

# Thyroid and Parathyroid Gland

Lecture-04

# The Thyroid Gland

- ⊙ Resembles a butterfly in shape; has right and left lobes
- ⊙ Located immediately **inferior** to the **thyroid cartilage of the larynx** and anterior to the trachea.
- ⊙ Both lobes of the thyroid gland are highly **vascularized**, giving it an intense reddish coloration.
- ⊙ Produces the hormones thyroxine, also known as T4, and triiodothyronine, which is called T3
- ⊙ These are produced in the thyroid gland from the mineral iodine.
- ⊙ Regulation of thyroid hormone secretion depends upon a complex **thyroid gland–pituitary gland negative** feedback process.

# Structure and Function of the Thyroid Gland

- ⊙ Regulates metabolic rate
- ⊙ Secretes thyroxine, governs cellular oxygen consumption, and thus, energy and heat production; the more oxygen that is used, the more calories are metabolized (“burned up”). Thyroxine assures that enough body heat is produced to maintain normal temperature even in a cold environment.

# Structure and Function of the Thyroid Gland (continued)

## ◎ Structure of the thyroid gland

- Located in the neck region, one lobe on either side of the trachea; a connecting strip, or isthmus, anterior to the trachea, connects the two lobes
- Just below the Adam's apple, the protrusion formed by part of the larynx
- The thyroid gland consists of follicles, microscopic sacs. Within these protein-containing follicles, the thyroid hormones, thyroxine and triiodothyronine, are made. Thin-walled capillaries run between the follicles in a position ideal to receive the thyroid hormones.

The thyroid gland produces 3 major hormones:

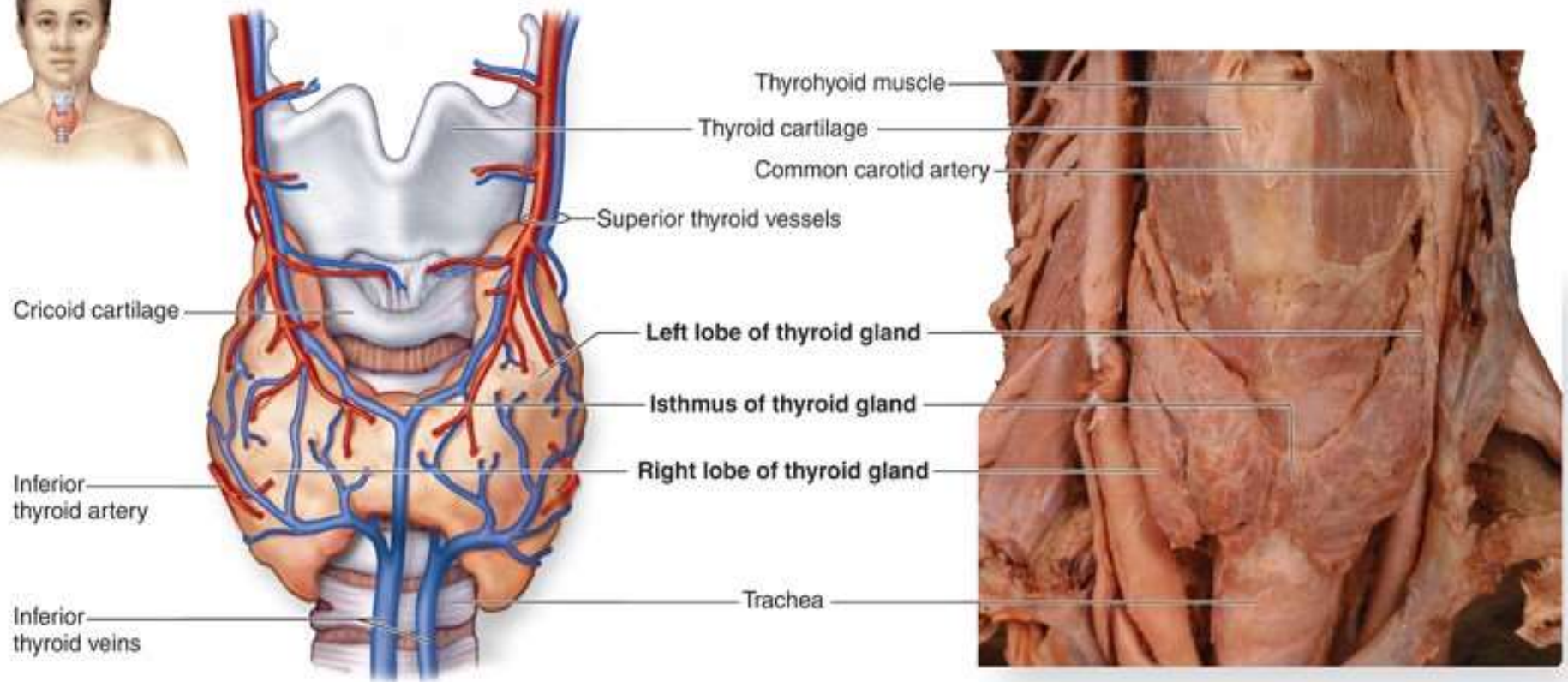
- Calcitonin: Reduce the concentration of calcium ions in the blood by aiding the absorption of calcium into the matrix of bones.
- Triiodothyronine (T3)
- Thyroxine (T4)

