal, pancreas, parathyroid, thymus & gonads (testis in males & ovary in females) are the organised endocrine glands in human body.
- Gastrointestinal tract, liver, kidney, heart also produce hormones.

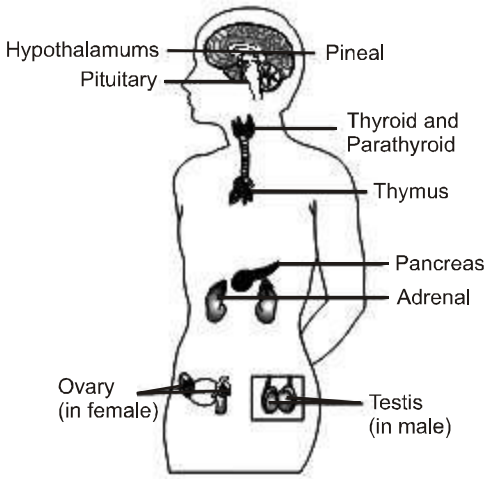


Fig : Location of endocrine glands

	Difference between Nervous and Endocrine coordination	
	Nervous	**Endocrine**
1	Information passes as electrical impulse along the axons (chemical across synapses).	Information as a chemical substance through blood stream.
2	Rapid transmission (high speed service.)	Slow transmission (low speed service).
3	Response short lived.	Response long lasting.
4	Response very exact and accurate. (Specific)	Response usually wide spread.

Differences between hormones and enzyme		
	Hormones	**Enzymes**
1	These are derivatives of either amino acids, or peptides or proteins or steroids.	These are usually complex proteins.
2	The molecular weight of hormone is low and can not diffuse through biomembrane.	Their molecular weight is very high and can diffuse through biomembranes.
3	The actions which are controlled by hormones are irreversible.	Enzyme action are reversible.
4	Hormones are used up in their action and lose their identity.	Enzyme control the action but themselves do not change. Maintain their identity.
5	Their place of secretion and action are different.	Their place of secretion and action may be the same or different.
6	Hormones may either accelerate metabolic reaction or may retard or inhibit the reaction.	The enzyme always accelerate the reaction.
7	Hormones are quite effective in low concentration. Their hypersecretion or hyposecretion may create physiological disorders.	These are also effective in low concentraction but the increase in enzyme quantity further accelerates the reaction.
8	Their action may be rapid or slow.	Their action is always rapid.

HYPOTHALAMUS

- Hypothalamus is the basal part of diencephalon (forebrain) and it regulates wide spectrum of body functions. So that it is known as master of master gland (pituitary gland).
- It contains several groups of neurosecretory cells called nuclei which produce hormones.
- It secretes 12 neurohomones. Among them some are releasig factor (hormone) which stimulate the secretion of pituitary hormone such as - G.H.R.F., T.S.H.R.F., P.R.F., M.S.H.R.F., A.C.T.H.R.F., L.H.R.F. Some are inhibiting hormone which inhibit secretion of pituitary hormones e.g. G.H.I.F., M.S.H.I.F.,P.I.F.
- GnRH (Gonadotropin releasing hormone) stimulates the pituitary synthesis & release of gonadotropin.
- Growth hormone inhibitory factor (GHIF) is also called **somatostatin**, which inhibit secretion of growth hormone from pituitary glands. δ cells of islets of langerhans also secrete this inhibitory factor.
- It also secrete oxytocin and ADH.

Hypothalamo hypophysial portal system -

- All the hormones of hypothalamus originatinating in the hypothalamic neurons pass through axons and released from their nerve endings.
- These hormones reach the pituitary gland through a portal system called hypothalamo hypophysical portal system which is present between the hypothalamus and adenohypophysis.
- Releasing factor and inhibitory factor comes into the adenohypophysis through this portal system, which regulate the function of anterior pituitary.

PITUITARY GLAND

- Smallest ***endocrine gland***.
- Also called as ***Hypophysis cerebri***.
- Pituitary term was given by ***vesalius***.
- Pituitary gland is ectodermal in origin.
- This is also called as master gland/ Leader of endocrine orchestra/ Chief executive of endocrine system.

- Pituitary gland is situated at the floor of diencephalon in sella tursica (Cavity in sphenoid bone) and is attached to hypothalamus by a stalk.
- It is homologus to herdmania's subneural gland and amphioxus muller organ.

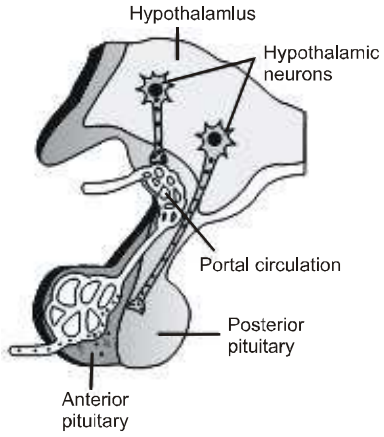
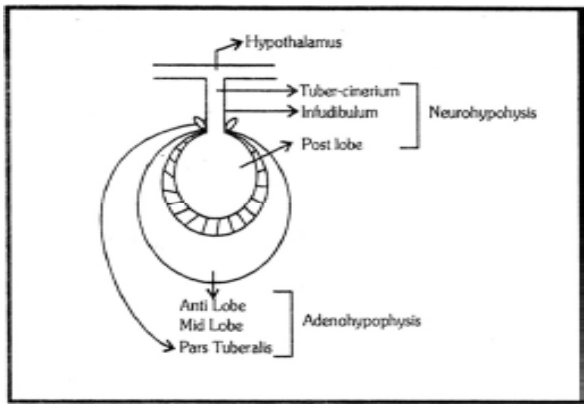


Fig : Diagrammatic representation of pituitary and its relationship with hypothalamus

Structure of Pituitary gland-



Structurally pituitary gland is divided into two parts-

(i) **Adenohypophysis** - (Anterior lobe + Intermediate lobe) This is divided into three parts -
(a) Pars distalis (b) Pars intermedia
(c) Pars tuberalis

(ii) **Neurohypophysis (posterior lobe) -** Consist of three parts -
(a) Pars nervosa
(b) Infundibulum or stalk of pituitary gland
(c) Median eminence or Tubercinerium.

