**BIOLOGY. CHAPTER 22. CHEMICAL COORDINATION & INTEGRATION.SYNOPSIS**

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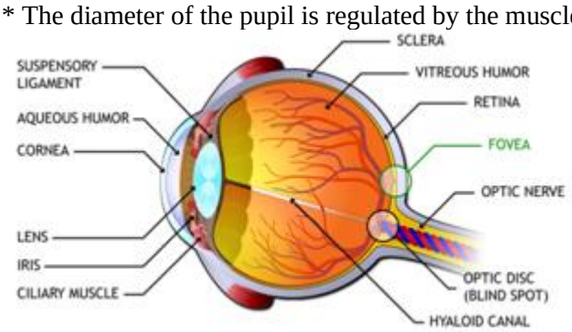
## ✍ The Eyes:

*These are pair of eyes sensitive to light. Each eye is enclosed in the orbit. It is protected by **Eyebrow** (protect from seat, dust, etc), and two eyelids (protect from injury, dust, germs, etc by repeated blinking) and **Lacrymal glands** or **Tear gland** (clean the eyes and protect it from bacteria with its secretion containing Lysozyme).
*Movement of eyelids is lubricated by secretion of **Meibomean gland**. The eye is cushioned with fatty tissue in the orbit. *The eyeball is a spherical organ about 2.5 cm in diameter and 6.5 gm in weight.
Our paired eyes are located in sockets of the skull called orbits.

**Parts of an eye**

*The adult human eye ball is nearly a spherical structure. The wall of the eye ball is composed of three layers.
*The external layer is composed of a dense connective tissue and is called the ***sclera***.
*The anterior portion of this layer is called the ***cornea***.
*The middle layer, ***choroid***, contains many blood vessels and looks bluish in colour.
* The choroid layer is thin over the posterior two-thirds of the eye ball, but it becomes thick in the anterior part to form the ciliary body.
* The ciliary body itself continues forward to form a pigmented and opaque structure called the iris which is the visible coloured portion of the eye.
*The eye ball contains a transparent crystalline lens which is held in place by ligaments attached to the ciliary body.
*In front of the lens, the aperture surrounded by the iris is called the pupil.
* The diameter of the pupil is regulated by the muscle fibres of iris.




**Retina:** This is the innermost sensory layer. It forms innermost posterior two third part of the eye. It is made up of different layers.
*Outermost layer of pigment cells just inside the choroid. They secrete melanin which helps in absorption of light.
*The second layer consists of photosensitive cells called ***Rods and Cones***.
**Rods**: These cells contain a purplish-red protein pigment called **Rhodopsin** (visual purple), which contains a derivative of Vitamin A. and are sensitive to dim light (Scotopic vision).
*Thus, they can function even at right by **twilight vision**. Depolarization of these cells takes place due to breaking down of pigment Rhodposin into **Scotopsin** and **Retinal.** The pigment can be reformed in dim light.
**Cones:** They contain a visual pigment called **Iodopsin**. These cells can function only in bright light (Photopic vision).
*In the human eye, there are three types of cones which possess their own characteristic photopigments that respond to **red, blue** and **green** lights. This layer is sensitive to colous but can function only in bright light.
*Next to cone cells is the layer of **Bipolar neurons** and innermost **ganglionic layer** of neurons that forms the **Optic nerve**. *The spot from where optic nerve leaves the eyeball, there is no sensitivity. This is known as **blind spot** whereas the spot exactly opposite the lens is highly sensitive.
*This is **Area centralis (yellow spot or Macula lutea).** It has a small depression in the center called **Fovea centralis** which is said to be point of maximum resolution Impulses received by these sensory cells are then carried by optic nerve towards optic lobes of brain.
**Orra serrata** is the small area next to Retina and is the only part of innermost layer which is not photosensitive.
**Choroid:** It is the second vascular layer containing may blood vessels. Anteriorly, it thickens to form ciliary body to which are attached the iris muscles.
*Attached to the ciliary body are **protractor lens muscles**. Iris muscles control the size of **pupil** which is a small black spot present in front of the lens.
*There are **radial** and **Sphincter muscles** in iris. Cavity of eyeball is divided into anterior **aqueous chamber** and posterior **vitreous chamber**.
* These cavities are filled with watery aqueous humour and gelatinous vitreous humour respectively. Just inside the iris muscles are present suspensory ligaments which hold the lens (circular, transparent) inside a lens capsule. Choroid is mainly responsible for darkening the eye for total absorption of light.

**Mechanism of Vision**

The light rays in visible wavelength focussed on the retina through the cornea and lens generate potentials (impulses) in rods and cones. As mentioned earlier, the photosensitive compounds (photopigments) in the human eyes is composed of opsin (a protein) and **retinal** (an aldehyde of vitamin A).
* Light induces dissociation of the retinal from opsin resulting in changes in the structure of the opsin. This causes membrane permeability changes.
*As a result, potential differences are generated in the photoreceptor cells. This produces a signal that generates action potentials in the ganglion cells through the bipolar cells.
*These action potentials (impulses) are transmitted by the optic nerves to the visual cortex area of the brain, where the neural impulses are analysed and the image formed on the retina is recognised based on earlier memory

and experience.

**Biochemistry of vision (Mechanism of Photoreception)** : **i) Role of Rhodopsin**: Light splits rhodopsin (visual purple) into a pigment retinene (= retinol)- a protein scotopsin (opsin). The process of splitting is called bleaching.

