



Thyroid gland (I)

By

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Learning outcomes:

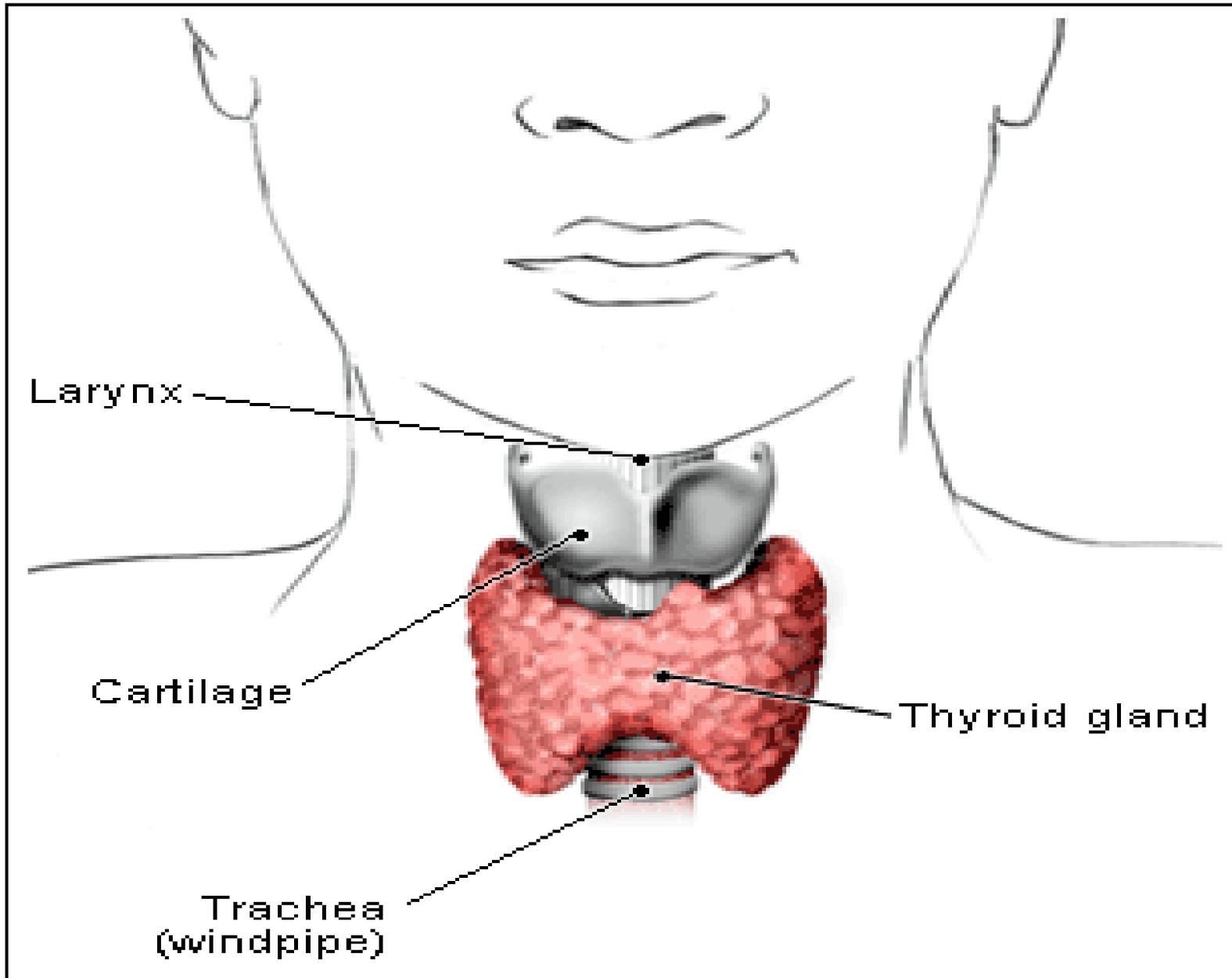
- **At the end of the lecture, you will be able to:**

1. Describe the gross anatomy and histology of thyroid gland.
2. Explain the synthesis, storage, release and transport of thyroid hormones.
3. Explain the transport of thyroid hormones.
4. Explain the mechanism of action of thyroid hormones.
5. Explain the functions (actions) of thyroid hormones.



Gross anatomy of thyroid gland

- Thyroid gland is formed of 2 lobes lying on either side of lower larynx & upper trachea (weighing 20 grams).
- Not essential for life.



