ENDOCRINE SYSTEM

- **Chemical Coordinating** system :
- During the course of evolution, metazoans have acquired two integrating systems, nervous and endocrine systems.
- These two systems co-ordinate and integrate functions of different parts of body in accordance with the changing needs of external and internal environments.
- Nervous system achieves functional coordination by transmitting information through nerve impulses.
- The Endocrine system achieves coordination and integration for slow and persistent responses of the body by transmitting impulses through **'chemical messengers'** called **hormones.**
- Endocrine glands release their hormones, into blood, circulate in the whole body and regulate metabolism, growth, secretion, homeostasis, gastrointestinal mobility and digestion, blood pressure and heart beat, kidney function, lactation, reproduction etc.

- Endocrine system includes certain glands, called ductless glands which secrete hormones directly into the blood.
- Therefore, these glands are called endocrine glands. Study of the endocrine glands and their hormones is called endocrinology. **Thomas Addison** is known as **'Father of Endocrinology'.**
- **Hormones:** *(Hormacin* - to excite). These are organic substances and can be defined as chemical messengers. The term hormone was suggested by **Starling.**
  a. Hormones are synthesized in the body by endocrine glands.
  b. They are never present in the food.
  c. Hormones are either proteinoids or steroids.
  d. Hormones are soluble in water and easily diffusible through cell membrane. They are always secreted in small amounts.
- They are not stored in the body. Those that are not used are quickly excreted in urine or inactivated or degraded.
- A particular hormone affects cells only of a specific type in definite parts of body. This is called **hormone specificity.**
- The specific cells or body parts affected by a hormone are called **target cells or organs.**
- Hormones are classified on the basis of biochemical structure into :
  1. Amine hormones : They are derived from single amino acid. e.g.: Thyroxine and catacholamines (epinephrine & nor epinephrine) are the derivatives of tyrosine, and melatonin is the derivative of tryptophan.
  2. Steroid hormones : They are derived from substances like cholesterol containing sterol ring. e.g.: Estrogen testosterone and progesterone, aldosterone, cortisol etc.
  3. Protein & peptide hormones : peptide hormones are formed of small peptides of 3 – 49 amino acids. e.g. :eg ADH and oxytosin
  Protein hormones are formed of 50 to 200 amino acids eg: insulin, prolactin, hGH, TSH etc.
- **Hormone action:** hormones are bind to specific proteins of target cells called receptors
- The activated receptor hormone complex influences gene expression
- Water soluble hormones cannot diffuse through the plasma membrane and bind to receptors on target cells
- A second messenger is produced (eg: cyclic AMP) inside the that causes a cascade of activation of enzymes/.-
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- **Endocrine glands**: This chapter is essentially dealt with reference to man.
- Three categories of glands constitute endocrine system in vertebrates. They are
  1) glands with definite function,
  2) Mixed glands and
  3) Other structures
- **I. Glands of definite function they are :**
  1. Thyroid 2. Parathyroid 3. Adrenal
  4. Pituitary 5. Thymus 6. Pineal

1. Thyroid :

- This is the largest endocrine gland located on the ventral side of the larynx. It is bilobed and connected by a median **isthmus**.
- The gland is endodermal in origin. It is probably homologous to the endostyle of protochordates.
- Thyroid gland secretes an iodine containing hormone called **thyroxine.** Iodine is obtained from food.
- The parafollicular cells of thyroid secrete a non-iodinised hormone named as **calcitonin.**
- The secretion of thyroxine is regulated by Thyroid-stimulating hormone (TSH) of pituitary.

- **Effect of thyroid hormone**: It helps in O_2 consumption of all organs except brain, retina, spleen and lymph nodes.
- There is also an increase in basal metabolic rate (BMR), maintains the body temperature and stimulates the protein synthesis.
- It stimulates the metamorphosis in lower vertebrates like frog.
- **Calcitonin** is the hormone secreted by parafollicular cells lowers calcium level in ECF (Extra Cellular Fluid). In Amphibians, thyroxine plays a significant role in metamorphosis. Hyposecretion results in neoteny.

