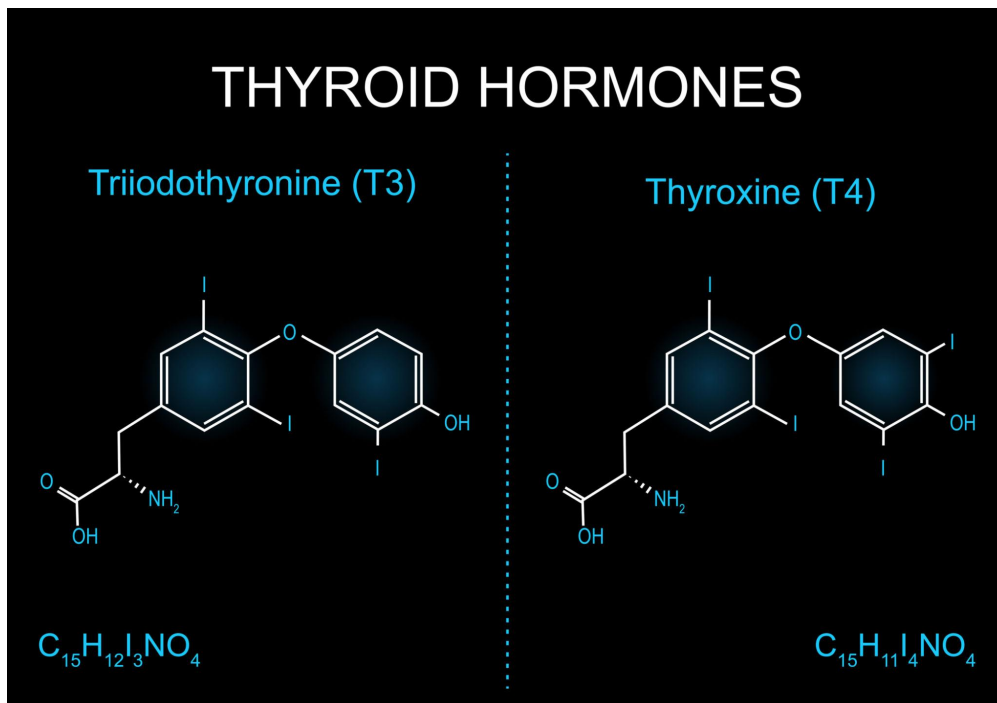


Thyroid Hormones

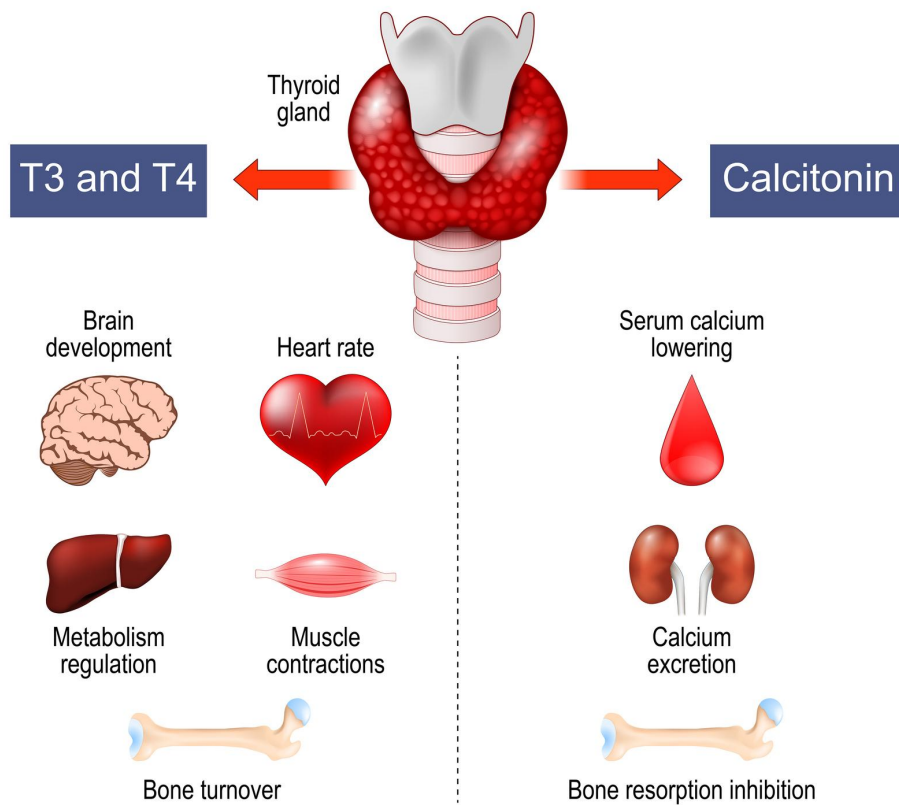
Thyroid Hormones

Thyroid Hormones (T₃ and T₄)



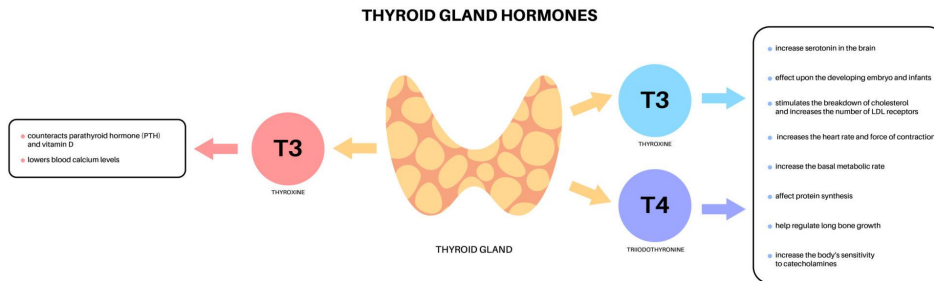
<https://www.researchgate.net/publication/372684807/figure/fig2/AS%3A11431281245830942%401716241944362/A-thyroid-follicular-cell>