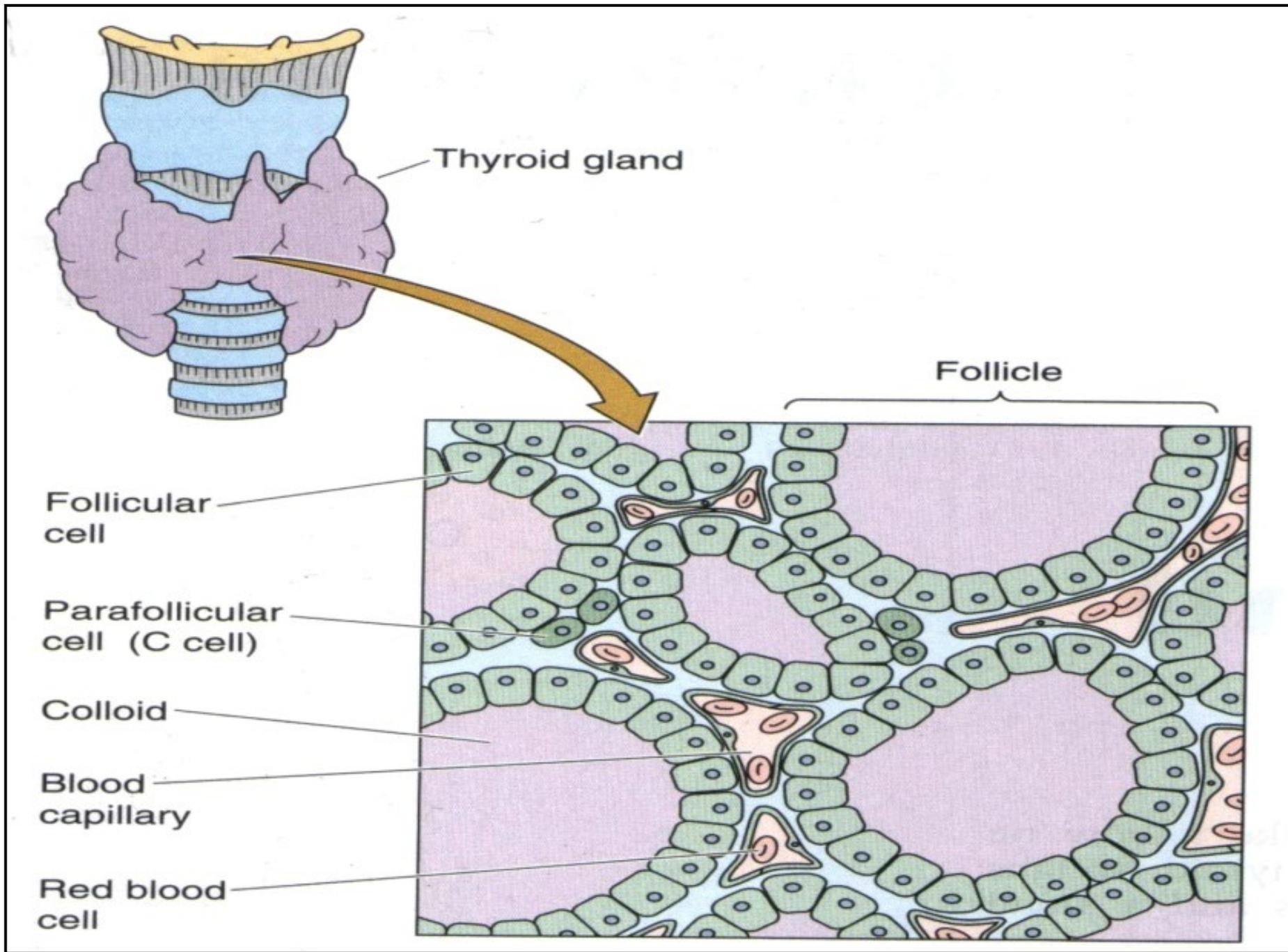


Histology of thyroid gland

1. Thyroid follicles: a hollow spherical unit:

- **Lined with** hormone secreting **cuboidal** cells carrying microvilli.
- **Filled with** thyroid **colloid** which contains **thyroglobulin** protein.