Thyroid irregularities and diseases in man :

i) **Hypothyroidism:** Hypothyroidism is caused by deficiency of secretion, less or non availability of iodine in foods,

- **Cretinism:** This occurs in childhood. The patient remains mentally retarded and sterile dwarf called **cretin**.
- Thick and dry skin, potbelly, gaping mouth, thick lips and enlarged tongue are symptoms of the disease.
- **Myxedema:** Hypothyroidism in adults cause myxedema. Mucous accumulates in the subcutaneous tissue causing puffiness of the skin.
- The body becomes heavy. Poor memory, muscular weakness, intolerance of cold, low blood pressure, hairfall are some important manifestations.

ii. **Hyper secretion of thyroid – hormones (Thyrotoxicosis)**

- It results in considerable increase in glucose and oxygen consumption by cells. Consequently the basal metabolic rate increases several folds.
- This results in nervous tension, restlessness and anxiety, muscular weakness, fatigue and tremors, weight loss, warm and soft skin, increased appetite etc.
- Hyperthyroidism may be because of over active cells of normal gland or enlargement of the gland causing goitre.
- Such a goitre is called exopohthalmic goitre or Grave's disease a condition in which eye balls protrude due to accumulation of mucus in the eyes of orbits.

iii. **Simple goitre :**

- It is due to iodine deficiency in food. In an effort to obtain more iodine from blood for normal secretion, the gland enlarges by increasing the follicles.
- The enlarged gland causes a swelling in the neck. This condition is called **goitre**. The areas where goitre is endemic are called **'goitre belts'**.
- In such areas the iodine is washed away in rainwater causing goitre as an endemic disease.

2. Parathyroid glands :

- Two pairs of small flattened ovoid disc like parathyroid glands are partially or completely embedded in dorsal surface of the two lobes of the thyroid gland.
- Parathyroids secrete a single harmone called **parathormone**. Parathormone helps in **homeostasis** by regulating the amount of calcium and phosphate in ECF.
- Parathormone promotes the absorption of calcium from food in the intestine and its reabsorption from nephrons in the Kidneys.
- i) **Hypoparathyroidism**: Undersecretion of parathormone, results in **hypocalcemia,** the level of calcium in ECF falls. This is responsible for goose flesh, muscles remain in sustained contraction. This is called **tetany.**
- ii) **Hyperparathyroidism**: Oversecretion of parathormone is rare and occurs usually due to overgrowth of one or more parathyroid glands. It causes demineralisation of bone which tends to become soft, weak and fragile. This condition is **osteoporosis**, further leading to '**osteitis fibrosa cystica.'**

3. **Adrenal or supra renal glands :**

- Adrenal gland is located on top of each kidney. Each gland has two parts, an internal reddish brown medulla and an external bright yellow cortex.
- The adrenal cortex is distinguished into three regions :
  1. Outer **Zona glomerulosa** with columnar cells.
  2. Middle **Zona fasciculata** with polyhedral cells.
  3. Inner **Zona reticularis** with anastomosing network.
- **Hormones:** Adrenal Cortex has about fifty steroid compounds. These are called corticosteroids. They fall into three categories.
  1. Mineralo corticoids 2. Glucocorticoids
  3. Sex corticoids.

1. Mineralo corticoids :

- These are secreted by zona glomerulosa. The principal mineral corticoid is aldosterone.
- It regulates the levels of sodium, potassium and chloride ions, by stimulating the absorption of sodium and chlorides and secretion of potassium.

2. Glucocorticoids:

- These are secreted by zona fasciculata. The two hormones cortisol and corticosterone play an important role in carbohydrate, protein and fat metabolism.
- They are also useful in inflammatory reactions and coping with stress.

3. Sex corticoids:

- These are secreted by zona fasciculta and zona reticularis.
- The male hormone is androgen while the female hormone is **estrogen.**
- They help in the development of secondary sexual characters.
- It is clear from the above accounts that adrenal cortex controls **stress reactions**, sugar and salt metabolism and development of sex.
- This **four S** gland is highly essential for proper development, existence and welfare of the body.

