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PRE-MEDICAL

ZOOLOGY

ENTHUSIAST | LEADER | ACHIEVER

STUDY MATERIAL

Chemical co-ordination and integration (Endocrine System)

ENGLISH MEDIUM

Copyright Statement

FREDERICK SANGER

Nobel Prize in Chemistry (1958)

Frederick Sanger was a British biochemist who won the Nobel Prize in 1958. He was awarded a Nobel Prize in chemistry for his work on "the structure of proteins, especially that of insulin".

Chibnall had already done some work on the amino acid composition of bovine insulin and suggested that Sanger look at the amino groups in the protein. Insulin could be purchased from the pharmacy chain and was one of the very few proteins that were available in a pure form. Up to this time Sanger had been funding himself.

Sanger's first triumph was to determine the complete amino acid sequence of the two polypeptide chains of bovine insulin, A and B, in 1952 and 1951, respectively. Prior to this it was widely assumed that proteins were somewhat amorphous. In determining these sequences, Sanger proved that proteins have a defined chemical composition.

EDWARD CALVIN KENDALL

Born March 8, 1886

Nobel Prize in Physiology or Medicine(1950)

Edward Calvin Kendall (March 8, 1886 - May 4, 1972) was an American chemist. In 1950, Kendall was awarded the Nobel Prize for Physiology or Medicine along with Swiss chemist Tadeus Reichstein and Mayo Clinic physician-Philip S. Hench, for their work with the hormones of the Adrenal gland. Kendall did not only focus on the adrenal glands, he was also responsible for the isolation of thyroxine, a hormone of the thyroid gland and worked with the team that crystallized glutathione and identified its chemical structure.

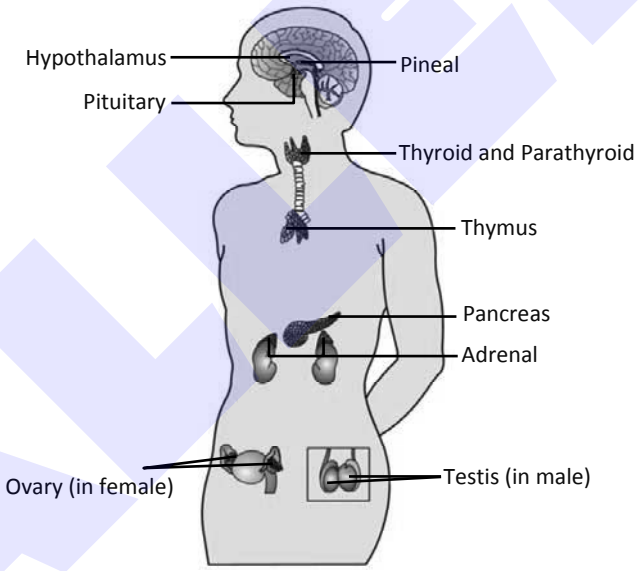
Kendall was a biochemist at the Graduate School of the Mayo Foundation at the time of the award. He received his education at Columbia University. After retiring from his job with the Mayo Foundation, Kendall joined the faculty at Princeton University, where he remained until his death in 1972. Kendall Elementary School, Norwalk is named after him.

CHEMICAL CO-ORDINATION AND INTEGRATION (ENDOCRINE SYSTEM)

01. INTRODUCTION

- **Introduction**
- **Hormone**
- **Mechanism of Hormonal Actions**
- **Pituitary Gland**
- **Hypothalamus**
- **Thyroid Gland**
- **Parathyroid Gland**
- **Adrenal or Supra Renal Gland**
- **Thymus Gland**
- **Pineal Body**
- **Pancreas**
- **Gonads and other Organs which Secrete Hormones**

- The neural system and the endocrine system jointly co-ordinate and regulate the physiological functions in the body.
- The neural co-ordination is fast, very exact and short lived, whereas chemical co-ordination is usually slow, widespread and long lasting.
- All cells of our body are not innervated by nerve fibres but the cellular function need to be continuously regulated so a special kind of coordination and integration has to be provided. This function is carried out by **endocrine system.**



Location of endocrine glands

NCERT XI Page No. 332, Figure No. 22.1

- The branch of biology which deals with the study of endocrine system and its physiology is known as **"Endocrinology"**.
- **‘‘Thomas Addison’’** is known as father of Endocrinology.

  Endocrine glands pour their secretion directly into blood. These glands lack ducts, so these glands are called ductless glands, whereas the gland with duct is called **exocrine** gland which secretes enzyme etc.
- Substances secreted by endocrine glands are known as hormones. The meaning of word 'hormone' in Greek is "to excite" **= hormaein**.

- **Organised endocrine gland :** Where hormone producing cells are present in cluster/tissue form called organised endocrine gland.

  Examples : Pituitary, Pancreas, Parathyroid, Pineal, Thyroid, Thymus, Adrenal and **Gonads.**

- **Non-organised endocrine gland :** Where hormone producing cells are present in scattered form called non-organised or diffused endocrine tissue.

  Example : Heart, Liver, Kidney, Gastrointestinal tract.

Differences between Nervous and Endocrine Coordination

	Nervous Co-ordination		**Endocrine Co-ordination (Chemical Co-ordination)**
1.	Information passes as electrical impulses along nerve fibres.	1.	Information passes as a chemical substance through the blood and lymph.
2.	There is rapid transmission of information.	2.	There is slow transmission of information.
3.	Response is immediate, very exact, short lived.	3.	Response is usually slow, wide spread, long lasting.

02. HORMONE

- The term hormone was coined by *"Starling"*.
- Hormones are also called "***Primary messengers***" or "**chemical messengers**".
- **Hormones are non-nutrient chemicals which act as intercellular messenger and are produced in trace amount.**
- First discovered hormone is **Secretin**. It was discovered by *"Bayliss & Starling in 1902"*.

(1) CHEMICAL NATURE OF HORMONES

Nature	**Harmone**	**Gland**
A. Proteinaceous (i) Amino acid derivatives	 Thyoxine (Iodothyronine) Epinephrine Non-epineprine	 Thyroid gland Adrenal medulla
(ii) Short peptides	Vasopressin, Oxytocin MSH	Hypothalamus Adenohypophysis
(iii) Long peptides	Parathyroid hormone Insulin Thyrocalcitonin ACTH	Parathyroid Pancreas Thyroid Adenohypophysis
(iv) Glyco – Proteins	TSH, FSH, LH	Adenohypophysis
B. Steroids	Mineralocorticoids Glucocorticoids Testosterone Oestrogen Progesterone	Adrenal cortex Adrenal cortex Testes Ovary Ovary

(2) PHYSICAL & CHEMICAL SPECIALITIES OF HORMONES

- The molecules of most of the hormones are small, and their molecular weight is low.
- Mostly hormones are soluble in water and few are soluble in fat and are easily diffusible in tissues.
- The secretion of hormone is always in very small quantity because these are very reactive substances.
- Hormones are destroyed after use i.e. hormones can not be stored in the body.

  Thyroxine is exception in this regards.
- Liver and kidneys separate hormones from blood and decompose them. The product formed after decomposition is excreted with urine. It can not be reutilized.
- Hormones are **non-antigenic** & **non-species specific** substances.
- Usually, hormones do not participate in the metabolic activities of target cells but they affect and control the activity level of these target cells.