*This depolarize the rod cells to release a neurotransmitter, transmitting the nerve impulse to the bipolar cells, ganglion cells and then to the optic nerve fibres.

*****In the dark, rhodopsin is resynthesized from retinene and scotopsin, making rods functional.

*In darkness, resynthesis of rhodopsin takes some time, so when we go suddenly from bright light into darkness or semidarkness. We can see things only after a few minutes.

*It is due to reappearance of rhodopsin. Similarly when we go from darkness into bright light we remain blinded for a few minutes till rhodopsin is depleted to enable comes cones to become active visual cells.

**ii) Roll of Iodopsin (Color vision)**: Iodopsin (visual violet) works in daylight and artificial light. This pigment is sensitive to bright light and colors. Its biochemistry is not properly understood. There are three different kinds-sensitive pigment.

- Cones that contain erythroable are most sensitive to red light.
- Cones that contain cholorable are most sensitive to green light.
- Cones that contain cyanoable are most sensitive to blue light. This is in accordance with the trichrmacy theory.

**Binocular vision**: When both the eyes can be focused simultaneously on a common object, as in human eyes, it is called binocular vision.

**Defects of Eye:** There can be small defects in the working of eye, these are:

***Myopia (short sightedness):** Such persons cannot see the objects beyond a particular distance. The near objects can be seen clearly. In this case, the eyeball becomes oblong and the retina is far from lens. A blurred image is formed and the defect can be corrected by using a concave lens of appropriate curvature (Focal length).

***Hypermetropia (Distant sightedness):** In this case, shape of the eyeball changes such that the retina comes close to the lens. Light rays converge at a point behind retina and therefore, clear image cannot be formed on retina. This defect also can be corrected by using appropriate convex lens.

***Presbyopia:** This is usually a defect caused due to ageing. The lens is not able to accommodate itself. Clear image cannot be formed (particularly close objects) on retina. Use of proper convex lens can correct this defect.

***Astigmatism:** In this disorder, shape of cornea or lens is changed and thus, proper formation of image on retina is not possible. Use of cylindrical lens can correct this defect.

***Glaucoma:** This is a defect in which the fluid pressure inside the eyeball increases. There is a pressure on retina causing disturbance in the blood supply to retina. Shortage of nutrients supply to retina can cause blindness. Surgical reduction of this fluid pressure can be the remedy for this defect.

***Cataract:** This is a condition wherein the lens becomes opaque and thus hampers the vision. It can happen due to ageing. The only treatment is to remove this opaque lens and to use appropriate biconvex glasses.

***Trachoma:** A bacterial stain **Chalmydia trachomatis** can infect the conjunctiva to cause chronic conjunctivitis (**conjunctivitis** can at times be an acute infection of conjunctiva caused by particular stran of **Staphylococcus**). This is called Trachoma. It can lead to progressive loss of sight and may lead to total blindness.

## The Ear:

*The ears perform two sensory functions, hearing and maintenance of body balance. Anatomically, the ear can be divided into three major sections called the **outer ear**, the **middle ear** and the **inner ear**.

*The outer ear consists of the pinna and external auditory meatus (canal). The pinna collects the vibrations in the air which produce sound.

*The external auditory meatus leads inwards and extends up to the tympanic membrane (the ear drum).

* There are very fine hairs and wax-secreting sebaceous glands in the skin of the pinna and the meatus.

* The tympanic membrane is composed of connective tissues covered with skin outside and with mucus membrane inside.

***Middle ear:** It consists of an air filled cavity called **Tympanic cavity.** It has a direct connection with pharynx through **Eustachian canal**. Through this tube the pressure on tympanum is balanced on both the sides. Middle ear is connected with internal ear through openings called **Fenestra ovalis** and **Fenestra rotunda**. Both these openings are closed by thin membranes.

***Ear Ossicles:** A chain of three small bones connect the middle ear with internal ear. These are malleus, Incus and Stapus is the smallest bone in human body.

* It is connected with the membrane of fenestra ovalis. These three bones convey sound waves from tympanum to internal ear and simultaneously amplify them. This happens by lever action.

***Internal ear:** It is fluid filled sack-like structure called Labyrinth. It includes **Bony labyrinth** and **membranous labyrinth**. Bony labyrinth is tubular part enclosing a fluid called **Perilymph**.

***Membranous labyrinth:** It includes Semicircular canals, Vestibule (includes Otolith and Cochlea).

***Semicircular canals:** There are three semicircular canals: Superior, Posterior and Lateral semicircular canals. They are placed in three different planes right angles to one another.

*Each semicircular canal has an enlarged base called **Ampulla.** It has a small projecting ridge called **Crista Ampullaris.** Sensory and supporting cells are contained in each crista.

*Sensory cells bear sensory hairs at their distal ends and are connected to nerve fibres on the proximal side. A gelatinous mass called **Cupula** encloses the sensory hairs.

***Otolith:** It is a sac like organ it is made up of two parts viz. **Sacculus** and **Utriculus**. Utriculus is larger saclike part located dorsally. The semicircular canals are connected to it.

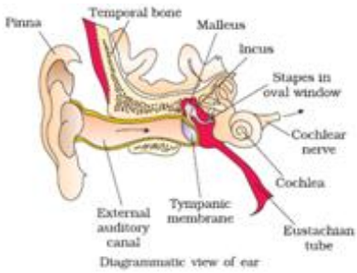
* Next to it is placed the small sacculus. Both are connected to each other by a thin **Utriculosaccular duct. Ductus endolymphaticus** opens into it and originates from **Saccus endolymphaticus. Ductus reunions** arising from lower part of Sacculus joins with cochlear duct.