THYROID GLAND HORMONES

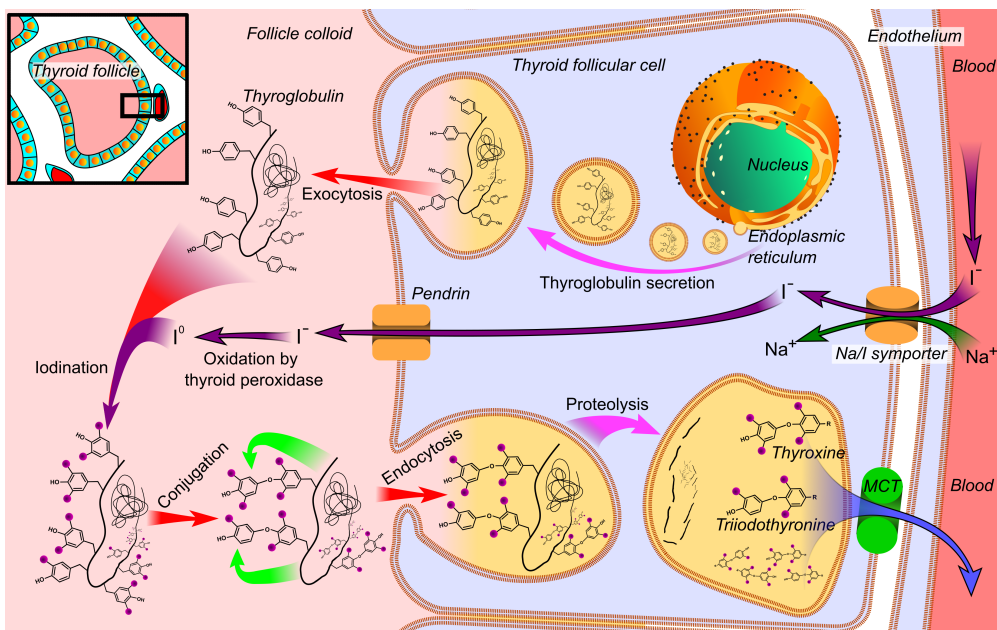


- Thyroid hormones are **iodinated derivatives of tyrosine**.
- Two major hormones:
 - **Thyroxine (T₄)** – major secretory product
 - **Triiodothyronine (T₃)** – more biologically active
- Synthesized and stored in the **thyroid follicles**.
- Bound to plasma proteins in circulation:
 - Thyroxine-binding globulin (TBG)
- Free hormone is **biologically active**.

Synthesis of Thyroid Hormones



<https://www.researchgate.net/profile/Bertrand-Nyuykonge/publication/320054797/figure/fig7/AS%3A642053302140929%4015300888443>



- Occurs in **thyroid follicular cells** and colloid.
- Requires **iodine**.

Steps of synthesis:

1. Iodide trapping

- Active transport of iodide into follicular cell.

2. Oxidation of iodide

- Iodide → iodine by **thyroid peroxidase**.

3. Organification

- Iodine binds tyrosine residues of thyroglobulin.
- Forms MIT and DIT.

4. Coupling reaction

- MIT + DIT → T₂
- DIT + DIT → T₄

5. Storage

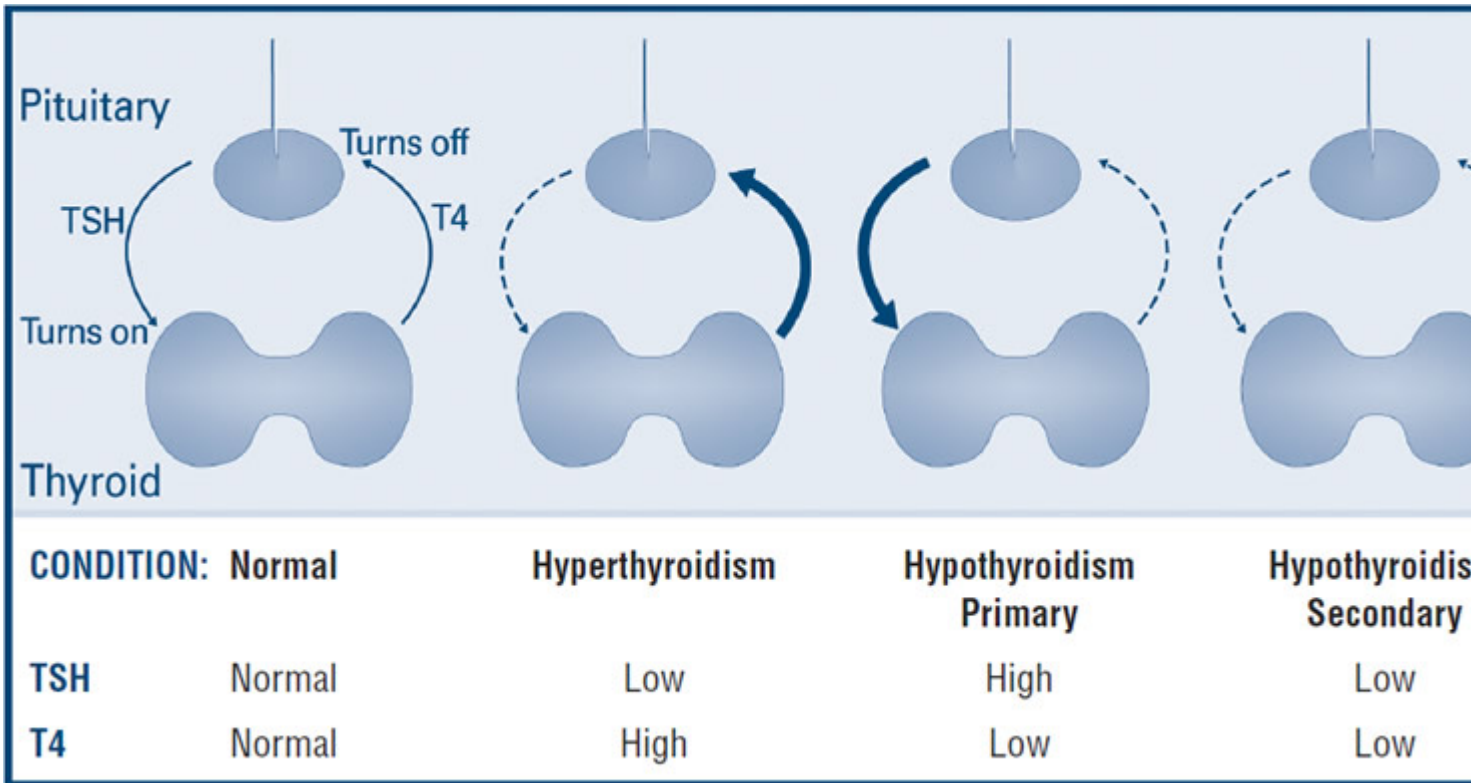
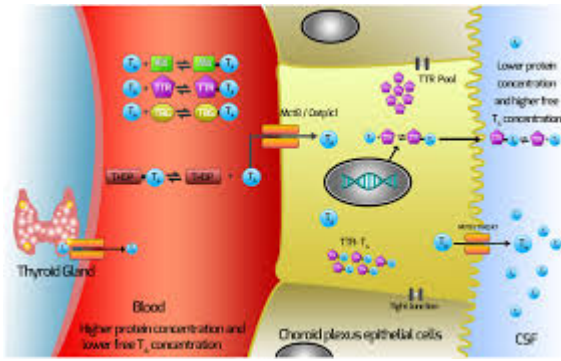
- Hormones stored in colloid as thyroglobulin.