03. MECHANISM OF HORMONAL ACTIONS

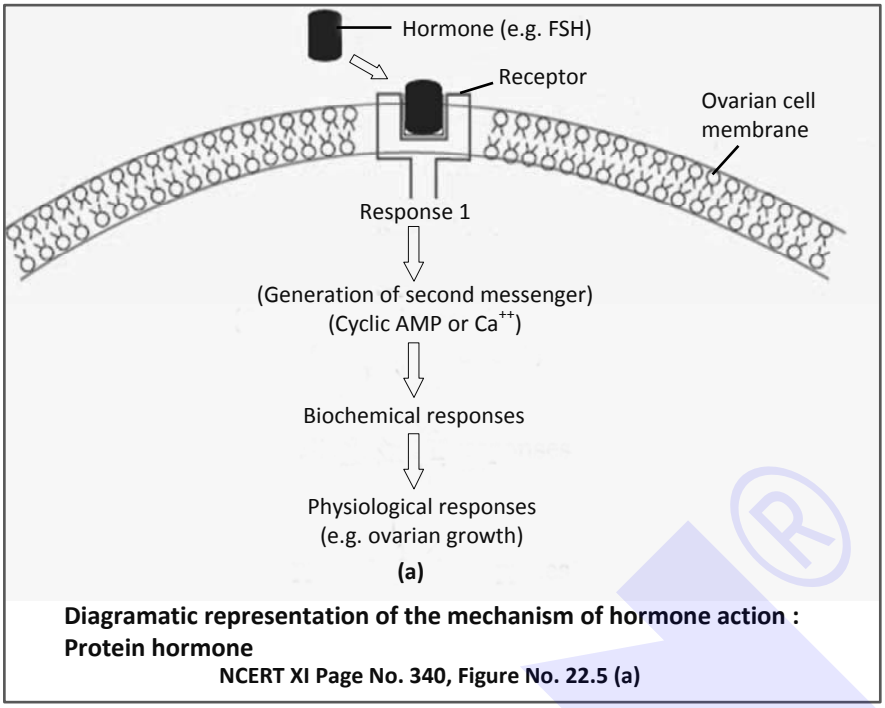
MECHANISM OF HORMONE ACTION — Two types

- Once hormone enters into blood stream it can reach almost to any cell in the body.
- However, each hormone affects only certain kind of cells, which is called as **target cells**.
- All hormones do not act in the same way due to location of their receptor.
- Hormones are two types :

  (i) Water soluble hormones (ii) Lipid soluble hormones
- 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**.
- 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 function are regulated by hormone.

(1) WATER SOLUBLE HORMONES

Hormone which interact with membrane bound receptor normally do not enter the target cell, but generate **secondary messenger** (eg. cyclic AMP, IP_3, Ca^{++} etc.) which in turn regulate cellular metabolism.

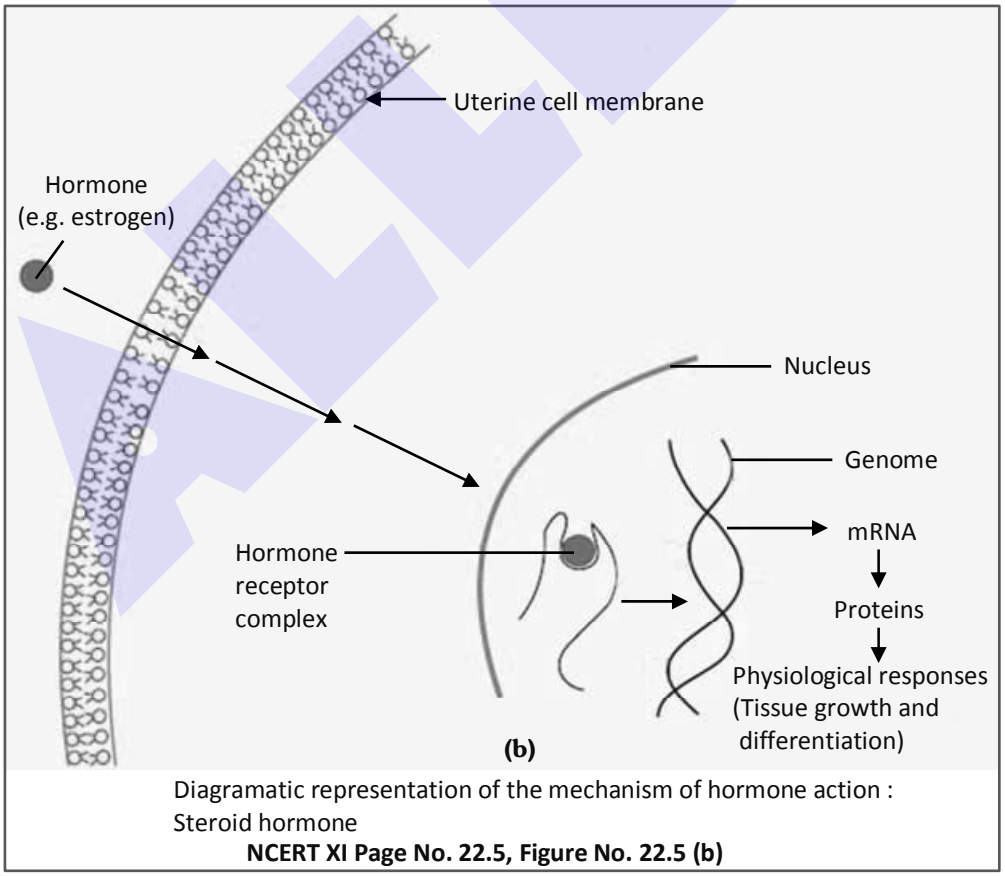


Diagramatic representation of the mechanism of hormone action : Protein hormone

NCERT XI Page No. 340, Figure No. 22.5 (a)

(2) LIPID SOLUBLE HORMONE

Hormone which interact with intracellular receptor (**Steroid, iodothyronine**) mostly regulate gene expression or chromosome function by the interaction of hormone receptor complex with the genome. Cumulative biochemical action results in physiological and developmental effects.



Diagramatic representation of the mechanism of hormone action : Steroid hormone

NCERT XI Page No. 22.5, Figure No. 22.5 (b)

The action of lipid soluble hormones is slower and lasts longer than the action of water soluble hormones.

BEGINNER'S BOX — MECHANISM OF HORMONE ACTION

1. Following are the example of organised gland except

(1) Pituitary (2) Pineal (3) Thyroid (4) Kidney

2. Which of the following characteristics is not mentioned in current scientific definition of hormone ?

(1) Non-antigenic substance (2) Non-nutrient chemical

(3) Act as intercellular messenger (4) Produced in trace amount

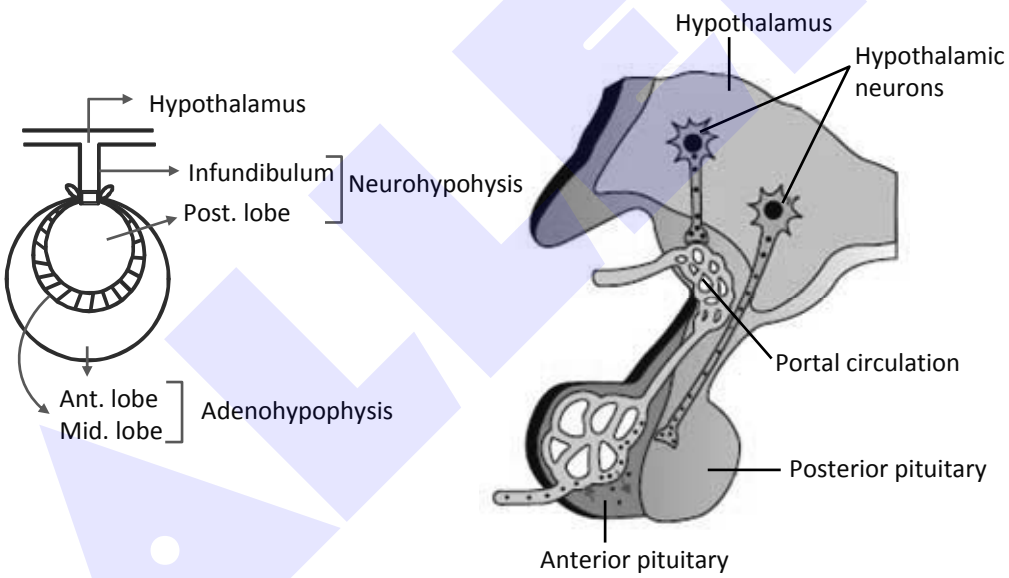
3. A hormone which binds with membrane bounded receptor except one :

(1) Insulin (2) Thyrocalcitonin (3) Oxytocin (4) Progesterone

4. Which of the following hormone not binds with cytoplasmic or nuclear receptor?

(1) Cortisol (2) Aldosterone (3) Insulin (4) Oestrogen

04. PITUITARY GLAND



Diagrammatic representation of pituitary and its relationship with hypothalamus

NCERT XI Page No. 333, Figure No. 22.2

- On the basis of development pituitary gland is completely **ectodermal**.
- It is situated in the ***sella–turcica*** of sphenoid bone.
- This gland is attached to the hypothalamus through a stalk which is called as **infundibulum**.
- It is divided anatomically into an **adenohypophysis** (anterior pituitary) and a **neurohypophysis** (posterior pituitary).
- The lower terminal end of infundibulum is bulging type which is called as **posterior lobe or pars nervosa**.