The hormones T3 and T4 work together to regulate the body's metabolic rate. Increased levels of T3 and T4 lead to increased cellular activity and energy usage in the body.

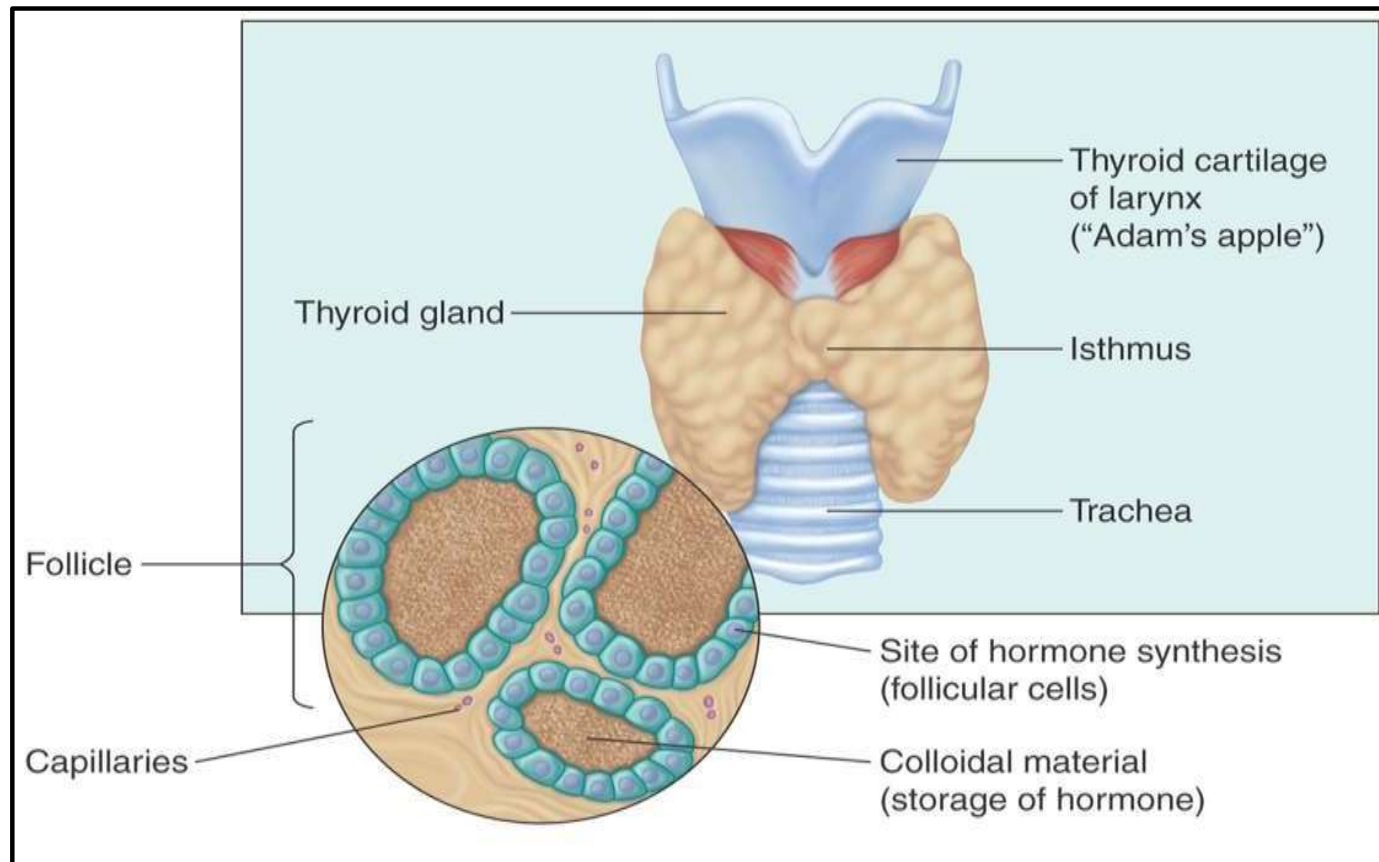
# The Thyroid Gland

- ⊙ Also secretes calcitonin in response to hypercalcemia (too high blood calcium level).
- ⊙ Its action is the opposite of parathyroid hormone and stimulates the increased deposition of calcium into bone, thereby lowering blood levels of calcium.