*__Mucula of Sacculus__ and **Macula of Utriculus** are the sensory spots on Otolith.

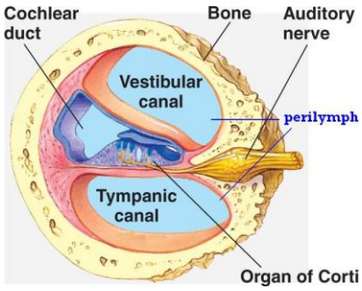
Sensory and supporting cells are present in macula. These sensory cells have non-motile hair and a cilium each.

*The hairs are enclosed in Otolith membrane. Microscopic otoconia are suspended near these. The maculae and cristate are sensitive to sound waves and body equilibrium respectively.

***Cochlea:** It is a spirally coiled tubular organ starting with a broad end and ending into a pointed apex. It has two membranes called **Reissner's membrane** and **Basilar membrane.**
*The membranous labyrinth is surrounded by three fluid filled chambers called **Scala vestibuli, scala tympani** and **scala media**.
*The former two are filled with **Perilymph** and are connected by small canal called **Helicotrema**, while scala media is filled with **Endolymph**. Scala vestibuli joins the fenestra ovalis and scala tympani joins fenestra rotundum.
*Scala media has its roof made of Basilar membrane and floor made of Reissner's membrane.
*Hearing organ called **Organ of Corti** is located in basilar membrane.
*There are sensory cells and supporting cells in it. Many non-motile hair like projections arise from the sensory cells. Next to these hair cells is elastic **Tectorial membrane.**



Diagrammatic view of ear

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**Mechanism of Hearing**
*The external ear receives sound waves and directs them to the ear drum.
*The ear drum vibrates in response to the sound waves and these vibrations are transmitted through the ear ossicles (malleus, incus and stapes) to the oval window.
*The vibrations are passed through the oval window on to the fluid of the cochlea, where they generate waves in the lymphs.
*The waves in the lymphs induce a ripple in the basilar membrane. These movements of the basilar membrane bend the hair cells, pressing them against the tectorial membrane. As a result, nerve impulses are generated in the associated afferent neurons.
*These impulses are transmitted by the afferent fibres via auditory nerves to the auditory cortex of the brain, where the impulses are analysed and the sound is recognised.

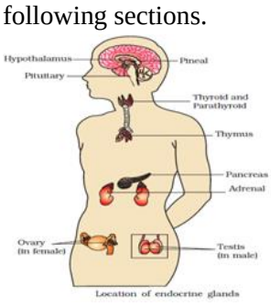
## Chemical co-ordination:

*Endocrine system like the nervous system, is meant for internal communication and regulation of the animal body.
*There are some basic differences between the two controlling systems (nervous system and endocrine).
*Many important functionings of the endocrine system are, in fact, under the control of nervous system.
*These two systems are often collectively called as neuroendocrine system.
**Nervous information:** It is sent as an electrical impulse along axons, and as a chemical across synapses. *Information travels rapidly in milliseconds. Information is directed to specific receptors- one or a few nerve fibres, gland cells or other neurons, i.e. it is addressed by name. It gets response immediately. Its effects are short-lived.
**Hormonal information**: ***The hormones are chemical messengers that regulate the biological processes in the organisms.OR***
***Hormones are informational molecules secreted by the endocrine cells in one part of the body in response to changes in external or internal environment and carried by blood to another part where they stimulate or inhibit specific physiological processes for the good of the body as a whole.***
* It is sent as a chemical messenger via blood stream. Information travels slowly.
*Information is spread throughout the body by blood from which the target cells or organs pick it up, i.e. it is addressed to whom it may concern. It gets response usually slowly. Its effects are generally more prolonged.
***A cell, a tissue or an organ which secretes certain useful chemical compounds required for particular functions is called a gland***.
**Types of Glands**: Gland is an organ, tissue or cell that secretes a chemical for performing a particular function.
**i**. ***Exocrine gland***: It is a gland that pours its secretion on the surface or into a particular region by means of ducts for performing a metabolic activity, eg: ***sebaceous glands, sweat glands, salivary glands, gastric glands, intestinal glands.***
***ii. Endocrine glands***: It is an isolated gland (separates even from epithelium forming it) which secretes informational molecules or hormones that are poured into venous blood or lymph for reaching the target organ because the gland is not connected with the target organ by any duct, therefore, also ***called ductless gland***.
***iii. Heterocrine Gland (mixed gland)***: It is a gland that has both exocrine and endocrine regions, the former pouring their secretion through ducts while the latter pouring their secretion directly into blood/lymph.
***iv. Mixed Organs***: It is an organ which has both an endocrine activity and a metabolic or cytogenic function eg: gonads.
***Target Organ/Cell:*** It is the organ/cell on which the product of another system acts. In hormonal system there can be three types of targets – primary, secondary and final. Ex: The primary target of TRH (thyrotropin releasing hormones) is anterior pituitary which releases TSH (thyrotropin or thyroid stimulating hormone) that has thyroid as secondary target.
*The secondary target or thyroid releases thyroxine which controls metabolic relations of different body cells.
***Human Endocrine System***:
*The endocrine glands vary in embryonic origin and are isolated from one another.
*The pituitary gland is called the primary target of the hypothalamic hormones.
*The endocrine glands influenced by the pituitary gland are termed the secondary targets of the hypothalamic hormones.
*The hormones of the secondary target glands affect the final target organs.
✍ **Types of Hormones**: Hormones were discovered by **Bayliss** and **Starling** in 1902.
*A hormone is chemical substance that is secreted into the body fluids by one cell or a group of cells and has a physiological control effect on other cells of the body.
*Some hormones are termed as **local hormones** while some are termed as **general hormones**. Examples of local

