B.Sc. IVth Semester
Unit - iii

Thyroid gland

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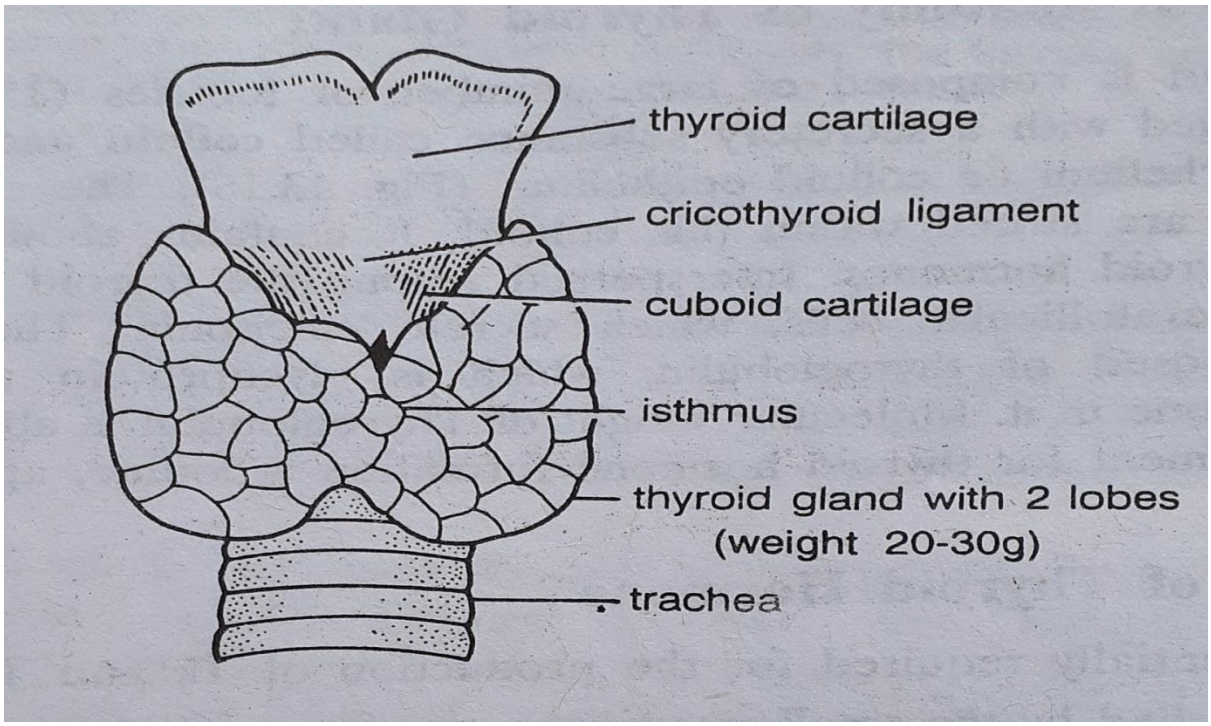
The name of the thyroid gland originate from Greek word “thyros” which means “shield”. The name is given because in general appearance it looks like as a shield. The weight of this gland is about 20 to 30 grams in adult human beings. This gland is present in all the vertebrates and phylogenetically it is related to the **endostyle of the protochordates**. In scoliodon it is a pear shaped structure situated just below the fork of the aorta while in adult cyclo stomes and many teleost fishes, it comprises groups of follicles scattered about the region of the ventral aorta.

In frog it is a small reddish body located over each external jugular vein where as in reptiles it is unpaired, in the turtles, crocodiles and snakes or paired structure in lizards , present near the middle region of the tracheal tube. In birds the thyroid are the paired structures lying on either sides of trachea.

In Mammals thyroid gland is composed of two lobes one on each side of the trachea, in the neck region immediately below the larynx. Thyroid gland is related with the metabolism of the body as it increases the BMR of the body.