(i) **ADENOHYPOPHYSIS**

- Adenohypophysis originated from the Rathke pouch of stomodeum.
- Adenohypophysis secretes 6 hormones.
  1. Growth hormone **2.** T.S.H.
  3. F.S.H. **4.** L.H.
  5. Prolactin **6.** ACTH
- Growth hormone + Prolactin secreted by acidophils or α– cells.
- TSH, FSH, LH, ACTH, Secreted by Basophils or β– cells.
- Chromophils are the precursor of α and β cells.

HORMONES OF ADENOHYPOPHYSIS (Anterior lobe of pituitary)

(1) **Growth Hormone (GH) or Somatotropic Hormone (STH) :**

- **It is proteinaceous hormone.**

Function :

- Stimulate the cell division.
- Act on the epiphysial plate of bone so bone increase in length so height also increase.
- It stimulate the gluconeogenesis .
- It helps in glycogenesis, Stimulate the lipolysis (oxidation of fats) and protein synthesis in this way it stimulate physical growth.

Effect of excess of growth hormone

(*i*) **Gigantism in childhood** → Below 18 years, Over secretion of GH stimulates abnormal growth of the body

(*ii*) **Acromegaly** - In adult. gorilla like organ : enlargement of hand and feet and the nose and lower jaw are lengthened.

Effect of deficiency of growth hormone.

Pituitary dwarfism :

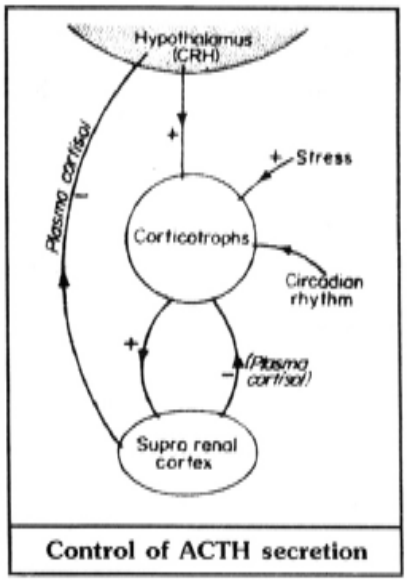
- Low secretion of GH results in stunted growth in childhood.
- In this patient's I.Q. is normal.
- They are called midgets or circus joker they are sterile.

(2) Thyroid stimulating hormone :

- TSH stimulates the thyroid follicles to secrete thyroid hormone.
- It affects indirectly.
- The Hormones that show its effect indirectly called **chalones**. e.g. TSH, ACTH, ICSH.

(3) ACTH (Adrenocorticotrophic Hormone) :

- It is long peptide hormone. Stimulate the adrenal cortex to release the adenocorticoid.



Control of ACTH secretion

Gonadotropins : - LH & FSH stimulate gonadial activity. Hence, are called gonadotrophins.

(4) FSH (Follicular stimulating hormone)-

- In male it stimulate the spermatogenesis.
- In female it stimulate the oogenesis.

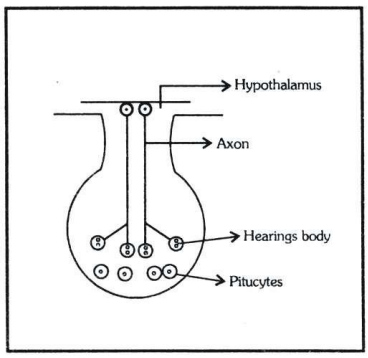
(5) LH (Lutenizing Hormone)- In male it is called ICSH [Interstitial cell stimulating hormone]

- It stimulate synthesis & secretion of hormone called androgens from testis.
- It also stimulate the leydig cells (interstitial cell) to secrete the testosterone.
- In female it is responsible for ovulation of fully mature follicle
- Responsible for rupturing of the graafian follicle, formation of corpus luteum occur and corpus luteum secrete progesterone.

(6) Prolactin - Also called milk synthesizing hormone.

- Stimulate the milk synthesis in mammary gland.
- **MSH -** Melanocyte stimulating hormone.
- It is only one hormones secretes from pars intermedia. However in human the pars intermedia is almost merged with pars distalis.
- It is long peptide hormone.
- It acts on melanocyte and regulate pigmentation of skin.

(ii) NEUROHYPOPHYSIS



- It is the posterior lobe of pituitary gland. It is formed by extra growth of diencephalon

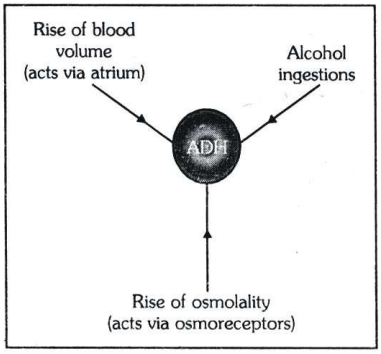
HORMONES OF NEUROHYPOPHYSIS

(i) Oxytocin (Pitocin) -

- Oxytocin is also called milk ejecting hormone because it helps in the milk ejection.
- Also called birth harmone.
- **Main role -** It contract the smooth muscles of upper segment of uterus and baby delivered easily.
- Parturition is normal physiological process which is mainly done by oxytocin.

