

# Thyroid Gland

**Dr.K.ARULDOSS**

Assistant professor

Periyar Gout Arts College cuddalore

# Outline

- Location
- Structure
- Synthesis
- Mode of action
- Effects
- Regulation
- Disorders

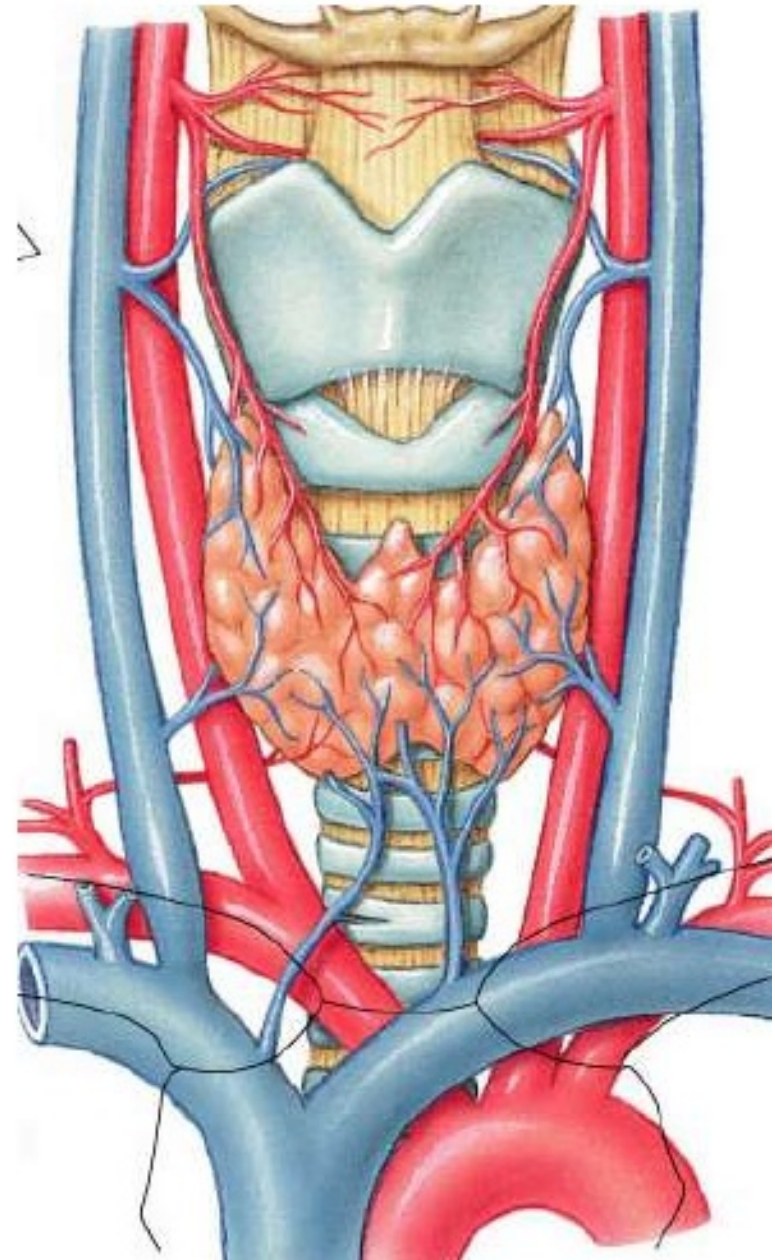
# Thyroid gland

- Largest gland in the body
- Location : in the neck inferior the larynx and spanning over the ventral surface of trachea
- Function:
  - Secretion of thyroxin and triiodothyronine
  - Secretion of calcitonin

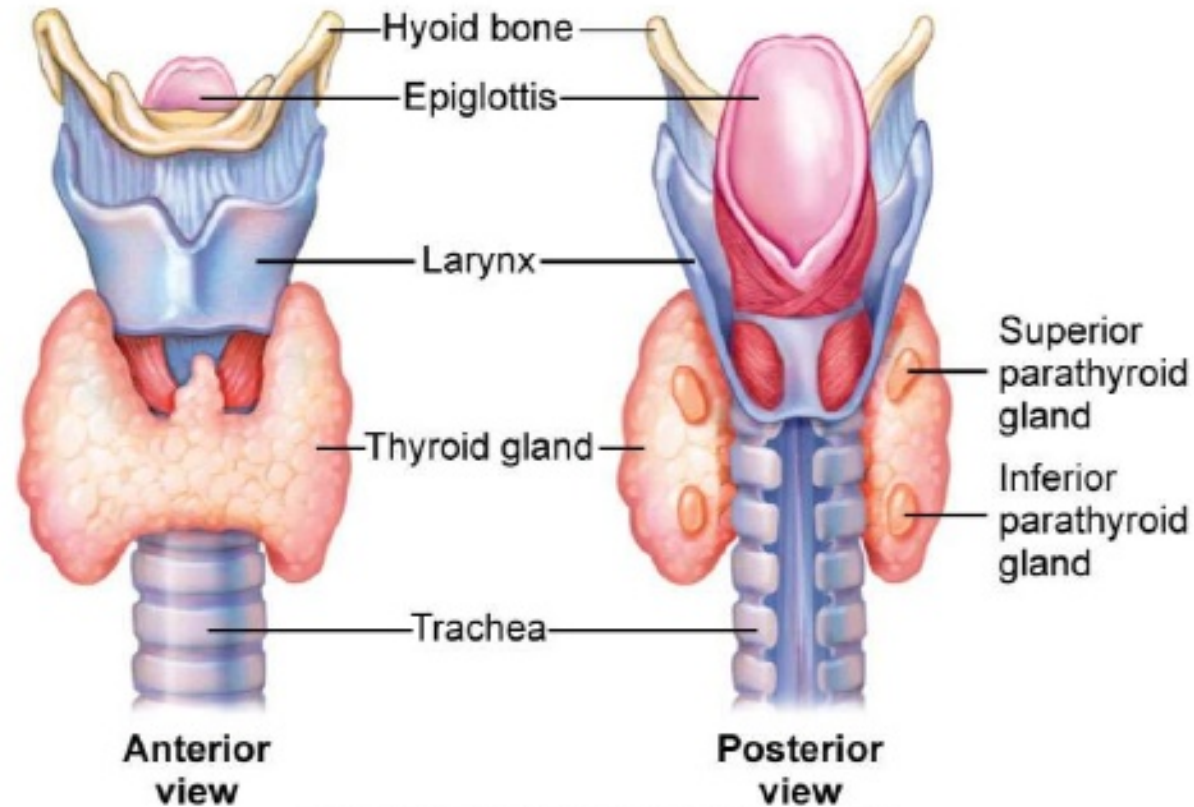
# Thyroid Gland

- Anterior surface of trachea just inferior of thyroid cartilage (or Adam's apple)
- Two lobes connected by isthmus
- Microscopic thyroid follicles produce thyroid hormone
- C Cells - produce calcitonin ( $\downarrow\text{Ca}^{2+}$ )