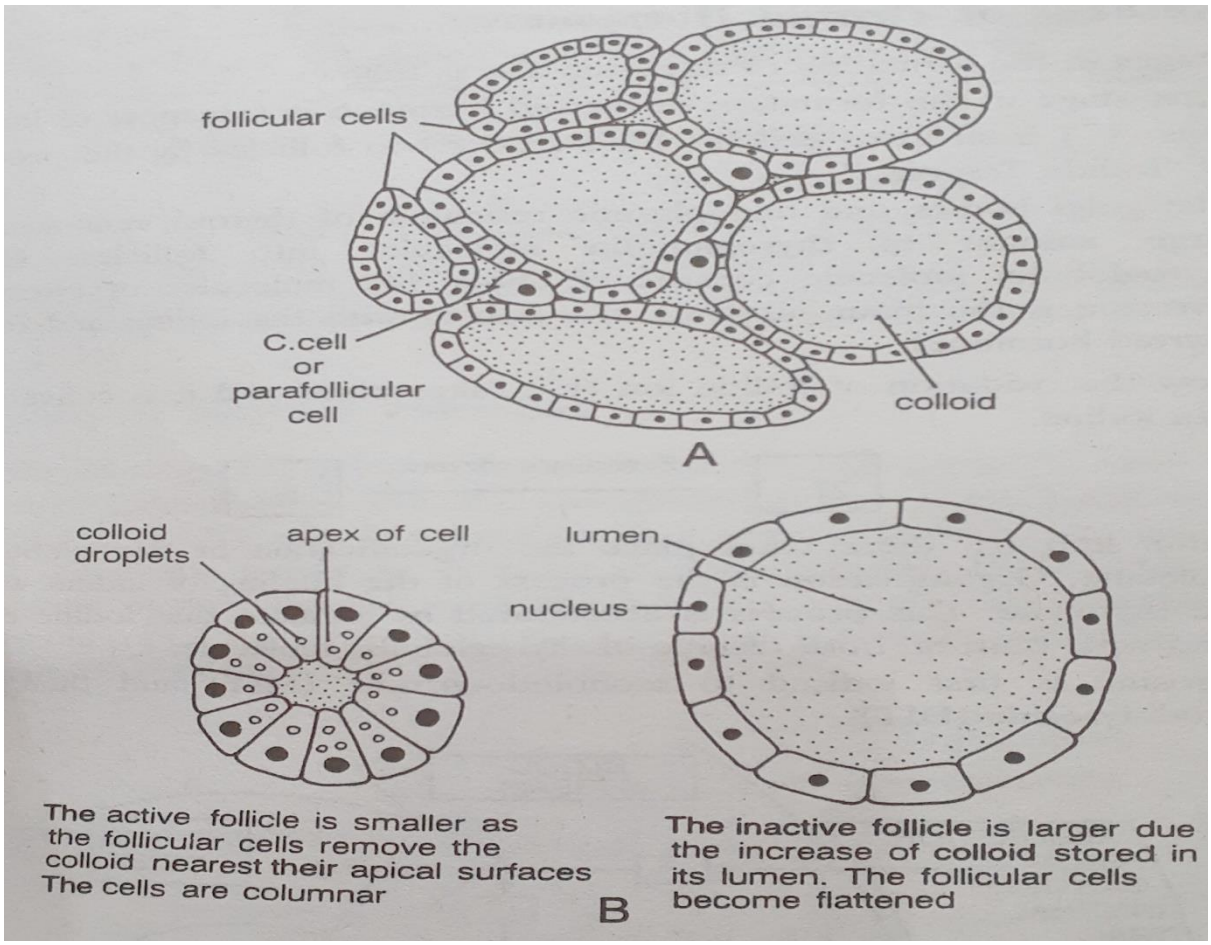


Position of thyroid gland

Origin - The thyroid gland arises in the mammals as an unpaired endodermal evagination of the pharyngeal floor. Later it loses its connection with the gut and is eventually separated as a bilobed gland.

Blood supply – Thyroid has a dual blood supply, it receives blood from the superior and inferior thyroid artery from the external carotid and subclavian artery respectively.

Physiological anatomy of the Thyroid – Thyroid gland is composed of large number of follicles, filled with a secetory substance called **colloid** and lined with cuboidal epithelium or colloid epithelium. The secretions of thyroid cells are stored within this colloid. **It contains about a months supply of thyroid hormones.** Interspread among the thyroid follicles, are C-cells or para follicular cells, which secretes calcitonin. The colloid is mainly composed of thyroglobulin which is glycoprotein and contain thyroid hormone in it.



A- Microscopic structure of thyroid gland. **B-** Diagram showing difference in appearance of active and inactive thyroid follicles**.**

Chief hormones and Chemistry of Thyroid hormone – The chief hormones of thyroid gland are hyroxine T_4 and tri-idothyronine T_3. Iodine is essential and required for the production of T_4 and T_3. Iodine is normally absorbed by the small intestine in the form of iodide ion from food and drinking water. Thyroid gland is very efficient at removing the iodide ions from the blood. The follicular cells actively transport iodide across their basal membranes against both the concentration gradient and an electrical gradient. The concentration of iodide inside follicular cell is usually 22-50 times greater than the plasma concentration. **This accumulation of iodide is referred to as iodide trapping.**

Almost all of the released thyroid hormones are bound to a specific plasma proteins. These binding proteins are **thyroxine binding globulin (TBG), thyroxine binding pre albumin (TBPA) and albumin.** However it is only the free and unbound hormone in the circulation that is biologically active.