Hormones of adrenal medulla:

- The cells of medulla are called chromaffin cells. They secrete two important hormones namely **adrenaline** or **Epinephrine** and **nor-adrenaline** or **nor-epinephrine**.
- Adrenaline is released when the animal is stimulated by emergency or stress conditions like fear, anger, intense pain, accident and injury etc.
- Adrenaline causes marked elevation of blood pressure, intensifies cardiac contraction and cardiac output. Adrenaline and noradrenaline are called fight, 'flight or fright', hormones.
- **Adrenal irregularities:** Hyposecretion of adrenal cortex causes **Addison's disease**.
- In Addison's disease considerable amount of sodium and water is excreted in urine, leading to dehydration, low blood pressure, hypotension and weakness. Brownish pigmentation or bronzing of skin occurs due to uneven deposition of melanin.
- Oversecretion of adrenocorticoids causes **hyperglycemia** and **Cushings disease**. Patients die of brain haemorhages, cardiac arrest, pneumonia etc. due to ***Cushings disease.***

Pituitary gland :

- This is a small, ovoid gland present in a small depression, the **Sella turcica** of the skull, It is connected to the ventral wall of diencephalon of the brain through infundibular stalk.
- Pituitary gland is formed by union of two main lobes, an adenohypophysis & a neurohypophysis.

A. Adenohypophysis : It is distinguished into a large anterior lobe pars anterior and a thin intermediate lobe (pars intermedium).

- In human beings the intermediate lobe is functional in the embryo but rudimentary in the adult.
- **Hormones secreted**. Seven protein hormones are secreted by the adenohypophysis. The secretion of these hormones is regulated by the secretions of hypothalamus.
- **a) Somatotropin or Growth Hormone(GH)** : The hormone is important for proper and normal growth of the body, it promotes biosynthesis of DNA, RNA and protein in all body cells.
- **b) Prolactin or Luteotropic Hormone (LTH)** : It is called as 'hormone of maternity and it stimulates the function of corpus leuteum during pregnancy.
- In human beings it helps in secretion of milk after child birth.
- **c) Follicle Stimulating Hormone (FSH):** Stimulates growth of seminiferous tubules and spermatogenesis in men and growth of ovarian follicles and oogenesis in women.
- **d) Leutinizing Hormone (LH) or Interstitial Cell Stimulating Hormone (ICSH) :** In males, it stimulates the Leydig cells of testes to secrete a male Hormone, testosterone, that regulates secondary sexual characters.
- In female it stimulates ovulation and development of corpus luteum.
- Since the FSH. LH stimulate growth and activities of the gonads, these are called as gonadotropie hormones.
- **e) Adrenocorticotropic Hormone (ACTH) :** The role of the hormone is to intensify synthesis of hormones in adrenal cortex under a 'feed back mechanism'.
- **f) Thyroid Stimulating Hormone (TSH) :** The hormone promotes growth and function of Thyroid gland.
- **g) Melanocyte Stimulating Hormone (MSH):** The hormone is secreted by intermediate lobe and hence 'Intermedin' is a preferred name.
- It brings about the darkening of the skin in the lower vertebrates. But its function in birds and mammals is not known.
- Diseases caused by the irregularities of the adenohypophysis.
- **a**. **Dwarfism :** Undcrsecretion of pituitary growth hormone in children causes dwarfism.
- **b**. **Gigantism :** Oversecretion of growth hormone during childhood causes over growth of the skeleton and the body becomes giant sized.
- **c**. **Acromegaly :** Over secretion of growth hormone in adults, causes disproportionate gigantism, gorilla like features

B. Neurohypophysis :

- A small out growth is formed from hypothalamus. The terminal region of this outgrowth is called infundibular process is formed into neurohypophysis and the remaining region is present as **infundibulum.**
- Neurohypophysis fuses with the Rathke's pouch to form the **pituitary gland.**
- Pituitary gland is connected to the hypothalamus by infundibulum.

- Neurohypophysis is **pars nervosa.** Two small peptide hormones called **vasopressin** and **oxytocin** are secreted by the hypothalamic neurons and flow down the axons of **hypothalamo-hypophysial tract** within the infundibulum.
- These hormones are released from pars nervosa.
- **a) Vasopressin:** It helps in promoting the reabsorption of water from the distal convoluted tubules of nephrons.
- Since the hormone reduces excretion of water in urine, it is also called as **antidiuretic hormone** (ADH).
- When vasopressin is released in large amounts, the urine becomes concentrated and ECF is diluted increasing the BP.
- When vasopressin is released in lesser amounts, urine becomes diluted and ECF is concentrated decreasing the BP.
- The quantity of urine thereby increases to about 20 litres per day. The condition is called **diabetes insipidus.**
- **b) Oxytocin:** The hormone stimulates contraction of uterine muscles and thus facilitates child birth.
- It also helps in normalising the uterus and contraction of breast muscles and lactic duct, thus help in release of milk (Milk ejecting).
- Pituitary gland besides regulating growth, sex and general behaviour is also responsible for regulating the secretory activities of other principle endocrine glands and gonads.
- Therefore pituitary has been often called as **'The Master Gland'** of endocrine system.