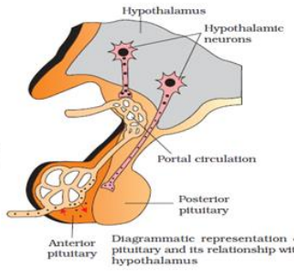
hormones are acetycholine released at the oarasympathetic nerve, secretin released by the duodenal wall, and cholecystokinin released in the small intestine. These hormones are functional in and around the area of their production.
***General hormones** are those which are transported into the blood to all parts of the body and cause many different reactions in different organs of the body. Examples are thyroid hormone, growth hormone.
* Hormones which control activity of other endocrine glands and/ or growth are called **trophic hormones**. Examples are epinephrine and norepinephrine, both of which are secreted by the adrenal medullae.
*Some other trophic hormones are thyroid stimulating hormone (TSH), follicle stimulating hormone (FSH) etc.
* Hormones that control the production of trophic hormobnes are known **Releasing hormones**. E.g.; Thyrotrophic Releasing Hormone (TRH).

- **Characteristics of Hormones**: ➢ They are secreted by endocrine or ductless glands.
- ➢ They are effective in very low concentrations as they have high biological activity.
- ➢ The hormone molecules are small in size and so are easily diffusible through the cell membrane.
- ➢ They are formed in response to specific stimuli.
- ➢ Their secretions are regulated by nerves or by feedback effect.
- ➢ They are transported through blood.
- ➢ They do not catalyze any reactions. Therefore they do not directly take part in metabolic reactions of the cell.
- ➢They function by stimulating or inhibiting the target organ.
- **Chemical Nature of Hormones**: ➢They may be proteins or peptides e.g.; insulin, glucagons, parathormone, antidiuretic hormone, oxytocin etc.
- ➢ They may be derivatives of amino acid tyrosine, e.g.; thyroxin, triiodothyronin, norepinephrine, epinephrine. Hormones which are proteins or peptides or amino acid derivatives are neuroectodermal or endodermal in origin.
- ➢ They may be steroids, e.g.; cortisol, aldosterone, estrogen, progesterone, testosterone. They are mesodermal in origin.

***Purely endocrine gland**: These are devoted entirely to the secretion of hormones. They include the hypothalamus, thyroid, parathyroids, thymus, adrenals or suprarenals, pituitary and pineal.
*. ***Partly endocrine glands***: These are partly endocrine and partly exocrine in function, i.e. they are heterocrine. *They include the kidneys, pancreas, gonads, mucous membrane of alimentary canal and placenta.
*The endocrine glands and hormone producing diffused tissues/cells located in different parts of our body constitute the endocrine system.
***Pituitary, pineal, thyroid, adrenal, pancreas, parathyroid, thymus and gonads (testis in males and ovary in females) are the organized endocrine bodies in our body.***
* In addition to these, some other organs, e.g., gastrointestinal tract, liver, kidney, heart also produce hormones. *A brief account of the structure and functions of all major endocrine glands and hypothalamus of the human body is given in the following sections.



Location of endocrine glands



Diagrammatic representation of pituitary and its relationship with hypothalamus

**The Hypothalamus:**
*Hypothalamus develops from the ectoderm of the embryo. Hypothalamus is located in the base of the diencephalon, a part of the forebrain.
*The hypothalamus is the basal part of diencephalon, forebrain and it regulates a wide spectrum of body functions.
*Hypothalamus contains several groups of neurosecretory cells called nuclei which produce hormones.
***The neurohormones are carried by the portal blood to the anterior lobe of the pituitary gland and stimulate the later to release its hormones**.
*These hormones regulate the synthesis and secretion of pituitary hormones.
*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).
They are usually peptides.

- ➢ **Thyroid stimulating – hormone releasing hormone (TRH)** also known as **Thyrotropin Releasing Hormone**.
- ➢ **Adrenocorticotropin** releasing hormone (ACTH), causes release of adrinocorticotropin from the anterior lobe of the pituitary.
- ➢ **Growth hormone releasing hormone (GHRH)/Somatotropin releasing hormone**.
- ➢ **Gonadotropin releasing hormone (GnRH)**.
- ➢ **Prolactin inhibitory factor (PIF)**
- ➢ **Prolactin releasing hormone (PRH)**
- ➢ **Melanocyte stimulating hormone releasing hormone (MSH-RH)**
- ➢ **Melanocyte stimulating hormone inhibiting hormone (MSH-IH).**

- **Pituitary Gland (Hypophysis):**

*Ex: Somatostatin from the hypothalamus inhibits the release of growth hormone from the pituitary.
*These hormones originating in the hypothlamic 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.