Fig 19-7



# Structures and Functions of Endocrine System

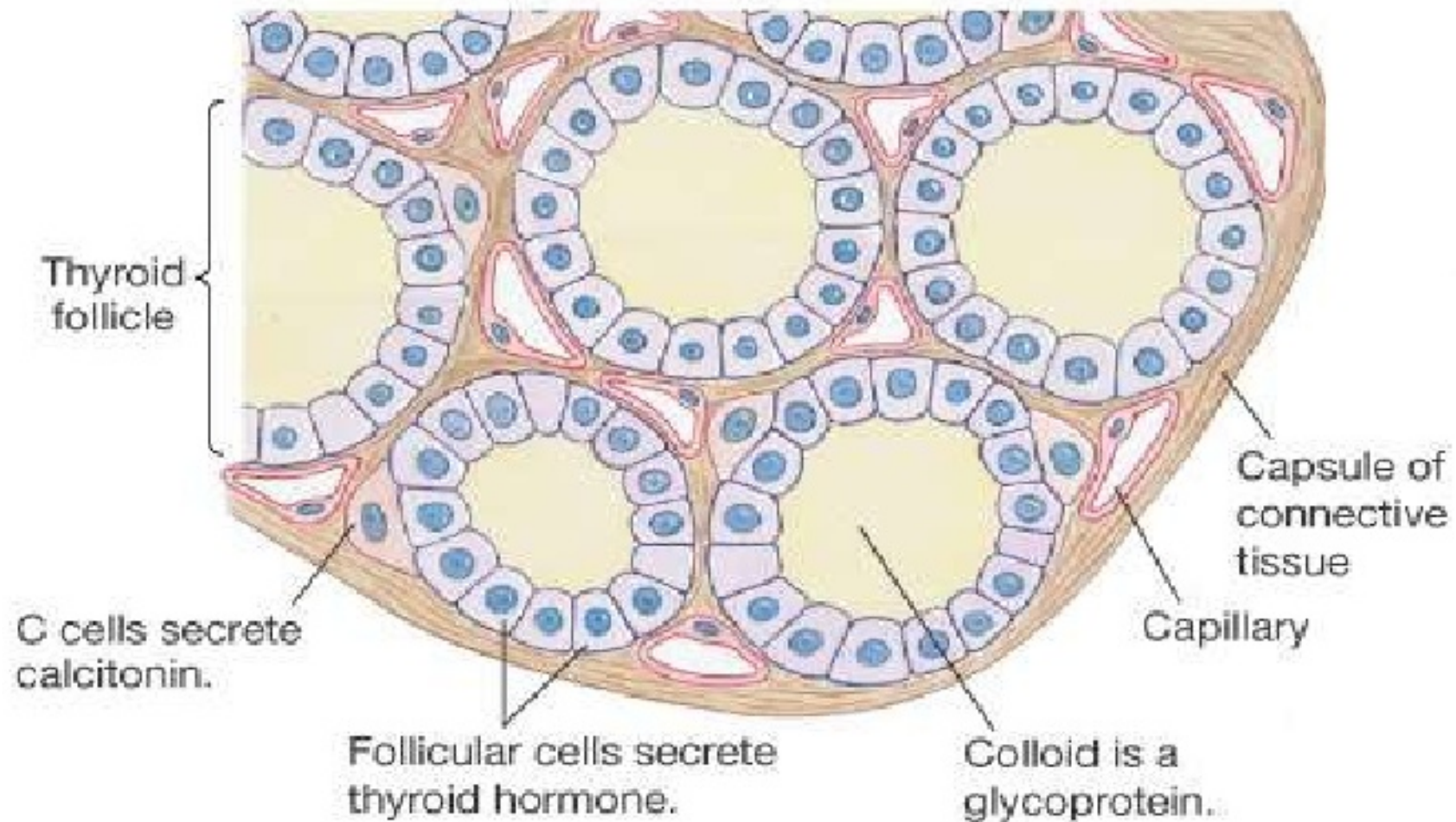


From Thiobodeau GA, Patton KT. The human body in health and disease, ed 4. St Louis, 2005. Mosby.

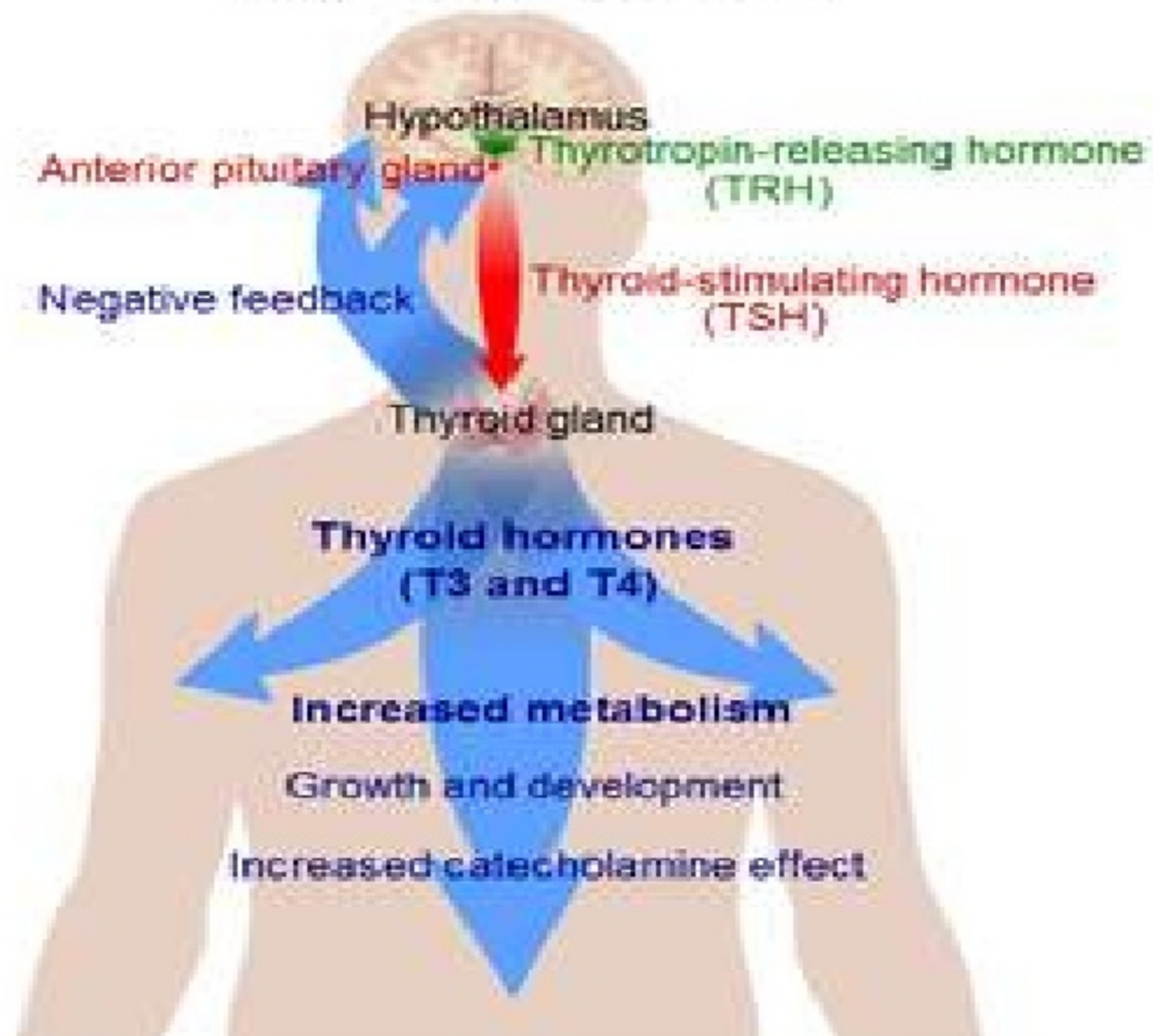
Fig. 48-10. Thyroid and parathyroid glands. Note the surrounding structures.