5. Thymus gland :

- This is a bilobed, somewhat flat gland located on the ventral side just in front of heart. The thymus is well developed in a new born child.
- It grows upto puberty and shrink to a small structure by the age of twenty five years. The Hormone produced is **thymosin**, which promotes maturation of T- lymphocytes that destroy the invading micro-organisms and antigens,

6. Pineal Gland :

- The Pineal body is a small gland present attached to the dorsal wall of the diencephalon. A hormone named **melatonin** is secreted by the gland.
- It stimulates concentration of melanophores in the skin. Effect of melatonin is antagonistic to that of melanocyte stimulating hormone.
- In mammals it has an inhibitory factor for sexual maturation and excitation. Probably it regulates seasonal and circadian sexual behaviour.
- It acts as **neuroendocrinal transducer**.

II. Mixed Gland : Pancreas
(Gr - *Pancrease* - Sweet bread)

- It is a flat, pinkish gland and secretes the digestive juice as well as two hormones, insulin and glucagon.
- About 98% of the gland is thus exocrine formed by pancreatic acini. In the stroma there are approximately 1 to 2 million small clusters of endocrine cells called **Islets of Langerhans.**
- Islets of Langerhans contain hundreds of small cells that are distinguished into 4 types - beta cells, alpha cells, and scattered **delta and F cells.**
- Beta cells of islets of langerhans secrete insulin. Insulin regulates carbohydrate metabolism. It facilitates diffusion of glucose from blood into the cells through cell membrane.
- Insulin ensures normal biosynthesis of RNA, DNA and Proteins, so that normal growth and repair in the body may continue without any obstruction.
- **Banting and Best** were first to extract insulin in pure form from the pancreatic islets of new bom calf.
- **Diabetes mellitus:** The normal glucose level in human blood is 100 milligrams/dl of blood. The glucose level increases after every meal.
- Insulin is then secreted so that extra amount of glucose is taken by body cells and normal glucose level of blood is restored.
- Due to deficiency in insulin secretion, the entire carbohydrate metabolism is disturbed and the glucose level in the blood is elevated.
- When glucose level reaches 300 to 500 mg/dl, glucose starts passing out through urine.
- **This is called diabetes mellitus. Excess secretion of insulin in blood causes 'coma (Insulin shock) and death.**
- **Glucagon:** Its function is to elevate glucose level in blood when glucose is deficient.
- Glucagon intensifies glycogenolysis, deamination and gluconeogenesis and inhibits glycogenesis in the liver cells. **Somatostatin** inhibits the secretion of insulin and glucagons. It slows down the absorption of nutrients from alimentary canal. **Pancreatic polypeptide** inhibits the secretion of somatostatin.
- F-cells secrete **pancreatic polypeptide.**

III. Other Structurers :

1. Gonads :

- Gonads are testes and ovaries. The gonads besides forming sex cells, also secrete steroid hormones.
- These hormones regulate growth and development of secondary sexual characters and sexual behaviour.
- **a. Testes:** Stroma around semineferious tubules in testes contains small clusters of endocrine cells called the interstitial cells or cells of Leydig.
- These cells produce androgens. The principal androgen is testosterone. **Testosterone** is a masculinization hormone. It is secreted in considerable amounts from puberty to adolescence.
- Due to its effect accessory- reproductive organs such as epididymis, seminal vesicle, scrotal sac, penis, accessory genital glands etc., grow to their normal sizes, muscles and bones grow stronger.
- The male secondary sexual characters like beard, mustache, low-pitch voice, strong muscular body and broad shoulders.
- Deficient secretion of testosterone before puberty retards the growth of genitalia, muscles and bones and development of sexual characteristics. This results in a sterile *Eunuch.*
- **b. Ovaries:** Estradiol is the Principal feminizing oestrogen. The cells of a ruptured follicle form a yellow glandular structure corpus luteum.
- Corpus luteum produces a hormone called progesterone.
- The function of progesterone is to prepare the uterus for implantation of the blastrocyst to establish pregnancy.