6. Release

- Proteolysis releases T₂ and T₄ into blood.

- TSH stimulates all steps.

Secretion and Transport

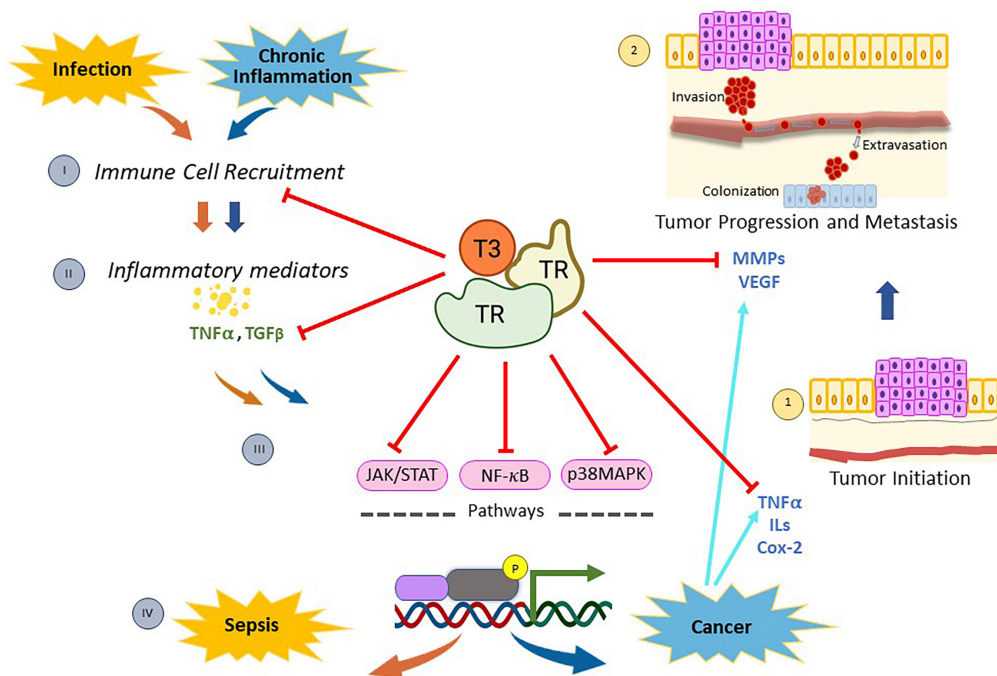


<https://www.researchgate.net/publication/372399748/figure/fig1/AS%3A11431281174991735%401689510741716/Regulation-of-thyroid-h>

- T₄ is secreted in greater quantity than T₃.
- In peripheral tissues:
 - T₄ → T₃ by 5 α -deiodinase.
- Transported bound to:

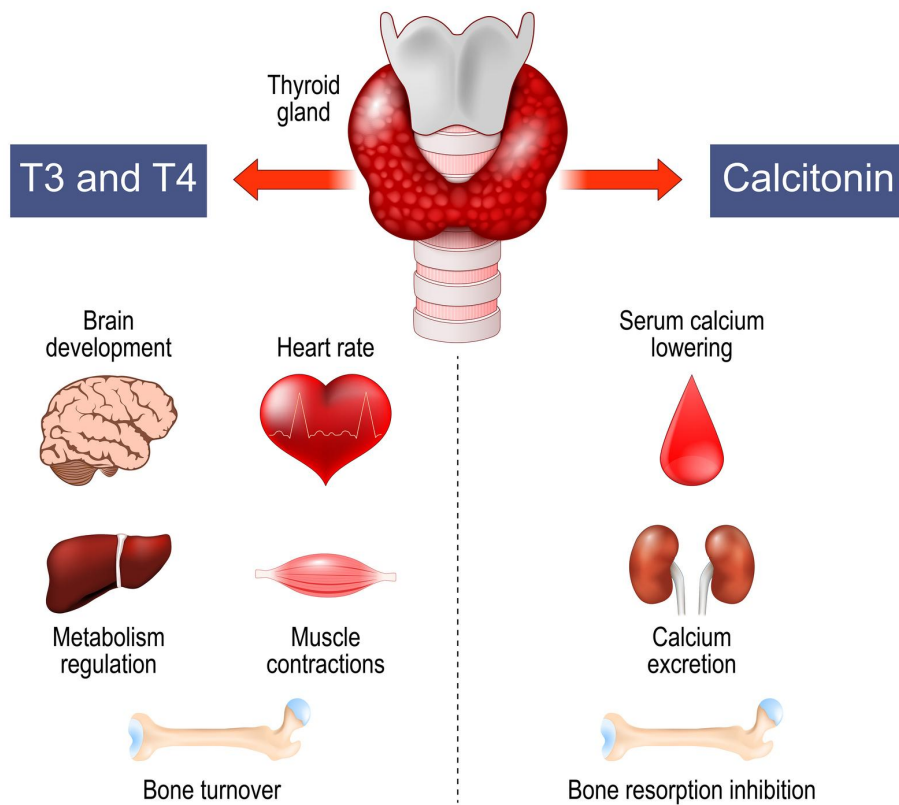
- TBG
 - Albumin
 - Transthyretin
- Only **free T₄ and T₃** are biologically active.