(ii) Vasopressin (Pitressin) -

- It acts on DCT and collecting duct, stimulates reabsorption of water & electrolyte and inhibits diuresis. Hence, it is called antidiuretic hormone (ADH).



Deficiency

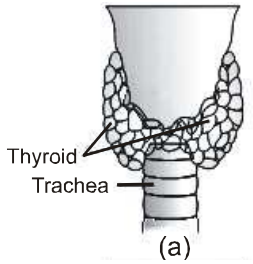
- The deficiency of antidiuretic hormone causes the diabetes insipidus.
- **Polyurea** - Increase in urine out put.
- **Polydipsia** - increase in take of water.
- In this disease urine output = 10 lit/day
- Normal urine output = 1.5 lit/day

PINEAL BODY

- The pineal gland is located on the dorsal side of forebrain.
- Pineal secretes a hormone called melatonin.
- Melatonin plays a very important role in the regulation of a 24-hour (diurnal) rhythm of our body. For example, it helps in maintaining the normal rhythms of sleep-wake cycle, body temperature. In addition, melatonin also influences metabolism, pigmentation, the menstrual cycle as well as our defense capability.

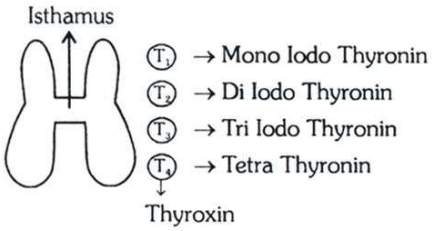
THYROID

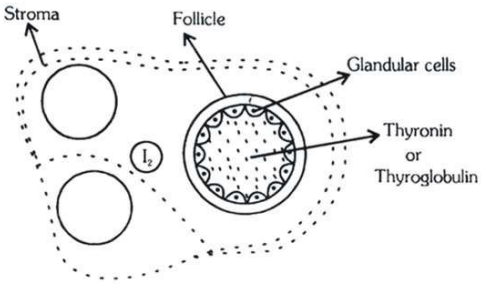
- Discovered by Thomas warton.
- Largest gland of the body.
- "H" shaped. Size - 5 × 2 × 2 cm
- Weight - 24 gm, (25-35 gm).
- Large in size in female.
- Present at ventral surface of larynx.



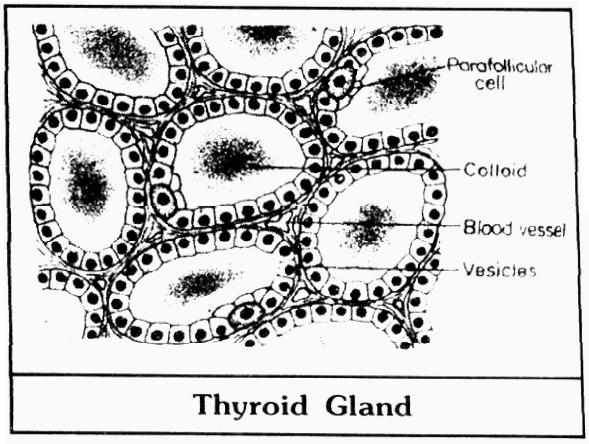
Structure of Thyroid gland -

- Single lobe in reptiles, Pisces & Amphibians.
- In human body it is consist of two lobes. Both lobes are interconnected with a thin flap of connective tissue called is isthmus.





- Each lobe have many thyroid follicles and stromal tissues.
- Each follicle is lined by a cuboidal glandular follicular epithelium of acinal cells and surrounds a gelatinous material, called **colloid** which is inactive **thyroglobulin**.
- Group of endocrine cells are found between thyroid follicles and connective tissue, those are called parafollicular cells or c-cells. C-cells secrete calcitonin or thyrocalcitonin hormone



Thyroid Gland

Hormones of Thyroid Gland -

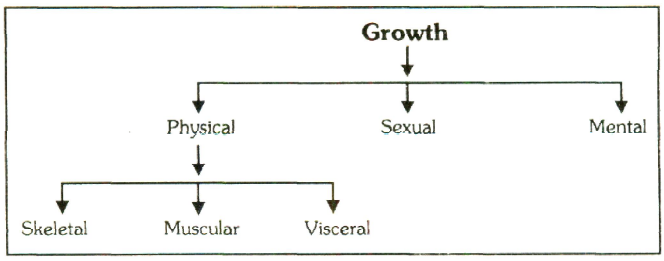
Iodine is essential for the normal rate of hormone synthesis in the thyroid gland.

T_3 (triiodothyronin)

T_4 (tetraiodothyronin)

Thyrocalcitonin

- Then thyroid hormone release into the blood.
- It controls the BMR in this, it stimulate the cell oxidation.
- The BMR (B.M.R.- Basal matabolic rate) in minimum energy requirement for normal functioning of body in male = 40 cal/m. or 2000 k.cal/day.
- The BMR in female = 37.5 cal/m.
- Helps in the metamorphosis. (meta = Transformation) So frog become adult because it help in the cell differentiation. (Metamorphosis = Tadpole larva ⟶ adult frog)
- These hormones also support the process of red blood cell formation. Thyroid hormones control the metabolism of carbohydrates, proteins and fats.
- Maintenance of water and electrolyte balance is also influenced by thyroid hormones.
- Thyroid gland also secretes a protein hormone called thyrocalcitonin (TCT) which regulates the blood calcium levels.