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(a)



The thyroid gland.



# Thyroid Hormone Synthesis

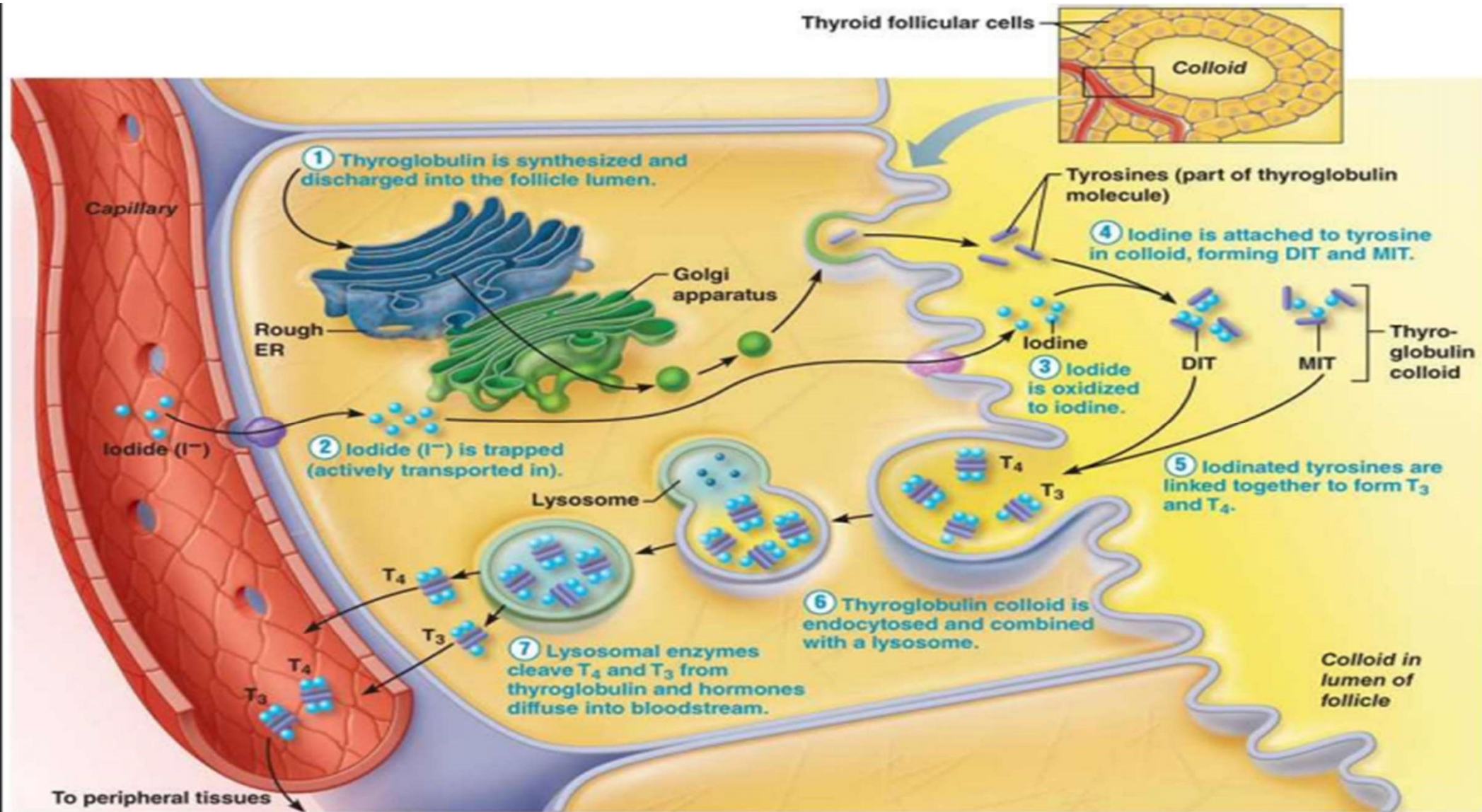
There are six steps in the synthesis of thyroid hormone-

- **Active transport** of Iodide into the follicular cell via Sodium-Iodide Symporter (NIS). This is actually secondary active transport, and the sodium gradient driving it is maintained by a Sodium-Potassium ATPase.
- **Thyroglobulin** (Tg), a large protein rich in Tyrosine, is formed in follicular ribosomes and placed into secretory vesicles.
- **Exocytosis** of Thyroglobulin into follicle lumen, where it is stored as colloid. Thyroglobulin is the scaffold upon which thyroid hormone is synthesised.

