Endocrine System Lect. 1

The endocrine system secretes hormones from their glandular cells. Hormones act as chemical messengers are synthesized from precursors in the blood. Once hormones released by glands, they are transported in the blood to other parts of the body where they exert their effects on specific targets. Some glands secrete substances into interstitial fluid, but because they are rapidly degraded, they do not reach the blood. These substances are more accurately defined as local messengers and include ***autocrine secretions***, ***paracrine secretions***.

The functions of the endocrine system are often associated and integrated with the nervous system. *Certain parts of the nervous system stimulate or inhibit the release of hormones, while hormones may promote or inhibit the generation of nerve impulses. Furthermore, some molecules act as hormones at some locations as neurotransmitters.*

The hormones of endocrine glands are involved in almost all aspects of normal body functioning. The growth and repair of tissues, the utilization of food to produce energy, responses to stress, the maintenance of homeostasis, and the proper levels and pH of body fluids, and the continuance of the human species all depend on hormones.

Types of Secretory Glands

1-Exocrine Glands:

Those glands which release their cellular secretions through a duct, which empties to the outside or into the lumen of an organ. ***These include certain sweat glands, salivary and pancreatic glands, and mammary glands*.** They are not considered a part of the endocrine system.

2-Endocrine glands:

Endocrine Glands: Are those glands which have ***no duct***, ***secrete their hormone directly into the surrounding cellular space***. The ***hormones then diffuse into nearby capillaries and are transported throughout the body in the blood.*** The collection of endocrine glands makes up the endocrine system. The endocrine system produces ***hormones that are helpful in maintaining homeostasis and regulating reproduction and development***. A ***hormone is a chemical messenger produced by a cell that affects specific change in the cellular activity of other cells (target cells).***

3-Mixed glands: - That have both exocrine and endocrine portions example pancreas.

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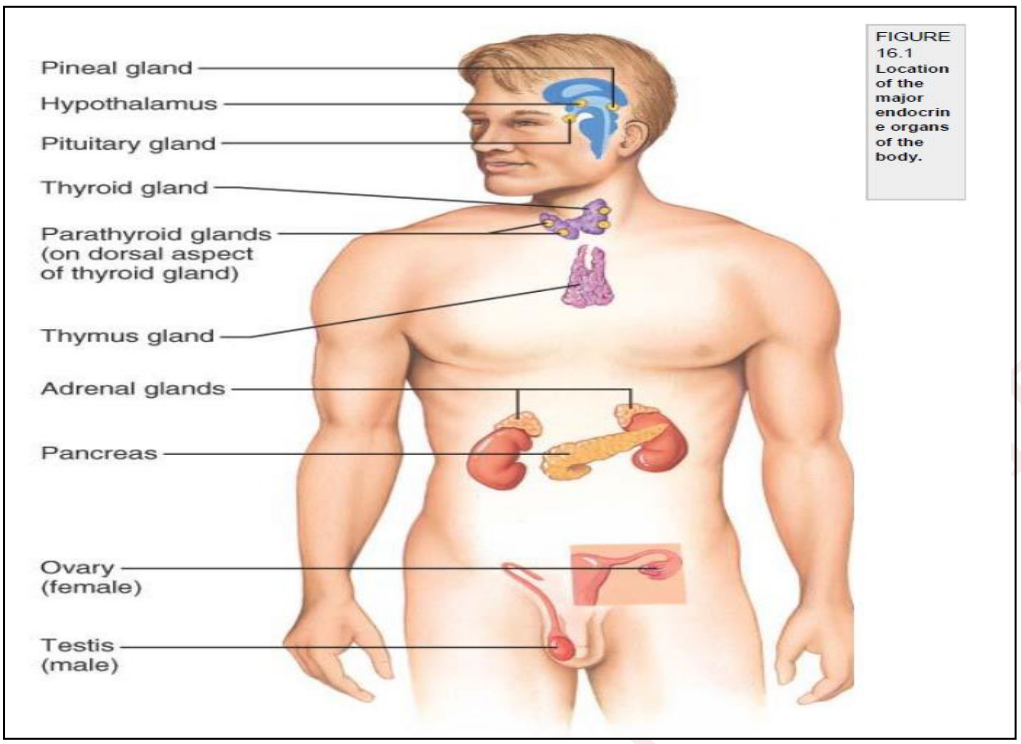