- Infundibulum & pars nervosa are collectively called as **neurohypophysis**.
- Adenohypophysis consists of pars distalis (anterior lobe) and **pars intermedia** (middle lobe).
- ***Hypophyseal portal vein*** collects the blood from hypothalamus and supplies to the ***anterior pituitary***.

(1) HORMONES SECRETED BY ADENOHYPOPHYSIS

(A) Growth Hormone or Somatotrophic Hormone :

[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.

Diseases due to hyposecretion or hypersecretion of somatotropin hormone :-

(a) Hyposecretion of STH : Due to deficiency of STH in childhood or adolescence, ***dwarfism*** is observed.

- Dwarfism due to the defect of pituitary is called **Ateliosis**.
- Clowns of circus are such dwarfs, they are called ***midgets***.

(b) Hypersecretion of STH :

(i) Due to hypersecretion of GH in childhood, the bones of legs & hands become very long and height of that person increases very much. Body becomes imbalanced. This disease is called **Gigantism**.

Acromegaly

(ii) Excess secretion of growth hormone in adults especially in middle age can result in severe disfigurement like excess enlargement of bones of face, vertebral column and fore limbs, called **Acromegaly,** which may lead to serious complications, and premature death if unchecked.

(B) 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 Thyrotrophin releasing factor of hypothalamus.

(C) Adreno Cortico Trophic Hormone or Corticotropine [ACTH] :

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

(D) Follicle Stimulating Hormone [FSH] :

- It is secreted in male and female both.
- In males, it stimulates **spermatogenesis** and normal functioning of seminiferous tubules.
- In females, it stimulates **oogenesis** and development of *Graafian follicles* in ovary.
- Estrogen hormone that is secreted by Graafian follicles is also affected by FSH.

(E) Luteinizing Hormone [LH or ICSH] or Interstitial Cell Stimulating Hormone :

- It stimulates **ovulation** in female. As a result of this corpus luteum is formed.
- Hormone **progesterone** which is secreted by corpus luteum is also stimulated by L.H.
- In men **LH** is called **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 called **gonadotrophic hormone GTH**.
- FSH and LH act in combined form so these are called **synergesic** hormone.
- Gonadotrophic hormones (FSH & LH) secretion starts during puberty. Their secretion is regulated by hypothalamus.

(F) Luteotrophic or Prolactin or Lactogenic or Mammotrophin Hormone (PRL) :

Lactation (Galactopoiesis) :- Prolactin is responsible for lactation (milk formation) in postpartum (after delivery) in women.

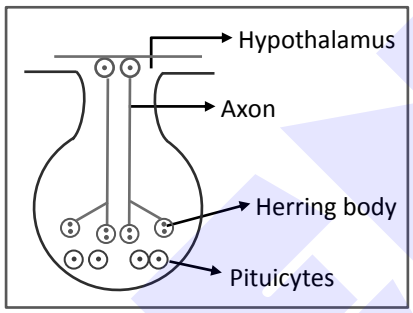
(G) Melanocyte Stimulating Hormone [MSH] :

- It is secreted by middle lobe but in human the pars intermedia is almost merged with pars distalis.
- In man, MSH is secreted by anterior lobe.
- MSH is also called ***Intermedin***.
- It stimulates the melanocytes to synthesize melanin in mammals, but role of MSH in determining skin colour 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.

(2) POSTERIOR LOBE OR NEUROHYPOPHYSIS

Posterior lobe of pituitary gland is $1/4^{th}$ part of total gland. It is just like nervous tissue, because in it, the terminal ends of the axons of neurosecretory cells of hypothalamus are swollen. These swollen ends are called **" Herring bodies"**. Hormones are released in these bodies.



- There are some large, branched fatty neuroglial supporting cells in between axons, that are called **"Pituicytes"**.
- Posterior pituitary hormones are not synthesised in the gland itself but they are synthesized 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.*

05. 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. However, the hormones produced by hypothalamus are of two types, the **releasing hormones** (which stimulate secretion of pituitary hormones) and the **inhibiting hormones** (which inhibit secretions of pituitary hormones). For example a hypothalamic hormone called **Gonadotrophin releasing hormone (GnRH)** stimulates the pituitary synthesis and release of gonadotrophins. On the other hand, **somatostatin** from the hypothalamus, inhibits the release of growth hormone 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.

BEGINNER'S BOX — PITUITARY & HYPOTHALAMUS

1. Which of the following adenohypophysis hormone have diabetogenic effect ?
(1) PRL (2) TSH (3) LH (4) GH

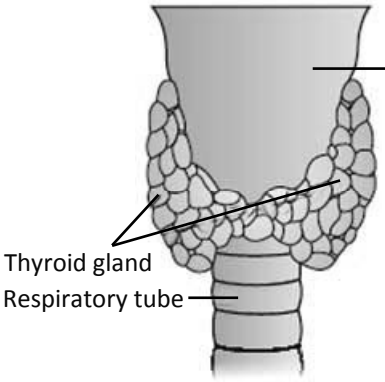
2. Abnormal growth of bones due to hypersecretion of growth hormone in adult is known as:
(1) Acromegaly (2) Dwarfism (3) Gigantism (4) Both (1) and (2)

3. Which of the following hormone induces ovulation ?
(1) FSH (2) LH (3) Vasopressin (4) Oxytocin

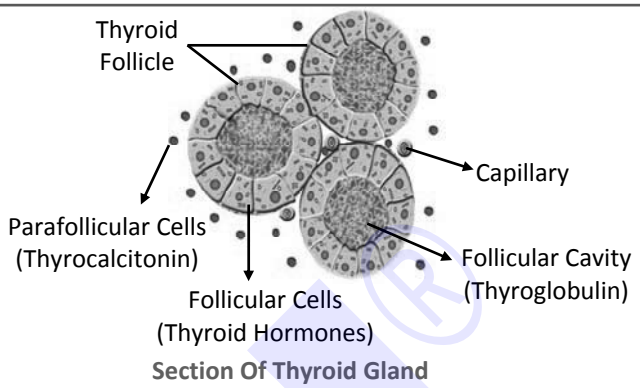
4. Hypophysial hormone that stimulates reabsorption of water and electrolyte by the distal tubules of kidneys is:
(1) Oxytocin (2) Aldosterone (3) Cortisol (4) Vasopressin

06. THYROID GLAND

It is the ***largest endocrine gland in the body***. This is *situated at the ventro-lateral side of the joint of trachea* and *larynx in the neck region of man*. It is bilobed and H-shaped. Both of its lobes are connected by non-glandular flap of a connective tissue called **isthmus**.



Diagrammatic view of the position of Thyroid and Parathyroid : Ventral side
NCERT XI Page No. 334, Figure No. 22.3 (a)



Section Of Thyroid Gland

- It is ***endodermal*** *in origin*.
- Each lobe of thyroid gland is made up of connective tissue. There are present so many **follicles** made up of glandular cells in connective tissue.
- These follicles are scattered in loose connective tissue, the **stroma**. 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.*
- Parafollicular cells are found in interstitial tissue in between the follicle & secrete **calcitonin (TCT) hormone**

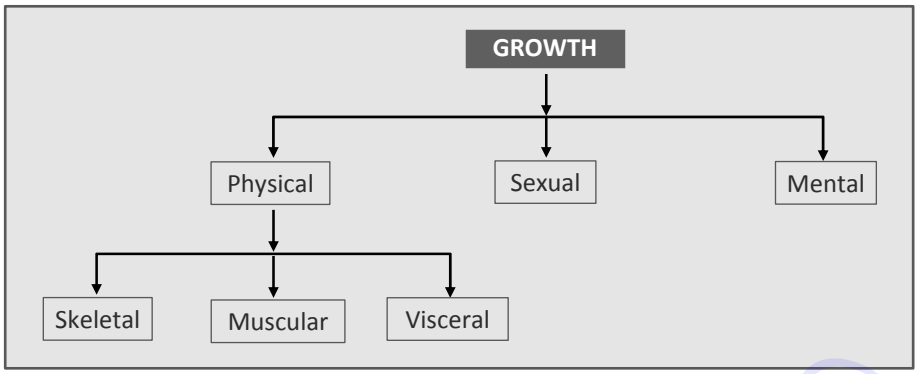
Production of hormones :–

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.

