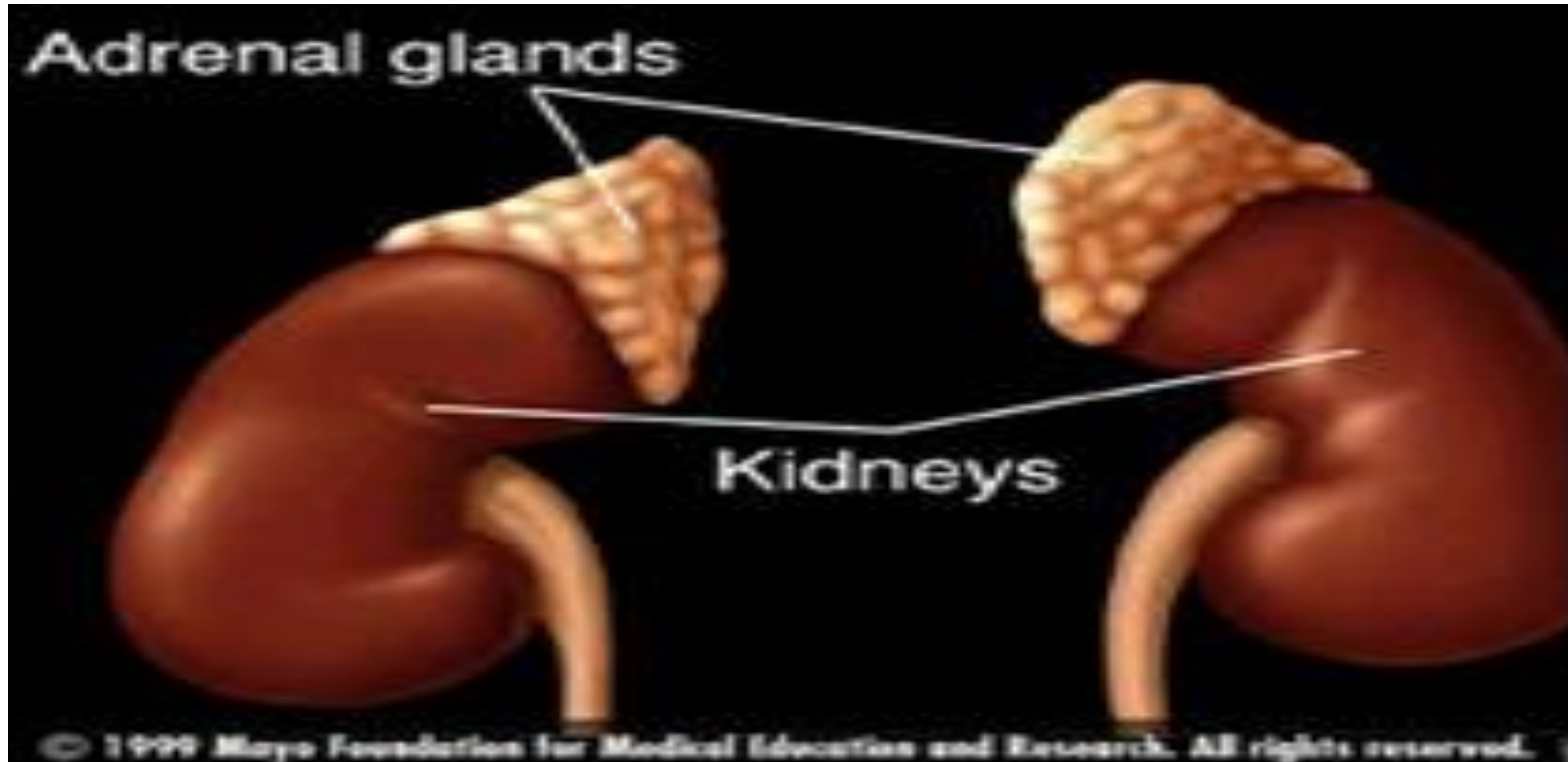


THE ADRENAL GLANDS

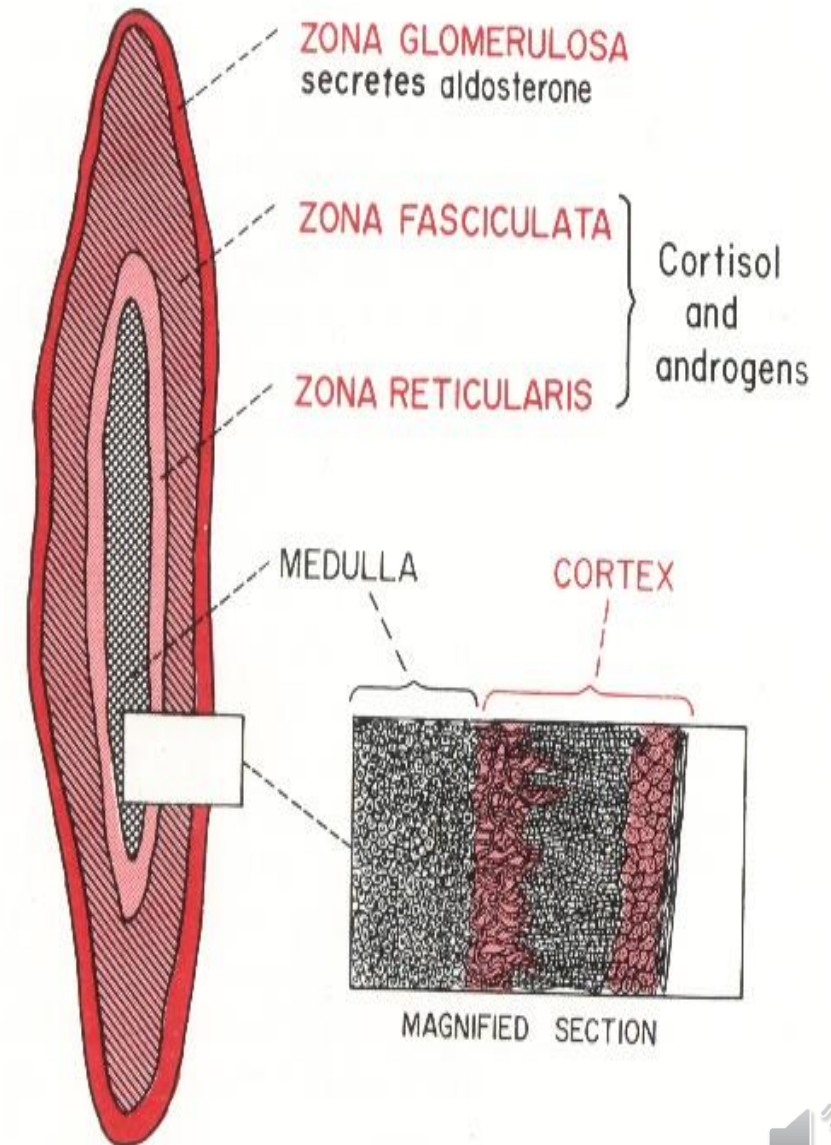
The adrenal glands, each of which weight about 4 grams, lie at the superior poles of the two kidneys.



THE ADRENOCORTICAL HORMONES

Each gland is composed of two distinct parts:

- 1. The inner adrenal medulla** (20% of the gland) is functionally related to the sympathetic nervous system; it secretes catecholamines (adrenaline, nor adrenaline, and dopamine) in response to sympathetic stimulation.
- 2. The outer adrenal cortex** (80% of the gland) secretes steroid hormones (corticosteroid) which are essential for the life and includes:



- 1. Mineralocorticoids (aldosterone):** affect the electrolytes of ECF, Na⁺ and K⁺
- 2. Glucocorticoids (cortisol):** It is affected by increasing blood glucose concentration, an additional effect on both protein and fat metabolism.
- 3. Androgenic hormones:** (small amounts): It has effects in the body as the male sex hormone testosterone.