***The Pituitary Gland*:**
**Pituitary gland orginates from the ectoderm of the embryo.**
**Location:** The pituitary is a small red grey, pea-shaped gland attached to the hypothalamus of the brain by a stalk or infundibulum in a bony cavity called ***sella tursica*** in front of the pons**.**

*It is divided anatomically into an **adenohypophysis** and a **neurohypophysis**. ***Adenohypophysis consists of two portions, pars distalis and pars intermedia***.
***The pars distalis region of pituitary***, commonly called anterior pituitary, produces growth hormone (GH), prolactin (PRL), **thyroid stimulating hormone** (TSH), **adrenocorticotrophic hormone** (ACTH), luteinizing hormone (LH) and **follicle stimulating hormone** (FSH).
*__Pars intermedia secretes only one hormone__* called **melanocyte stimulating hormone**(MSH). However, in humans, the pars intermedia is almost merged with pars distalis.
*__Neurohypophysis (pars nervosa) also known as posterior pituitary__*, stores and releases two hormones called **oxytocin** and **vasopressin**, which are actually synthesised by the hypothalamus and are transported axonally to neurohypophysis.

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

* GH is secreted by the somatotropes of adenohypophysis.
* It is responsible for transfer of amino acids into the cells and synthesis of Proteins.
* Its chief function is to act on hard and soft tissues to increase the rate of growth by promoting protein metabolism, carbohydrate and lipid metabolism, retention of calcium.
* It is responsible for the growth of long bones as well as other parts of skeletal tissue etc.
* It stimulates the synthesis of proteins and inhibits protein breakdown.
* During childhood and teenage it induces growth of cells especially those of skeletal and muscular tissues.
* It helps in maintaining muscle and bone size and stimulates tissue repair.
* It brings about conversion of glycogen to glucose and prevents uptake of glucose by cells and oxidation of glucose to produce ATP.

**Hyposecretion or deficiency**: In children causes infantilism or dwarfism.
* The symptoms are stunted growth, reduced rate of metabolism and delay in attaining sexual puberty.
* The child will be dwarf and condition is known as Dwarfism.
* It produces mainly two types of pituitary dwarf's namely.

**Lorain type**: Here the individual will be physically and mentally normal.
**Frohlisch's type:** The growth will be stopped here the individual will be abnormal with obesity.
**Simmond's disease:** It is a disorder due to hyposecretion of growth hormone in the adults.
It is a rare condition and the patient becomes thin and show sign of premature ageing.
Skin becomes dry and wrinkled, early senility with loss of hair, degeneration of sex organs.
**Hypersecretion or over secretion:** In children results in ***Gigantic condition*** (Pituitary Gigantism).
* It occurs during child hood before the closure of epiphyseal plates at the end of bones.
* It is characterized by extraordinary growth in height caused by abnormal elongation of long bones.
* Excessive growth of connective tissue.

In adults ***Hyper secretion*** results in ***Acromegaly***.
* This occurs only after the closure of epiphyseal plate at the end of long bones.
* It is characterized by abnormal growth of hand, feet, face especially lower jaw.
* Hands and feet become large and appear spade-like.
* Increase in thickness of the ridges present above the eyebrows i.e. the supra orbital ridges.
* Formation of hump or kyphosis on the back, a characteristic feature of an acromegalous patient.
* Excessive growth of body hair.

**2. TSH (Thyroid stimulating Harmone): Thyrotropin**.
* It is secreted by thyrotropes cells of the adenohypophysis.
* It controls structure and functioning of thyroid gland to synthesize and release of its hormones thyroxin and tri-iodothyronine.
* Maintenance of Iodine intake by the Thyroid gland.

**Hyposecretion** of thyrotropic hormone results in non-stimulation of the thyroid gland due to which the required amount of thyroxin is not produced. This is called hypo-thyroidism. It leads to **Cretinism and Gull's disease**.
**Hypersecretion** of thyrotrophic hormone results in hyper stimulation of the thyroid gland due to which more of the hormone is produced. This is called hyperthyroidism. It results in **Exophthalmic Goiter**.

**3. ACTH (Adrenocarticotropic hormone):**
* ACTH is secreted by corticotropes of adenohypophysis.
*It is necessary of the development and maintenance of the Normal structure and functioning of the Adrenal cortex.
* It controls the production and secretion of certain adrenal cortex hormones like glucocorticoids, sex corticoids.
* It also increases rate of protein and fat metabolism.

**Hyposecretion** of adrenocorticotropic hormone results in the **Addison's disease**.
**Hypersecretion** of adrenocorticotropic hormone results in disorder **Cushing's disease**.

**GONADOTROPINS (Gonadotropic hormone):**
* ***The hormones stimulate the Gonads to secrete the hormones from the Gonads are called Gonadotropins***.
* Adenohypophysis produces the gonadotropic hormones like FSH, LH in females and ICSH in males.

**4. Follicle stimulating Hormone (FSH):**
* It stimulates the ovarian follicles.
* It promotes the growth and maturation of the Graafian follicles.
* It stimulates the secretion of the estrogen.
* promotes the development of somniferous tubule and plays an important role in production of Sperms in testis,

**5. LH (Luteinizing hormone) in female:**
* LH stimulates the final maturation of the ovarian follicles.
* LH together with estrogen stimulates ovulation.
* It helps in development of corpus luteum for secretion of progesterone secretion.

**L H in males is called ICSH (Interstitial cell stimulating hormone):**
* It activates Leydig cells of testis to secrete testosterone and other androgen to regulate secondary sexual characteristics.

**6. Prolactin: (PRL): or lactogenic or mammotrophic or luteotrophic hormone (LTH).**
* Lactotropic cells secretes hormone called prolactin.
* It is known as hormone of maternity because it stimulates development of mammary gland during pregnancy period.