(1) FUNCTIONS OF THYROXINE

- **Growth and Development :**



- **Basal metabolic rate :**

(i) 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 $\rightarrow$ Body Temp. increase $\rightarrow$ 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**.

(ii) 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.

- **Metabolism :**

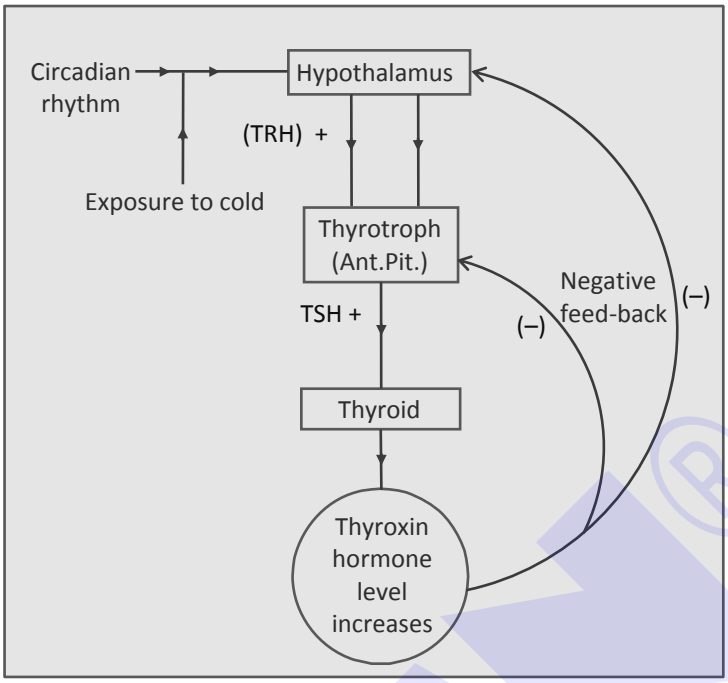
(i) **Fat :** Enhances enzyme activity both synthesis & predominantly catabolism of cholesterol.

(ii) **Carbohydrate :** Blood sugar increases, act as a diabetogenic hormone.

(iii) **Protein :** Both catabolism & anabolism but at optimum concentration of thyroxine, **anabolism** is dominant.

- **CNS :-** Development and maturation of CNS.
- **Blood :-** Stimulate erythropoiesis.
- **Maintenance** of H_2O and electrolytes balance is also influenced by thyroid hormone.
- **Gonads :-** Regulates menstrual cycle.

Regulation of Thyroid Hormone Secretion :



(2) THYROID DISORDERS

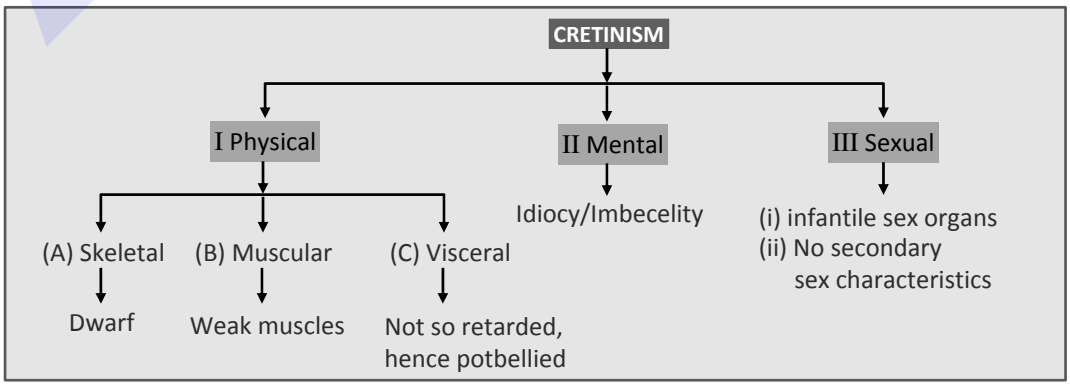
(A) Hypothyroidism :

(i) Simple/Colloid goitre : If there is deficiency of iodine in food then thyroid try to absorbs more and more iodine from blood and increases its size it is 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. When most of the people show the symptoms of this disease then it is called **endemic goitre**. Persons who take sea foods, never show the symptoms of goitre.


Cretinism

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



(iii) Thyroid myxodema : In adults, hypothyroidism causes **Myxoedema**. (Gull's disease). In adults women, menstrual cycle becomes irregular.

(B) Hyperthyroidism :

Due to cancer of thyroid gland or due to development of nodules of 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 goitre

Exopthalmic Goitre or Grave's disease, Basedow's disease or thyrotoxicosis :-

Exopthalmic goitre is a form of hyperthyroidism, characterised by enlargement of the thyroid gland, protrusion of the eyeballs, increased basal metabolic rate, and weight loss also called **Graves' disease.**

Parafollicular cells or C–cells :

These cells are found in the stroma of thyroid gland & basal part of follicle. These cells are of endocrine nature. These cells secrete **thyrocalcitonin (Calcitonin) hormone** which lacks iodine. It is a **protein**.

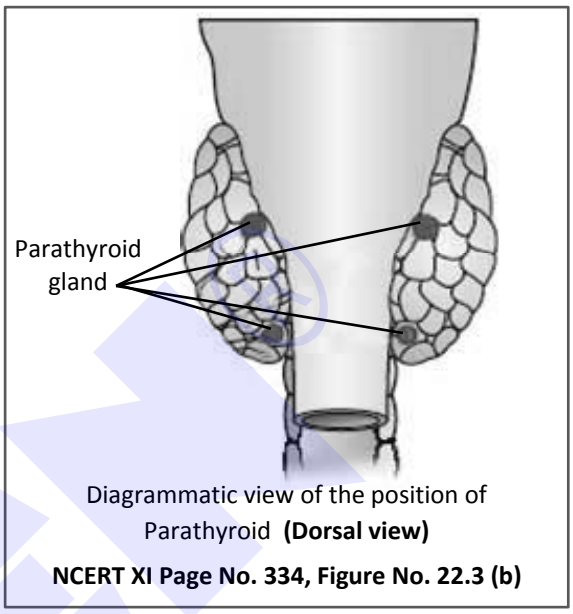
Thyrocalcitonin reduces the destruction of bones and increases the rate of excretion of Ca^{++} in urine, thus reduces the number of Ca^{++} in extra cellular fluid.

- It enhances the deposition of Ca^{++} in bones thus making bones solid and strong.
- This hormone is antagonistic to ***Collip's hormone*** or ***parathormone***.

07. 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 hypercalcaemic hormone that increases blood Ca^{+2} level by :-
  - (i) Stimulating the process of bone resorption / dissolution / demineralisation.
  - (ii) Promoting the absorption of Ca^{+2} from food in the intestine.
  - (iii) Promoting the reabsorption from the nephrons in the kidneys.



Diagrammatic view of the position of Parathyroid **(Dorsal view)**
NCERT XI Page No. 334, Figure No. 22.3 (b)

- 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.
- 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 ECF (It is known as ***hypocalcaemia***) and amount of PO_4^{-3} is increased.

- 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 brittle and weak. This condition is called as **Osteoporosis**.

- When quantity of Ca^{++} is increases in ECF and level of PO_4^{---} is reduced, this condition is known as *hypercalcaemia* and *hypophosphatemia* respectively.
- Due to excess deposition of Ca^{++} in kidneys, **Stones** are formed.

08. 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.