Mechanism of Action



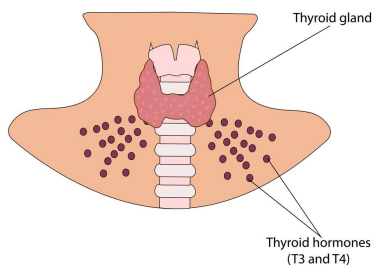
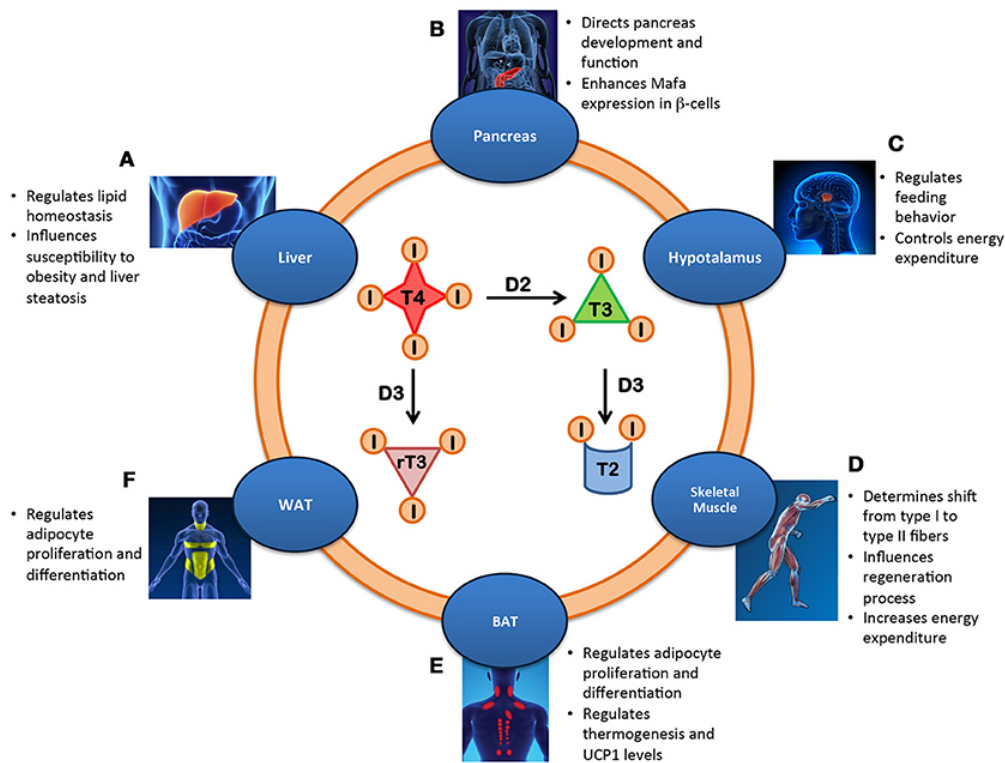
<https://www.researchgate.net/publication/362553411/figure/fig1/AS%3A11431281258732724%401720127162840/Mechanisms-of-action-c>

THYROID GLAND HORMONES

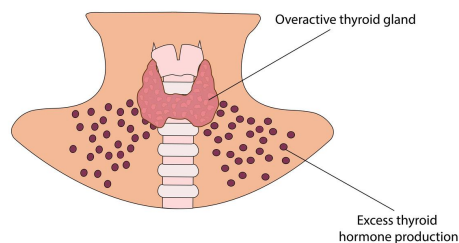


- Thyroid hormones are **lipophilic**.
- Enter cells by diffusion.
- T₄ converted to T₃ inside cell.
- T₃ binds to **nuclear thyroid hormone receptor**.
- Hormone-receptor complex binds DNA at **thyroid response elements**.
- Alters **gene transcription and protein synthesis**.
- Action is **slow in onset but long-lasting**.

Metabolic Effects of Thyroid Hormones



Normal Thyroid



Hyperthyroidism

<https://www.researchgate.net/publication/326785252/figure/fig4/AS%3A962715828903944%401606540748178/Effects-of-thyroid-hormon>

Thyroid hormones increase **basal metabolic rate (BMR)**.

Carbohydrate metabolism

- ? Glucose absorption
- ? Glycolysis
- ? Gluconeogenesis

Lipid metabolism

- ? Lipolysis
- ? Serum cholesterol
- ? Fatty acid oxidation

Protein metabolism

- Physiological levels ? ? protein synthesis
- Excess ? protein catabolism

Calorigenic effect

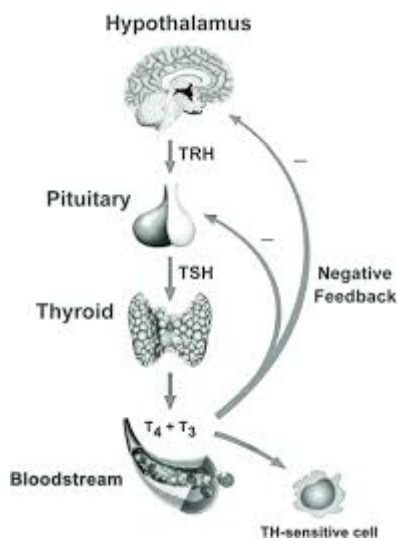
- ? Oxygen consumption
- ? Heat production