2. Para follicular cells: between the follicles.





- **N.B:**

- When the gland is **inactive**, follicles are **large**, colloid is **abundant** & follicular cells are **flat**.
- When the gland is **active**, follicles are **small**, colloid is **little** & follicular cells are **columnar**.



Thyroid hormones

1. Thyroid follicles: → produce:

- Tetraiodothyronine (T4) (thyroxine).
- Tri iodo thyronine (T3).

2. Para follicular cells → produce

- Calcitonin.

• **N.B.**



T3 and T4: T_3 is **3-5 times more active** than

T_4 at cellular level **although T_4** :

- Constitute **90%** of thyroid output.
- Persists in blood **longer** time than T_3 .



Synthesis of T3 and T4

1- Iodide (I⁻) uptake:

Iodide (I⁻) from plasma by active pump → I- concentration in thyroid acinar cells is 10 times its plasma concentration.

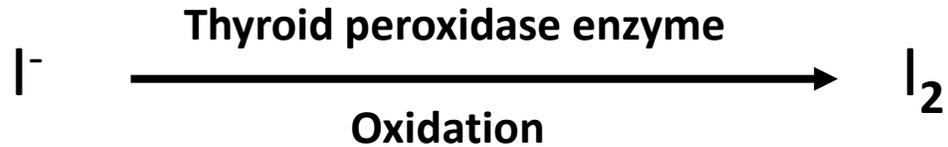
➤ Accelerated by → TSH.

➤ Inhibited by:

- Thiocyanate .
- Perchlorate.



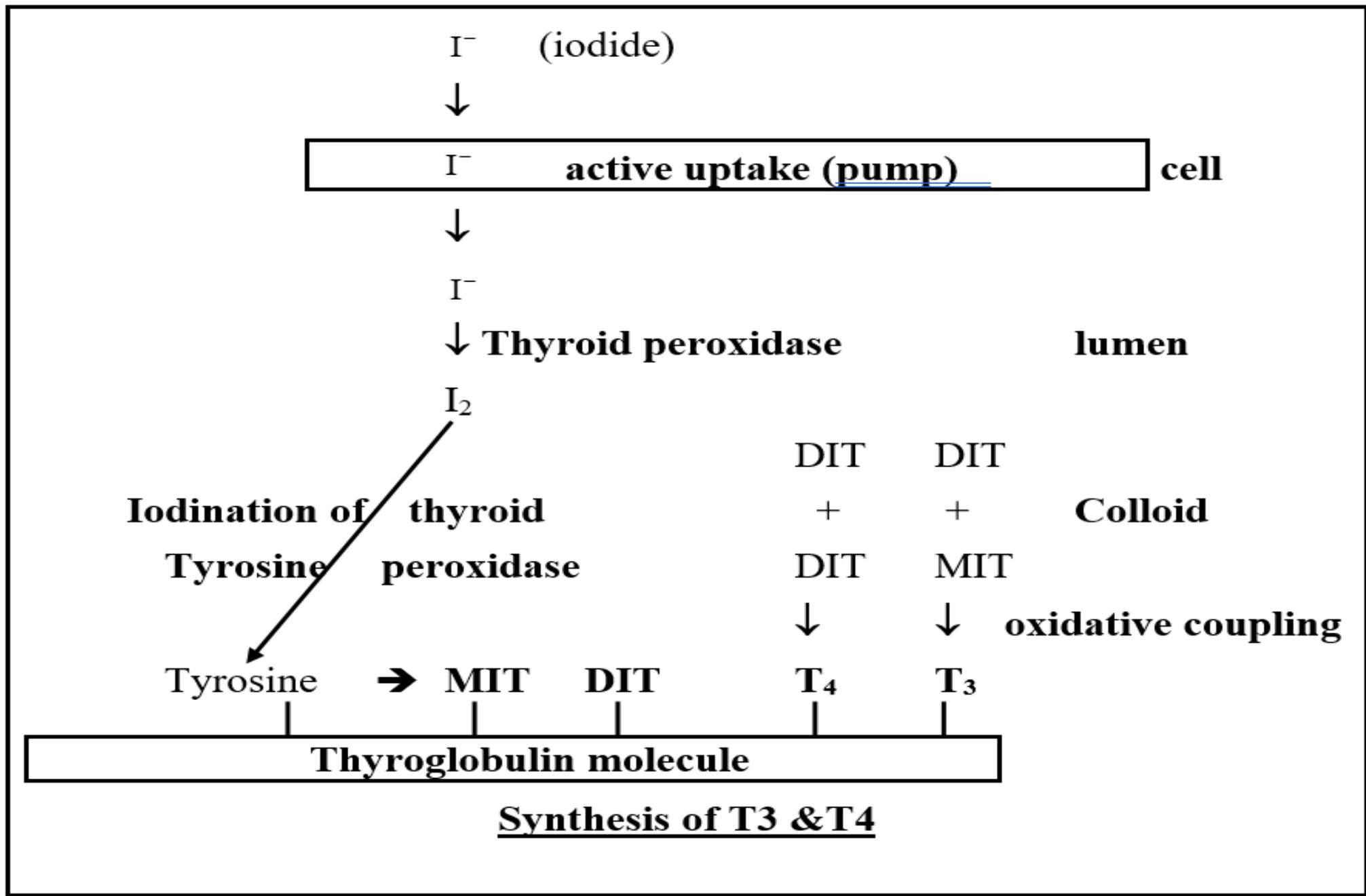
2- Oxidation of iodide (I⁻) to iodine (I₂):