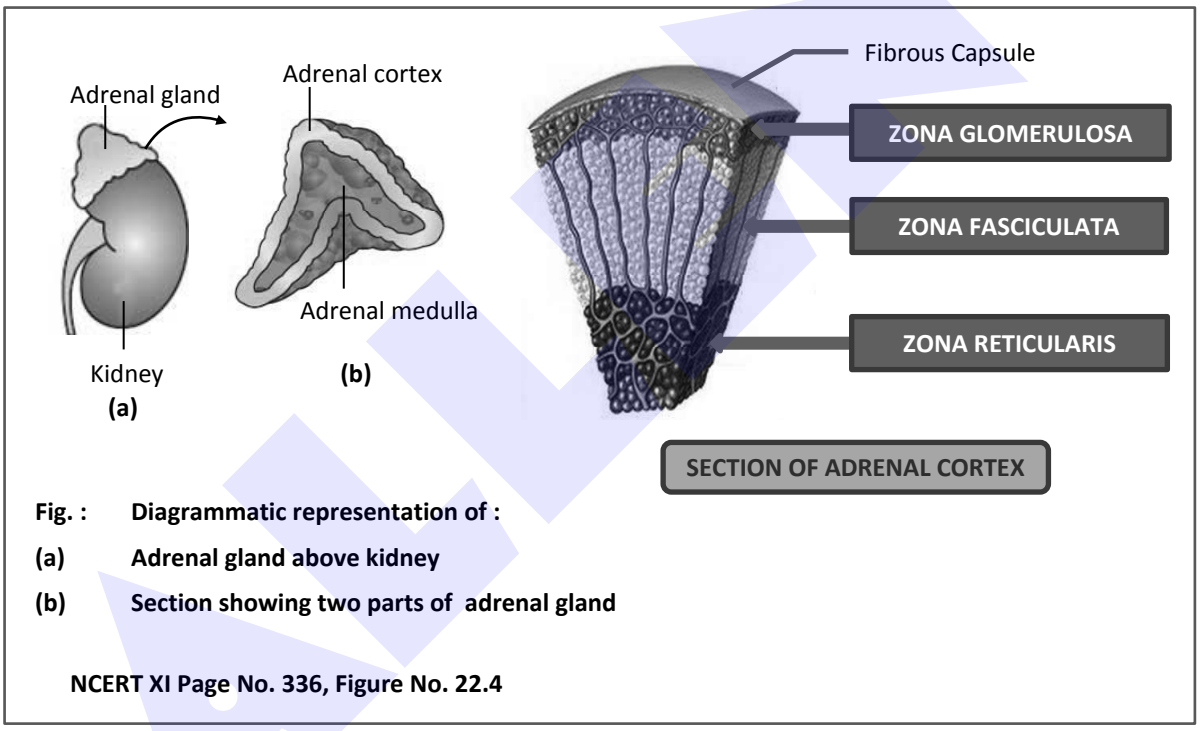


Fig. : Diagrammatic representation of :
(a) Adrenal gland above kidney
(b) Section showing two parts of adrenal gland

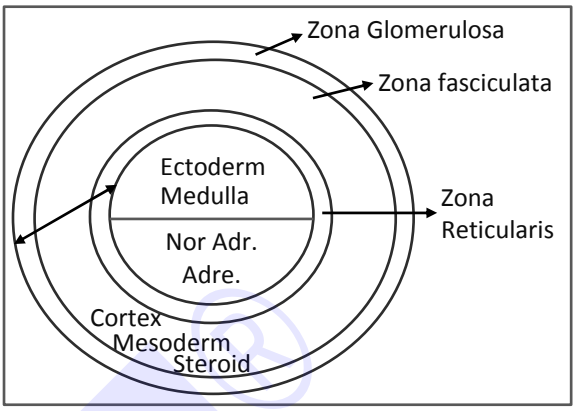
NCERT XI Page No. 336, Figure No. 22.4

- Whole gland is surrounded by a fibrous capsule.
- Each gland has two parts :-

  Outer part of gland is called ***cortex*** and inner part is called ***medulla***.
- **Cortical portion** is 80-90% and is developed from **mesoderm of embryo.**
- **Medullary portion** of this gland is made up of **neural - ectoderm of embryo.** Only 10 - 20% part is medullary part of gland.

(1) ADRENAL CORTEX

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



(i) Outer zone or Zona glomerulosa :

Mineralocorticoid hormones are secreted by this zone.

(ii) Middle zone or Zona fasciculata :

This zone secretes **glucocorticoid** hormones.

(iii) Inner zone or Zona reticularis : 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.

(A) 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 maintenance 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**).

(B) Glucocorticoids :

(Secretion control by ACTH).

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

Metabolic Effect :

(i) On carbohydrate metabolism : *Stimulate gluconeogenesis and increases sugar in blood (hyperglycemic hormone)*

(ii) Fat metabolism : Stimulates **lipolysis** in adipose tissue.

(iii) 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**.

(C) Sex - Hormones/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.

(2) ADRENAL MEDULLA

Origin : The adrenal medulla develops from the **neuroectoderm 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.**

Hormones 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 :

(i) 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.

(ii) Increases the heart beat, the strength of heart contraction and thus circulation of blood becomes faster.

(iii) 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.

(iv) The hormone enhances the flow of blood by *vasodilation* of blood vessels of brain, heart, liver and skeletal muscles.

(v) It constricts the blood vessels of skin (*Vaso constriction*).

(vi) It also stimulates the breakdown of glycogen resulting in an increased concentration of glucose in blood. It also stimulate the breakdown of lipids and proteins.

(vii) The hormone stimulates contraction in spleen, as a result of it, spleen pours its stored blood into blood stream.

(viii) It checks the secretion of saliva and reduces the peristaltic movements in alimentary canal.

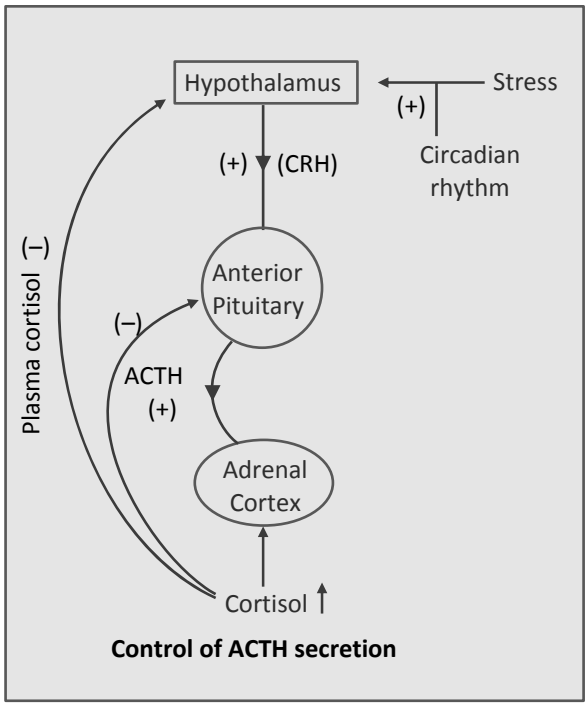
- Adrenaline provides the body with an emergent chemical defence mechanism in stress conditions that threaten the physical integrity and chemical consistency of the body e.g. accident, restlessness, fear anger, mental tension, pain etc. It immediately prepares the body to face the emergency by a violent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



Control of ACTH secretion

- 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 :

(i) Hyposecretion :

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

(ii) 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 characterised by - moon face, fish mouth, buffalo hump.

BEGINNER'S BOX — THYROID, PARATHYROID AND ADRENAL GLAND

1. Non iodinised hormone secreted by thyroid gland is :

(1) T_3 (2) T_4 (3) Calcitonin (4) Oxytocin

2. The secretion of PTH in man is regulated by :

(1) Circulating level of sodium.

(2) Circulating level of potassium.

(3) Circulating level of calcium.

(4) Circulating level of magnesium.

3. Deficiency of adrenal cortex hormone may cause :

(1) Simmond's disease (2) Acromegaly

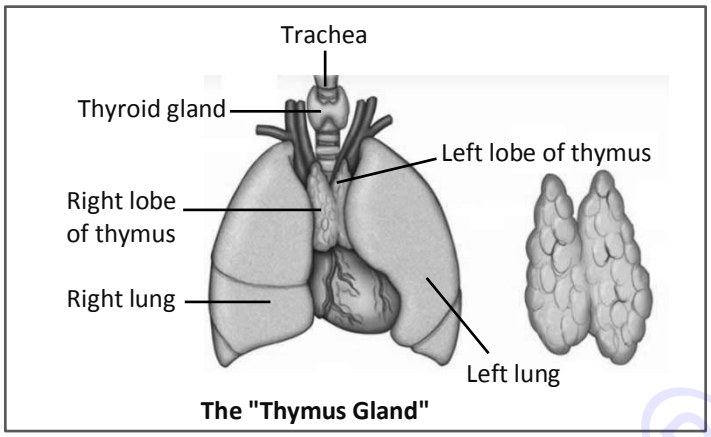
(3) Cushing's syndrome (4) Addisson's disease

4. Which of the following is the widest layer of adrenal cortex ?

(1) Zona glomerulosa (2) Zona fasciculata

(3) Zona reticularis (4) Both (2) and (3) options are equally wide

09. THYMUS GLAND



The "Thymus Gland"

- It is **endodermal** in origin.
- Thymus is a **bilobed gland** located between lungs (mediastinal space) behind sternum on the **ventral side of 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 internally both the lobes are redevising in to small lobules.