Major endocrine glands 1. Pineal gland 2. Hypothalamus 3. Pituitary gland 4. Thyroid gland 5. Parathyroid 6. Thymus 7. Adrenal gland 8. Pancreas 9. Ovary 10. Testis

The Main endocrine glands

1- **Pituitary** (***Hypophysis***) *anterior and posterior lobes*). The pituitary gland is attached to the hypothalamus of the lower forebrain.
2- **Thyroid.** The thyroid gland consists of two lateral masses, connected by a cross bridge, that are attached to the trachea. They are slightly inferior to the larynx.
3- **Parathyroid**. The parathyroid glands are four masses of tissue, two embedded posteriorly in each lateral mass of the thyroid gland.
4- **Adrenal** (***cortex and medulla***). One adrenal gland is located on top of each kidney. The cortex is the outer layer of the adrenal gland. The medulla is the inner core.
5- **Pancreas**. The pancreas is along the lower curvature of the stomach, close to where it meets the first region of the small intestine (**duodenum**).
6- **Gonads.** The gonads (***ovaries and testes***) are found in the pelvic cavity.
7- **Pineal gland.** The pineal gland (*also called the pineal body or* ***epiphysis***) is a small endocrine gland in the brain.
8- **Thymus gland.** Located in the upper thorax, declines in size and function with age. Its hormones, ***thymosins***, ***thymic factor***, and ***thymopoietins***, are ***important to the normal development of the immune respons***

Chemistry of Hormones

Hormone **is a chemical messenger produced by a cell that effects specific change in the cellular activity of (target cells). They are classified into three groups: -**

1. Proteins: - Either (**A**) chains of **amino acids** or **(B) peptides are short chains** such as: ***Insulin, GH, glucagon are proteins***; ***ADH and oxytocin are peptides***.

2. Amines: - structural variations of **the amino acid: - *tyrosine; thyroxin, epinephrine (E) Norepinephrine (NE).***

3. Steroids: - made up from **cholesterol; *cortisol, aldosterone, estrogen, testosterone***.

Mechanisms of Hormone Action: **target cell or organ is the body tissue that a particular hormone will affect**
- specific protein receptors must be present on target cell's plasma membrane or interior where a certain hormone can attach or bind
- hormone is a Greek word meaning "to stimulate" by altering cellular activity

- **Negative feedback: - *most hormone production is managed by a negative feedback system.*** The nervous system and certain endocrine tissues monitor various internal conditions of the body. If action is required to maintain homeostasis, ***hormones are released, either directly by an endocrine gland*** or ***indirectly through the action of the hypothalamus of the brain, which stimulates other endocrine glands to release hormones.*** *In negative feedback, when the original (abnormal) condition has been repaired, or canceled, corrective actions decrease or discontinue*). *For example, the amount of glucose in the blood controls the secretion of insulin and glucagon via negative feedback.*

- **Positive feedback**: - The production of some hormones is controlled by positive feedback. **In such a system, hormones cause a condition to increase, rather than decrease.** As the condition intensifies, hormone production increases. ***Such positive feedback is uncommon***, but it occurs during childbirth, ***where hormone levels build with increasingly intense labor contractions.*** Also ***in lactation, hormone levels increase in response to nursing; this causes an increase in milk production***.