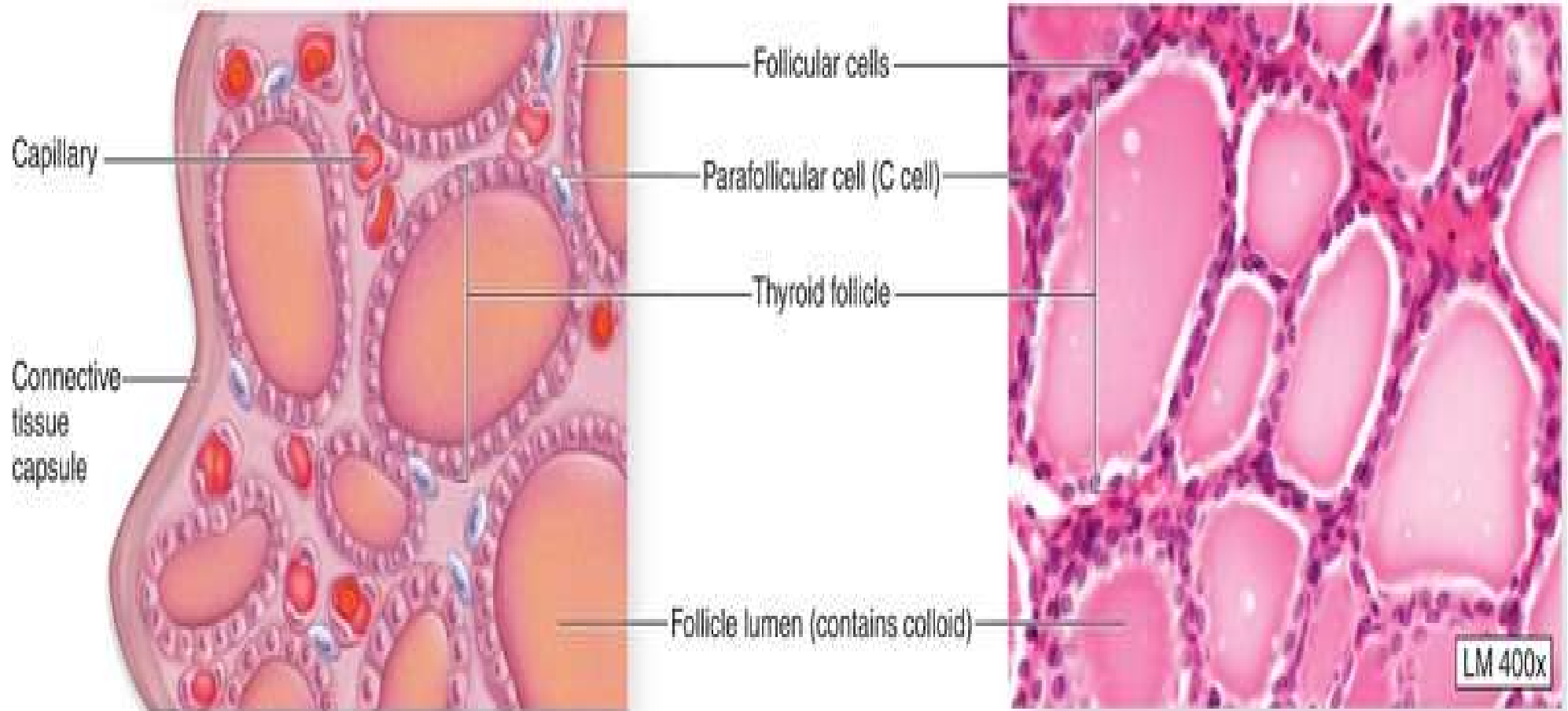
- **Iodination** of the Thyroglobulin. Iodide is made reactive by the enzyme thyroid peroxidase. Iodide binds to the benzene ring on Tyrosine residues of Thyroglobulin. First formed is moniodotyrosine (MIT) then diiodotyrosine (DIT).
- **Coupling** of MIT and DIT to give Triiodothyronine (T3) hormone and coupling of DIT and DIT to give Tetraiodothyronine (T4) hormone, also known as Thyroxine.
- **Endocytosis** of iodinated thyroglobulin back into the follicular cell. Thyroglobulin undergoes proteolysis in lysosomes to cleave the iodinated tyrosine residues from the larger protein. Free T3 or T4 is then released, and the Thyroglobulin scaffold is recycled.