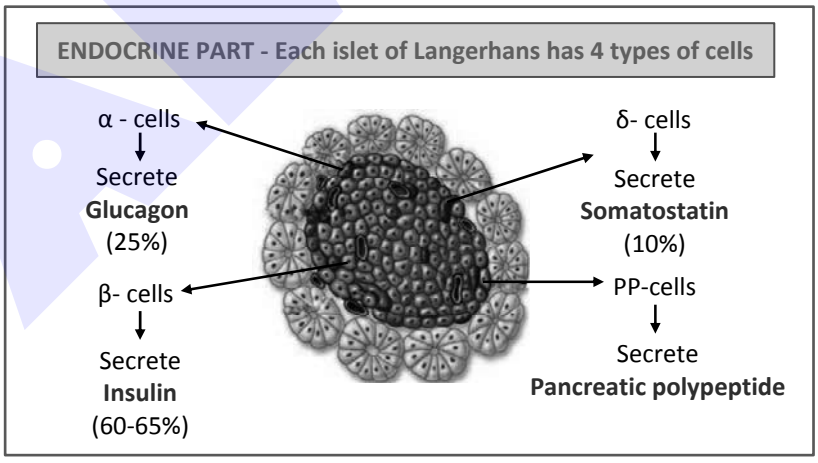
Hormones and functions of thymus gland :-

- Thymus gland secretes peptide hormone called **thymosins or thymin hormone.**
- After the birth, **T - Cells** or **T - lymphocytes** are matured in thymus gland, then these lymphocytes are released by thymus gland, reach to lymphatic organs like spleen, payer's patches and lymph nodes & deposited in it
- Thymosin hormone stimulates the maturation of lymphocytes to destroy the antigens produced by bacteria or pathogen.
- Thymus provide **cell mediated immunity** (Cellular immunity) and also promote production of antibodies to provide **humoral immunity.** So thymus is also called **"Throne of immunity"** or **"Training school of T-lymphocytes"**.

10. PINEAL BODY

- 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.
- 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** & **defence 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 behaviour in mammals. It inhibits the sexual irritation, and also inhibits the development of genitalia and their functions.
- Maximum development of pineal body upto 7yr & then it undergoes involution & at the age of 14 yr interstitial tissue and crystals of $CaCO_3$ or Ca_3PO_4 are deposited in it, these are called "**Brain sand**" or "**Acervuli**".

11. PANCREAS



- It is **endodermal** in origin.
- Pancreas is a pink coloured mixed gland (heterocrine) situated in the backside of stomach in abdominal cavity. (Curve of Duodenum)

- Acini are found in pancreas which secrete digestive enzymes. Acini form **99%** part of pancreas gland. These are **exocrine** in nature. There are found numerous small endocrine glands scattered between the acini, these small endocrine glands, are called **Islets of Langerhans (1 to 2 million cell).** They form only **1%** part of the gland. These were discovered by **Langerhans**.
- Each islet of Langerhans has 4 types of cells

(A) **Alfa cells (α - cells) :** These are the largest cells present in peripheral region these are approximately 25% of the total cells. They secrete **glucagon** hormone.

(B) **Beta cells (β - cells) :** These are the small cells present in central region. These are about 60–65% part of total cells. They secrete **Insulin** hormone.

(C) **Delta cells (δ - cells) OR Gamma cells (γ - cells) :**

These cells are found in middle region. These are about 10% part of total cells, They secrete **somatostatin** hormone which regulates the activities of α - cells and β - cells.

(D) **F cell or PP – cells :** These cells secrete **pancreatic polypeptide** hormone. Which probably helps in reabsorption of food in intestine.

(1) INSULIN

- One molecule of Insulin is made up of **51 - amino acids** that has 2 chains.
  (i) α - chain - It is made up of **21** amino acids
  (ii) β - chain - It is made up of **30** amino acids. Both the branches or chains are bind together with cross bonds of disulphide bonds.

Functions of Insulin hormone :

(A) On Membrane Permeability :

Except **brain cells**, **R.B.Cs**, **retina** and **genital epithelium**, insulin stimulates the permeability and consumption of glucose in all somatic cells.

(B) Actions on Metabolism :

(i) Carbohydrate :

(a) Insulin inhibits gluconeogenesis.

(b) Promotes *glycogenesis*. There are two major sites of glycogenesis, **liver** and the **muscles**.

(c) Enhances peripheral utilization **(oxidation)** of glucose, causing the blood sugar level to fall.

(d) Inhibits glycogenolysis.

(ii) Fat :

Insulin promotes *lipogenesis* and inhibits lipolysis.

Insulin also inhibits formation of ketone bodies.

(iii) **Protein :** Insulin promotes protein synthesis by promoting uptake of amino acid by liver and muscle cell.

(iv) **Nucleic acid :** Insulin promotes *synthesis of DNA and RNA*.

Normal concentration of sugar in blood is **90 - 110 mg. per 100 ml.** of blood.

It affect the BMR in cells.

- **Hyposecretion of Insulin :– [Diabetes mellitus (Sugar disease)]**

Hyperglycemia-

- 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**.
- **Glycosuria :** Glucose is excreted through urine, if amount of glucose exceeds from 180 mg/dl in the blood, this is known as "**Glycosuria**".
- **Polyuria :** The amount of water increases (in this stage) in the urine, so intervals of urination reduced, it is called **polyuria**.
- **Polydipsia** :- Due to excess excretion of urine (Urination at short intervals), probability of dehydration is enhanced. The patient feels excessive thirst called polydipsia.
- **Polyphagia** : Excessive hunger.
- **Ketoacidosis :** Due to active and incomplete decomposition of fats in fatty tissues, ketone bodies are formed. These ketone bodies are toxic like *acetone, aceto acetic acid* and *beta hydroxy butyrate*.
- **Ketonuria :** Excretion of toxic ketone bodies through urine.
- The combined effect of ketoacidosis, dehydration and hyperglycemia may cause **diabetic coma** to the patient, patient becomes unconscious and even may die.
- Insulin hormone is given to the patient by injection **(subcutaneously)** in this disease, Insulin given orally is not effective, because it gets digested in the alimentary canal like other proteins.
- **Hypersecretion of Insulin :– (Hyperinsulinism)**
- Due to hypersecretion of insulin amount of glucose decreases in blood. It is called **hypoglycemia**.
- In this stage, body cells take more and more glucose from blood. So need of glucose for nervous system, retina of eye, genital epithelium is not fulfilled, as a result of that patient looses his reproductive power and sight. Due to excess irritation in brain cells, patient feels exhausted, unconsciousness, cramps and the patient may even die.

(2) GLUCAGON

- This is secreted by **α-cells**.
- Glucagon is a **hyperglycemic factor**.
- It is made up of chain of polypeptide of 29 amino acids.
- It is antagonistic to insulin. It is secreted by the gland, when sugar level of blood reduces.
- Glucagon hormone 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 stimulates *lipolysis* of fats in fatty tissues.
- It decomposes the glycogen into glucose in liver i.e. it stimulates *glycogenolysis* in liver.
- The secretion of insulin and glucagon is controlled by a limit control 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.

BEGINNER'S BOX — THYMUS, PINEAL AND PANCREAS

1 Which of the following disease is not caused by hyper/hyposecretion of hormone ?
(1) IDDM (2) NIDDM
(3) Acromegaly (4) Myxoedema

2. Following are the principle action of insulin except :-
(1) Increase transport of Glucose in to the cells
(2) Stimulate glycogenesis
(3) Promote Glycogenolysis
(4) Increase lipogenesis

3. Diabetes insipidus is due to :
(1) Hypersecretion of insulin
(2) Hyposecretion of vasopressin
(3) Hypersecretion of vasopressin
(4) Hyposecretion of insulin

4. Pineal body originates from :
(1) Dorsal part of diencephalon
(2) Ventral part of diencephalon
(3) Ventral part of cerebellum
(4) Dorsal part of cerebellum

12. 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.), 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 pregnancy and increases secretory surface of alveoli, thus it supports milk secretion in lactating mother.