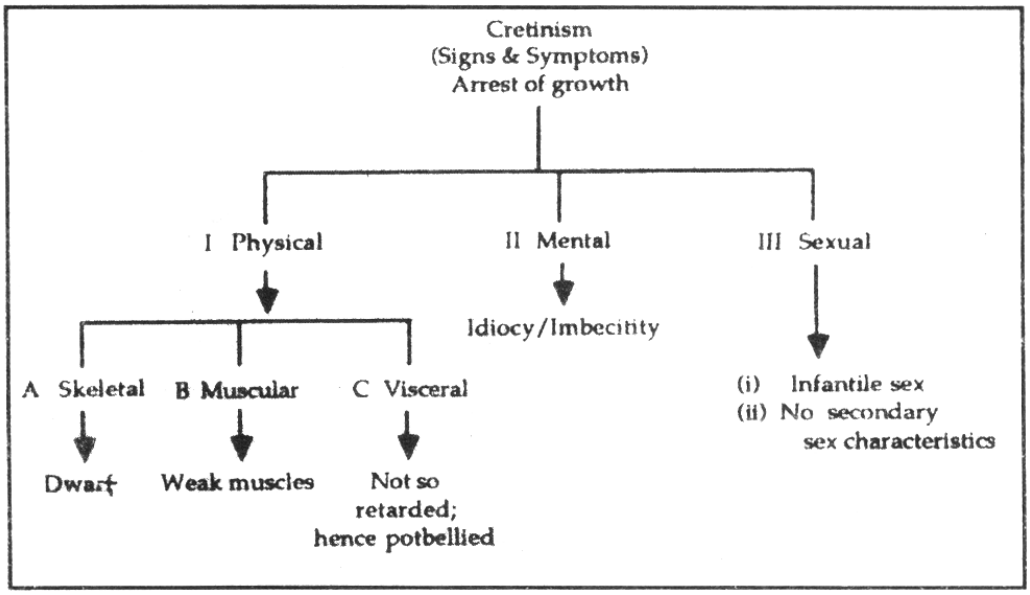
- Help or play role in the mental physical and sexual development of gonads.
- Increase or stimulate the gluconeogenesis.

Effect of deficiency -

Hypothyroidism - Deficiency of Iodine in our diet results in hypothyroidism then is causes decrease of T_4 and T_3. In adult women hypothyroidism may cause menstrual cycle to become irregular. Following diseases are charcacterized by hypothyroidism.

(i) **Cretinism** (Disease of infant) - Decrease of T_4 and T_3 in child causes the mentally retarded dwarf called **cretin**.

- In this low intelligence quotient, abnormal skin, deaf mutism etc..
- In this heart rate decrease , low BP and body appear cold.



(ii) Myxoedema (Gull's disease) - Decrease of T_4 & T_3 in adult.

- Due to deposition of myxomatous tissue (mucopolysaccharide).
- Puffyness on face and neck occur due to collection of water.
- Feels cold. HR (Heart rate) Decreases , BP Decrease, Hypokinetic Movement, Inability to concentrate.

(iii) Endemic goiter or Simple goiter- Due to deficiency of iodine, synthesis of thyroid hormone decrease.

- (Endemic = localised area).
- Low level of thyroid hormone causes increase secretion of TSH. ($T_4 \downarrow$ TSH $\uparrow$) = feed back machanism).
- TSH stimulate the thyroid follicles to secrete the thyroid hormone.
- Continuous stimulation of TSH causes the enlargement of thyroid gland. This enlargement is called goiter.

(iv) Hashimoto's disease - Also called auto immune thyroiditis.

- In this auto antibodies are synthesizes against the thyroid hormone, thyroglobulin and cells of thyroid follicles, so thyroid gland is destroyed.
- It is called suicide of thyroid. It may also be induced in the patient of hypothyroidism by therapeutic hormone therapy.

Hyperthyroidism -

Increased level of thyroid hormone. Due to cancer of the thyroid gland or due to development of nodules of the thyroid glands, the rate of synthesis and secretion of the thyroid hormones is increased to abnormal high levels leading to a condition called **hyperthyroidism** which adversely affects the body physiology.

Following diseases are charcacterized by hyperthyroidism.

Grave's disease -

Protrusion of eye ball occur due to deposition of Mucous behind the eye ball. It is called exopthalamous. Exophthalmic goitre is main symptom of this disease.

- HR$\uparrow$, B.P.$\uparrow$, Hyperkinetic movement, Insomnia, Anxiety happens in this disease.

PARATHYROID GLAND *Or* COLLIP GLAND

- It is two pairs or 4 in number.
- Each lobe of thyroid gland have one pair of parathyroid gland at the posterior side.
- Parathyroid gland secrete a peptide hormone **i.e. para thyroid hormone** (PTH). It is also called collips hormone and it discovered by Phillips Collips.
- The secretion of PTH is regulated by the circulating level of Ca^{++} ions in blood.
- PTH is secreted in response to decrease blood calcium level.
- PTH stimulate the activity of osteoclast cell. It dissolves the bone and release the Ca^{++} into the blood. In this way it increase Ca^{++} in blood, decrease in PO_4.
- PTH increase the absorption of Ca^{+2} from intestine and tubules of nephron. It is thus clear that PTH is a hypercalcemic hormone i.e. it increase the blood calcium level.
- PTH increase the excretion of PO_4^{-} ions

(b)