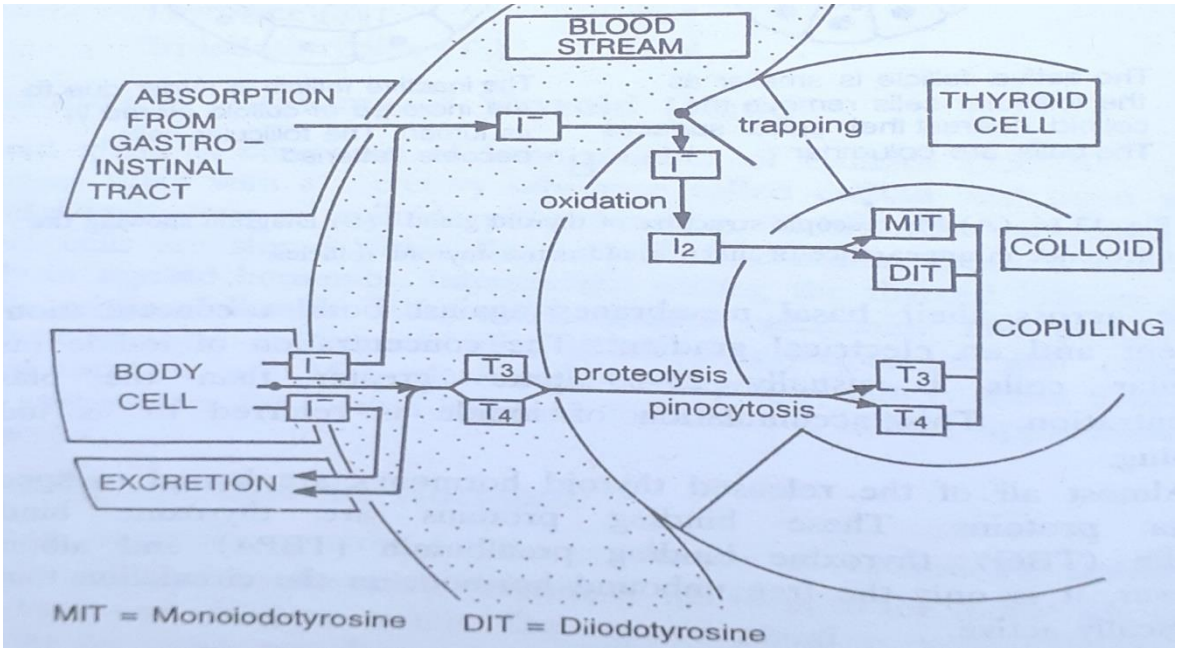
Biosynthesis of Thyroid hormones –

Various steps and stages in the formation of thyroxine hormone are as follows.

1. The first step in the formation of thyroid hormone is transport of iodide ions from extracellular fluid to follicles by the process of **Iodide trapping.**
2. Golgi body and endoplasmic reticulum of the thyroid cells secrete large amount of **thyroglobulin** molecules into the follicles. Each thyroglobulin molecules consists of about 140 molecules of **tyrosine**. **In fact tyrosine is the main substrate to combine with iodine to form thyroid hormone.**
3. Now the oxidation of iodide ions (I^-) takes place and it is converted into iodine.