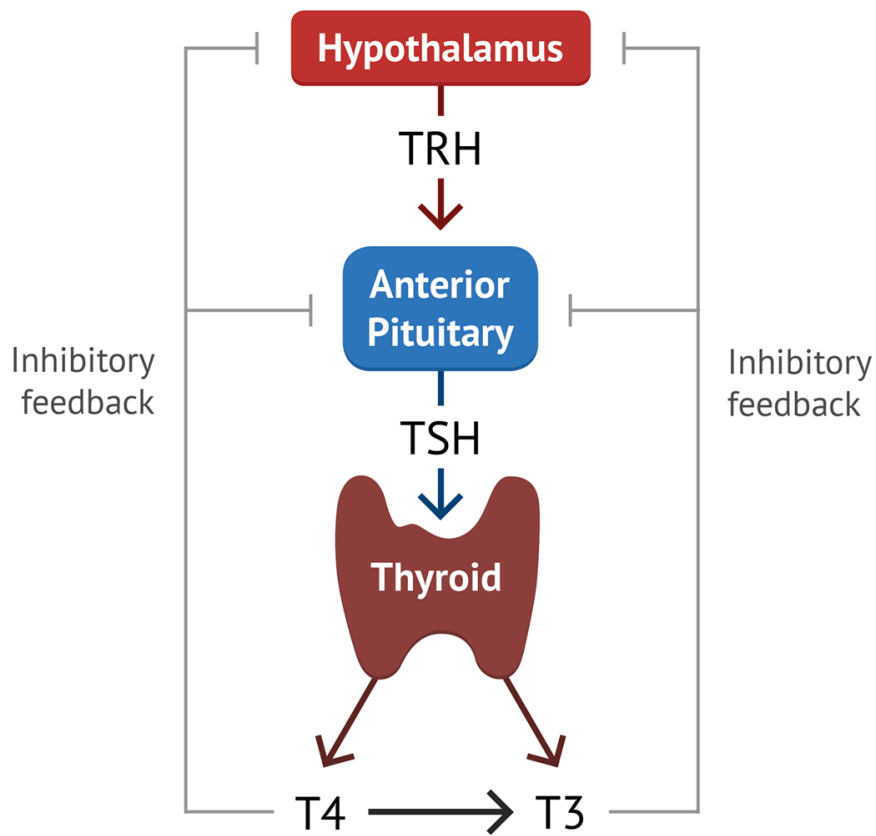
Effects on Organ Systems (High-Yield)

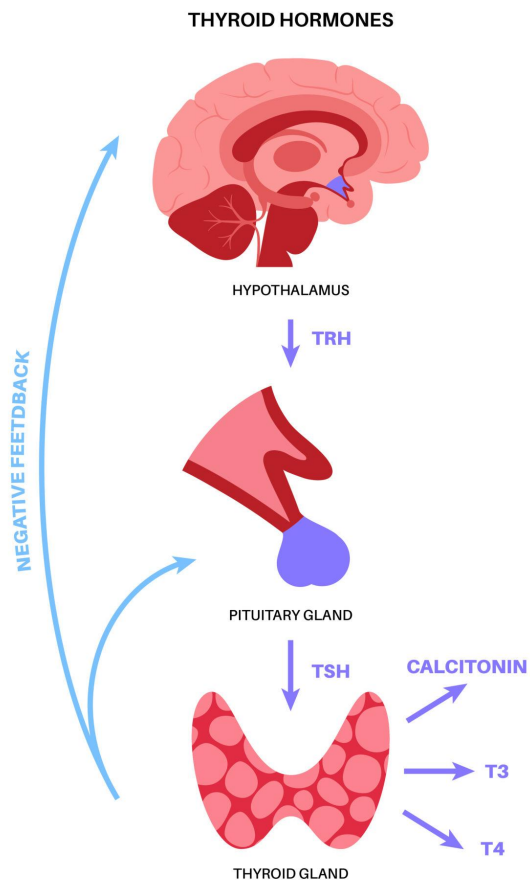
- **Cardiovascular** ? ? heart rate, ? cardiac output
- **Nervous system** ? alertness, reflexes

- **Growth & development** ? brain maturation
- **GIT** ? ? appetite and motility
- **Musculoskeletal** ? normal bone growth

Regulation of Thyroid Hormones







- **TRH (hypothalamus)** ? stimulates TSH
- **TSH (pituitary)** ? stimulates thyroid hormone synthesis
- **Negative feedback** by T₃ and T₄ on TRH and TSH.

High-Yield Exam Points

- T₃ is **3–5 times more potent** than T₄.
- Thyroid hormones are stored in **colloid**.
- Thyroid peroxidase is essential for synthesis.

- Nuclear receptor-mediated action.
- Increase BMR and oxygen consumption.
- Essential for **growth and CNS development**.

Assessment of Thyroid Function



Thyroid Function Tests

Variable	Value	Normal Value	Units
TSH	1.46 mU/ml	0.24-3.70	mIU/ml
FT4	1.22 ng/dl	0.9-1.8	ng/ml
FT3	3.42 pg/ml	2.4-4.3	pg/ml
	530 ng/dl	<30	ng/ml
	0.4 U/ml	<40	U/ml

<https://img.medscapestatic.com/pi/meds/ckb/67/30867tn.jpg>

Thyroid function is assessed by evaluating **hormone levels, regulation, and gland activity**.

Serum TSH

- **Most sensitive screening test**
- ? TSH ? primary hypothyroidism
- ? TSH ? hyperthyroidism
- Reflects **pituitary response** to circulating thyroid hormones

Serum T₄ and T₃

- Total T₄ and T₃ measure **bound + free hormone**
- Free T₄ and free T₃ reflect **biologically active hormone**

- T₄ rises earlier in hyperthyroidism

Thyroid Binding Proteins

- Thyroxine-binding globulin (TBG)
- Alter total hormone levels but **not free hormone**

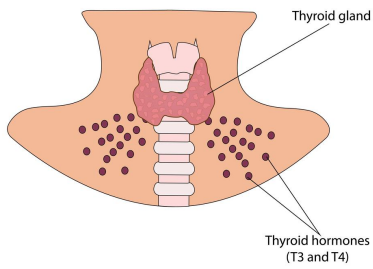
Radioactive Iodine Uptake (RAIU)

- Measures **iodine trapping and hormone synthesis**
- ? Uptake ? Graves disease
- ? Uptake ? Thyroiditis

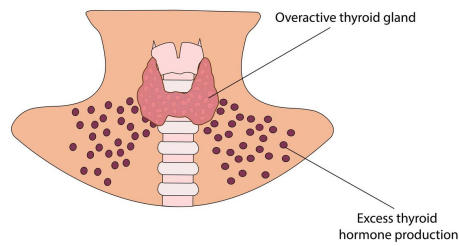
Thyroid Antibodies

- Anti-TPO antibodies ? autoimmune thyroid disease
- Anti-thyroglobulin antibodies