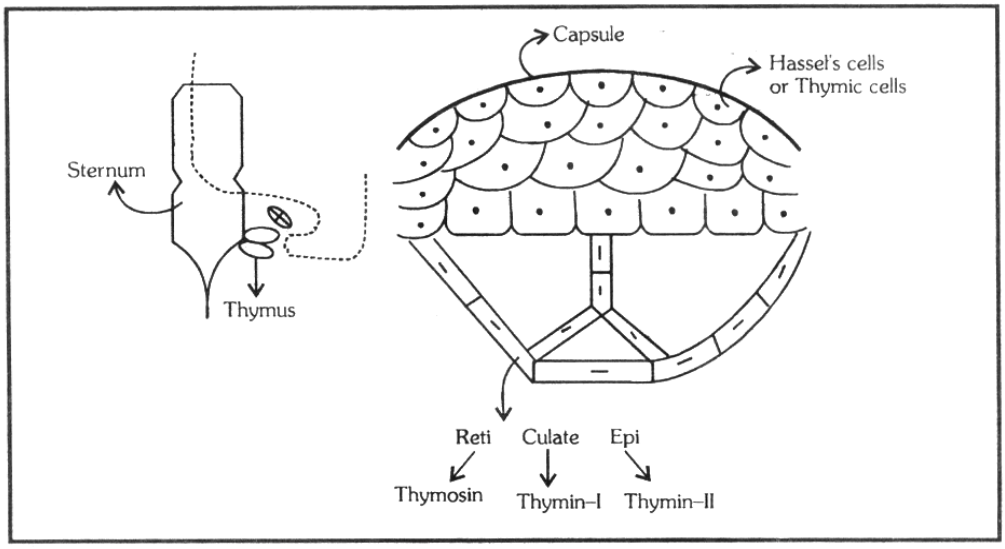
Hyperparathyroidism - Increase in PTH.

- It causes the osteoporosis bones become fragile.
- It is called ostetic fibrous cystica.
- More chances of forming of renal stones.

Hypoparathyroidism-

Low level of parathyroid hormone leads to hypocalcimia, which causes **tetany**.In tetany muscle remain in state of contraction or inability to relax.

THYMUS

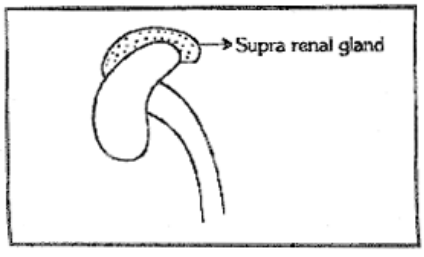


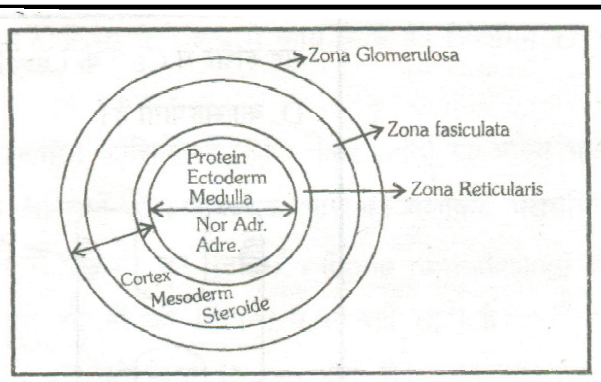
- Thymus gland is a lobular structure, present in the mediastenum between pericardium and sternum(on the dorsal side of heart & aorta).
- Actually it is lymphoid tissue that is form of lymphocyte.
- At the periphery of thymus gland thymocyte are present.
- Central portion has **Hassle's corpuscle**. Hassle's corpuscle is phagocytic tissue.
- Thymocyte secrete 3 hormones–
  (i) Thymosin (ii) Thymin-I (iii) Thymin-II
- Helps in the differentiation and maturation of T-lymphocyte, which play an important role in cell mediated immunity.
- Thymosin increase the activity of T-lymphocyte
- In addition thymosin also promote production of antibodies to provide humoral immunity.
- Tumor of thymus gland called **thymoma**. In this condition defective T-helper cells are formed. These defective T-helper cells stimulate the B-lymphocyte to form the auto antibodies against the acetylcholine receptors. Auto antibodies are found at neuromuscular junction. Auto antibodies distroy their receptors. So acetylcholine does not produce its effect, so the neuromuscular transmission does not occur so contraction in muscles also does not occur and this disease is called **Myasthenia Gravis** (Severe muscle Weakness).
- At the time of puberty thymus gland attain maximum activity.
- After that gradually starts to shrink and at old age become microscopic. (Immunogenic theory of ageing thymus gland shrink with age).

ADRENAL GLAND

- Also called supra renal gland (emergency gland).
- One pair of adrenal gland present on anterior part of each kidney
- Also called 4S gland.

  4S
  S – Salt
  S – Sugar
  S – Sex
  S – Stress
- Also called 3-F gland. suitable for adrenal medulla.
  (i) FEAR (ii) FIGHT (iii) Flight
- Adrenal gland consist of Two parts outer is cortex and inner is medulla.





(I) **Cortex** - Mesodermal in origin. Consist of three layers.

(1) G - Zona glomerulosa - Mineralocorticoid

(2) F - Zona fasciculata - Glucocorticoid

(3) R - zona reticularis - Sex hormone & Glucocorticoid

Commonly all the hormones secreted by adrenal cortex called corcoid hormone.

Mineralocorticoids :

- Cortiocoids which regulate the balance of water & electrolyte in human body are called mineralocorticoids.
- Zona glomerulosa secrete the mineralocorticoids. Ex- Aldosterone or salt retaining hormone.
- Angiotensin II stimulate the secretion of mineralocorticoids (R.A.A.S.).
- Aldosterone is the main mineralocorticoid in human body.
- Aldosterone - Act on DCT and collecting duct and increase the Na+ ion absorption (Passive absorption).