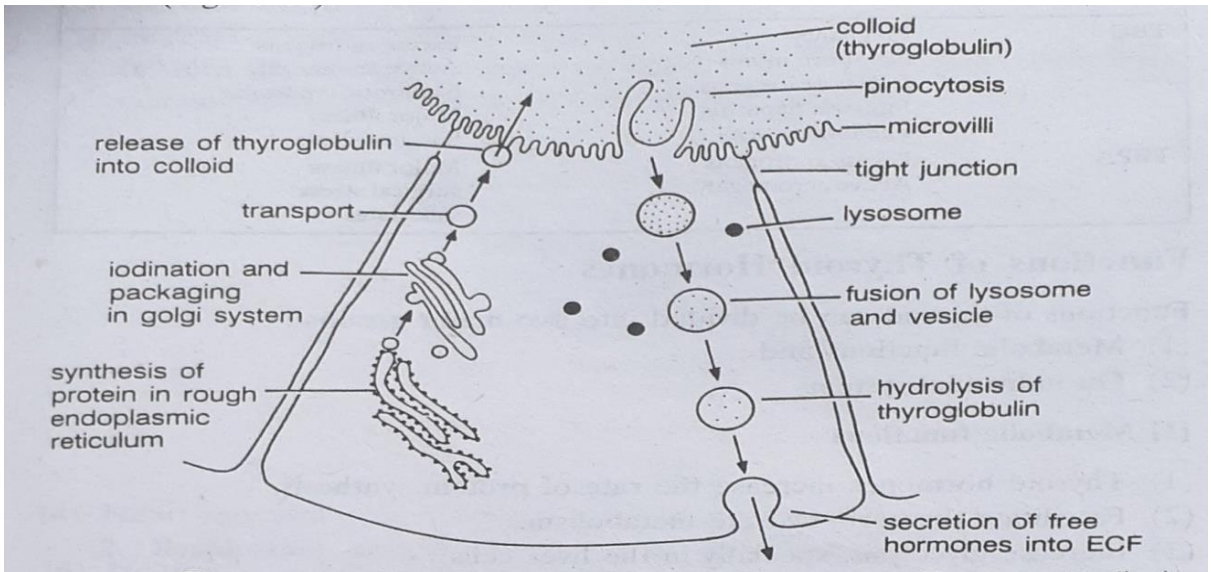
$$2I^- \xrightarrow{\text{Peroxidase}} I_2$$

4. After third step the organification of thyroglobulin molecule takes place. Organification is a method or process of binding of iodine with the thyroxine This process is increased or accelerated by iodinase through which iodine can bind with $\frac{1}{5}^{th}$ or $\frac{1}{6}^{th}$ residues of thyroglobulin molecule.
5. Tyrosine is first iodised to monoiodotyrosine **(MIT)** and then to diiodotyrosine **(DIT).**
6. **After sometime these MIT and DIT are coupled with each other and form triiodothyronine T_3 and thyroxine T_4.**



Biosynthesis of thyroid hormone and its fate

Release of thyroid hormone – Thyroglobulin is not secreted from the thyroid cells, instead T_4 and T_3 are released from Thyroid cells and transported to the blood. Lysosomes are helpful in this T_4 and T_3 release i.e. lysosome bind with hormone vesicle and digest that vesicle by different enzymes such as proteinase. This process causes digestion of thyroglobulin molecule and release of T_4 and T_3. Now these hormones enter the blood and through blood into the body tissues.



The two steps in the secretion of the thyroid hormones. The thyroglobulin is synthesised in the rough endoplasmic reticulum, iodinated and packaged in the Golgi complex, and transported into the colloid. When the gland is stimulated colloid is taken up by vesicles that fuse with lysosomes. The lysosomal enzymes hydrolyse the thyroglobulin with the production of free hormones, which pass out into the blood.

Functions of the thyroid hormones –

Function of Thyroid hormone can be grouped under two major heads

1. Metabolic functions
2. On individual systems

Metabolic functions –

a. **Increase glycolysis especially in the liver cells.**
b. **Stimulate Beta cells to secrete insulin.**
c. **Increase vitamin formation.**
d. **Increase free fatty acid level.**
e. **It produces lipolytic effect.**
f. **Thyroid hormone increases the rate of protein synthesis.**
g. **Increases gluconeogenesis.**
h. **Facilitate carbohydrate metabolism.**
i. **Increase enzyme formation.**
j. **Increases β carotene synthesis in liver.**
k. **Facilitate calcium metabolism. In foetal life causes mineralization of bones, essential for development of bones.**

On Individuals systems –

1. **Respiratory system -** Thyroid hormone increases the BMR which eventually increases the oxygen consumption which in turn stimulates the increase CO_2 in blood and stimulates the respiratory Centre. This will result finally the increase rate and depth of the respiration**.**
2. **Central nervous system –** It causes Rapid cerebration. (working of brain, thinking) . It also increases synapse activity as well as important for myelination of neurone. Another important function of the thyroid hormone on central nervous system is to increase the sensitivity of nervous tissue for catecholamines.
3. **Cardiovascular vascular system –** It increases the motility, number and affinity of β adrenergic receptors which increases vasodilation which consequently increases the blood flow and finally increases the heart rate.
4. **Digestive system –** Thyroid hormone increases the motility of the gastrointestinal tract and increase in appetite. Thyroid hormone stimulates the rate of absorption of sugar such as glucose and galactose through the intestine.

5. **On metamorphosis – in amphibians thyroid hormones facilitate the process of metamorphosis.**
6. **On reproductive system –** Uterine muscles are not affected by the thyroid hormone but Thyroid hormones are responsible for maintenance of menstruation cycle. Thyroid hormone also responsible for specification of germ cell. (Gonadal cells)
7. **On skeletal muscles-** Thyroid hormone increases skeletal muscles activity but when thyroid hormone concentration increases more than normal it causes **thyrotoxic myopathy i.e. weakness of muscle**.