## Secretion of thyroid hormone-

- Thyroid hormones are released as part of a hypothalamic-pituitary-thyroid axis. The Hypothalamus detects a low plasma concentration of thyroid hormone and releases Thyrotropin-Releasing Hormone (TRH) into the hypophyseal portal system.
- TRH binds to receptors found on thyrotrophic cells of the anterior pituitary gland, causing them to release Thyroid Stimulating Hormone (TSH) into the systemic circulation. TSH binds to TSH receptors on the basolateral membrane of thyroid follicular cells and induces the synthesis and release of thyroid hormone.



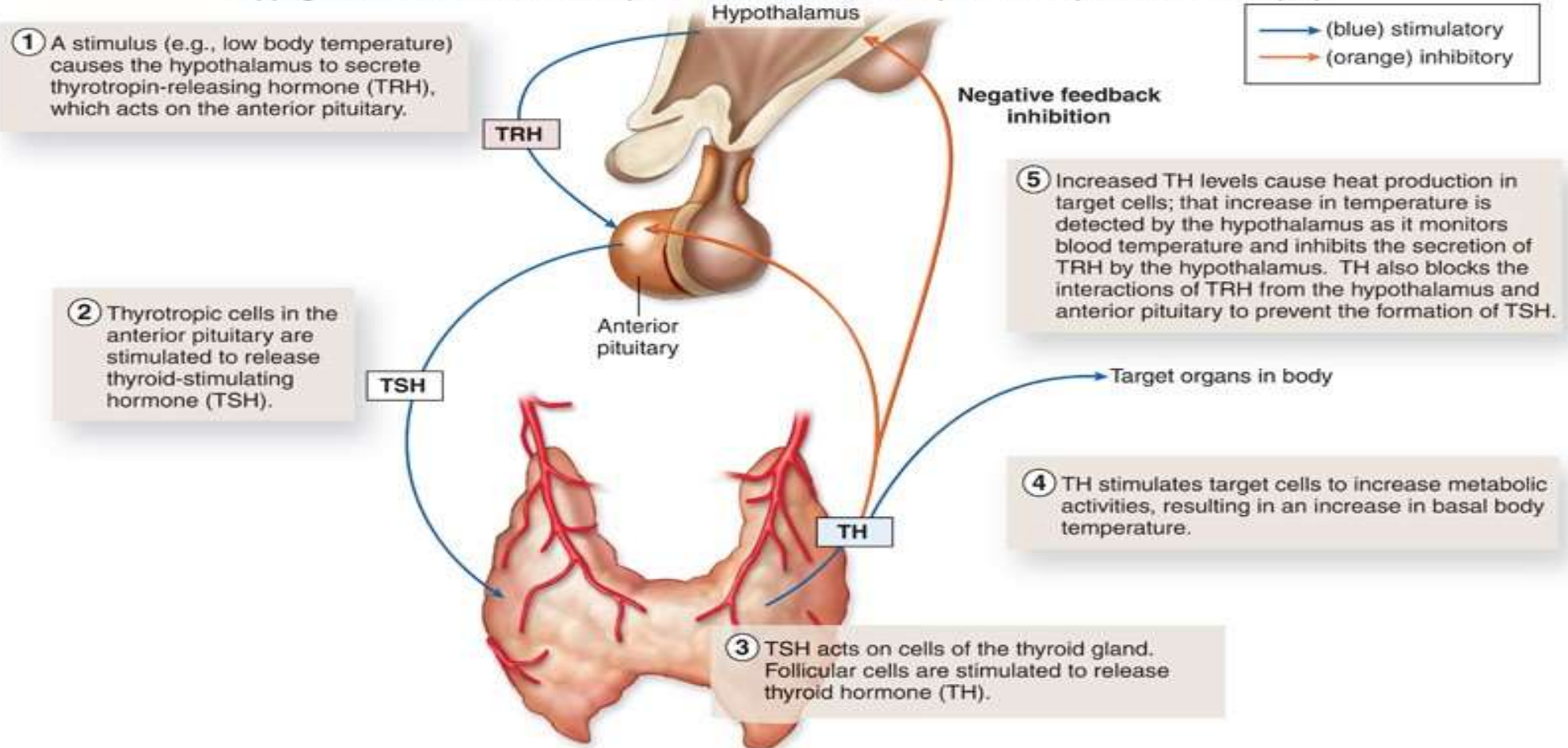
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(b)



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# Function of the Thyroid Gland

- ◎ The thyroid gland synthesizes, stores, and releases thyroid hormones, which contain iodine.
  - Most of the iodide ions of the body are taken into the thyroid gland by a mechanism called the iodide trap.
  - Iodine combines with an amino acid; two of these groups join, and the thyroid hormones are formed.
- ◎ The hormones are stored until needed and then released into the blood capillaries. In the blood, the thyroid hormones combine with plasma proteins.

# Effects of Thyroid Hormones

☉ Thyroxine: secreted in the largest quantity.