Glucocorticoids -

The corticoids which are involve in carbohydrate metabolism called as glucocorticoids. It stimulate the gluconeogenesis, lipolysis, proteolysis and inhibit cellular uptake and utilisation of amino acid In human body main glucocorticoid is cortisol. It is also involved in maintaining the cardio-vascular system as well as the kidney functions.

- **Zona fasiculata** - Mainly secreate the glucocorticoid. Sex hormones are also secreted in small amount.
- Mainly stimulate the conversion of amino acids into glucose.
- Hormone that increase the blood glucose level called diabetogenic factor Ex. Glucagon, glucocorticoid, growth hormone.
- Protein catabolism occur. Glucocorticoids stimulate the deamination and urea formation.
- Glucocorticoid (mainly cortisol) is **anti inflammatory agent**. It stops the WBC function and prevent the inflammation.
- It is immuno supressant. Helps in organ transplantation. (due to supression of auto antibody). Stimulate the Eosinopenia [decrease the immunity of Eosinophils] = Anti allergic Action. Penia = decrease, Philia = Increase.

Sex Hormones:

Zona reticularis - Mainly secrete sex hormone and in small quantity it secrete glucocorticoids.

- **In male secrete** - Dehydroepiandrosterone (DHEA)
- In female it secrete estradiol. DHEA and oestradiol both are secreted by every male & every female but dominant secondary sex character is depend on dominency in between these two hormone.
- These are also play a role in the growth of axial hair, pubic hair and facial hair during puberty.

EXCESS

(i) **Cushing syndrome (increase glucocorticoids) -**

(i) BP increase.

(ii) Bones irregular

(iii) Weight loss. due to protein catabolism

(iv) Moon face

(v) Buffalo hump– Fat pad deposition on neck & thorax.

(ii) **Adrenal virilism -**

In female (oestradiol < DHEA).

- Feminizing character decrease. Excess hair growth occur, male character in female (Hirsutism).

Effect of deficiency of Adrenocorticoid - Addison's disease :

- Low level of adrenocorticoids causes increase secretion of ACTH.
- When excessive secretion of ACTH occurs then MSH also secrete in high quantity. MSH Stimulate the melanin pigment synthesis. That causes the frog (Blackish brown) skin.

(II) Adrenal medulla - Adrenal medulla consists of chromaffin cells. chromaffin cells secrete the noradrenaline (nor epinephrine) and adrenaline (epinephrine), these are commonly called as a catecholamines.

- Adrenaline and noradrenaline are rapidly secreted in response to stress of any kind and during emergency situations and are called **emergency hormones** or **hormones of Fight or Flight**.
- These hormones increase alertness, pupilary dilation, piloerection (raising of hairs), sweating etc. Both the hormones increase the heart beat, the strength of heart contraction and the rate of respiration.
- Catecholamines also 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.

PANCREAS

- Pancreas is a composite gland, which acts as both exocrine and endocrine gland.
- Endocrine part of pancreas is called islets of langerhans it has 5 type of cells.
  (i) α cells - (15 -25%) - Glucagon
  (ii) β cells - (65 - 80%) - Insulin
  (iii) γ cells - (10-15%) - Gastrin
  (iv) δ cells (2-8%) - Somatostatin.
  (v) PP cells or F cells
- There are about 1 to 2 million Islets of Langerhans in a normal human pancreas representing only 1 to 2 percent of the pancreatic tissue.

(1) INSULIN - Banting and **Best** first obtain from calfs's pancreas. He discovered the function of insulin also.

- It is a peptide hormone, which play important role in regulation of glucose homeostasis.
- It is composed of 51 amino acids and its molecular weight is 6000.
- It is composed of two type of polypeptide chain. Polypeptide-A (21) + Polypeptide-B (30) = 51
- It acts mainly on hepatocytes & adipocytes.
- Insulin is called hypoglycemic factor or antidiabetic factor because it decreases blood glucose level by increasing the uptake of glucose by cell, Inhibiting the gluconeogenesis and stimulating the glycogenesis.
- Stimulate the lipogenesis.
- It stimulate the protein synthesis. Growth hormone become more effective in presence of insulin.

Deficiency of insulin -

(i) Diabetes mellitus - Characterized by
  - ✔ Hyperglycemia
  - ✔ Polyurea
  - ✔ Polydypsia

- Cells utilize the lipids. Incomplete oxidation of lipids produce ketone bodies. e.g. Acetoacetate, Acetobutyric acid. So acidosis (Diabetic keto acidosis) occur. So patient become unconscious and it leads to coma. It is called Hyperglycemic coma.

Excess of Insulin -

- Tumor of insulin secreting cells **(insulinoma)** characterized by **Hypoglycemia.**

(2) GLUCAGON -

- Glucagon is a peptide hormone, which plays an important role in maintaining normal blood glucose level.
- Causes hyperglycemia (increase blood sugar level) by following mechanism:

- ✔ Glucagon acts mainly on the liver cells (hepatocytes) and stimulates glycogenolysis resulting in an increased blood sugar level (hyperglycemia).
- ✔ It stimulates the process of gluconeogenesis (formation of glucose from non carbohydrate substance) which also contributes to hyperglycemia.
- ✔ Glucagon reduces the cellular glucose uptake and utilisation.

Note - The glucose homeostasis in blood is maintained jointly by the two hormone insulin & glucagon.