Disorders of thyroid gland functioning -

Generally there are four types of abnormalities concerned with abnormal functioning of thyroid gland these are as follows.

1. Euthyroid
2. Goitre
3. Hypothyroidism includes cretinism and myxoedema
4. Hyperthyroidism includes the graves's disease

Euthyroid - It is a condition in which thyroid binding protein is decreased, that's why the concentration of hormone is normal but the functional ability is decreased.

Goitre - In simple words the enlargement of thyroid gland is called goitre. It may be of following types.

Simple goitre - It is due to decrease of iodine content in drinking water.

Idiopathic non toxic goitre - It is due to the fact because at certain intervals gland activity somewhat declines so as to compensate that, the follicular cells and enlarge sometimes and causes idiopathic non toxic goitre.

Cabbage goitre - It is because of presence of anti-thyroid substances i.e. goitrogen which is present in cabbage and turnips which may cause such kind of goitre.

Toxic goitre or nodular goitre - It is because of the increased thyroid hormones in the blood due to this the thyroid gland becomes nodulous and lead to toxic goitre.

Hypothyroidism - The retarded development of the thyroid or abnormal decreased ability of thyroid hormone secretion leads to a condition which is known as hypothyroidism. In **children's** it causes **cretinism or dwarfism** and In adult it is called **myxoedema.**

Cretinism in children - Cretinism occurs in children important symptoms are as follows -

1. Completely mentally retarded child, as thyroid helps in the development of central nervous system.
2. Children's will be dwarf as thyroid will help in development of bones and tissues.
3. Decreased gastrointestinal motility
4. Muscular weakness
5. Decreased basal metabolic rate and intolerant to cold.
6. Skeletal growth decreases but the vessel growth continues and increases so leads to **macroglocia meaning by large protruding tongue in buccal cavity. Secondary sexual character retarded.**

Myxoedema in adult symptoms

1. Skin become yellow dry and coarse.
2. Speech ability and thought ability decreased or become slow.
3. Body weight may be increased.
4. Tachycardia.
5. Increased serum cholesterol
6. Decreased cardiac output.
7. Increase plasma protein level
8. Nitrogen metabolism is decreased.
9. Increased sluggishness

Hyperthyroidism - It is due to the overproduction of thyroid hormones and condition is called as hyperthyroidism. It produces Graves's disease.

Graves's disease – Various symptoms include are the enlargement of thyroid gland hence the name is given as exophthalmic goitre ,bulging eyes, (Graves's opthalmopathy) fatigue, frequent bowel movements, erectile dysfunction etc. **Graves's disease is also called as basedow's disease.**

The symptom of exophthalmic goitre are just opposite of the myxoedema such as intolerance to heat, BMR increases upto 40 to 50%, appetite increased, increased muscular weakness, protein catabolism increased , nitrogen metabolism increased, **insomnia** i.e. increased synaptic activity at the

spinal cord level , retraction of the upper eyelids, weakness of the external eye muscles, heart beat fast and irregular.

Beside thyroxine hormones and other hormone known as **calcitonin** or **thyrocalcitonin** is secreted from the **parafollicular** cells or **C cells** of the thyroid gland, hence the name is given thyrocalcitonin. These cells are found in the basement membrane of the thyroid follicles and are partially of the neural crest origin.

Chemistry of calcitonin – Among the vertebrate the structure of human calcitonin has been determined. Calcitonin is a polypeptide of 32 amino acid. Salmon calcitonin is interesting because it is about 20 or more times as active as human calcitonin. Calcitonin so named because it reduces the blood calcium level. Its molecular weight is about 3000 and half life is less than 10 minutes. Human calcitonin and also been synthesized in the laboratory and found to be biological as active as Natural one.

The secretion of calcitonin is directly proportional to the concentration of calcium ion in plasma. High blood calcium level stimulates calcitonin secretion whereas low level inhibit its secretion. It has been also observed from the recent studies that the gastrointestinal hormone such as gastrin and cholecystokinin pancreozymin are potent stimulator for calcitonin secretion.

Principal action of calcitonin:- Calcitonin basically lower the blood level of calcium by accelerating calcium absorption by the bones. Calcitonin also reduces plasma calcium ion concentration. Calcitonin increases the intestinal secretion of water and electrolytes. Calcitonin protects the bone in pregnant female from excess calcium loss during the pregnancy, so plasma concentration of calcitonin is increased in the pregnancy. In fact the bone formation in Infant and lactation are major drains on calcium stores of the mother.

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