Hyperthyroidism

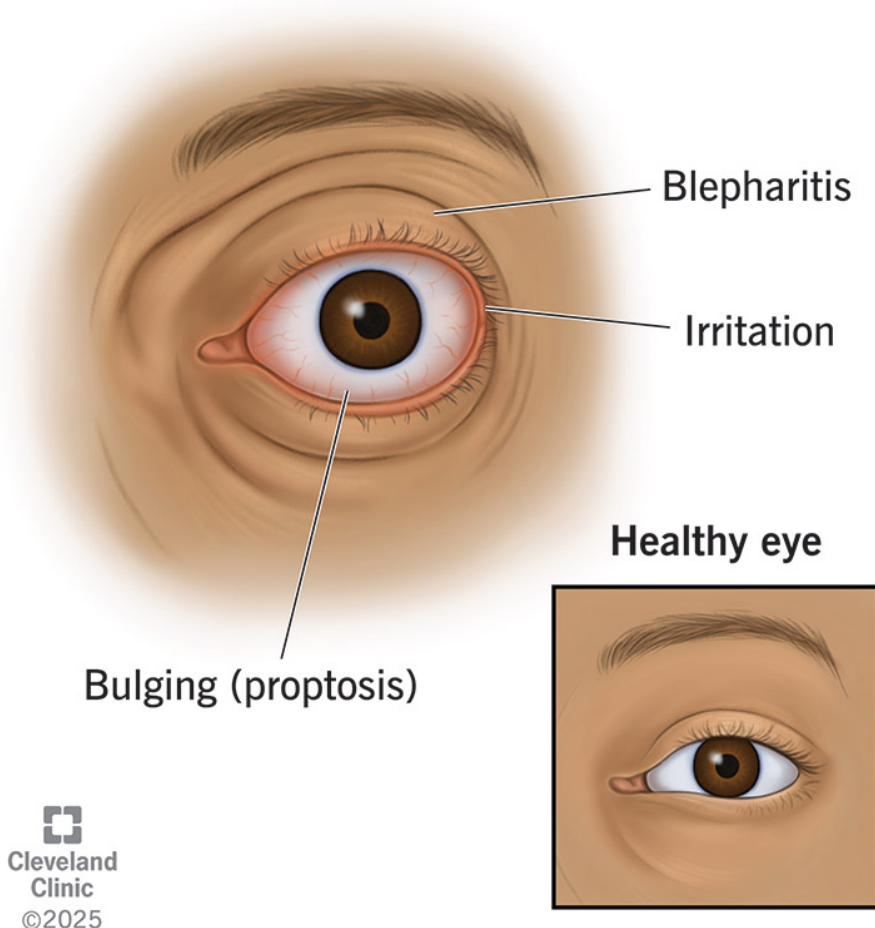


Normal Thyroid



Hyperthyroidism

Thyroid eye disease (Graves' eye disease)



Some symptoms of thyrotoxicosis



Increased sweating.



More frequent pooping.



Unexplained weight loss.



Feeling anxious or nervous.



Rapid heart rate.



Shakiness.



Hyperthyroidism is a state of **excess thyroid hormone action**.

Causes

- Graves disease (most common)
- Toxic multinodular goiter
- Thyroid adenoma
- Excess thyroid hormone intake

Biochemical findings

- ? TSH
- ? Free T₄ and/or T₃
- ? Radioiodine uptake (except thyroiditis)

Clinical features

- Weight loss despite increased appetite
- Heat intolerance
- Sweating
- Palpitations
- Tachycardia
- Tremors
- Anxiety
- Goiter
- Exophthalmos (Graves disease)

Metabolic effects

- ? Basal metabolic rate
 - ? Lipolysis
 - ? Protein catabolism
-

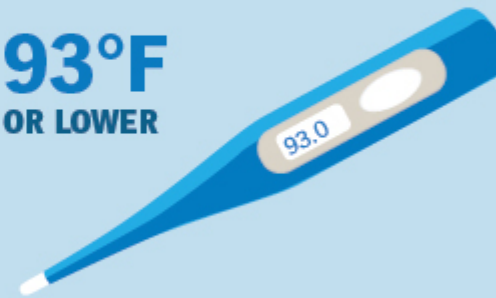
Hypothyroidism

Symptoms of myxedema coma



**Confusion/
disorientation**

**93°F
OR LOWER**



**Low body
temperature**

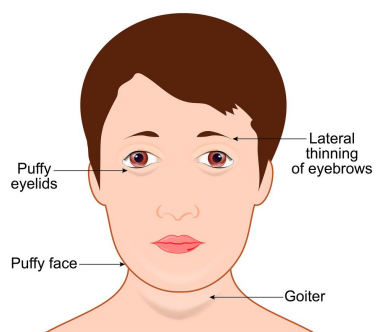


Low blood pressure

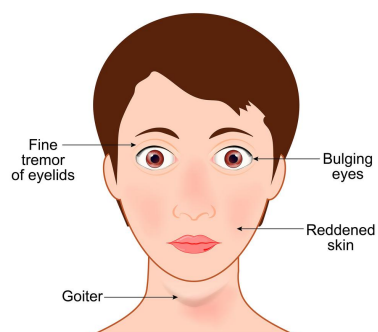


Slow heart rate





HYPOTHYROIDISM



HYPERTHYROIDISM

Hypothyroidism is a state of **deficient thyroid hormone action**.

Causes

- Hashimoto thyroiditis (most common)
- Iodine deficiency
- Thyroidectomy
- Drugs (antithyroid drugs)
- Congenital absence of thyroid

Biochemical findings

- ↑ TSH (primary hypothyroidism)
- ↓ Free T₄
- Normal or low T₃

Clinical features

- Weight gain
- Cold intolerance
- Fatigue
- Constipation
- Bradycardia
- Dry skin
- Hair loss

- Depression
- Puffy face (myxedema)

Special forms

- **Cretinism** (children)
 - Mental retardation
 - Growth failure
- **Myxedema** (adults)
 - Non-pitting edema
 - Hypothermia
 - Reduced metabolism

Comparison (Very High-Yield)

FEATURE	HYPERTHYROIDISM	HYPOTHYROIDISM
TSH	?	?
T ₃ / T ₄	?	?
BMR	Increased	Decreased
Weight	Loss	Gain
Heat tolerance	Decreased	Increased
Heart rate	Increased	Decreased

High-Yield Exam Points

- TSH is the best screening test
- T₃ toxicosis ? early hyperthyroidism
- Graves disease ? autoimmune hyperthyroidism
- Hashimoto thyroiditis ? autoimmune hypothyroidism
- Iodine deficiency ? hypothyroidism
- Thyroid hormones regulate **BMR and growth**

FAQs

What is the most sensitive test for assessing thyroid function?

Serum TSH.

Why is TSH considered the best screening test?