*The prolactin is also involved in inducing behavioral changes such as maternalism paternalism in males.
* It maintains the secretion of estrogen and progesterone.

**7. Melanocyte Stimulating Hormone (MSH):**

* Its effect in man is not certain.
***** The effect of MSH is very clear in fishes, amphibians and reptiles.
* It stimulates melanocytes to produce melanin pigments in humans but does not influence skin colour changes.

**Posterior lobe or Neurohypophysis:**

* It is attached to the hypothalamus by a stalk called infundibulum.
* It is mainly made up of glial like cells called pituicytes.
* This **lobe does not secrete any hormones** but only stores the hormones.
* The hormones are ADH and Oxytocin.
* These hormones are produced by certain neurosecretory cells of the hypothalamus called ***supraoptic and paraventricular nuclei.***
*The hormones are stored in the neurohypophysis.

**<u>Oxytocin</u> (pitocin):**

* It is secreted by the paraventricular nerve cells of hypothalamus.
* It is also called birth hormone or delivery hormone because it stimulates uterine contraction during child birth.
* It also called milk ejection hormone because it induces contraction of the mammary glands.

**2. ADH (Antidiuretic hormone or vasopressin or pitressin):**

* It is secreted by the supraoptic nerve cells of hypothalamus.
* It influences reabsorption of water in the nephrons of the kidneys; therefore it is called antidiuretic hormone.
* It is released with concentration of urine.
* It brings about constriction of arterioles and increases BP.

**Hyposecretion** or Deficiency results in excretion of dilute urine. This condition is called ***Diabetes insipidus*** or water **diuresis**.

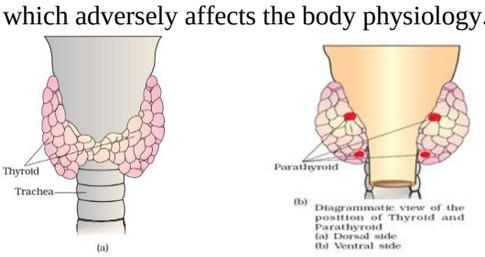
**Hypersecretion or over secretion results** in the production of small quantities of concentrated urine this condition is called **Antidiuresis**.

**<u>The Pineal Gland</u>:**

***It is a small endocrine gland present between thecerebral hemisphere and and above the third ventricle.**
*****The pineal gland is located on the dorsal side of forebrain.
* Pineal secretes a hormone ***called Melatonin***. Pineal also contains ***serotonin*** just as all parts of brain.
*<u>**Melatonin**</u>: This hormone is meant for maintaining diurnal rhythm.
*The level of melatonin is highest at midnight and lowest during day time.
* Light is found to be reducing melatonin level. Thus the hormone controls biological clock.
* The effect of light on melatonin takes place when retina is exposed to light.
* Darkness stimulated secretion of Melatonin increasing its level during night.
* A blind child attains sexual maturity little earlier because there is no exposure to light and melatonin level is high. Higher melatonin level **induces sleep**. Hence, it is known as **sleep hormone.**

**Serotonin:** It is known as a stimulant in body and regulates all cyclic phenomena within the body.

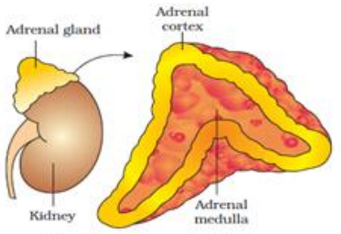
**<u>Thyroid Gland</u>:** The thyroid gland is composed of two lobes which are located in the neck region on either side of the trachea.
*In human structure thyroid gland is H shaped gland or Butterfly shaped and weight around 20-25 gm.
*Both the lobes are interconnected with a thin flap of connective tissue called **isthmus**.
* The thyroid gland is composed of ***follicles*** and **stromal tissues**.
* Each thyroid ***follicl***e is composed of follicular cells, enclosing a cavity.
*These follicular cells synthesise two hormones, ***tetra-iodothyronine*** or ***thyroxine***(Td) and **tri-iodothyronine** (Tc).
*Some isolated clusters of cells are found in the connective tissue between the follicles. These are called para follicular cells or C cells. They produce ***calcitonin hormone.***
* **Iodine** is essential for the normal rate of hormone synthesis in the thyroid.
**Deficiency of iodine** in our diet results in **hypothyroidism** and enlargement of the thyroid gland, commonly called **goitre**.
*<u>***Hypothyroidism***</u> 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.
*In adult women, hypothyroidism may cause menstrual cycle to become irregular.
*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.




*Thyroid hormones play an important role in the regulation of the basal metabolic rate.
*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.

**<u>Parathyroid Gland</u>:** In humans, four parathyroid glands are present on the back side of the thyroid gland, one pair each in the two lobes of the Thyroid gland.
*The parathyroid glands secrete a peptide hormone called **parathyroid hormone Or Collip's hormone** (PTH). *The secretion of PTH is regulated by the circulating levels of calcium ions.