# Thyroid Gland: Hormones and Iodine Metabolism

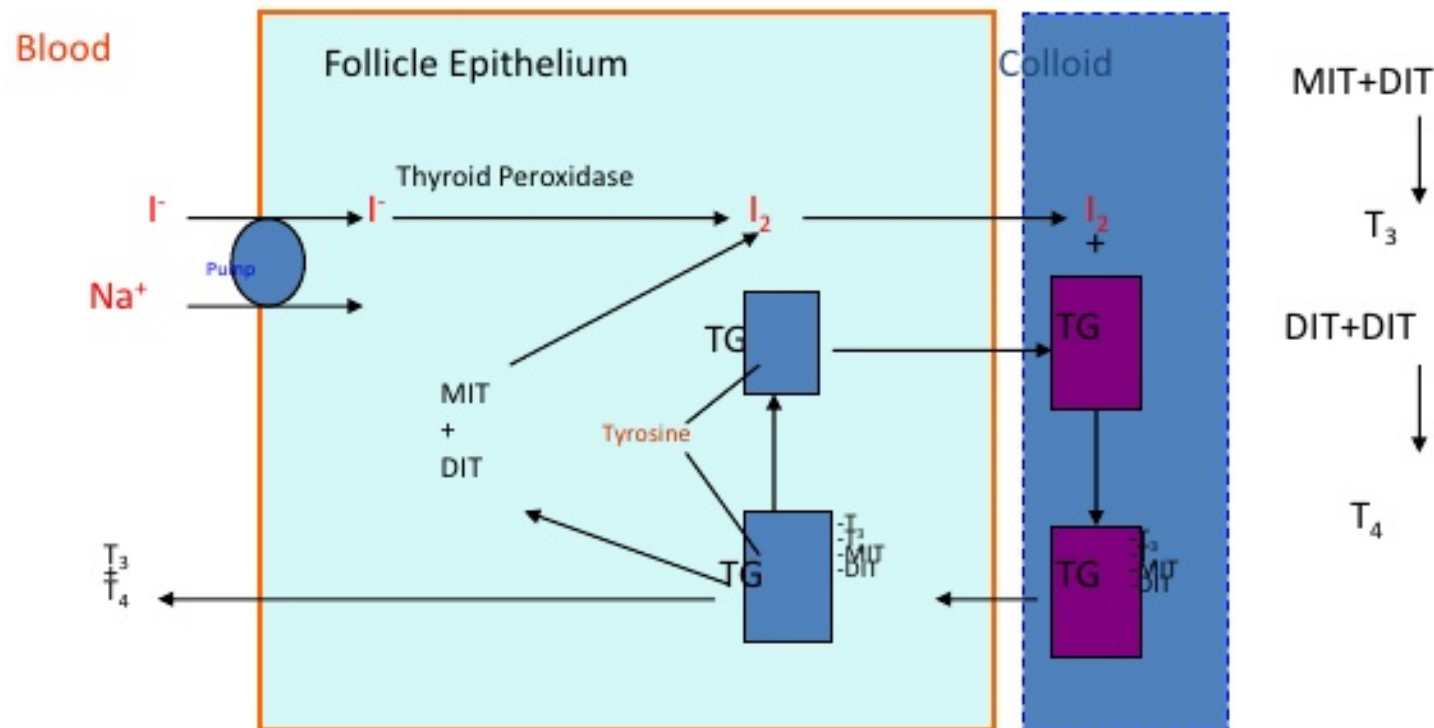
(b) Section of thyroid gland



# Thyroid system



# Synthesis of Thyroid Hormone

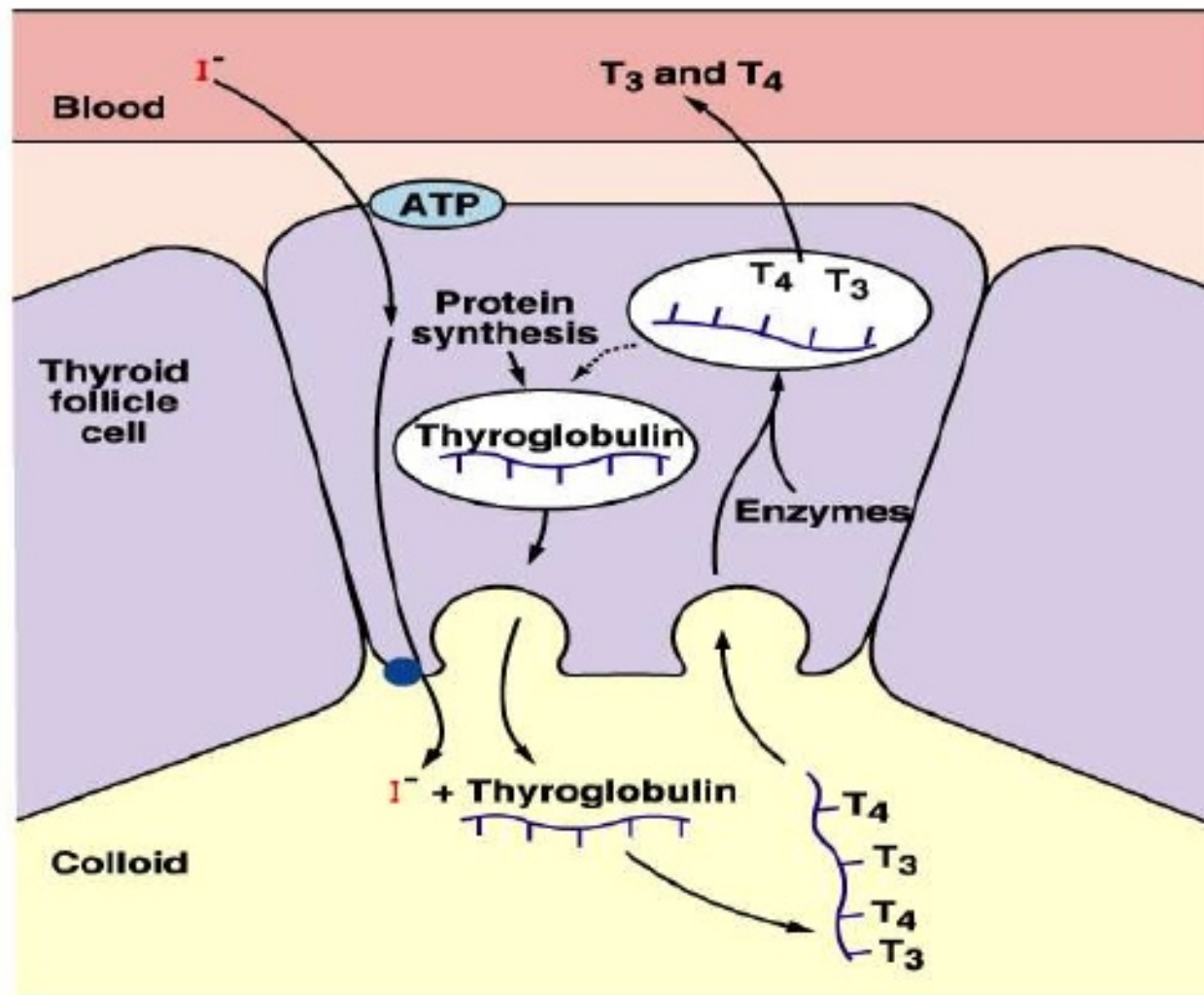


Thyroid hormone synthesis and secretion involves processes that occur within follicular epithelial cells and in colloid.

$I^-$ : iodide ions;  $I_2$ : iodine; TG: thyroglobulin; MIT: monoiodotyrosine; DIT: diiodotyrosine.



# Releases of Thyroid Hormone



# Synthesis of thyroid hormones

## 1. Iodide trapping

- By sodium iodide symporter
- Blocked by:
  - Thiocyanate  $\text{SCN}^-$
  - Perchlorate  $\text{ClO}_4^-$
  - Pertechnetate  $\text{TcO}_4^-$

## 2. Oxidation of iodide

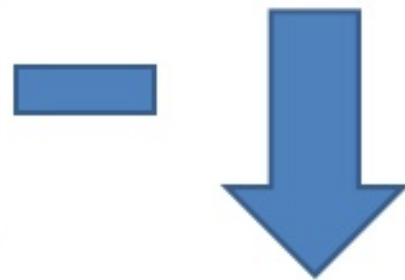
- By thyroid peroxidase
- Inhibited by:
  1. large intake of iodide  $>150\text{mcg/day}$
  2. Thioamides (refer to hyperthyroidism therapy)

# Synthesis of thyroid hormones

## 3. Organification

- Tyrosine residues of thyroglobulin is iodinated

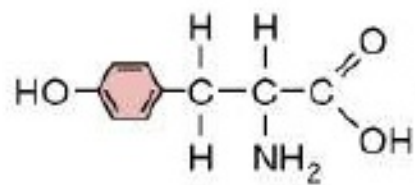
1. Inhibited by large intake of iodide >150mcg/day
2. Thioamides (refer to hyperthyroidism therapy)