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- **Hyposecretion** *Primary hyposecretion* occurs when an endocrine gland is secreting too little of its hormone because of an abnormality within that gland. *Secondary hyposecretion* takes place when an endocrine gland is normal but is secreting too little hormone because of a deficiency of its tropic hormone. The following are among the many different factors (each listed with an example) that may cause primary hyposecretion:

  (1) Genetic (inborn absence of an enzyme that catalyzes synthesis of the hormone, such as the inability to synthesize cortisol because of the lack of a specific enzyme in the adrenal cortex);

  (2) Dietary (lack of iodine, which is needed for synthesis of thyroid hormone);

  (3) Chemical or toxic (certain insecticide residues may destroy the adrenal cortex);

  (4) Immunologic (autoimmune antibodies sometimes destroy thyroid tissue);

  (5) Other disease processes (cancer or tuberculosis may coincidentally destroy endocrine glands);

  (6) *Iatrogenic* (physician induced, such as surgical removal of a cancerous thyroid gland);

  (7) *Idiopathic* (meaning the cause is not known).

- **Hypersecretion** Like hyposecretion, hypersecretion by a particular endocrine gland is designated as primary or secondary depending on whether the defect lies in that gland or results from excessive stimulation from the outside, respectively. Hypersecretion may be caused by :

  (1) Tumors that ignore the normal regulatory input and continuously secrete excess hormone and

  (2) Immunologic factors, such as excessive stimulation of the thyroid gland by an abnormal antibody that mimics the action of TSH. Excessive levels of a particular hormone may also arise from substance abuse, such as the outlawed practice among athletes of using certain steroids that increase muscle mass by promoting protein synthesis in muscle cells

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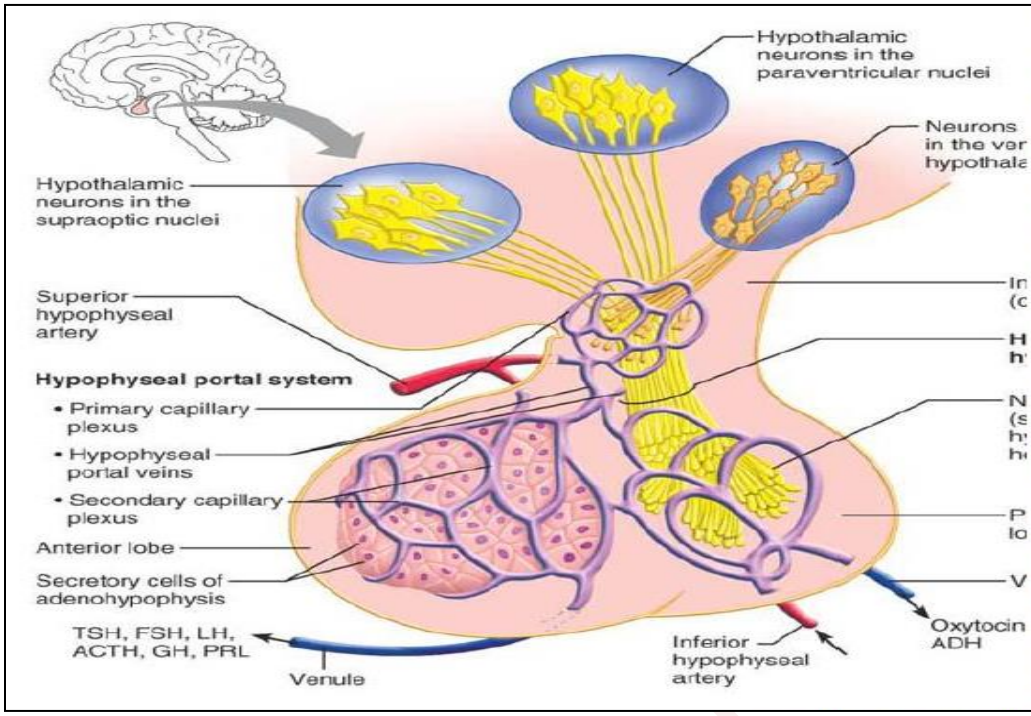
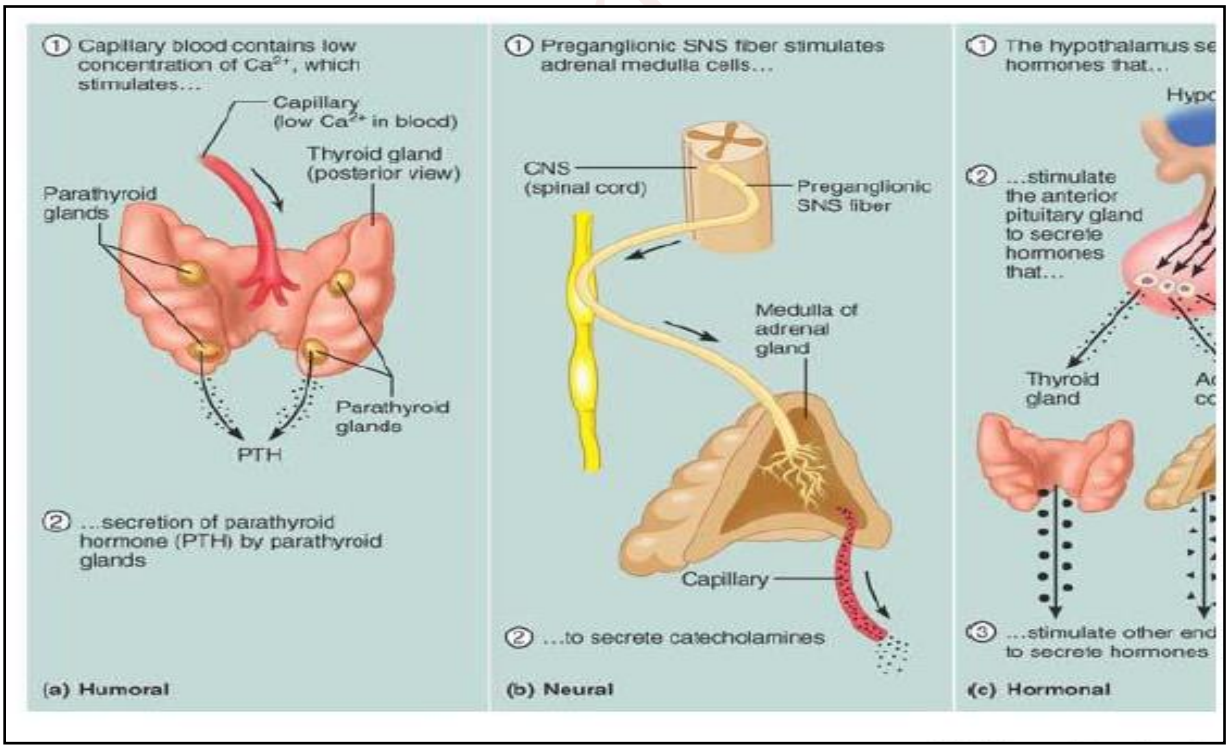