*Parathyroid hormone (PTH) increases the $Ca^{2+}$levels in the blood. PTH acts on bones and stimulates the process of bone resorption (dissolution/demineralisation).
*PTH also stimulates reabsorption of $Ca^{2+}$by the renal tubules and increases $Ca^{2+}$ absorption from the digested food.
* It is, thus, clear that ***PTH is a hypercalcemic hormone, i.e., it increases the blood $Ca^{2+}$ levels***.
* Along with TCT, it plays a significant role in calcium balance in the body.
**Thymus:** The thymus gland is a lobular structure located on the dorsal side of the heart and the aorta.
* The thymus plays a major role in the development of the immune system.
*This gland secretes the peptide hormones called ***thymosins***.
* ***Thymosin***s play a major role in the differentiation of T-lymphocytes, which provide cell-mediated immunity.
*In addition, thymosins also promote production of antibodies to provide humoral immunity.
*Thymus is degenerated in old individuals resulting in a ***decreased production of thymosins***.
* As a result, the immune responses of old persons become weak. It also hastens attainment of sexual maturity.
**Adrenal Gland:** These glands are also called suprarenals. They are mesodermal in origin.
*They are two, relatively large, triangular-shaped organs that measure about 1.5 inches in height and 3 inches in length.
*They are located on top of each kidney. Each adrenal gland is comprised of two distinct structures – the outer part of the adrenal glands is alled the adrenal cortex. The inner region is known as the adrenal medulla.
*****Our body has one pair of adrenal glands, one at the anterior part of each kidney.
* The gland is composed of two types of tissues. The centrally located tissue is called the **adrenal medulla**, and outside this lies the **adrenal cortex** .



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

***Adrenal medulla:***
*The ***adrenal medulla*** secretes two hormones called ***adrenaline or epinephrine and noradrenaline*** or **norepinephrine**. These are commonly called as 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.
**Adrenal cortex:**
*The adrenal cortex can be divided into three layers, called **zona reticularis** (inner layer), **zona fasciculata** (middle layer) and **zona glomerulosa** (outer layer).
*The adrenal cortex secretes many hormones, commonly called as corticoids. They are **steroid hormones**.
*The corticoids, which are involved in carbohydrate metabolism are called glucocorticoids.
* In our body, cortisol is the main glucocorticoid.
* Corticoids, which regulate the balance of water and electrolytes in our body are called mineralocorticoids.
*Aldosterone is the main mineralocorticoid in our body.
*****Glucocorticoids*** stimulate, gluconeogenesis, lipolysis and proteolysis; and inhibit cellular uptake and utilisation of amino acids.
***Cortisol** is also involved in maintaining the cardio-vascular system as well as the kidney functions.
*Glucocorticoids, particularly cortisol, produces antiinflamatory reactions and suppresses the immune response.
*Cortisol stimulates the RBC production.
***Aldosterone** acts mainly at the renal tubules and stimulates the reabsorption of $Na^+$ and water and excretion of $K^+$ and phosphate ions.
*****Aldosterone helps in the maintenance of electrolytes, body fluid volume, osmotic pressure and blood pressure***.
* Small amounts of androgenic steroids are also secreted by the adrenal cortex which play a role in the growth of axial hair, pubic hair and facial hair during puberty.
**Pancreas:** Pancreas is a composite gland which acts as both exocrine and endocrine gland.
* The endocrine pancreas consists of 'Islets of Langerhans'.
*There are about 1 to 2 million Islets of Langerhans in a normal human pancreas representing only 1 to 2 per cent of the pancreatic tissue.
*The two main types of cells in the Islet of Langerhans are ***called α-cells and β-cells.***
*****The α-cells secrete a hormone called glucagon, while the β-cells secrete insulin.***
Insulin is a peptide hormone, which plays a major role in the regulation of glucose homeostasis.
* Insulin acts mainly on hepatocytes and adipocytes (cells of adipose tissue), and enhances cellular glucose uptake and utilisation.
*As a result, there is a rapid movement of glucose from blood to hepatocytes and adipocytes resulting in decreased blood glucose levels (hypoglycemia).
* **Functions of insulin:**
* It converts excess of glucose into glycogen by a process called **glycogenesis**.
* It stimulates the body cells to absorb glucose.
*It converts excess of glucose into lipids by a process called **lipogenesis**.
*By these functions blood glucose level is brought into normal (below120 mg/100ml) level. Therefore Insulin is called **hypoglycemic factor**.

* When the blood glucose level declines below the norm (80 mg/100ml)after skipping a meal, the gluco receptors present in the blood send message to the hypothalamus.
*The modulator (hypothalamus) which in turn sends the message to the **α-** cells of islets of Langerhans.
* **α-** cells of islets of Langerhans secrete **glucagon** and releases into the blood and it reaches the liver where it performs the following functions.

**Glucagon**:

*Glucagon is a peptide hormone, and plays an important role in maintaining the normal blood glucose levels. *Glucagon acts mainly on the liver cells (hepatocytes) and stimulates glycogenolysis resulting in an increased blood sugar (hyperglycemia).

**Functions of glucagon**:

*It converts stored glycogen into glucose by a process called **glycogenolysis**.
*It converts stored lipids and proteins into glucose by process called **gluconeogenesis**.
*It nullifies the function of insulin.
*By these functions blood glucose level is brought up into normal (above 80mg/ 100ml) level. Therefore glucagon is called **hyperglycemic factor**.
*It is noted that both insulin and glucagon maintain the normal blood glucose level.
*Hypo secretion of insulin leads to an increase in the blood sugar level accompanied by a decrease in the glycogen content of liver and muscle cells this leads to hyperglycemia.
* The condition of a person with an increased level of glucose in the blood above the normal (120mg/100ml) level is known as **hyperglycemia**.
* When it reaches a critical level the urine sugar level also increases. Thin condition is called **glycosuria**. As a result, glucose is excreted along with urine.
*The condition of excretion of glucose in urine is called **diabetes mellitus**.
*The glucose homeostasis in blood is thus maintained jointly by the two – insulin and glucagons.
*Prolonged hyperglycemia leads to a complex disorder called **diabetes** mellitus which is associated with loss of glucose through urine and formation of harmful compounds known as ketone bodies.
* Diabetic patients are successfully treated with insulin therapy.