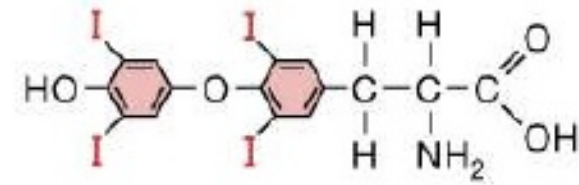
- Produce monoiodotyrosine residues MITnd diiodotyrosine residues DIT

# Thyroxine and its precursors: Structure & Synthesis

**Tyrosine**

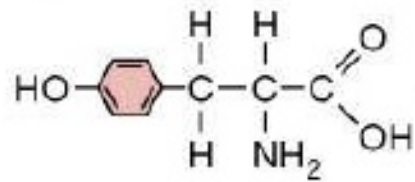


**Thyroxine (T<sub>4</sub>)**

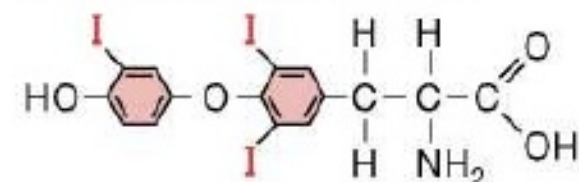


(2 tyrosine + 4 I)

**Tyrosine**



**Triiodothyronine (T<sub>3</sub>)**

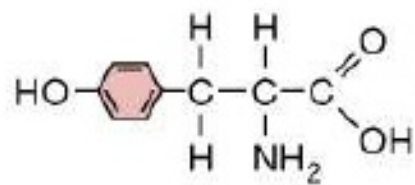


(2 tyrosine + 3 I)

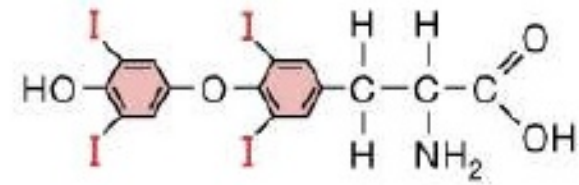
Figure 1-1: Thyroid hormones are made from tyrosine and iodine

# Thyroxine and its precursors: Structure & Synthesis

**Tyrosine**

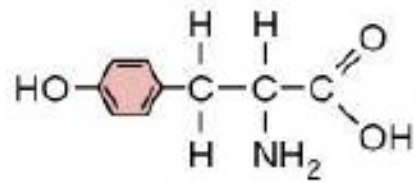


**Thyroxine (T<sub>4</sub>)**

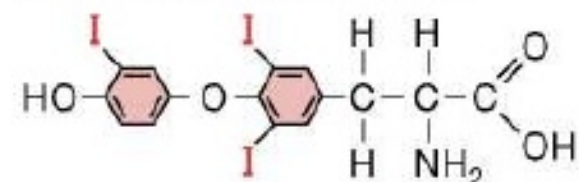


(2 tyrosine + 4 I)

**Tyrosine**



**Triiodothyronine (T<sub>3</sub>)**



(2 tyrosine + 3 I)

Figure 1-1: Thyroid hormones are made from tyrosine and iodine

# Production Of Thyroid Hormones



Dietary iodide ( $I^-$ ; atomic wt. 127)