Glucocorticoids:

1. **Cortisol** (very potent, account for 95% of all glucocorticoid activity).
2. **Corticosterone** (4% of total glucocorticoid activity, less potent than cortisol).
3. **Cortisone** (synthetic, almost as potent as cortisol).
4. **Prednisolone** (synthetic, 4 times as potent as cortisol).
5. **Dexamethasone** (synthetic, 30 times as potent as cortisol).



Effect of glucocorticoids (cortisol):

1. ***Effects on CHO metabolism:*** Stimulation of gluconeogenesis and ↓Glucose utilization by the cells will lead to elevated blood glucose concentration
2. ***Effect on protein metabolism:*** cause increase protein catabolism (muscle weakness) AA concentration in the blood will increase.
3. ***Effect on fat metabolism:***
 - a. Cortisol causes mobilization of FA from the adipose tissue → ↑ FFA in plasma → ↑ utilization of FA for energy.
 - b. Ketogenic effect

Obesity caused by cortisol: Excess cortisol secretion lead to excess deposition of fat in the chest and head regions of the body, giving to a *buffalo like torso* and a rounded face called *moon face*.



4. *Effects on blood cells and lymphatic organs.*

5. *Resistance to stress.*

6. *Anti-allergic effect.*

7. *Anti-inflammatory effect .*

8. *Other effects:* glucocorticoids in high doses lead to: ↓GH secretion, ↓TSH secretion and accelerate the maturation of surfactant in the lungs of fetus



THE MINERALOCORTICOIDS

1. **Aldosterone** (very potent, account for 95% of mineralocorticoid activity).
2. **Deoxycorticosterone** (one fifteenth as potent as aldosterone, very small quantities secreted).
3. **Corticosterone** (slight activity).
4. **Cortisol** (very slight activity).
5. **Cortisone** (synthetic, slight activity).

Physiological effects

1. ↑ Reabsorption of Na^+ in exchange for (K^+) and (H^+) ions in the renal.
Thus causing water retention, urine acidity, and ↓ H^+ ion concentration in ECF.
1. ↑ Reabsorption of Na^+ ions from the sweat, saliva, gastric juice, and intestinal secretion.



Regulation of aldosterone secretion:

- ***K⁺ ion concentration in the ECF:*** increase 1meq/L in K⁺ concentration in ECF can directly stimulate the zona glomerulosa cells to secrete aldosterone.
- ***Renin-angiotensin system:*** elevated values of renin and angiotensin lead to ↑ aldosterone secretion.
- ***Quantity of body sodium:*** decreased Na⁺ lead to → ↓ECF volume → ↑renin secretion → formation of angiotensin → stimulate aldosterone secretion.
- ***ACTH:*** ACTH. It also has effect on aldosterone secretion



Abnormalities of adrenocortical secretion

Hypoadrenalism (Addison's disease): failure of adrenal cortices to produce adrenocortical hormones

Causes: (TB, autoimmune diseases, and invasion by cancer)



Features:

1. Mineralocorticoid deficiency

- \downarrow Na⁺ reabsorption(Na⁺, Cl⁺, and water lost in urine) \rightarrow (\downarrow ECF volume)
 \rightarrow shock \rightarrow death
- Hyperkalemia (\uparrow K⁺)
- Acidosis

2. Glucocorticoid deficiency

- Impossible to maintain normal glucose concentration between meals (impaired gluconeogenesis)
- \downarrow of fat and protein \rightarrow (\downarrow metabolic function of the body)
- **Melanin pigmentation** in the skin and mucous membrane \rightarrow (\downarrow cortisol secretion) \rightarrow (\uparrow ACTH and MSH secretion) \rightarrow melanin pigmentation.