**Gastrin (exocrine) :** This hormone aids digestion by stimulating certain cells in the stomach to produce acid.

**Somatostatin**: When levels of other pancreatic hormones, such as insulin and glucogan, get too high, somatostatin is secreted to maintain a balance of glucose and/or salt in the blood. Somatostatin is produced by the **delta cells of the islets of Langerhans,** where it serves to block the secretion of both insulin and glucagons from adjacent cells.
*Insulin glucagons, and somatostatin act in concert to control the flow of nutrients into and out of the circulation.
*The relative concentrations of these hormone regulate the rates of absorption, utilization, and storage of glucose, amino acids and fatty acids.

**Vasoactive intestinal peptide (VIP**): This hormone helps control water secretion and absorption from the intestines by stimulating the intestinal cells to release water and salts into the intestines.
*It stimulates the secretion of electrolytes and water by the intestinal mucosa.

**Gonads: 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.

* **Testosterone**:
* It is a male sex hormone secreted in the testis.

***Functions of testosterone:***

* It is responsible for the male body configuration.
* It induces sex at puberty.
* It stimulates the development of pubic hair.
* Controls development, growth and maintainance of male sex organs.
* It is responsible for development of male secondary sexual characters like deep voice, growth of facial hair, muscular body etc.
* Responsible for production of sperms or spermatogenesis.
*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.

**Ovary:** Females have a pair of ovaries located in the abdomen.
*There are actually three major estrogens, known as **estradiol, estrone, and estrol**.
* These are a group of steroid hormones mainly secreted by follicular epithelial cells of Graafian's follicle through these are also produced by the adrenal cortex and placenta.
*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.

*** Gynogens (Ovarian hormones)** are a group of steroid hormones produced by the cells of theca interna of the matured follicles.

**Ovarian hormones** are secreted by ovaries in females.
* Common female sex hormones are ***estrogen and progesterone***.

**Estrogen** is secreted by the follicular cells of the ovary namely theca interna and membrana granulosa.
* The principal estrogen is estradiol.
*****The functions are:***

*Stimulates the female body configuration like narrow shoulders, broad hips, body hair pattern and fat distribution.
* It is responsible for the growth of various parts of female reproductive system.
* It is responsible for expression of female secondary sexual characters such as high pitched voice.
* It is responsible for fat distribution in the female body.
* Responsible for the development of mammary glands.
* It stimulates the development of pubic hair.
* It increases the secretion of mucous in the cervix.

**Progesterone:**

*** It is commonly called pregnancy hormone.**

It is secreted by the corpus luteum and the placenta.

*Functions of progesterone are:*

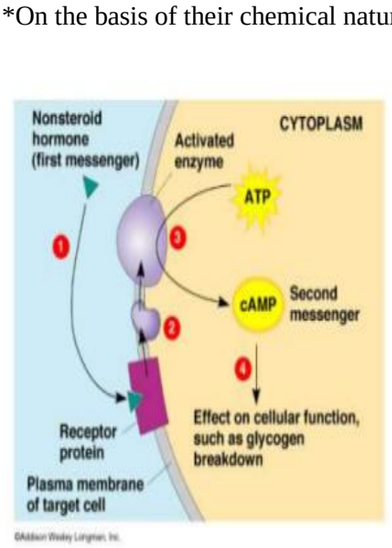
* It is considered as the ***pregnancy hormone*** since it maintains pregnancy and prevents premature expulsion of foetus.
* It thickens endometrium and prepares for implantation.
* It suppresses reproductive cycle.
* It decreases the contraction of the uterine tubes and myometrium.
*Estrogens also regulate female sexual behaviour.
*Progesterone also acts on the mammary glands and stimulates the formation of alveoli (sac-like structures which store milk) and milk secretion.

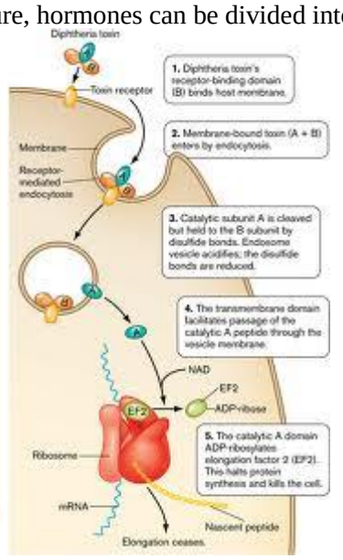
**Hormones of Heart, Kidney and Gastrointestinal Tract:**

*** Hormones** are also secreted by some tissues which are not endocrine glands.
* For example, 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.
*ANF reduces the blood pressure.
*The juxtaglomerular cells of kidney produce a peptide hormone called erythropoietin which stimulates erythropoiesis (formation of RBC).
*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.
* ***Cholecystokinin*** (CCK) acts on both pancreas and gall bladder and stimulates the secretion of pancreatic enzymes and bile juice, respectively.
***Gastric inhibitory peptide (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.

**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.
*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, IP3, Ca++ etc) which in turn regulate cellular metabolism. 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.