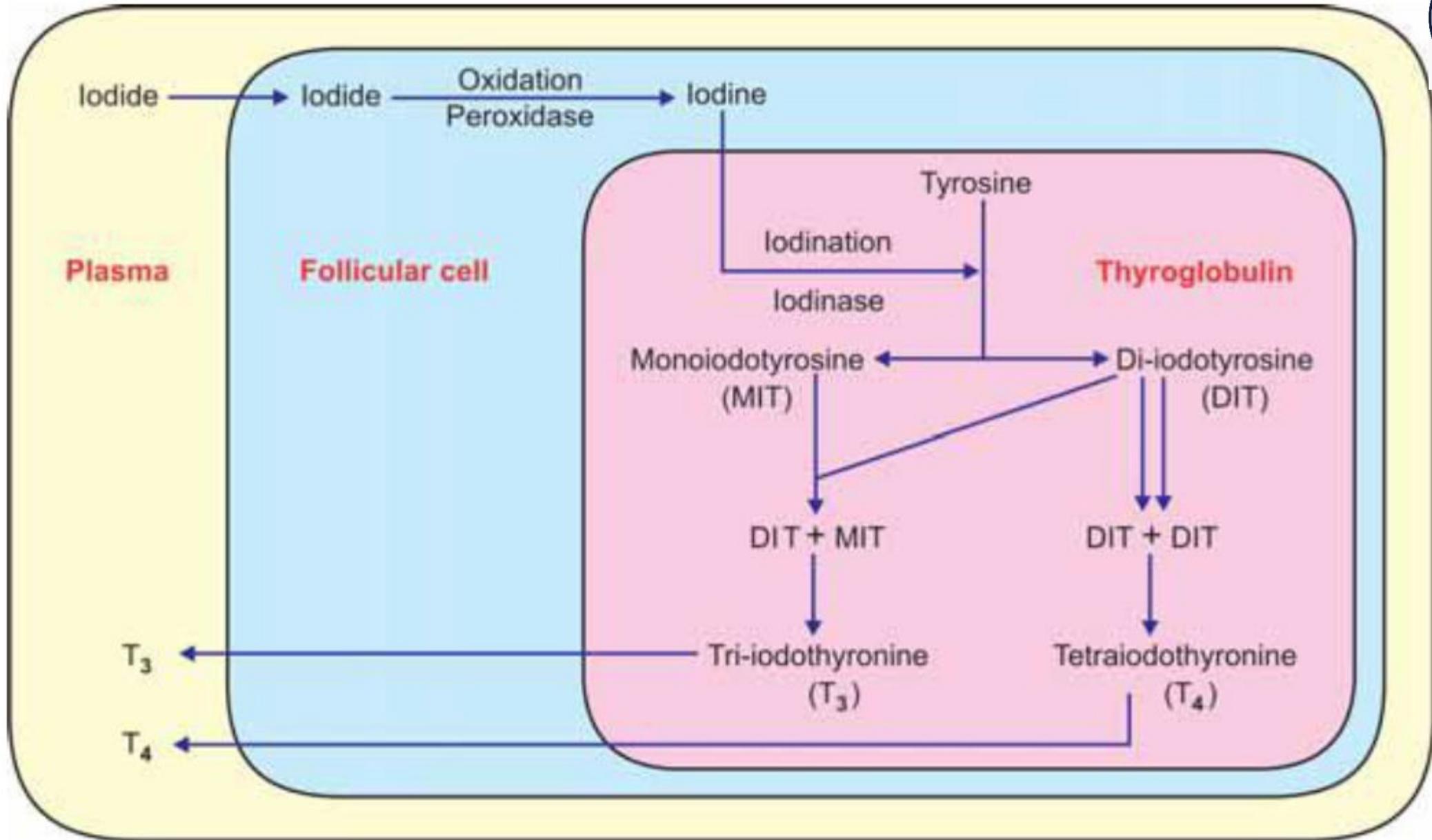


3- Iodination of tyrosine → Mono iodo tyrosine (MIT) and di iodo tyrosine (DIT).

4- Oxidative coupling:









• N.B.

- Oxidation of I^- , iodination of tyrosine and oxidative coupling require thyroid peroxidase enzyme.
- Block of this enzyme by thiocarbamide group
e.g. thiouracil and carbimazole → inhibit these reactions → so used in treatment of hyperthyroidism.



Iodine requirement

□ 1 mg /week

□ Persons living in areas away from the sea

e.g. oases must receive iodized table salt to

prevent iodine deficiency.