- Thyroxine stimulates cellular metabolism by increasing the rate of oxygen use with subsequent energy and heat production.
- Nutrients are converted to energy in the presence of oxygen and the waste products of metabolism, including carbon dioxide, are formed.
- As cellular metabolism increases, respiration and cardiac output increases.
- Heat is produced through cellular metabolism
- Increases secretion of digestive enzymes and movement through the digestive system.



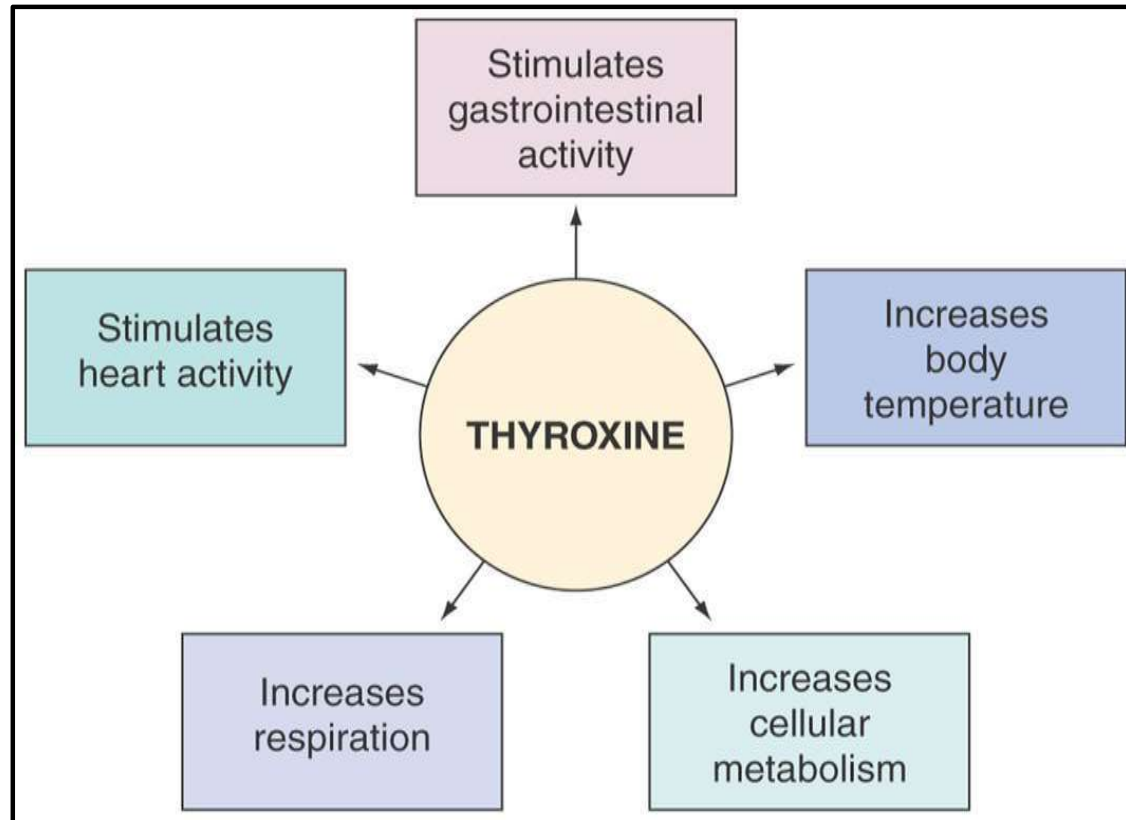


Figure 13-9: Effects of thyroxine.

# Control of Circulating Thyroxine Level

- ⊙ Anterior pituitary gland stimulates the thyroid by releasing thyroid-stimulating hormone, TSH.
- ⊙ The thyroid, in turn, releases thyroxine, which circulates in the blood to all cells and tissues. When the level of circulating thyroxine is high, the anterior pituitary is inhibited and stops releasing TSH (negative feedback mechanism).
  - An adequate level of thyroxine prevents further synthesis of the hormone. When the level of thyroxine falls, the anterior pituitary is released from the inhibition, and once again sends out TSH. This feedback mechanism is shown in Figure 13.10.