FIGURE 16.6 **Relationships of the pituitary gland and hypothalamus**. Hypothalamic neurons in the supraoptic and paraventricular nuclei synthesize ADH and oxytocin, which are transported along the hypothalamic-hypophyseal tract to the neurohypophysis for storage. Neurons in the ventral hypothalamus have short axons that discharge releasing and inhibiting hormones to the capillaries of the hypophyseal



Control of Hormone Secretion

Three types of stimuli control secretion of most hormones: -

The availability of hormones depends on their secretion. Stimuli may alter synthesis, release, or both processes to change plasma levels of a hormone.

1- Neural stimuli:- A sympathetic stimulus on adrenal gland activates the release of Epinephrine& Norepinephrine; due to pain fear or trauma .The release of **E** & **NE** reinforce the actions of sympathetic Nervous system.

2- Hormonal stimuli. The **TRH** from the hypothalamus activates **TSH** which stimulate the thyroid follicle cells to release T3 & T4 **(TH),** for keeping blood level of TH relatively constant is a ***negative feedback loop*** of free T3 &T4 in plasma inhibit secretion of **TSH.** ***The secretion of most hormones is regulated by negative feedback mechanisms.***

3- Humoral stimuli: include the concentration of ions & nutrients in plasma for example; increased plasma glucose triggers insulin secretion to initiate glucose up take by tissue cells. ***Increasing plasma glucose levels initiate negative feedback loop that causes glucose to return to the pre-fasting level***.