(3) SOMATOSTATIN

- It is growth hormone inhibiting hormone (GHIH)

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.**
- Interstitial cells or Leydig cells secrete a group of hormone called androgen mainly testosterone.
- Testosterone and other Androgens are important in development, maturation & function of sex organ and secondary sexual characters in male.
- 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.
- Sertoli cells - **Inhibin** hormone which decrease the secretion of FSH.

OVARY

- Females have a pair of ovaries located in the abdomen. Ovary is the primary female sex organ which also work as endocrine gland.
- Ovary produces two groups of steroid hormones called **estrogen** and **progesterone**.
- Theca interna of follicular cells secreate the **estrogen.** It regulate female sexual behaviour, stimulation of growth and activities of female secondary sex organs.
- After ovulation ruptured follicle is converted into corpus luteum which secrete progesterone.
- Progesterone supports pregnancy. Progesterone also acts on the mammary glands and stimulates the formation of alveoli and milk secretion.

PLACENTA

- It develops only in pregnant eutherian placental female.
- It is the connection between foetus and mother.
- It produces some important hormones.

(i) **HCG -** Human Chorional Gonadotropic. It helps in development and maintenance of placenta. HCG releases in urine on the basis of it gravidex test has been done.

(ii) **Placental estrogen and Placental Progesterone-**Both helpful in development of mammary glands.

(iii) **Placental lactogen -** Helps in milk secretion

(iv) **Relaxin -** Helps in parturition.

KIDNEY

- J.G. (Juxta Glomerular) Cells → Renin.
- Renin is enzymatic hormone. Angiotensinogen $\xrightarrow{\text{Renin}}$ Angiotensin I $\xrightarrow{\text{Convertase enz}}$ Angiotensin II.
- This induce secretion of aldosterone and it is a vasoconstrictor.
- The juxtaglomerular cells of kidney produce a peptide hormone called erythropoietin which stimulates erythropoiesis (formation of RBC).

GASTROINTESTINAL MUCOSA

Gastrointestinal hormones in mammals

Hormone	Source	Stimulus for secretion of Hormone	Target organ of Hormone action	Action
Gastrin	Mucosa of pyloric stomach	Distension of stomach on food entry	Stomach	Stimulates secretion of gastric juice. Constricts cardiac sphincter.
Enterogastrone	Duodenal epithelium	Chyme entry into duodenum	Stomach	Slows gastric contractions to delay its emptying. Stops secretion of gastric juice.
Secretin	Duodenal epithelium	Acidic chyme entry into duodenum	Pancreas Liver Stomach	Release of sodium bicarbonate in pancreatic juice. Steps up secretion of bile. Inhibits secretion of gastrin.
Cholecystokinin (pancreozymin)	Duodenal epithelium	Presence of fats in duodenum	Pancreas Gall Bladder	Release of enzymes in pancreatic juice. Release of bile from gall bladder.

HEART

- The atrial wall of our heart secretes a very important peptide hormone called **atrial natriuretic factor** (ANF), which decreases blood pressure.
- When blood pressure is increased, ANF is secreted which causes dilation of the blood vessels. This reduces the blood pressure.

MECHANISM OF HORMONE ACTION

Hormones produce their effects on target tissues by binding to specific proteins called **hormone receptors** located in the target tissues only. Hormone receptors present on the cell membrane of the target cells are called membrane-bound receptors and the receptors present inside the target cell are called intracellular receptors, mostly nuclear receptors (present in the nucleus). Binding of a hormone to its receptor leads to the formation of a **hormone-receptor complex** (Figure 22.5 a, b). Each receptor is specific to one hormone only and hence receptors are specific.

Hormone-Receptor complex formation leads to certain biochemical changes in the target tissue. Target tissue metabolism and hence physiological functions are regulated by hormones. On the basis of their chemical nature, hormones can be divided into groups :

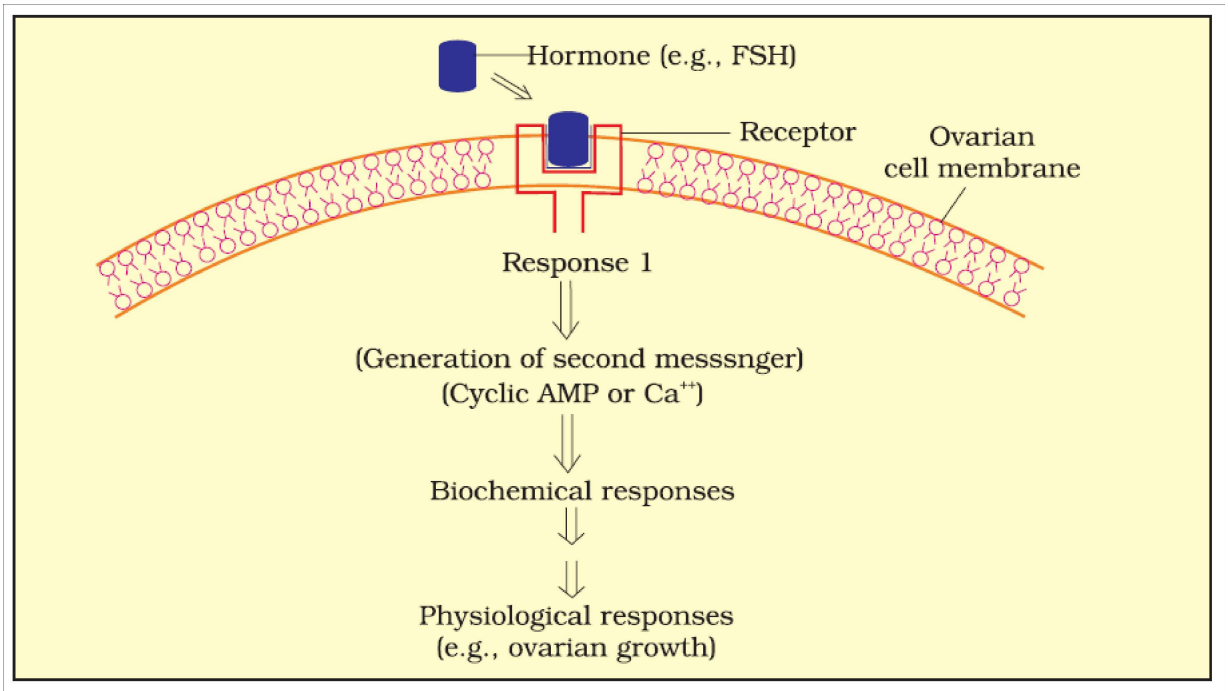
(i) **peptide, polypeptide, protein hormones** (e.g., insulin, glucagon, pituitary hormones, hypothalamic hormones, etc.)