2. Placenta :

- Secretes **Chorionic gonadotropin**, which acts with other hormones to maintain pregnancy.
- Progesterone produced by the placenta supplements that produced by the ovary and maintains pregnancy.
- Pacenta also secretes oestrogens.
- **Relaxin** is another hormone which helps in relaxing the pelvic ligaments to facilitate the easy birth of the young ones.
- Placenta also secretes oestrogens.

3. Gastro intestinal mucosa :

- It secretes many, peptide hormones. These hormones affect the secretory function of stomach, intestine, liver, pancreas, gall bladder etc.
- Of all the gastro intestinal hormones the following are the most important.
- **1. Gastrin:** The pyloric glands of stomach secrete an inactive compound called progastrin. In the presence of HCl progastrin changes into gastrin hormone.
- It stimulates gastric mobility, secretion of pepsinogen and HCl by gastric glands
- **2 Secretin:** When chyme reaches the intestine, HCl stimulates the mucous membrane of the duodenum to secrete a hormone called secretin. Secretin stimulates the pancreas.
- **3. Cholecystokinin:** Incomplete digestion of proteins and fats stimulates the secretion of Cholecystokinin. The hormone contracts the gall bladder and help in release of bile.
- **4. Pancreozymin :** Stimulates the pancreas for secretion of digestive enzymes.

5.Enterogastrone: Secreted by the mucous membrane of the duodenum. It inhibits the secretion of HCL by gastric glands

Source (Endocrine gland)	Hormone	Physiologic effects (Functions)
1. Pineal body	Melatonin	Stimulates concentration of melanophores in the skin
2. Pituitary		
(a) Anterior lobe	I . Somatotropin	Controls growth and metabolism of protein. Deficiency causes dwarfism, excess causes gigantism and acromegaly
	2. Thyroid Stimulating Hormone (TSH)	Stimulates thyroid
	3. Adrenocorticotropin (ACTH)	Stimulates adrenal cortex
	4. Follicle-stimualting hormone (FSH)	Affects growth of Graafian follicles in ovary and seminiferous tubules in testis.)
	5. Luteinizing hormone (LH)	Affects production and release of gonadial hormones
	6. Prolactin (LTH)	Affects mammary glands and milk production
(b) Intermediate lobe	Intermedin or Melanocyte Stimulating Harmone (MSH)	Affects pigments in skin chromatophores
(c) Posterior lobe	1. Oxytocin	Stimulates contraction of uterine muscles and ejection of milk.
	2. Vasopressin	Regulates blood pressure and water loss by kidneys.
3. Thyroid	Thyroxine	Increases O_2 consumption or basal metabolic rate.

		Deficiency leads to cretinism in children and myxoedema in adults. Hyperthroidism causes goitre exopthalmic.
4. Parathyroids	Parathormone	Regulates calcium and phosphorus metabolism
5. Thymus	Thymosin	Regulates, sexual maturity and promotes maturation of lymphocytes.
6. Isalets of Langerhans		
(a) Beta cells	1. Insulin	Diffusion of glucose from blood into cells and its conversion into glycogen. Deficiency causes diabetes mellitus.
(b) Alpha cells	2. Glucagon	Conversion of liver glycogen into blood glucose.
7. Adrenal		
(a) Cortex	1. Cortisone	Metabolism of proteins lipids carbohydrates
	2. Aldosterone	Regulates levels of sodium potassium chloride ions and water
	3. Androgen	Stimulates male characteristics
(b) Medulla	1. Epinephrine or adrenaline	Supplements action of sympathetic nervous system during emergencies
	2. Norepinephrine	Norepinephrine Regulates normal blood pressure
8. Gonads		
(a) Testes	Testosterone	Development and maintenance of male sex characters.
(b) Ovaries	1. Estrogen	Development and maintenance of female. characteristics
	2. Progesterone	Changes associated with pregnancy.
(c) Placenta	I. Chorionic gonadotropin	Acts associated with other hormones to maintain pregnancy.
	2. Relaxin	Helps in relaxing the pelvic ligaments to facilitate the easy discharge of child during delivery (birth).
	3. Progesterone	Supplements the progesterone produced by the ovary.
9, Alimentary canal		
(a) Stomach	Gastrin	Induces gastric secretion
(b) Duodenum	1 . Enterogastrone	Slows down gastric secretion
	2. Secretin	Stimulates pancreatic secretion
	3. Cholecystokinin	Stimulates contraction of gall bladder