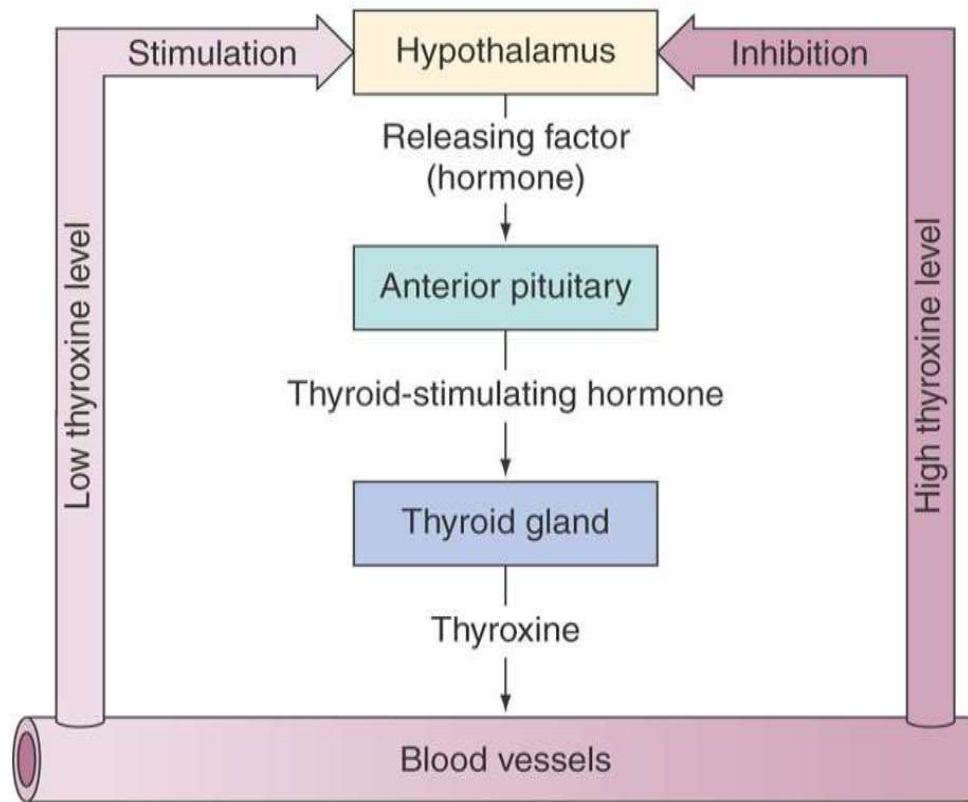


Figure 13-10: Control of thyroxine secretion through negative feedback.

# Negative Feedback Failure

- ⊙ Constitutes one basis for a thyroid disease
- ⊙ The thyroid gland may be perfectly healthy, but if the body's iodine supply is inadequate, the gland cannot produce thyroxine.
- ⊙ It is possible for the thyroid gland to be over-stimulated or understimulated by the anterior pituitary.
- ⊙ The thyroid gland itself may be diseased, with a resultant hyperactivity or hypoactivity. These are some of the conditions that will be discussed.

## Thyroid Conditions-

- **Goiter:** A general term for thyroid swelling. Goiters can be harmless, or can represent iodine deficiency or a condition associated with thyroid inflammation called Hashimoto's thyroiditis.
- **Thyroiditis:** Inflammation of the thyroid, usually from a viral infection or autoimmune condition. Thyroiditis can be painful, or have no symptoms at all.
- **Hyperthyroidism:** Excessive thyroid hormone production. Hyperthyroidism is most often caused by Graves disease or an overactive thyroid nodule.
- **Hypothyroidism:** Low production of thyroid hormone. Thyroid damage caused by autoimmune disease is the most common cause of hypothyroidism .

- **Graves disease:** An autoimmune condition in which the thyroid is overstimulated, causing hyperthyroidism.
- **Thyroid cancer:** An uncommon form of cancer, thyroid cancer is usually curable. Surgery, radiation, and hormone treatments may be used to treat thyroid cancer.
- **Thyroid nodule:** A small abnormal mass or lump in the thyroid gland. Thyroid nodules are extremely common. Few are cancerous. They may secrete excess hormones, causing hyperthyroidism, or cause no problems.
- **Thyroid storm:** A rare form of hyperthyroidism in which extremely high thyroid hormone levels cause severe illness

# Thyroid function tests-

- Thyroid function tests are a series of blood tests used to measure how well your thyroid gland is working. Available tests include the T3, T3RU, T4, and TSH.

## **T4 & TSH results-**

- The T4 test and the TSH test are the two most common thyroid function tests. They're usually ordered together.
- The T4 test is known as the thyroxine test. A high level of T4 indicates an overactive thyroid (hyperthyroidism). Symptoms include anxiety, unplanned weight loss, tremors, and diarrhea. Most of the T4 in your body is bound to protein. A small portion of T4 is not and this is called free T4. Free T4 is the form that is readily available for your body to use. Sometimes a free T4 level is also checked along with the T4 test.
- The TSH test measures the level of thyroid-stimulating hormone in your blood. The TSH has a normal test range between 0.4 and 4.0 milli-international units of hormone per liter of blood (mIU/L).