(3) 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.*

(4) KIDNEY

The juxtaglomerular cells of kidney produce a peptide hormone called **erythropoietin** which *stimulates erythropoiesis (formation of RBC)*.

(5) GASTRO INTESTINAL TRACT HORMONE

Endocrine cells present in different parts of the gastro intestinal tract secrete four major peptide hormones, namely **gastrin, secretin, cholecystokinin (CCK)** and **gastric inhibitory peptide (GIP)**

- **Gastrin** acts on the gastric glands and stimulates the secretion of hydrochloric acid and pepsinogen.
- **Secretin** acts on the exocrine pancreas and stimulates secretion of water and bicarbonate ions.
- **CCK** acts on both pancreas and gall bladder and stimulates the secretion of pancreatic enzymes and bile juice/respectively.
- **GIP** inhibits gastric secretion and motility.
- Several other non-endocrine tissues secrete hormones called **growth factors.** These factors are essential for the normal growth of tissues and their repairing/regeneration.

EXTRA POINTS

HORMONES WHICH ALWAYS REMAIN IN TISSUE FLUID

There are some hormones which never reach upto blood stream but always remain in ECF.

These are as follows :-

(1) Prostaglandin :– There are called *local hormones*. These are fatty acids. These are most active substances among all the known substances.

- Prostaglandin are of so many types. Kidneys, gonads, seminal vesicles, thymus, brain etc. organs and their cells secrete these hormones in ECF.
- These prostaglandins are first of all observed in semen of man. These stimulate contraction of unstriated muscles.
- These prostaglandins are secreted by seminal vesicles and reach upto vagina of female through semen of male, and then these activate the muscles of uterus of female.

(2) Kinins :– These are chemicals which are secreted by any organ of body at the time of chemical change in ECF, and reduce the B.P. by expanding blood vessels. These also reduce the time of blood clotting.

Kinins are also called as **"First aid hormone".**

- **Heterocrine gland :-** These are those endocrine glands which are involved in hormone secretion as well as some other function eg. pancreas, gonads, GI mucosa and kidneys.
- Contrary to thyroid dwarf (cretins), the pituitary dwarf have a normal mental development and proportionate body.
- **Simmond's disease :-** This condition is due to atrophy of the anterior lobe of pituitary gland.
- **Growth hormone :-** Stimulates the liver to form **"Somatomedins"** ("Insulin like growth factors"). These somatomedins have potent effects on bone growth.
- In heart CGMP has antagonistic effect to CAMP, CAMP mediate muscle contraction in response to adrenaline, while CGMP slow down muscle contraction is response to acetylcholine.
- CGMP used in second messenger in atrial natriuretic peptide and nitric oxide.
- Adrenal gland is also known as ***4 - S gland***

  4–S
  - S – Sugar metabolism
  - S – Salt retaining actions
  - S – Sex hormones
  - S – Stress reactions

- Pituitary tumor may cause visual problem because it exerts pressure on optic chiasma and thus affect and transmission of sight impulses.
- The **cortisol** hormone of adrenal cortex serves to maintain the body in living condition and recover it from the severe effects of stress reactions. Thus, an increased output of cortisol is "**life saving**" in "**shock conditions**". So it is also known as **life-saving hormone**.
- The hormones of **adrenal medulla** prepare the animal for fear, fight or flight in emergency conditions, (by excess secretion of these hormones) Adrenaline hormone is called **3F = FFF hormone** and adrenal gland is called "**triple F gland**" (FFF gland)
- The amount of cortisol and ACTH in blood is maximum in the morning and minimum in early part of night.
- Secretion of thymin decreases the neuromuscular transmission, so hypersecretion of thymine may cause ***myasthenia gravis***. It provides the antibody against receptor & block the NM junction.
- **Synergestic hormone** – When two or more hormone complement the function of each other and both are needed for full expression of hormone effect.

  Example : Insulin and growth hormone/Thyroxine have synergestic effect for body growth.

  Estrogen, progesterone, prolactin and oxytocin have synergestic effect for physical growth of mammary gland.
- **Antagonistic hormone** – When two hormones oppose the actions of each other.

  Example : Insulin and glucagon

  Calcitonin and Parathyroid hormone

  MSH and melatonin

- **Type – I** diabetes or **Insulin-dependent diabets 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.**
  - World diabetes day - 14 November
  - "**Insulin shock**" - At the time of physical labour or fasting, if a diabetic patient takes an insulin injection, sugar level in blood reduces quickly up to 40 mg/100ml of blood. It is called insulin shock. The patient may be unconscious or even may die.
- Melatonin suppress hypothalamus, causes suppression of the anterior pituitary gonadotropins leading to suppression of menstruation and gonadal activity. Does that mean hypothalamus is under control by melatonin?

BEGINNER'S BOX — ANSWERS KEY

MECHANISM OF HORMONE ACTION

Que.	1	2	3	4
Ans.	**4**	**1**	**4**	**3**

PIUITARY AND HYPOTHALAMUS

Que.	1	2	3	4
Ans.	**4**	**1**	**2**	**4**

THYROID, PARATHYROID AND ADRENAL GLAND

Que.	1	2	3	4
Ans.	**3**	**3**	**4**	**2**

THYMUS, PINEAL AND PANCREAS

Que.	1	2	3	4
Ans.	**2**	**3**	**2**	**1**

ESSENCE

HORMONES REGULATE

- **Metabolism**
- **Growth**
- **Developement**

- Hormones are non nutrient chemicals, which act as intercellular messengers and are produced in trace amounts

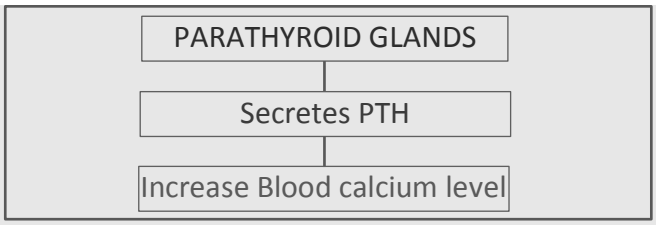
PITUITARY GLAND

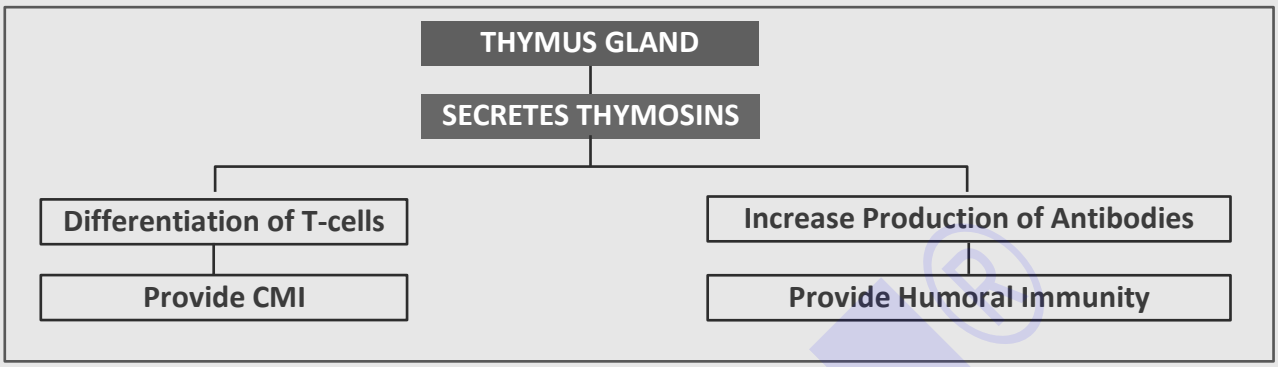
- **Pars distalis** → Produce 6 trophic hormones
  - GH, TSH, ACTH, FSH, LH, PRL
    - GH → Growth and development of somatic tissue
    - TSH, ACTH, FSH, LH → Regulate activities of peripheral endocrine glands
  - Regulated by Hypothalamic hormones
- **Pars Intermedia** → Secrete one hormone
  - MSH
- **Pars Nervosa** → Secrete two hormones
  - ADH → Promote reabsorption of water & electrolytes
  - Oxytocin → Parturition
  - Hormones synthesized by hypothalamus