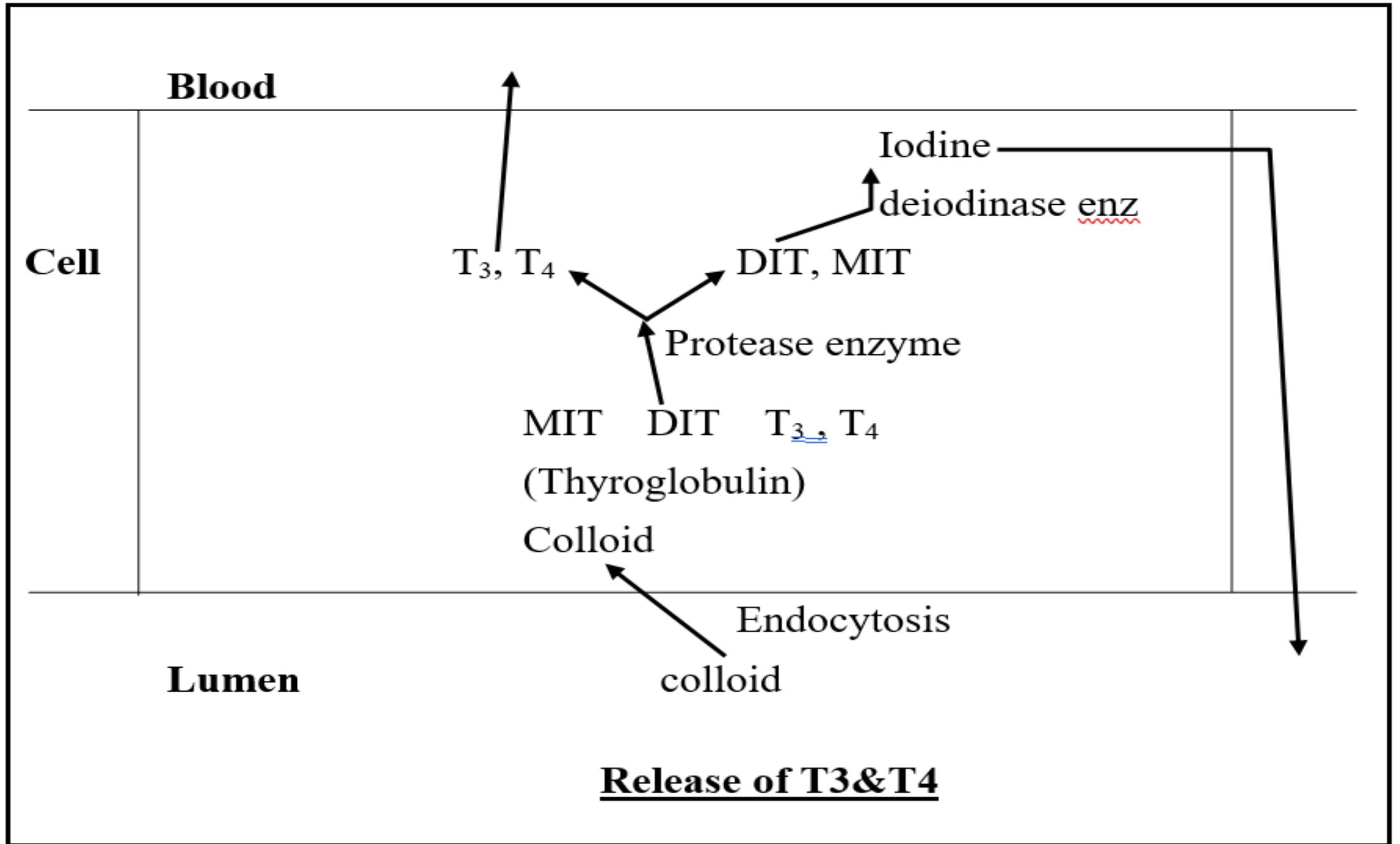
Storage of thyroid hormones

Thyroid hormones (T_3 and T_4) are stored in **colloid** in a **peptide linkage** with **thyroglobulin**.