(ii) **steroids** (e.g., cortisol, testosterone, estradiol and progesterone)

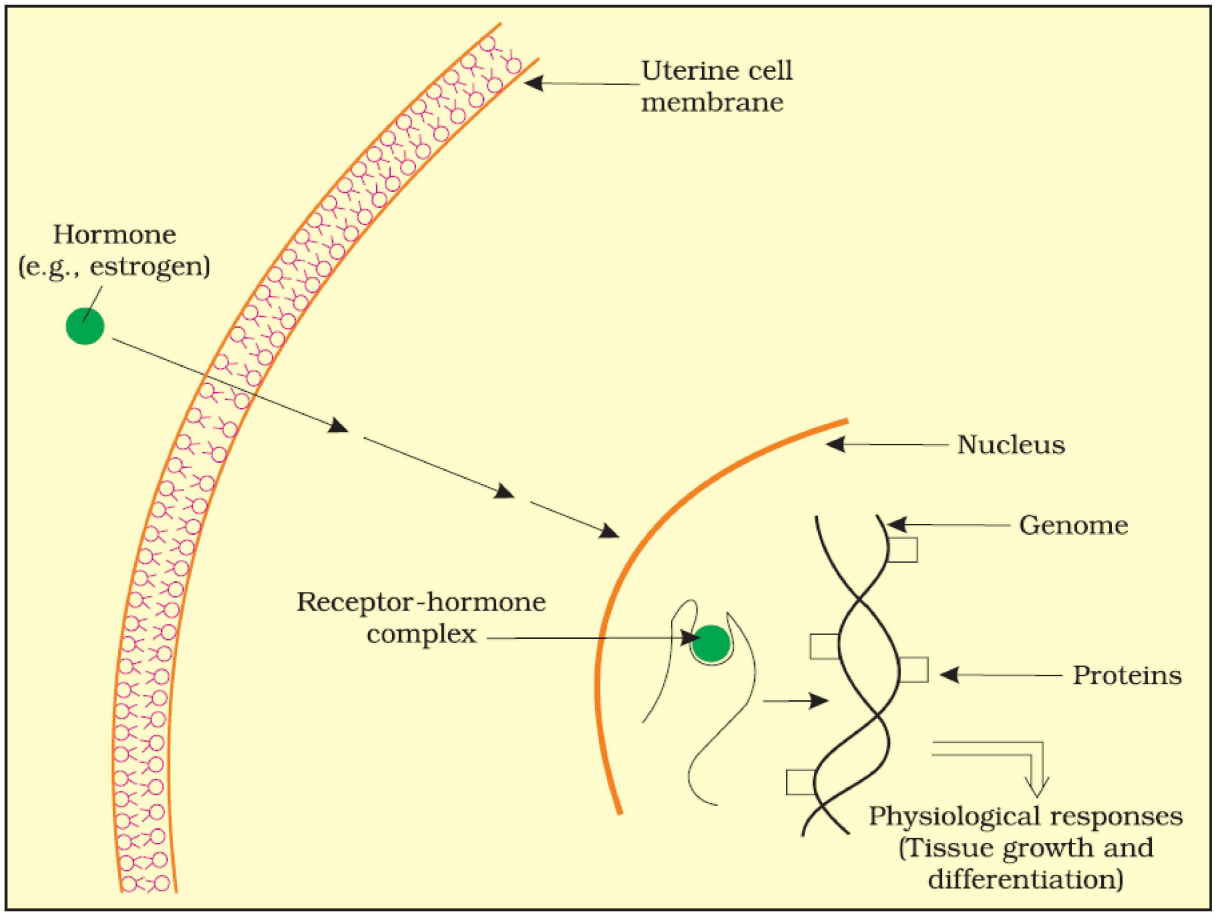
(iii) **iodothyronines** (thyroid hormones)

(iv) **amino-acid derivatives** (e.g., epinephrine).

Hormones which interact with membrane-bound receptors normally do not enter the target cell, but generate second messengers (e.g., cyclic AMP, IP_3, Ca^{++} etc) which in turn regulate cellular metabolism (Figure 22.5a). Hormones which interact with intracellular receptors (e.g., steroid hormones, iodothyronines, etc.) mostly regulate gene expression or chromosome function by the interaction of hormone-receptor complex with the genome. Cumulative biochemical actions result in physiological and developmental effects (Figure 22.5b).



(a)



(b)

Figure 22.5 Diagramatic representation of the mechanism of hormone action : (a) Protein hormone (b) Steroid hormone