A. Rapid absorption

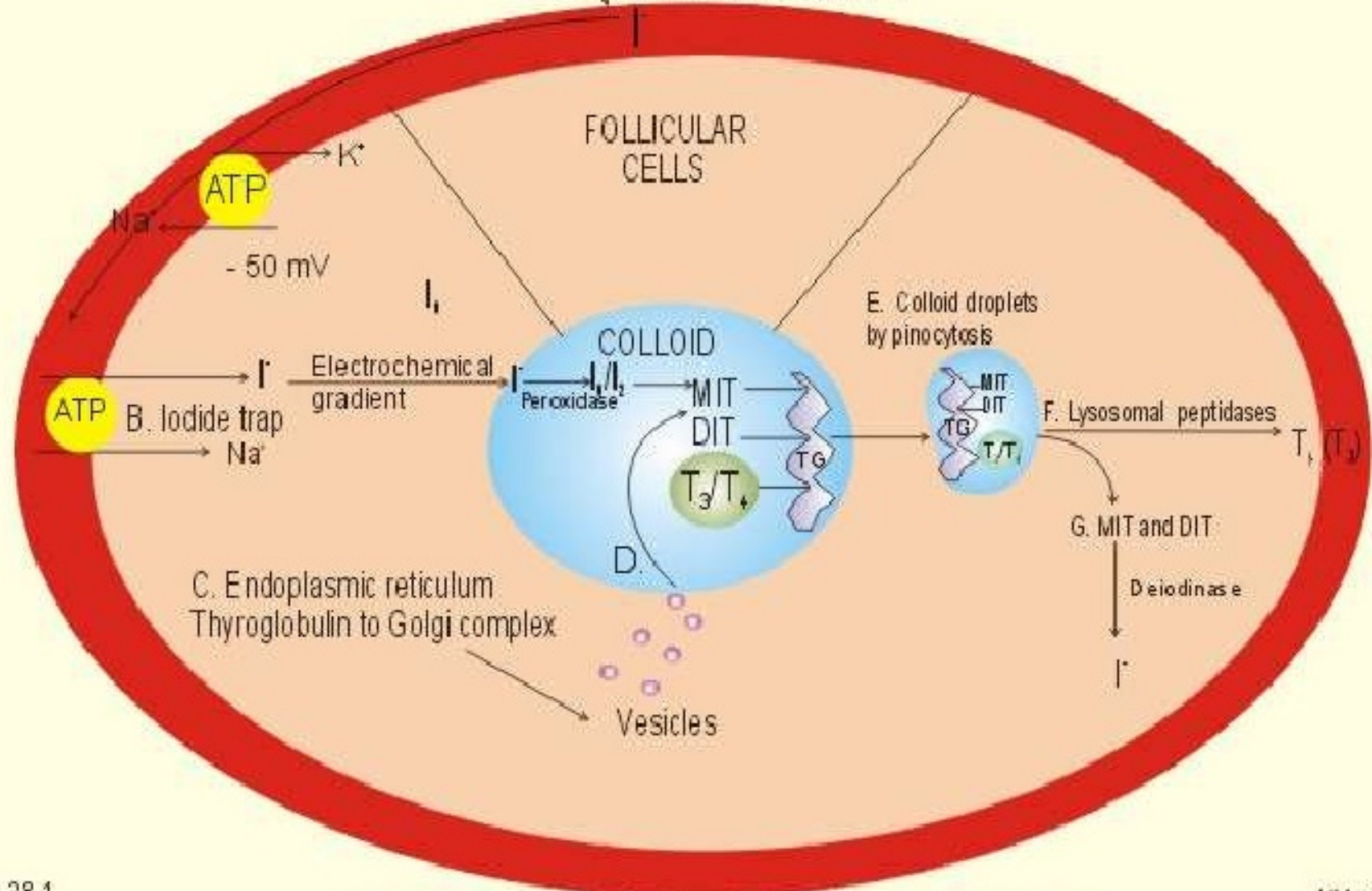


Fig. 28-1

**H. TSH stimulates thyroid hormone synthesis and secretion**

KMc

# Synthesis of thyroid hormones

## 4. Coupling

- $DIT+MIT=T3$
- $DIT+MIT=T4$

## 5. Storage :

- Along with thyroglobulin

## 6. Exocytosis and proteolysis

- Release of T4 & T3

## 7. Conversion of T4 to T3 in peripheral tissue

# Synthesis of thyroid hormones

## 4. Coupling

- $DIT+MIT=T3$
- $DIT+MIT=T4$

## 5. Storage :

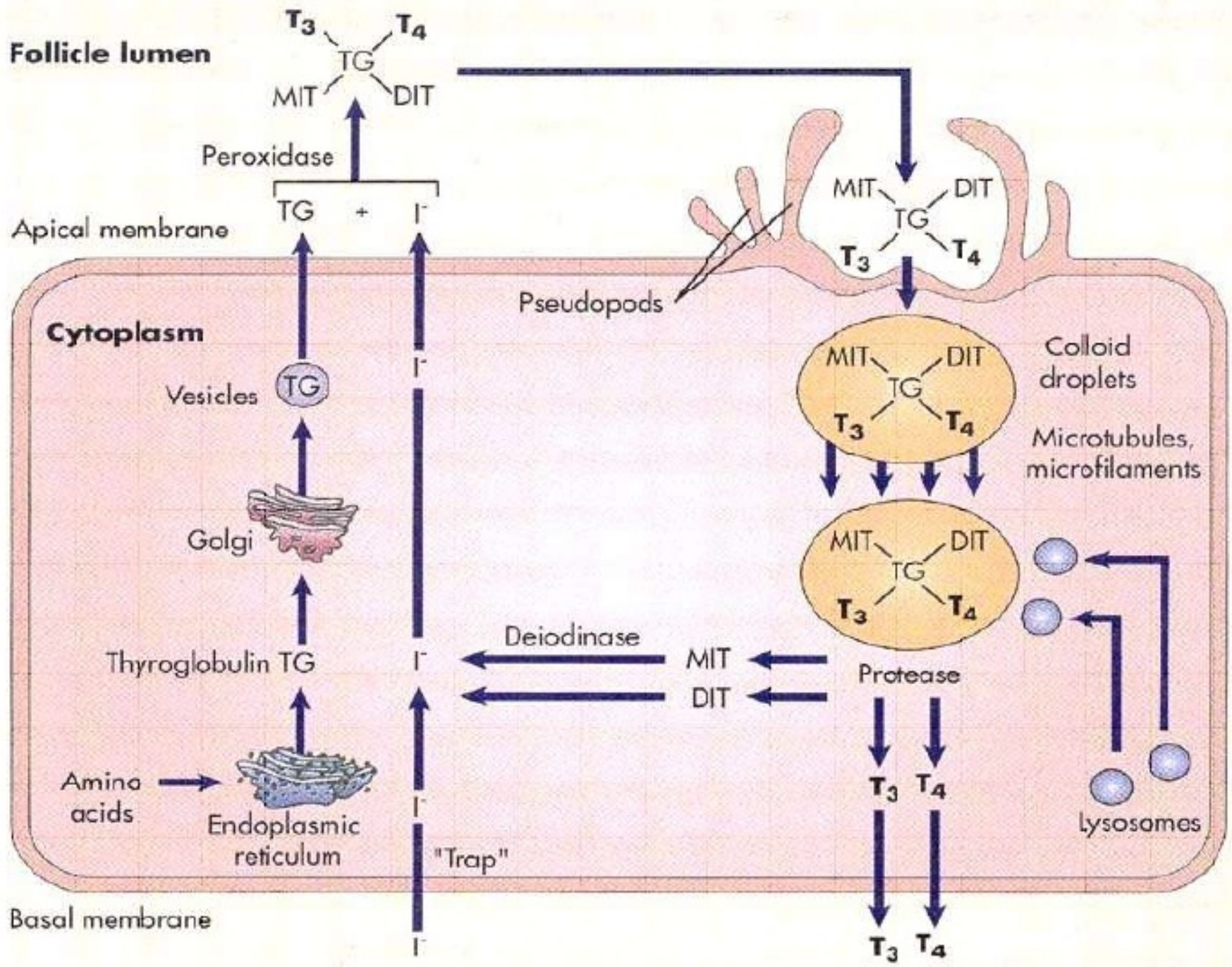
- Along with thyroglobulin

## 6. Exocytosis and proteolysis

- Release of T4 & T3

## 7. Conversion of T4 to T3 in peripheral tissue





## Drugs that inhibit 5'deiodenase

- Steroids
- Amiodarone
- Beta blockers
- Thioamides

# T4 vs T3

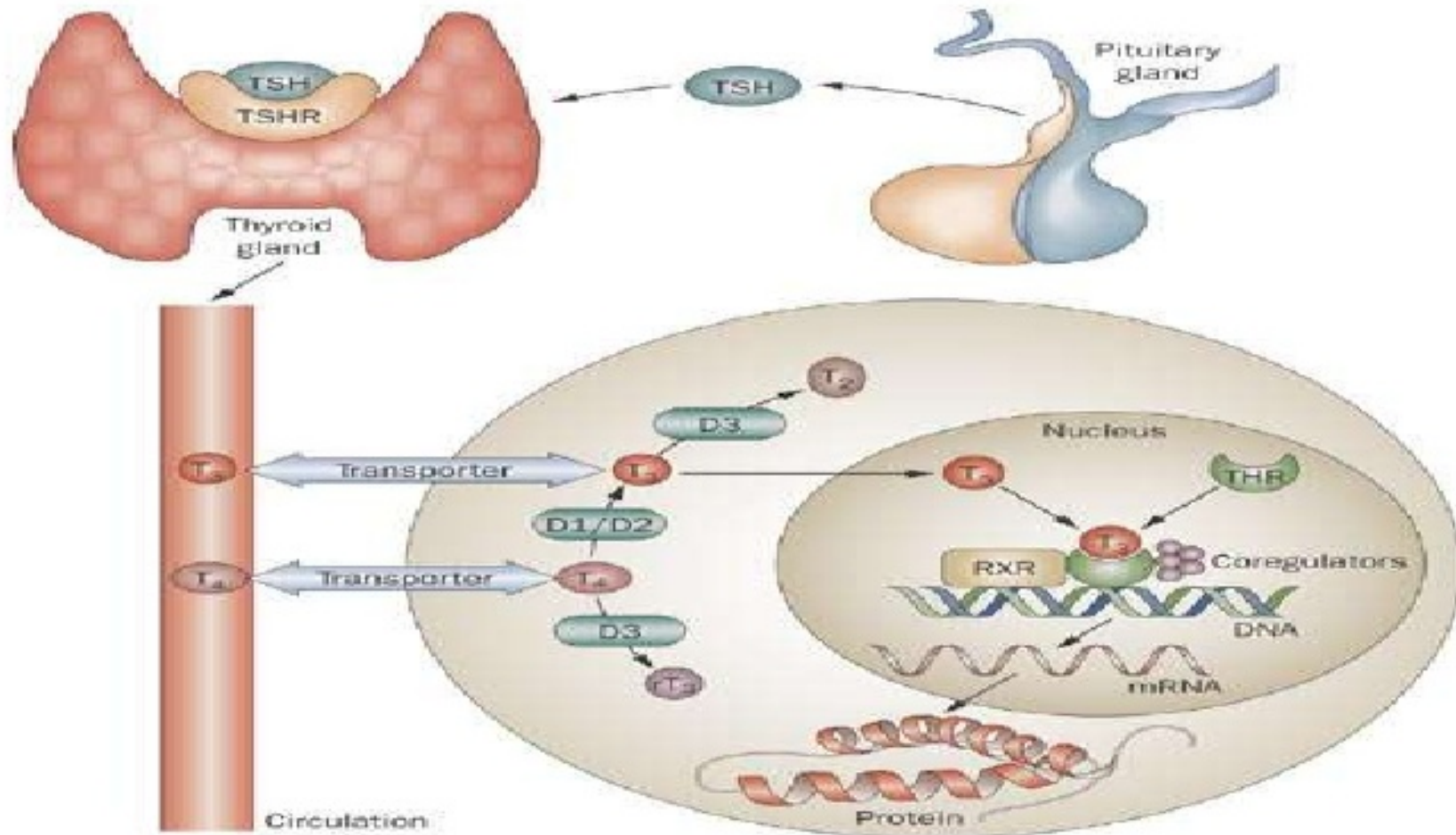
## T4

- Thyroid gland synthesizes 90%
- 0.04% free
- Not active
- Long T<sub>1/2</sub>

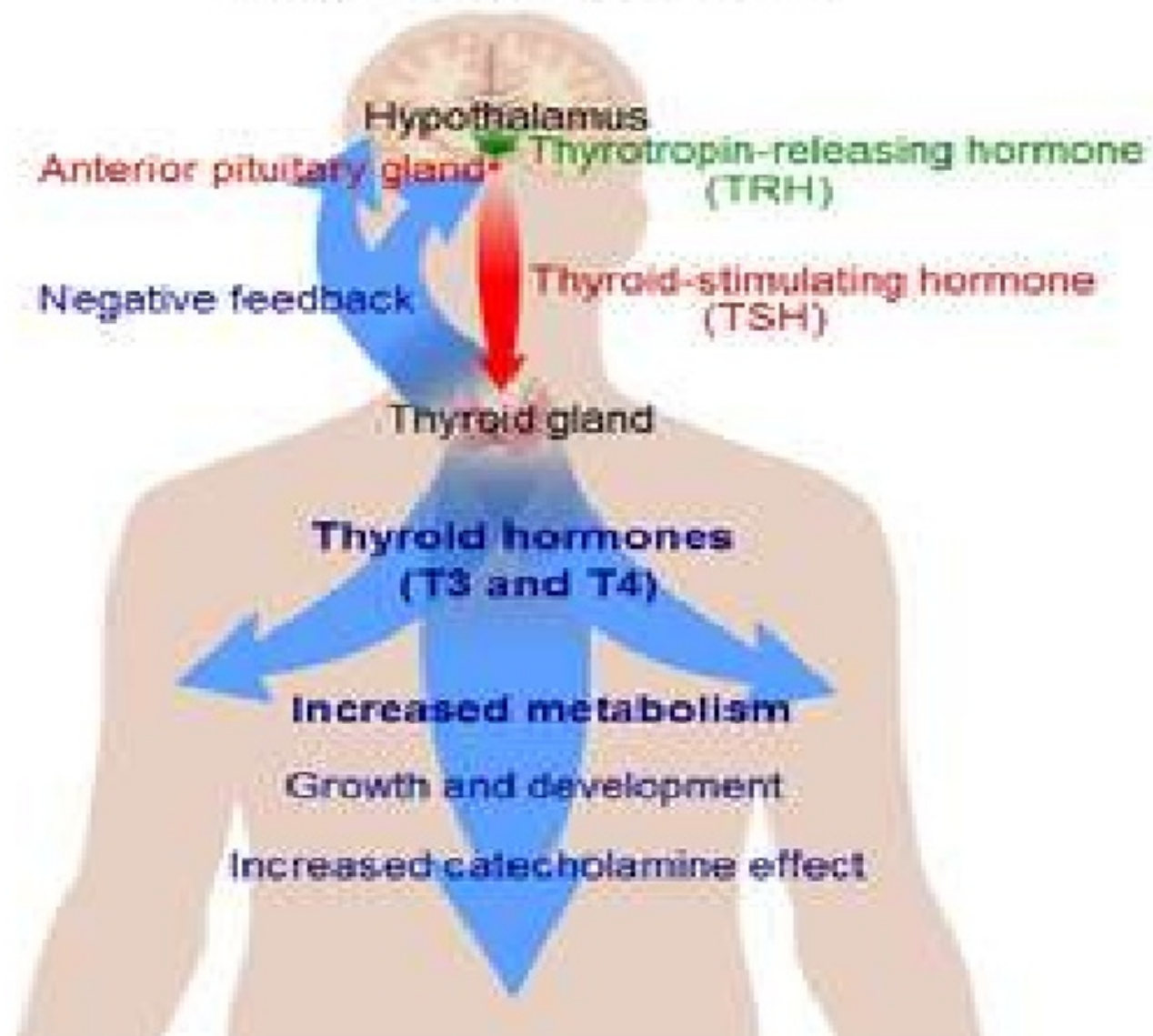
## T3

- Thyroid gland synthesizes 9%
- 0.4% free
- active

# Mechanism of action of thyroid hormones



# Thyroid system



# Thyroid Gland

- Thyroid hormones target almost every body cell
- Can enter cells & bind to intracellular receptors on mitochondria & in nucleus
- Effects include:
  - increased ATP production