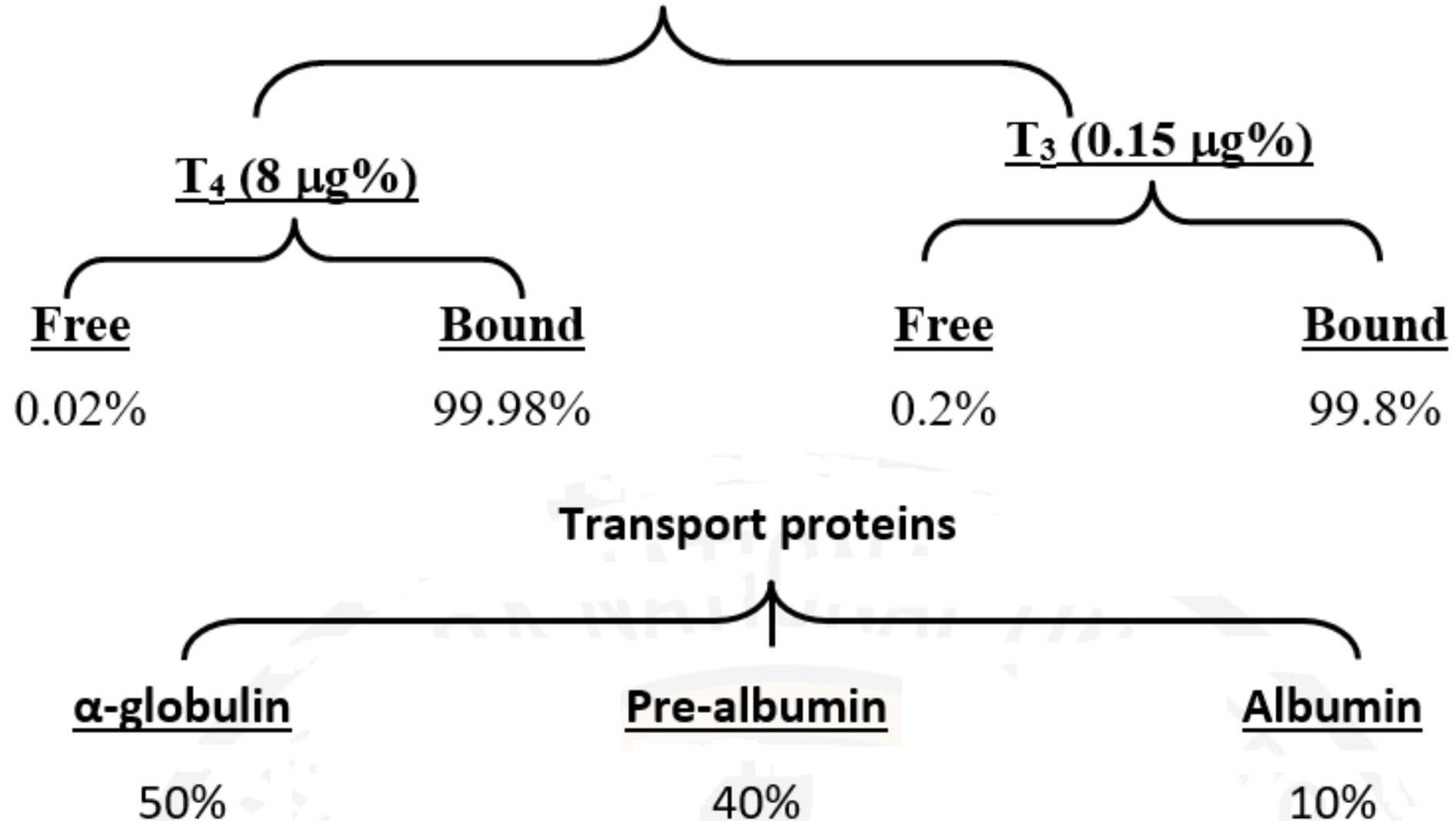


Release of thyroid hormones

- Stimulation of thyroid gland by TSH (act by ↑ing cAMP) → thyroglobulin is taken up by follicular cell by endocytosis.
- Lysosomes secrete proteases which break peptide links → release free T₃ and T₄ → T₃, T₄ diffuse through basal membrane → blood in capillaries.
- Iodotyrosines (MIT and DIT) $\xrightarrow{\text{De iodinase enzyme}}$ iodine → recycle in the gland → formation of additional T₃ and T₄.