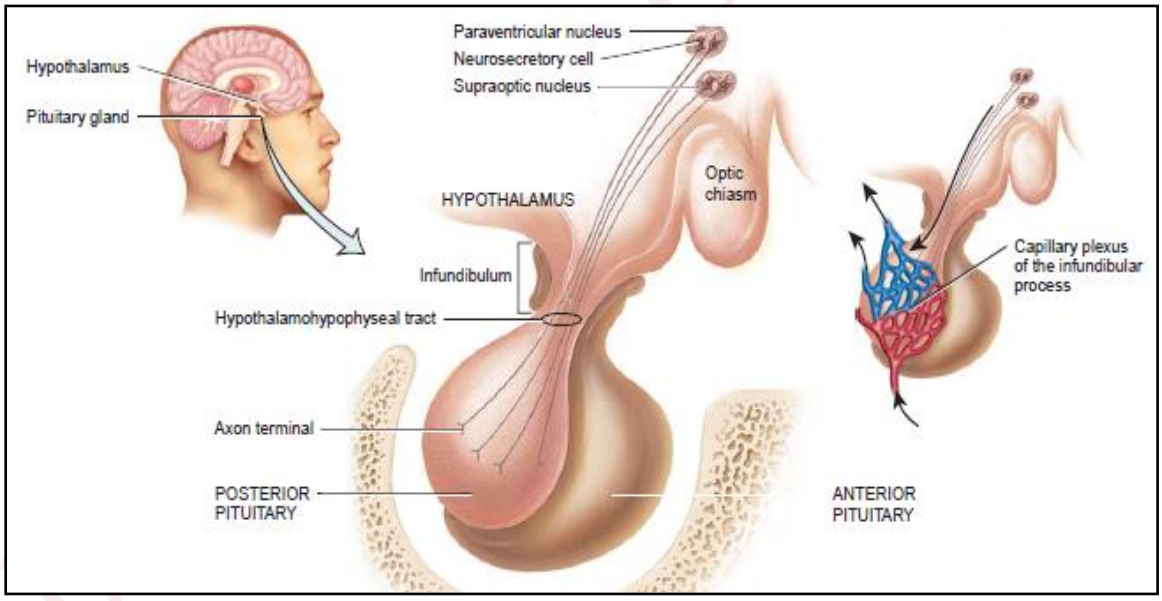


Fig (1) Pituitary Gland

Hypothalamus

The **hypothalamus,** lies just above the brain stem. The **pituitary gland (hypophysis)** is attached to the bottom of the hypothalamus by a slender stalk called the ***infundibulum.***

The hypothalamus controls the glandular secretion of the pituitary gland.

- The hypothalamus oversees many internal body conditions.
- It receives nervous stimuli from receptors throughout the body and monitors chemical and physical characteristics of the blood, including ***temperature, blood pressure, and nutrient, hormone, and water content.***
- The hypothalamus stimulates cellular activity in various parts of the body by directing the release of hormones from the anterior and posterior pituitary glands.
- The hypothalamus communicates directives to these glands by the following pathways:

The Pituitary gland is found in the inferior part of the brain and is connected by the Pituitary Stalk. Hormones **(*releasing hormones and inhibiting hormones*)** produced by the hypothalamus and delivered to the anterior pituitary via a network of capillaries.

The releasing and inhibiting hormones are produced by specialized neurons of the hypothalamus called **neurosecretory cells**, are released into a capillary network and transported through portal veins, to secondary plexus that supplies the anterior pituitary. The hormones then diffuse from the secondary plexus into the anterior pituitary, where they initiate the production of hormones by the anterior pituitary.