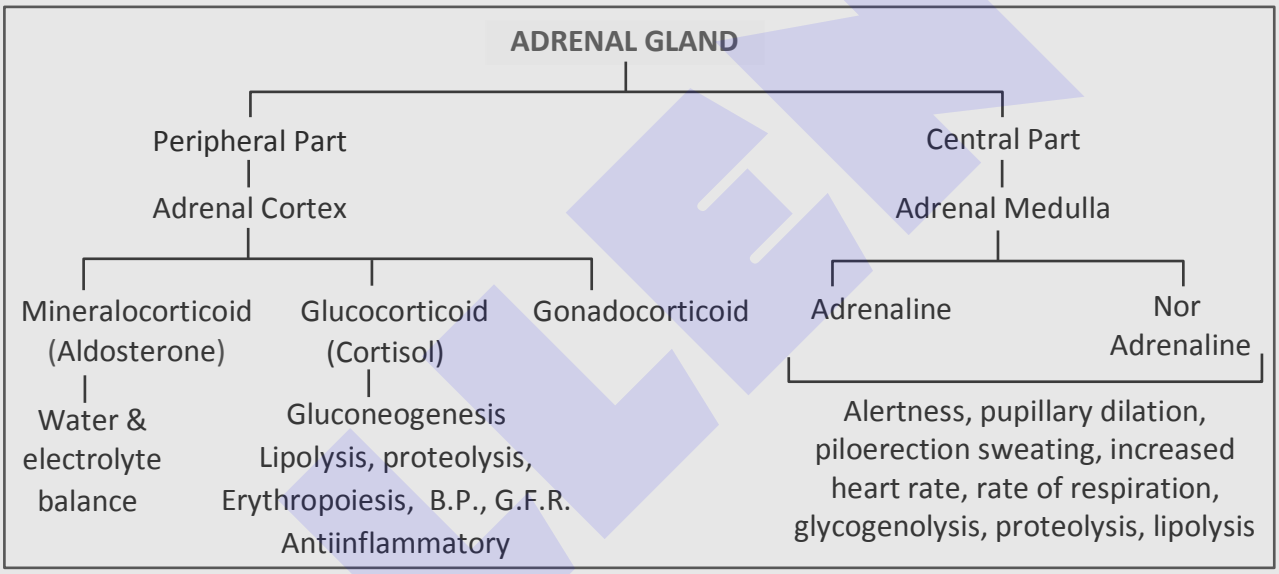
- Pineal Gland → Melatonin → Regulates
  - Diurnal rhythm
  - Body temp.
  - Pigmentation
  - Immune response

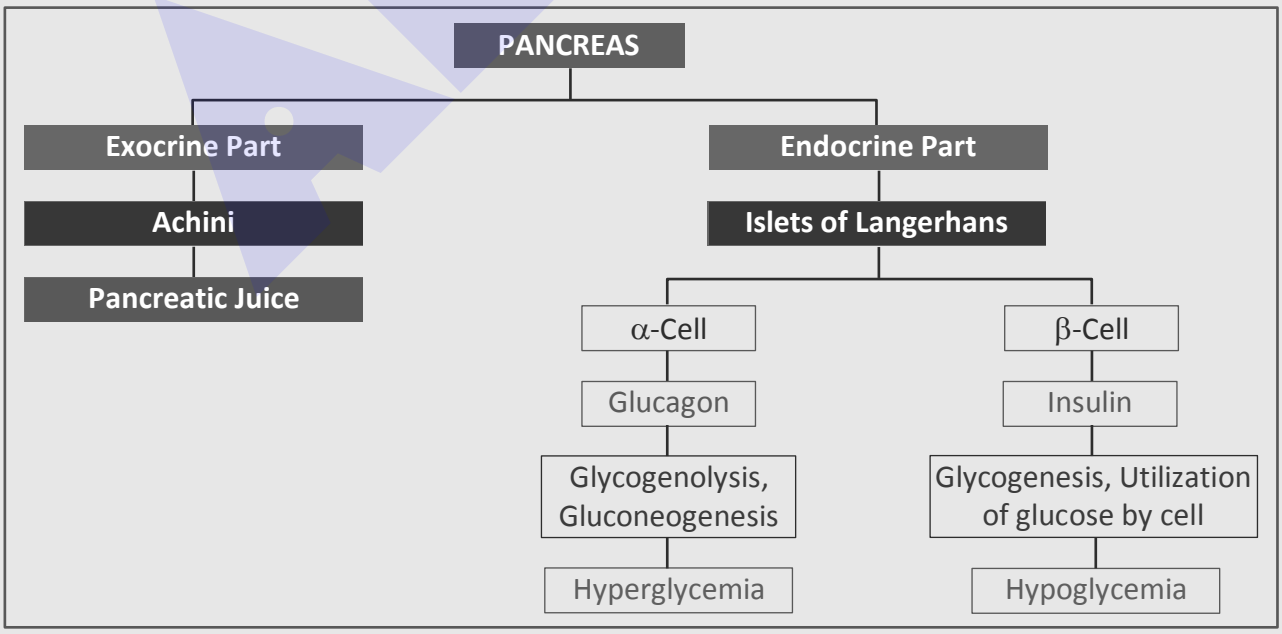
THYROID GLAND

- **Follicles** → Secretes T_3 & T_4 (Thyroxin) → Regulate
  - BMR
  - Development & maturation of CNS
  - Erythropoiesis
  - Metabolism
  - Menstrual cycle
- **Para follicular cells** → Secretes TCT → Decrease blood calcium level


PARATHYROID GLANDS
Secretes PTH
Increase Blood calcium level


THYMUS GLAND
SECRETES THYMOSINS
Differentiation of T-cells
Provide CMI
Increase Production of Antibodies
Provide Humoral Immunity


ADRENAL GLAND
Peripheral Part
Adrenal Cortex
Central Part
Adrenal Medulla
Mineralocorticoid (Aldosterone)
Water & electrolyte balance
Glucocorticoid (Cortisol)
Gluconeogenesis
Lipolysis, proteolysis,
Erythropoiesis, B.P., G.F.R.
Antiinflammatory
Gonadocorticoid
Adrenaline
Nor Adrenaline
Alertness, pupillary dilation, piloerection sweating, increased heart rate, rate of respiration, glycogenolysis, proteolysis, lipolysis


PANCREAS
Exocrine Part
Achini
Pancreatic Juice
Endocrine Part
Islets of Langerhans
α-Cell
Glucagon
Glycogenolysis, Gluconeogenesis
Hyperglycemia
β-Cell
Insulin
Glycogenesis, Utilization of glucose by cell
Hypoglycemia

Endocrine glands	Name of Hormones	Hyposecretion disorder	Hypersecretion disorder
Pituitary	Growth hormones ADH	Child-pituitary dwarfism Diabetes Insipidus	Child – Gigantism Adult – Acromegaly
Thyroid gland	Thyroxine	Goitre Child = Cretinism	Adult – Exopthalmic goitre or Grave's disease
Adrenal gland	Glucocorticoid	Addisons disease	
Pancreas	Insulin	Diabetes mellitus	

- The testis secretes androgens, which stimulate the development, maturation and functions of the male accessory sex organs, appearance of the male secondary sex characters, spermatogenesis, male sexual behaviour, anabolic pathways and erythropoiesis.
- The ovary secretes estrogen and progesterone.
- Estrogen stimulates growth and development of female accessory sex organs and secondary sex characters.
- Progesterone plays a major role in the maintenance of pregnancy as well as in mammary gland development and lactation.
- The atrial wall of the heart produces atrial natriuretic factor which decreases the blood pressure.
- Kidney produces erythropoietin which stimulates erythropoiesis.
- The gastrointestinal tract secretes gastrin, secretin, cholecystokinin and gastric inhibitory peptide.

Disorders

- Dwarfism – Deficiency of GH.
- Gigantism – Over secretion of GH in growth age.
- Acromegaly – Over secretion of GH.
- Diabetes insipidus – Deficiency of ADH.
- Cretinism – Deficiency of thyroid hormones in embryo.
- Myxoedema – Deficiency of thyroid hormones in adults.
- Simple goitre – Deficiency of iodine in dist.
- Exophthalmic goitre – Over secretion of thyroid hormones.
- Tetany – Deficiency of PTH
- Osteoporosis – Over secretion of PTH.
- Diabetes mellitus – Deficiency of insulin.