Because it reflects the **pituitary response** to circulating thyroid hormones.

What do free T₃ and free T₄ indicate?

The **biologically active fraction** of thyroid hormones.

Why can total T₃ be altered without thyroid disease?

Due to changes in **thyroxine-binding globulin (TBG)** levels.

What is radioactive iodine uptake (RAIU) test used for?

To assess **iodine trapping and thyroid hormone synthesis**.

What does increased RAIU indicate?

Hyperfunctioning thyroid (e.g., Graves disease).

What does decreased RAIU suggest?

Thyroiditis or exogenous thyroid hormone intake.

Which antibodies are seen in autoimmune thyroid disease?

Anti-thyroid peroxidase (anti-TPO) and anti-thyroglobulin antibodies.

What is hyperthyroidism?

A clinical state of **excess thyroid hormone action**.

What is the most common cause of hyperthyroidism?

Graves disease.

What are the biochemical findings in hyperthyroidism?

? TSH, ? free T? and/or T?.

What is T? toxicosis?

Hyperthyroidism with **elevated T? and normal T?**.

What are common symptoms of hyperthyroidism?

Weight loss, heat intolerance, palpitations, tremors, anxiety.

Why does weight loss occur in hyperthyroidism?

Due to **increased basal metabolic rate**.

What causes exophthalmos in Graves disease?

Autoimmune inflammation of **retro-orbital tissues**.

What is hypothyroidism?

A condition of **deficient thyroid hormone action**.

What is the most common cause of hypothyroidism?

Hashimoto thyroiditis.

What are the biochemical findings in primary hypothyroidism?

? TSH, ? free T?.

What is myxedema?

Severe adult hypothyroidism with **non-pitting edema**.

What is cretinism?

Congenital hypothyroidism causing **mental retardation and growth failure**.

Why does weight gain occur in hypothyroidism?

Due to **decreased metabolic rate**.

Why does hyperpigmentation not occur in hypothyroidism?

Because ACTH levels are **not elevated**.

What happens to cholesterol levels in hypothyroidism?

They are **increased**.

What cardiovascular changes occur in hyperthyroidism?

Tachycardia and increased cardiac output.

What cardiovascular changes occur in hypothyroidism?

Bradycardia and reduced cardiac output.

How do thyroid hormones affect growth and development?

They are essential for **normal CNS development and growth**.

How does iodine deficiency affect thyroid function?

Leads to **hypothyroidism and goiter**.

What is subclinical hypothyroidism?

Elevated TSH with **normal T₃ and T₄**.

What is subclinical hyperthyroidism?

Low TSH with **normal T₃ and T₄**.

Summarize the importance of thyroid function tests.

They help diagnose, classify, and monitor **thyroid disorders** accurately.

MCQs

1. The most sensitive screening test for thyroid function is:

- A. Total T₄
- B. Free T₄
- C. Serum TSH
- D. Radioiodine uptake

Answer: C

2. The biologically active fraction of thyroid hormone is:

- A. Total T₄
- B. Protein-bound T₄

- C. Free T₄ and Free T₃
- D. Thyroxine-binding globulin

Answer: C

3. Increased total T₄ with normal free T₄ is most likely due to:

- A. Graves disease
- B. Hypothyroidism
- C. Increased TBG
- D. Thyroiditis

Answer: C

4. Radioactive iodine uptake (RAIU) is increased in:

- A. Subacute thyroiditis
- B. Thyroid hormone overdose
- C. Graves disease
- D. Hypopituitarism

Answer: C

5. Low RAIU with high thyroid hormones suggests:

- A. Graves disease
- B. Toxic multinodular goiter
- C. Thyroiditis
- D. Iodine deficiency

Answer: C

6. The most common cause of hyperthyroidism is:

- A. Toxic adenoma
- B. Thyroiditis
- C. Graves disease
- D. Iodine excess

Answer: C

7. Typical biochemical finding in hyperthyroidism is:

- A. ? TSH, ? T?
- B. ? TSH, ? T?
- C. ? TSH, ? T?
- D. ? TSH, ? T?

Answer: B

8. T? toxicosis refers to:

- A. Increased T? only
- B. Increased T? with normal T?
- C. Increased TSH
- D. Decreased T?

Answer: B

9. Exophthalmos is characteristically seen in:

- A. Hashimoto thyroiditis
- B. Subacute thyroiditis
- C. Graves disease
- D. Iodine deficiency goiter

Answer: C

10. Weight loss in hyperthyroidism occurs due to:

- A. Decreased appetite
- B. Decreased metabolism
- C. Increased basal metabolic rate
- D. Malabsorption

Answer: C

11. The most common cause of hypothyroidism is:

- A. Iodine deficiency
- B. Hashimoto thyroiditis
- C. Thyroid adenoma
- D. Pituitary tumor

Answer: B

12. Typical biochemical finding in primary hypothyroidism is:

- A. ? TSH, ? T?
- B. ? TSH, ? T?
- C. ? TSH, ? T?
- D. Normal TSH, ? T?

Answer: B

13. Myxedema refers to:

- A. Congenital hypothyroidism
- B. Severe adult hypothyroidism
- C. Hyperthyroid crisis
- D. Thyroid cancer

Answer: B

14. Cretinism is caused by:

- A. Adult hypothyroidism
- B. Hyperthyroidism in infancy
- C. Congenital hypothyroidism
- D. Pituitary insufficiency

Answer: C

15. A child with untreated hypothyroidism is most likely to develop:

- A. Hypertension
- B. Precocious puberty
- C. Mental retardation
- D. Hyperglycemia

Answer: C

16. Serum cholesterol levels in hypothyroidism are:

- A. Decreased
- B. Normal
- C. Increased
- D. Unchanged

Answer: C

17. Bradycardia is commonly seen in:

- A. Hyperthyroidism
- B. Graves disease
- C. Hypothyroidism
- D. Thyroid storm

Answer: C

18. Subclinical hypothyroidism is defined as:

- A. Normal TSH with low T?
- B. High TSH with normal T?
- C. Low TSH with normal T?
- D. Low TSH with low T?

Answer: B

19. Subclinical hyperthyroidism shows:

- A. ? TSH, normal T?
- B. ? TSH, normal T?
- C. ? TSH, ? T?
- D. ? TSH, ? T?