Hyperadrenalism (Cushing's syndrome): (↑ increase cortisol secretion)

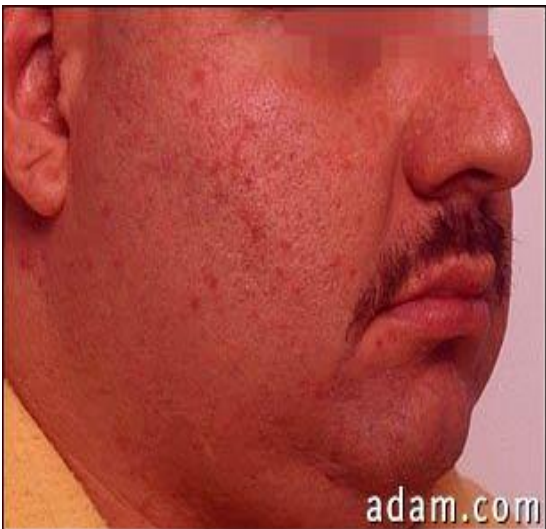
1. Tumor in the adrenal cortex → ↑ secrete cortisol
2. Hyperplasia of both adrenal cortices (↑ACTH secretion)
 - a. ↑ACTH secretion from anterior pituitary (microadenoma)
 - b. Ectopic secretion of ACTH by tumor e.g. abdominal carcinoma
3. Iatrogenic (drug up use)





Features:

- *Buffalo torso.*
- *Moon face.*
- *Acne and hirsutism.*
- *Hypertension (80%).*
- *Adrenal diabetes.*
- *Sever muscle weakness.*
- *Suppressed immunity* → infection (death)
- *Purplish striae (abdomen).*
- *Osteoporosis (bone weakness)* → fracture.



Diagnosis:

- *Clinical features.*
- \uparrow *plasma cortisol level.*
- \uparrow *secretion of 17 hydroxysteroid in urine.*

Treatment: → according to the cause



- Hypertension (80% of the patients)→ slight mineralocorticoid effect of cortisol
- ↑in blood glucose concentration (↑gluconeogenesis) →diabetes mellitus.
- Severe muscle weakness (protein catabolism).
- Suppressed immunity→ death(infection)
- Diminished collagen fibers in subcutaneous tissues (SC), SC tissues tears easily→ purplish striae (abdomen).
- Lack of protein deposition in the bones osteoporosis (bone weakness) fracture.



Primary aldosteronism:

1. Tumor of the adrenal cortex → secrete aldosterone.
2. Hyperplasia of adrenal cortices secrete aldosterone rather than cortisol