  - increased cellular metabolism, energy utilization & oxygen consumption
  - increased body temperature
  - growth & development of skeletal, muscular & nervous system in fetus & children

## Effects Of Thyroid Hormones On The Cardiovascular System

- Increase heart rate
- Increase force of cardiac contractions
- Increase stroke volume
- Increase Cardiac output
- Up-regulate catecholamine receptors

# Effects Of The Thyroid Hormones On The Renal System

- Increase blood flow
- Increase glomerular filtration rate



# Effects Of The Thyroid Hormones On Oxygen Carrying Capacity

- Increase RBC mass
- Increase oxygen dissociation from hemoglobin

## Thyroid Hormone Actions Which Increase Oxygen Consumption

- Increase mitochondrial Size, Number and Key Enzymes
- Increase Plasma membrane Na-K ATPase Activity
- Increase Futile Thermogenic Energy Cycles
- Decrease Superoxide Dimutase Activity

## Effects Of The Thyroid Hormones On Intermediary Metabolism

- Increase glucose absorption from the GI tract
- Increase carbohydrate, lipid and protein turnover
- Down-regulate insulin receptors
- Increase substrate availability

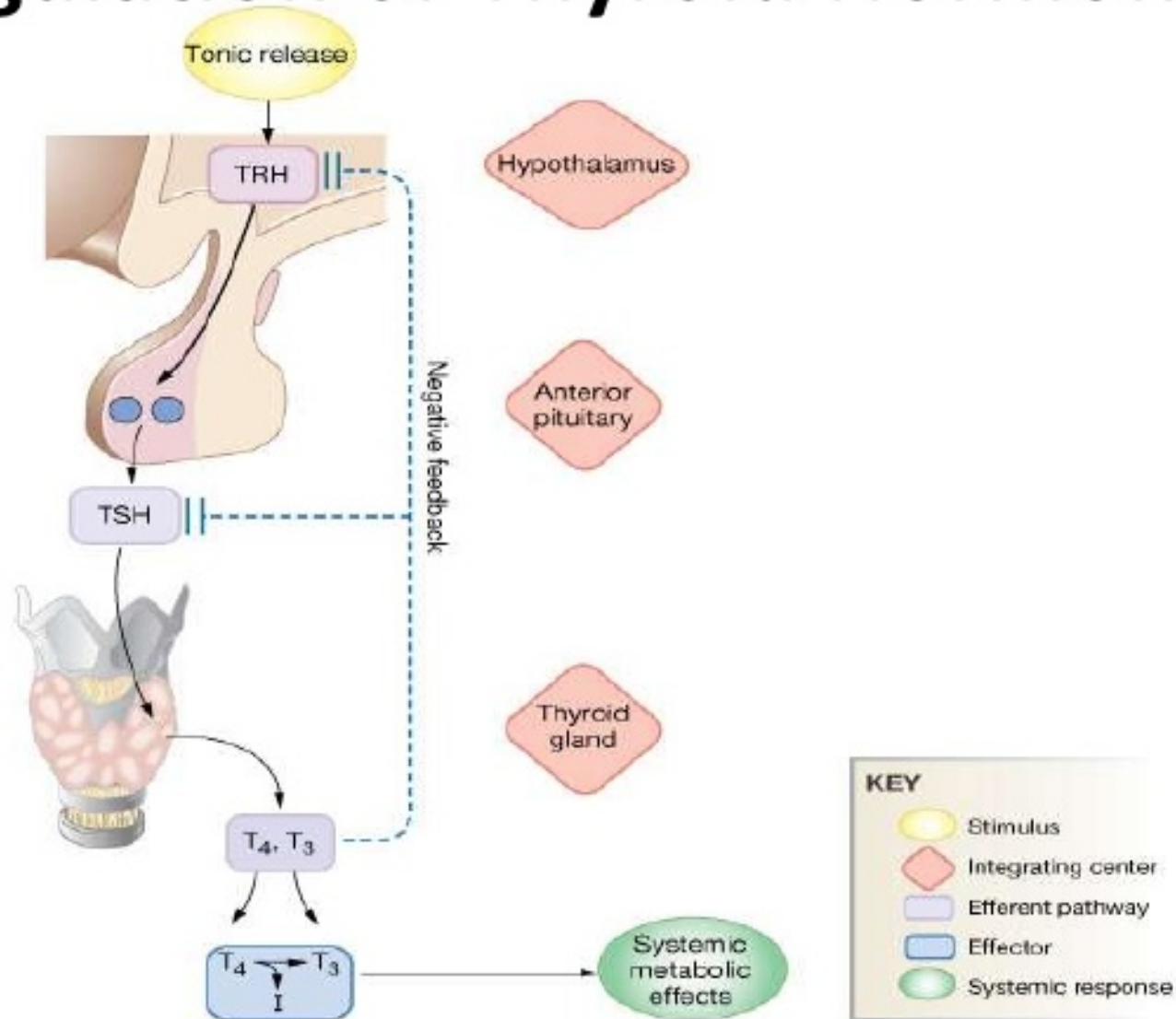
# Effects Of The Thyroid Hormones In Growth And Tissue Development