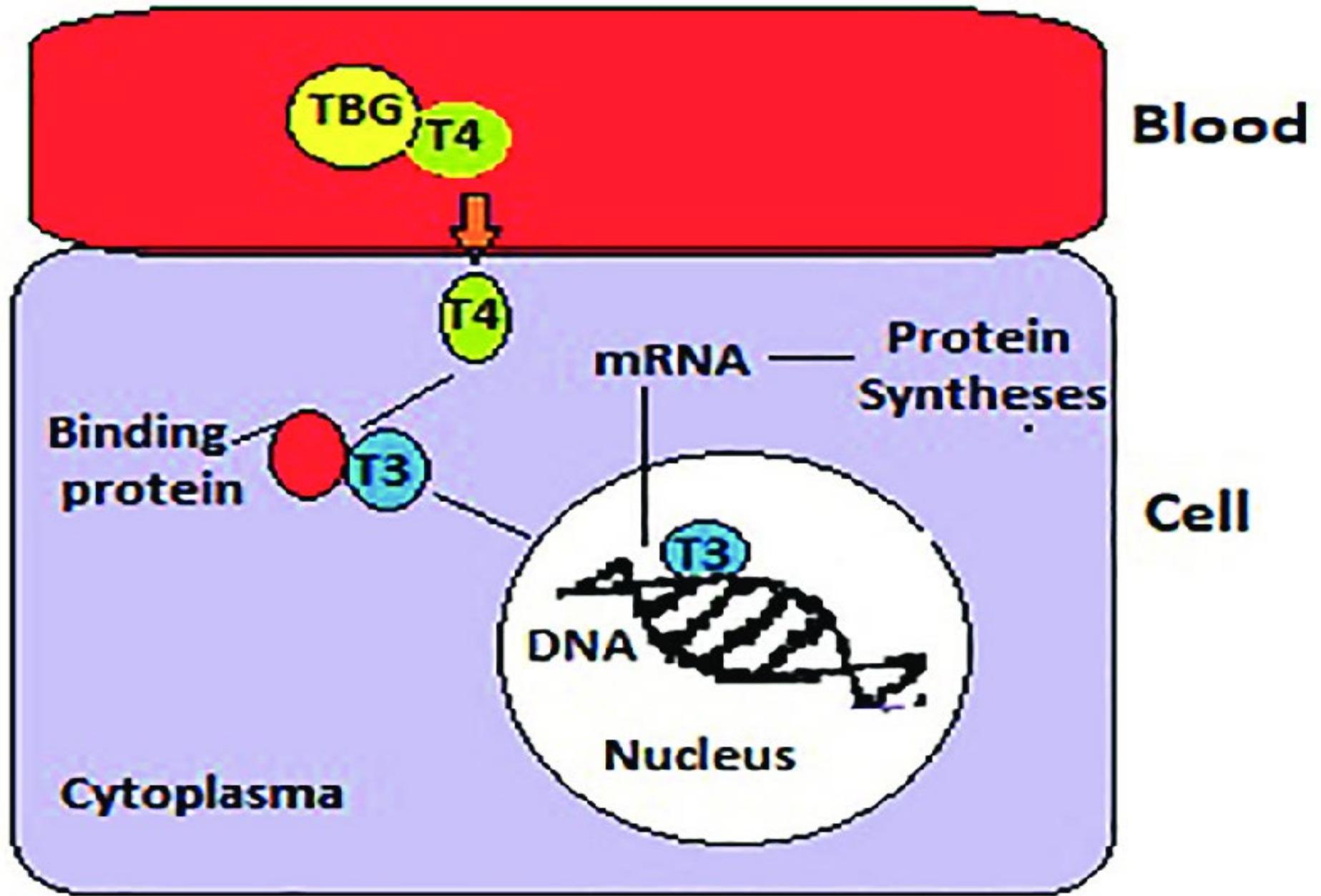
Transport of thyroid hormones



Mechanism of action of thyroid hormones

➤ Bind to specific nuclear receptors (*T₃ has more affinity to the receptor than T₄*) → hormone – receptors complex → interact with DNA → stimulating mRNA formation → stimulating synthesis of specific **proteins**.

➤ ↑ size and number of mitochondria.



Blood

Cell

Binding protein

T3

mRNA

Protein Syntheses

DNA

Nucleus

Cytoplasm

- ↑ amino acids transport across cell membrane → facilitate protein synthesis.
- ↑ activity and amount of membrane Na⁺ - K⁺ ATPase.
- ↑ intracellular enzymes.

Action (functions) of thyroid hormones



(A) On metabolism:

1- General metabolism:

- i) Stimulating O_2 consumption, glucose uptake by cells.
- ii) ↑ Basal metabolic rate (BMR).
- iii) ↑ Heat production.

2- Carbohydrate metabolism:

➤ In physiological concentrations:

- a) Potentiate the action of insulin
- b) Promote glycogenesis & glucose utilization.

➤ In pathological high concentrations: → hyperglycemia by:

- a) Stimulating gluconeogenesis.
- b) Potentiate glycogenolytic effect of epinephrine.
- c) Promote intestinal absorption of glucose.



3- Lipid metabolism:

- **↑** blood level of **free fatty acids** and **glycerol**.
- **↓** blood level of **triglycerides, cholesterol** and **phospholipids**.

4- Protein metabolism:

- **In physiological concentration:** **↑** protein anabolism.
- **In pathological concentration:** **↑** protein catabolism.



5- Vitamins and drugs:

- ↑ synthesis of **vitamin A** from carotenes in liver.
- Stimulating **utilization** and **clearance** of **vitamins**.
- Stimulating **clearance** of **drugs** as digitalis.



(B) On growth and development:

1- Mental growth: Important for:

- Growth, development & function of CNS during fetal life & 1st few years after birth.