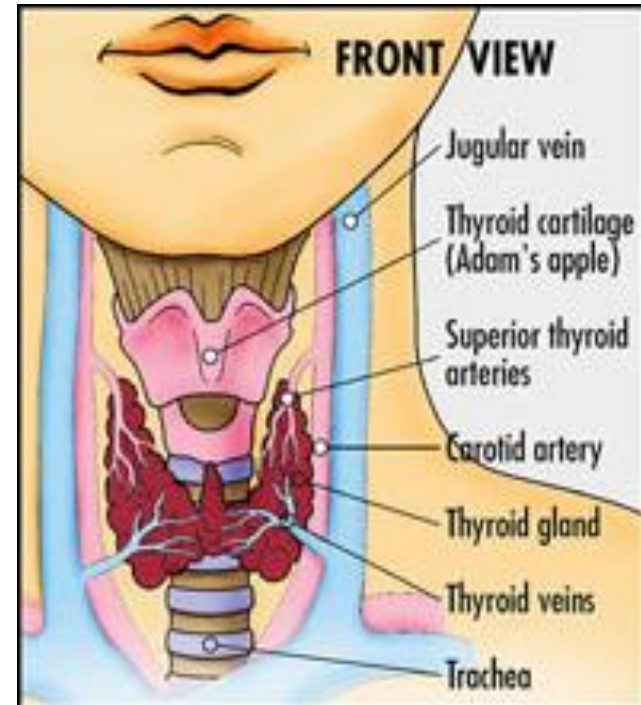
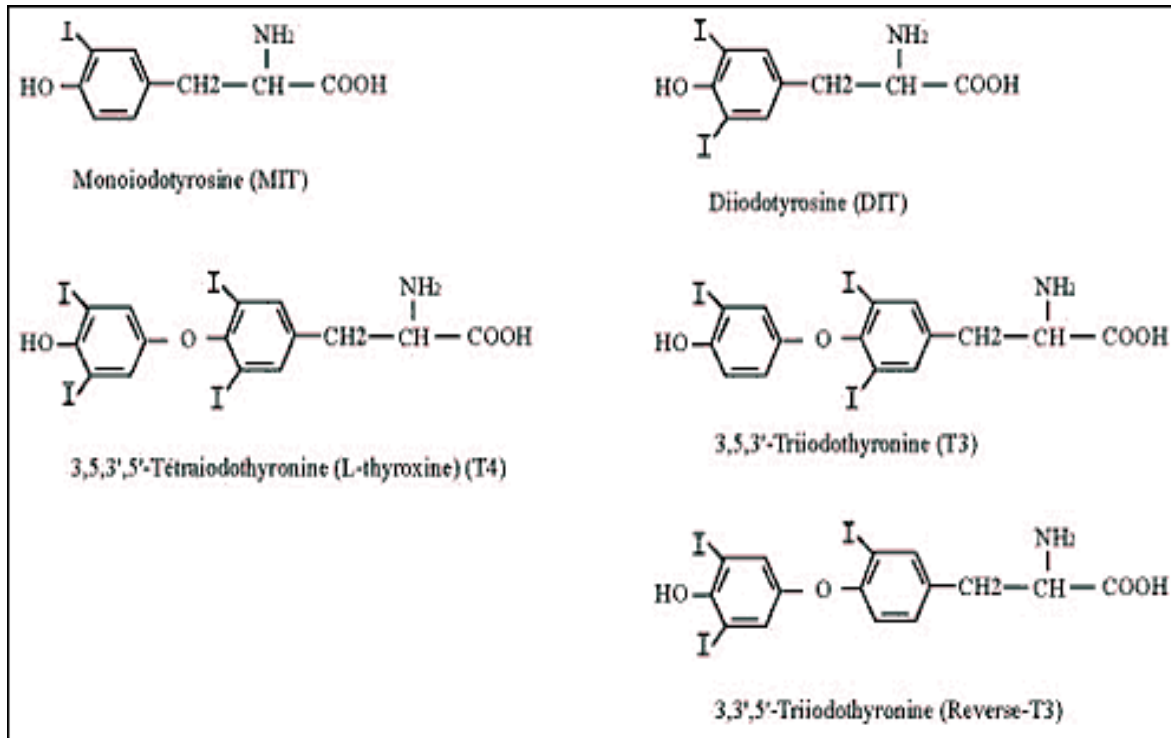
Features:

- $\uparrow \text{Na}^+$ reabsorption → $\uparrow \text{Na}^+$ concentration in ECF (slight) → \uparrow ECF volume → almost always *hypertension*
- $\downarrow \text{K}^+$ in ECF (hypokalemia) → periods of muscle weakness



THE THYROID GLAND

- The thyroid gland consists of 2 lobes (R and L lobes) connected by a bridge of tissue called *the thyroid isthmus*.
- Follicular cells → thyroxine (90%) and triiodothyronine (10%)
Parafollicular cells → calcitonin
- T3 is 4 times as potent as T4 but its present in lower concentration and its duration of action is shorter → (effect of T3 = effect of T4).
- Considerable portion of T4 is converted to T3 in blood & tissues



Thyroglobulin: is a large glycoprotein synthesized in the thyroid cells .

Transport of thyroid hormones:

More than 99% of T4 and T3 are bound to plasma proteins.

Functions of thyroid hormones in tissues:

1. An \uparrow in the overall metabolic rate: thyroid hormones \uparrow metabolic rate of almost all tissues of the body (except brain, retina, testes, spleen, and lungs).
2. In children, stimulation of growth.
 - Hypothyroidism \rightarrow growth retardation
 - Promote growth and *development of brain* during fetal life and 1st few years of postnatal life (lack of thyroid hormones during this period \rightarrow mental retardation)



Effects of thyroid hormones on specific body mechanisms:

1. Effect on CHO metabolism:

- ↑ Thyroid hormones → decrease cholesterol, TG and ↑FFA.
- Thyroid hormones → increase in basal metabolic rate (60-100%).
decrease body weight and increases the appetite.