- Increase growth and maturation of bone
- Increase tooth development and eruption
- Increase growth and maturation of epidermis, hair follicles and nails
- Increase rate and force of skeletal muscle contraction
- Inhibits synthesis and increases degradation of mucopolysaccharides in subcutaneous tissue

# Effects Of The Thyroid Hormones On The Reproductive System

- Required for normal follicular development and ovulation in the female
- Required for the normal maintenance of pregnancy
- Required for normal spermatogenesis in the male

# Regulation of Thyroid Hormones





Goiter

## Thyroid Gland Function

- Thyroxin (T4) and triiodothyronine (T3) → speed up metabolic rate
- Calcitonin → lowers blood  $\text{Ca}^{2+}$  levels
- Thyroid pathologies:  
Hyper- and Hypothyroidism



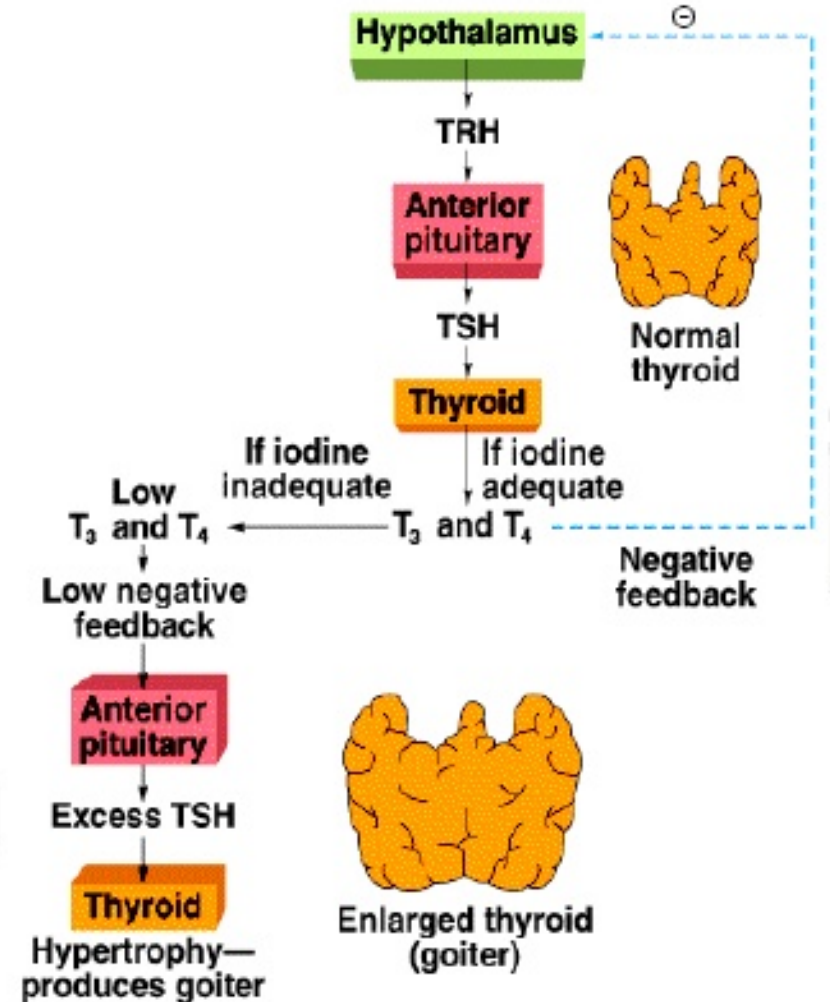
Exophthalmus



# Goiter Formation

- Lack of iodine
- Interferes with negative feedback control of TSH
- Results in abnormal enlargement of the thyroid gland

Copyright © The McGraw-Hill Companies, Inc. Permission required for reproduction or display.





# Hyperthyroidism

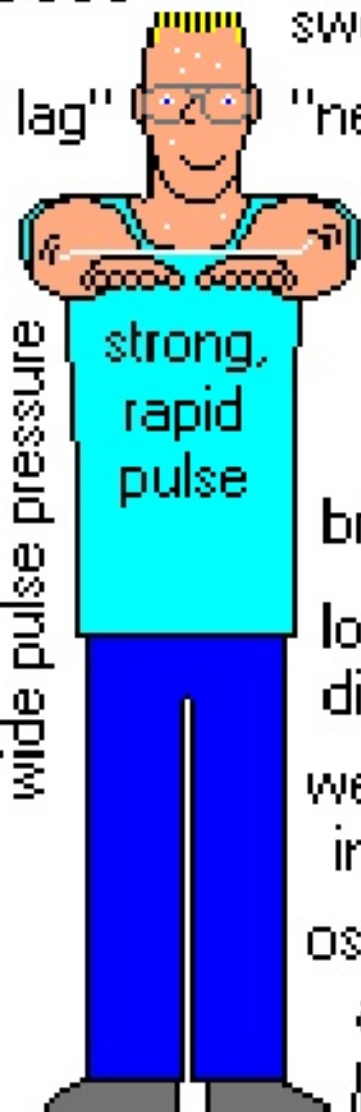


Illustration of a man with hyperthyroidism symptoms. He is wearing a blue tank top and blue pants. He has a wide pulse pressure, strong, rapid pulse, and fine tremor (paper test). He is sweating and has "neurotic anxiety". He has a "lag" in his reflexes. He has brisk reflexes, low LDL, diarrhea, weight loss despite increased appetite, osteoporosis??, and atrial fibrillation. A dashed line indicates a high level of sweating.

sweating

"neurotic anxiety"

Fine tremor (paper test)

strong, rapid pulse

brisk reflexes

low LDL

diarrhea

weight loss despite increased appetite

osteoporosis??

atrial fibrillation

wide pulse pressure

"lag"

# Hypothyroidism

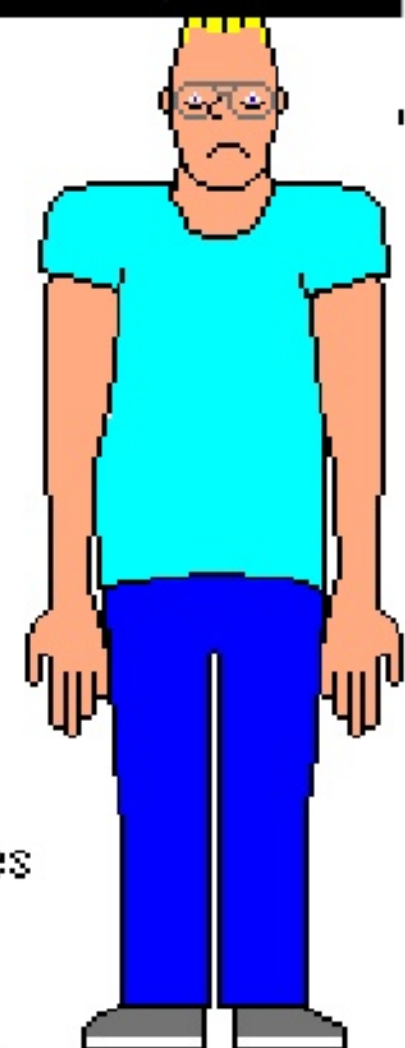


Illustration of a man with hypothyroidism symptoms. He is wearing a blue t-shirt and blue pants. He has a "slowing of mind and body", hair thinning, depression, "schizophrenia", irritability, big tongue, croaky voice, dry skin, cold skin, and cold intolerance. A black box indicates a "slowing of mind and body".