## **T3 result-**

- The T3 test checks for levels of the hormone triiodothyronine. It's usually ordered if T4 tests and TSH tests suggest hyperthyroidism. The T3 test may also be ordered if you're showing signs of an overactive thyroid gland and your T4 and TSH aren't elevated.
- The normal range for the T3 is 100–200 nanograms of hormone per deciliter of blood (ng/dL). Abnormally high levels most commonly indicate a condition called Grave's disease. This is an autoimmune disorder associated with hyperthyroidism.

# Goiter

- ⊙ An enlargement of the thyroid gland.
- ⊙ May be caused by hypoactivity or hyperactivity of the thyroid or a deficiency in iodine needed to synthesize thyroid hormones
- ⊙ Types: diffuse colloidal goiter or nontoxic goiter
- ⊙ Endemic goiter because it is common in a particular geographic region
  - The usual cause of an endemic goiter is insufficient iodine in the diet.

# Goiter (continued)

- ⊙ Etiology of goiter
  - Continuous secretion of thyroid-stimulating hormone causes the thyroid gland to enlarge as a compensatory mechanism.
  - An enlargement of the neck is generally the only symptom. Usually enough thyroxine is produced to prevent the symptoms of hypothyroidism.
- ⊙ Treatment: iodides: the use of iodized salt prevents endemic goiter formation. If the goiter is very advanced, surgery may be necessary. A very large goiter puts pressure on the esophagus, causing difficulty in swallowing, or presses on the trachea, causing a cough or choking sensation.
- ⊙ Other factors can cause a simple diffuse colloidal goiter; for example, a defect in the thyroxine-synthesizing mechanism. A young girl entering adolescence may develop this type of goiter because of an increased need for thyroxine at this time.

# Graves' Disease

- ⊙ Goiter develops; the entire gland hypertrophies, and there are no nodules
- ⊙ Severe hyperthyroidism
- ⊙ More common in women than in men and usually affects young women
- ⊙ Characteristic facial expression is strained and tense, and there is a stare in the eyes. The eyeballs protrude outward, a condition called exophthalmos. This is caused by edema in the tissue behind the eyes. The bulging of the eyes can be so severe that the eyelids do not close, and the swelling sometimes damages the optic nerve. This symptom generally persists even when the hyperthyroidism is corrected.

## Graves' Disease (continued)

- ⊙ The person has a tremendous appetite but loses weight to the point of appearing emaciated, as calories are burned up at a rapid rate. Thyroxine speeds the passage of food through the digestive tract. There is no time for the normal reabsorption of water from the large intestine, so diarrhea frequently accompanies the disease.
- ⊙ Tachycardia, rapid pulse rate, and palpitation are also among the symptoms. The person is extremely nervous, excitable, and is always tired but has difficulty sleeping because of the hyperactivity of the body. The high metabolic rate causes excessive heat production, which results in profuse perspiration. The skin is always moist, and an insatiable thirst follows the loss of water.

# Signs and Symptoms of Graves' Disease

- ⊙ Exophthalmos
- ⊙ Profuse perspiration
- ⊙ Hand tremors
- ⊙ Goiter
- ⊙ Weight loss
- ⊙ Nervousness/excitability
- ⊙ Rapid pulse
- ⊙ Polydipsia
- ⊙ Diarrhea
- ⊙ Tachypnea
- ⊙ Insomnia
- ⊙ Graves' disease is an autoimmune condition in which antibodies to a thyroid antigen stimulate hyperactivity of the thyroid gland. This causes the thyroid to produce too much thyroxine.
- ⊙ Graves' disease can sometimes be treated with medication that inhibits the synthesis of thyroxine, or by administration of radioactive iodine, which destroys the thyroid gland. Removal of the thyroid gland, however, may be necessary. If the gland is removed, hormonal supplements must be given. Partial removal of the thyroid gland allows the remaining portion to secrete hormones.

# Cretinism

- ⊙ Congenital thyroid deficiency in which thyroxine is not synthesized; thyroxine is essential to both physical and mental development.
- ⊙ Mental retardation and an abnormal, dwarfed stature
- ⊙ Etiology: error in fetal development if the thyroid gland fails to form or is nonfunctional, or may be endemic where the mother suffers from an inadequate iodine supply
- ⊙ The cretin is a dwarf with a stocky stature and a characteristically protruding abdomen. The sexual organs do not develop, and the face of the cretin is typically misshapen: a broad, sunken nose, small eyes set far apart, puffy eyelids, and a short forehead. A thick tongue protrudes from a wide-open mouth, and the face is expressionless.
- ⊙ The earlier this condition is diagnosed and treated with thyroxine, the more optimistic is the prognosis. Lifelong hormonal therapy will be required.