- Myelination of nerve fibers & development of synapses.
- Its deficiency during fetal development → mental retardation (neurons are smaller and fewer).

2- Physical growth:

- Has a permissive effect on GH & potentiate the effect of somatomedins.
- Development of teeth.
- Closure of fontanelles.

3- Sexual growth:

- Essential for normal menstrual cycle & spermatogenesis (fertility).
- Stimulates milk secretion during lactation.

(C) On body systems and organs:

1- Cardiovascular system:

- ↑ heart rate.
- ↑ stroke volume.
- ↑ SBP.
- ↓ DBP due to VD of peripheral arterioles (as a result of accumulated metabolites).

2- On the respiratory system:

- ↑ respiratory rate.
- ↑ depth of breathing.
- ↑ pulmonary ventilation.

3- Gastro-intestinal tract:

- ↑ Glucose absorption from intestine.
- ↑ Appetite and GIT motility.

4- Gonads and other endocrine systems:

- Thyroid hormones are essential for *proper sexual functions.*
- ↑ sex hormone – binding globulin.
- ↓ clearance of testosterone and estrogen.
- ↑ clearance of glucocorticoids by liver → ↑ ACTH release from anterior pituitary.
- Hyper and hypothyroid states → **infertility** in males & females.



5- Hemopoietic system:

- Stimulate erythropoietin production → stimulating erythropoiesis.
- Stimulate *dissociation of O₂ from HB* by increasing formation of *2,3 diphosphoglycerate (2,3 DPG)*.

6- Skeletal muscles

- Normal skeletal muscle function.
- Muscle weakness occur in:
 - Hypothyroidism.
 - Hyperthyroidism (due to ↑ catabolism of muscle proteins).



References

1. Costanzo, Linda S. "BRS Physiology (Board Review Series)." (2018).
2. Ganong, William F. "Review of medical physiology." (2020).
3. Hall, John E and Hall, Micheal E. "Guyton and Hall Textbook of medical physiology." (2021).