slowing of mind and body

hair thinning

depression

"schizophrenia"

irritability

big tongue

croaky voice

dry skin

cold skin

cold intolerance

# Disease of thyroid gland

## Hypothyroidism

- Hashimoto thyroiditis (autoimmune disorder)
- Iodine deficiency
- Drugs (amiodarone)
- Radiation exposure
- Pituitary tumors
- Myxedema (life threatening condition of hypothyroidism)

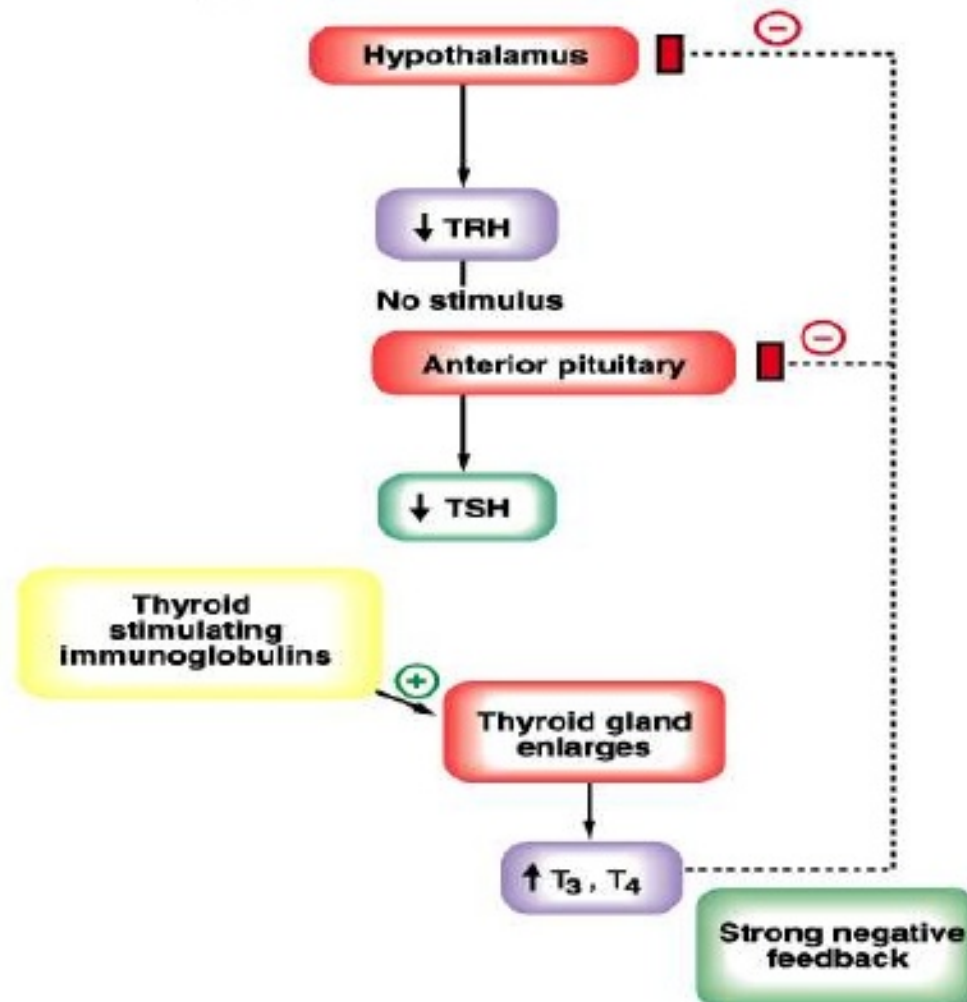
## Hyperthyroidism

- Graves disease (autoimmune disease)
- Toxic multinodular goiter
- Drugs (amiodarone)
- Thyroid storm (life threatening condition of hyperthyroidism)

# 6. Clinic connection

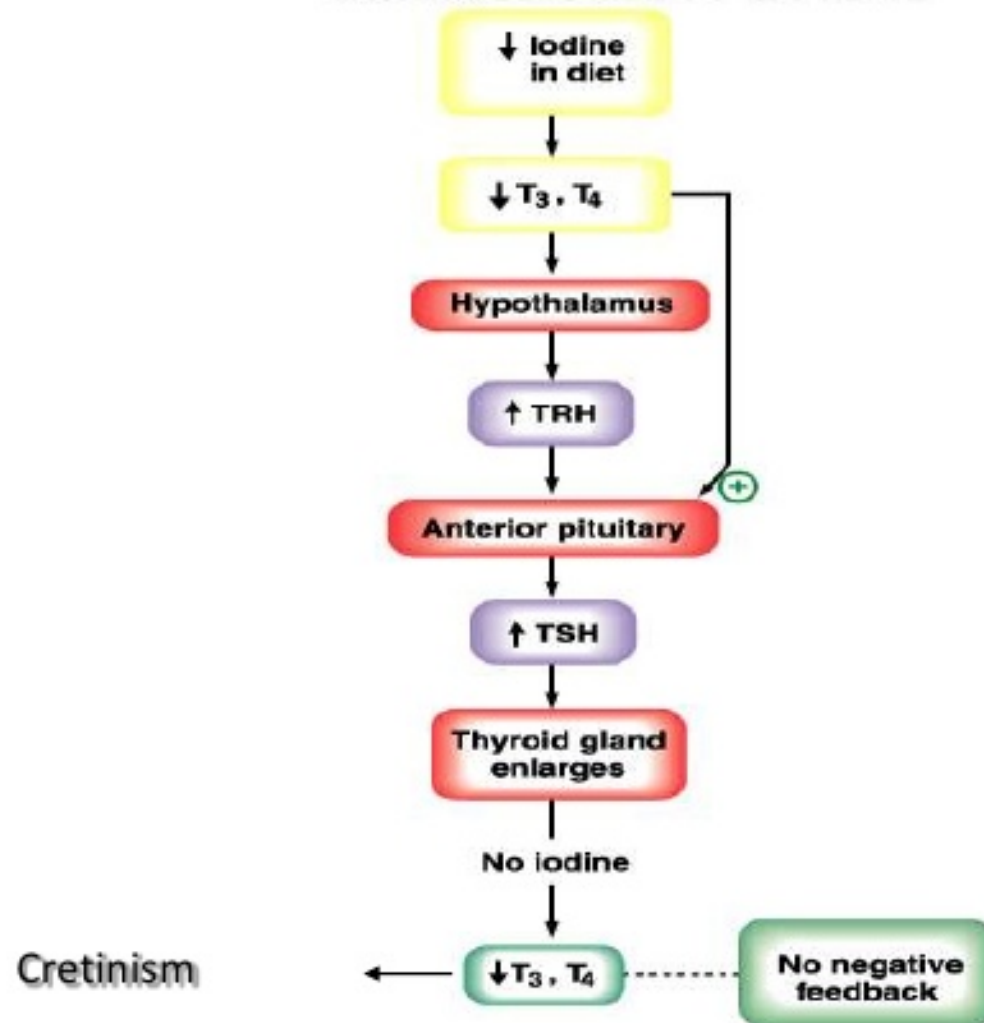
## Hyperthyroidism

Hyperthyroidism due to Graves' disease



# Hypothyroidism

Hypothyroidism due to low iodine



# Apply Your Knowledge



True or False:

ANSWER:

T Thyroid hormones stimulate protein synthesis.

F The thyroid gland ~~does not store hormones.~~

Thyroid follicles store some hormones.

F PTH activates ~~osteoblasts.~~

PTH activates osteoclasts.

F Calcitonin increases cellular energy production.

Thyroid hormone increases cellular energy production.

T The four parathyroid glands are located on the thyroid gland.

T Calcitonin lowers blood calcium levels.

**Bravo!**