2. Effect on the CVS:

- a. Blood flow and cardiac output:(↑ in COP)
- b. Heart rate: increase in heart rate **and** strength of heart rate
- c. Blood volume: increased (vasodilatation).
- d. Arterial pressure: Diastolic blood pressure (↓), Systolic blood pressure (↑)



1. Effect on respiration: \uparrow metabolism \rightarrow (\uparrow in O_2 utilization and CO_2 production)
 \rightarrow increase rate and depth of respiration.

2. Effect on Gastrointestinal system:

a. \uparrow in appetite and food intake

b. \uparrow secretion

c. \uparrow motility \rightarrow diarrhea

3. Effect on CNS:

\uparrow Thyroid hormone \rightarrow extreme nervousness

11. Effect on the function of the muscle:

- \uparrow in the hormone \rightarrow muscle reacts with vigor

- Excessive \uparrow in the hormones \rightarrow muscle weakness (protein catabolism)

- Lack of hormone \rightarrow muscle become sluggish and relaxes slowly after contraction

- Muscle tremor: fine muscle tremor is characteristic sign of hyperthyroidism.

12. Effect on sleep:

- Hyperthyroid \rightarrow difficult to sleep

- Hypothyroid \rightarrow extreme somnolence.



Causes: Hyperthyroidism:

- (Toxic goiter, thyrotoxicosis, Graves' disease)
- Toxic adenoma

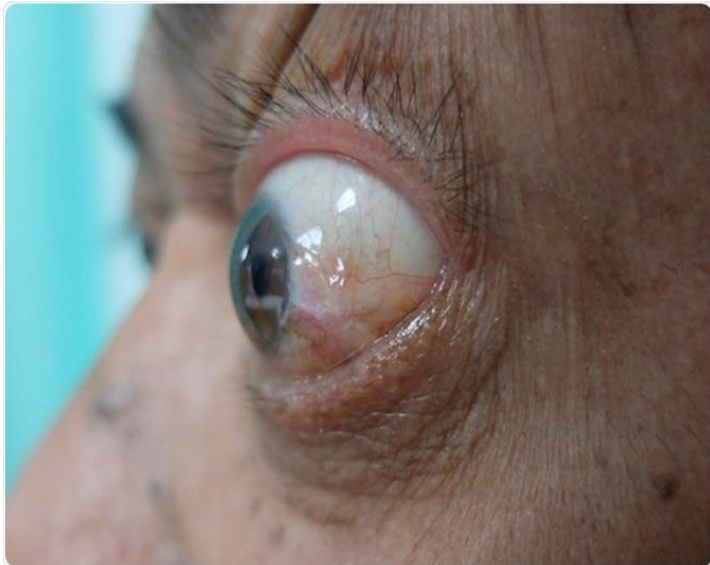
Graves' disease:

- Gland hyperplastic, 2-3 times of normal size (goiter).**
- Rate of thyroid hormone secretion increased 5-15 times of the normal (changes similar to that produced by TSH stimulation of the gland).
- TSH level low



Symptoms of hyperthyroidism:

- intolerance to heat, \uparrow sweating, weight loss, diarrhea, muscular weakness, nervousness, inability to sleep, \uparrow pulse pressure, and tremor of the hands.
- Exophthalmos: protrusion of the eyeball (occur in most hyperthyroid), usually disappear or \downarrow by treatment of hyperthyroidism



Hypothyroidism

1. **Autoimmunity** → destruction of the gland (inflammation→ fibrosis) → hypothyroidism.
2. **Endemic colloid goiter:** Iodine deficiency→ decrease thyroid hormone synthesis and secretion→ increase TSH → stimulation of secretion of thyroglobulin (colloid)→ goiter
3. **Food** which has propylthiouracil type of antithyroid activity e.g. of these goitrogenic substances are turnips and cabbage.

Characteristic of hypothyroidism:

- Fatigue and extreme somnolence (sleeping 14-16 hours a day), extreme muscular sluggishness, bradycardia, ↑body weight, constipation, mental sluggishness, edematous swelling of the body (myxedema) and atherosclerosis (↑ plasma cholesterol).