Answer: B

20. Thyroid hormones are essential for:

- A. Only adult metabolism
- B. Only reproductive function
- C. Growth and CNS development
- D. Electrolyte balance only

Answer: C

Clinical Problem–Based Questions

Clinical Problem 1

A 28-year-old woman presents with weight loss, palpitations, heat intolerance, and tremors. Her pulse is 110/min. Laboratory tests show low TSH and elevated free T₄.

Question:

What is the most likely diagnosis?

Answer:

Hyperthyroidism

Clinical Problem 2

A patient has hyperthyroid symptoms with low TSH, high T₄, and normal T₃.

Question:

What is this condition called?

Answer:

T₄ toxicosis

Clinical Problem 3

A 32-year-old woman presents with goiter and protrusion of eyes. Radioactive iodine uptake is increased.

Question:

What is the most likely cause?

Answer:

Graves disease

Clinical Problem 4

A patient with thyrotoxic symptoms has low radioactive iodine uptake.

Question:

What is the most likely diagnosis?

Answer:

Thyroiditis or exogenous thyroid hormone intake

Clinical Problem 5

A patient has increased total T₄ but normal free T₄ and normal TSH.

Question:

What is the likely explanation?

Answer:

Increased thyroxine-binding globulin (TBG)

Clinical Problem 6

A 45-year-old woman complains of weight gain, cold intolerance, constipation, and fatigue. Examination shows dry skin and bradycardia. TSH is elevated.

Question:

What is the diagnosis?

Answer:

Primary hypothyroidism

Clinical Problem 7

A patient with hypothyroidism shows high anti-thyroid peroxidase antibodies.

Question:

What is the most likely cause?

Answer:

Hashimoto thyroiditis

Clinical Problem 8

A patient with pituitary tumor has low TSH and low T₄.

Question:

What type of hypothyroidism is this?

Answer:

Secondary hypothyroidism

Clinical Problem 9

A newborn presents with large tongue, hypotonia, and delayed milestones.

Question:

Which thyroid disorder explains these features?

Answer:

Congenital hypothyroidism (cretinism)

Clinical Problem 10

A child with untreated hypothyroidism develops severe mental retardation.

Question:

Why does this occur?

Answer:

Because thyroid hormones are essential for **normal CNS development**.

Clinical Problem 11

A patient presents with non-pitting edema of face and extremities, hypothermia, and bradycardia.

Question:

What is this condition called?

Answer:

Myxedema

Clinical Problem 12

A patient shows elevated TSH with normal T₄ and T₃ levels.

Question:

What is the diagnosis?

Answer:

Subclinical hypothyroidism

Clinical Problem 13

A patient has low TSH with normal thyroid hormone levels.

Question:

What is this condition termed?

Answer:

Subclinical hyperthyroidism

Clinical Problem 14

A hyperthyroid patient develops atrial fibrillation.

Question:

Which metabolic effect of thyroid hormone explains this?

Answer:

Increased β -adrenergic sensitivity and cardiac output

Clinical Problem 15

A patient with hypothyroidism has elevated serum cholesterol.

Question:

Why does this occur?

Answer:

Due to **reduced LDL receptor activity and decreased lipid metabolism**

Clinical Problem 16

A patient with hyperthyroidism experiences muscle weakness and weight loss.

Question:

Which metabolic effect is responsible?

Answer:

Increased protein catabolism

Clinical Problem 17

A woman treated with excess levothyroxine shows suppressed TSH.

Question:

What does this indicate?

Answer:

Iatrogenic hyperthyroidism

Clinical Problem 18

A patient has goiter with normal thyroid hormone levels.

Question:

What is this condition called?

Answer:

Euthyroid goiter

Clinical Problem 19

A patient with iodine deficiency develops goiter.

Question:

Why does goiter occur despite low thyroid hormone levels?

Answer:

Due to TSH-mediated thyroid hyperplasia.

Clinical Problem 20

A hyperthyroid patient complains of excessive sweating and heat intolerance.

Question:

Which hormone effect explains this?

Answer:

Increased basal metabolic rate and heat production

Rapid-Fire Viva-Voce

Most sensitive screening test for thyroid function?

Serum TSH

Biologically active thyroid hormones?

Free T₄ and Free T₃

Main thyroid hormone secreted by the gland?

Thyroxine (T₄)

Most potent thyroid hormone?

Triiodothyronine (T₃)

Transport protein with highest affinity for thyroid hormones?

Thyroxine-binding globulin (TBG)

Enzyme responsible for iodide oxidation?

Thyroid peroxidase

Test that measures iodine trapping by thyroid?

Radioactive iodine uptake (RAIU)

Increased RAIU is seen in?

Graves disease

Decreased RAIU with thyrotoxicosis suggests?

Thyroiditis or exogenous hormone intake

Most common cause of hyperthyroidism?

Graves disease

Autoimmune antibody in Graves disease?

TSH receptor antibody

Eye signs in Graves disease are due to?

Autoimmune inflammation of retro-orbital tissues

Typical biochemical finding in hyperthyroidism?

? TSH, ? T₄/T₃

T₄ toxicosis means?

High T₄ with normal T₃

Why weight loss occurs in hyperthyroidism?

Increased basal metabolic rate

Cardiac effect of hyperthyroidism?

Tachycardia

Most common cause of hypothyroidism?

Hashimoto thyroiditis

Autoantibody seen in Hashimoto thyroiditis?

Anti-thyroid peroxidase antibody

Typical biochemical finding in primary hypothyroidism?

? TSH, ? T?

Myxedema refers to?

Severe adult hypothyroidism

Cause of non-pitting edema in myxedema?

Glycosaminoglycan deposition

Cretinism is due to?

Congenital hypothyroidism

Key effect of hypothyroidism on heart?

Bradycardia

Lipid abnormality in hypothyroidism?

Hypercholesterolemia

Subclinical hypothyroidism shows?

? TSH with normal T₄/T₃

Subclinical hyperthyroidism shows?

? TSH with normal T₄/T₃

Effect of thyroid hormones on CNS development?

Essential for normal brain maturation

Regulation of thyroid hormones occurs via?

Hypothalamic-pituitary-thyroid axis

Negative feedback hormone on TSH?

T₄ and T₃

Why goiter occurs in iodine deficiency?

Chronic TSH stimulation

Best single test to monitor thyroid therapy?

Serum TSH