The hypothalamus secrets Releasing hormones activates anterior pituitary include:

1-Thyrotropin-releasing hormone **(TRH)**
2-Corticotropin-releasing hormone **(CRH)**
3- Prolactin- releasing hormone(**PRH)**
prolactin inhibiting hormone **(PIH)** also called Dopamine **(DA).**
4-Gonadotropin-releasing hormone **(GnRH)**
5-Growth hormone releasing hormone **(GHRH)**
Growth hormone inhibiting hormone **(GHIH)** or **somatostatin**

These hormones from the hypothalamus cause release of the respective hormone from the pituitary.

The control of release of hormones from the pituitary is via negative feedback from the target gland.

For example, homeostasis of thyroid hormones is achieved by the following mechanism; (**TRH)** *from the hypothalamus stimulates the release of* (**TSH)** *from the anterior pituitary*. The (**TSH)**, in turn, stimulates the release of **thyroid hormones** form the thyroid gland.

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The thyroid hormones then cause negative feedback, suppressing the release of **TRH** and **TSH**.

Pituitary Gland *(Hypophysis)* Lect.2

Hangs from hypothalamus by the ***infundibulum***; (Fig 1)

Posterior Pituitary *(Neurohypophysis)*

- Communication between the hypothalamus and the posterior pituitary occurs through **neurosecretory cells**. Hormones produced packaged in vesicles and transported through the axon and stored in the axon terminals that lie in the posterior pituitary. Two hormones, **oxytocin** and **antidiuretic hormone (ADH),** are produced and released this way. ***Decreased ADH release or decreased renal sensitivity to ADH produces a condition known as* diabetes insipidus.**
- Diabetes insipidus is characterized by polyuria (excess urine production), ***hypernatremia*** (increased blood sodium content) and ***polydipsia*** (thirst).

  Stimulus: nerve impulses from hypothalamus when body water decreases.
- **ADH** is also known as arginine vasopressin (AVP) or simply **vasopressin.**
- **Oxytocin**. is secreted by paraventricular nucleus and a small quantities secreted by supraoptic nucleus in hypothalamus.

  Oxytocin is secreted in both males and females.
- In males facilitates release of sperm in to urethra by causing contraction of vasdeferens.
- In female acts on mammary glands and uterus. **Oxytocin stimulates contraction of myometrium of uterus during labor, and release of milk from mammary glands**.

  Stimulus: nerve impulses from hypothalamus as cervix is stretched or as infant sucks on nipple.

Anterior pituitary (*Adenohypophysis)*

The anterior lobe communication with the hypothalamus occurs through hormones **(releasing hormones and inhibiting hormones)** produced by the hypothalamus and delivered to the anterior pituitary via a network of capillaries. Many of the hormones produced by the anterior pituitary are **(Tropic hormones or tropins** which *are hormones that stimulate other endocrine glands to secrete their hormones*).

The anterior pituitary lobe receives releasing hormones from the hypothalamus via a portal vein system known as the **hypothalamic-hypophyseal portal system**.

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The anterior pituitary secretes

1-Thyroid-stimulating hormone **(TSH)**
2-Adrenocorticotropic hormone **(ACH)**
3-Prolactin **(PRL)**
4-Follicle-stimulating hormone **(FSH)**
5-Luteinizing hormone **(LH)**
6-Growth hormone **(GH)**

The anterior pituitary secrets hormones in response to a variety of chemical signals from the hypothalamus, which travels to the anterior lobe by way of a special capillary system from the hypothalamus down to the anterior lobe.

1- Growth Hormone: - increases amino acid transport into cells and increases protein synthesis; increases rate of mitosis; increases use of fats for energy.

Stimulus: **GHRH** from the hypothalamus.

2- TSH: - increases secretion of thyroxine and T3 by the thyroid.

Stimulus: TRH from the hypothalamus.

3- ACTH: - increases secretion of cortisol by the adrenal cortex.

Stimulus: **CRH** from the hypothalamus.

4- Prolactin—initiates and maintains milk production by the mammary glands.

Stimulus: **PRH** from the hypothalamus.

5-FSH

In women: ***initiates development of ova in ovarian follicles and secretion of estrogen by follicle cells.***

In men: ***initiates sperm development in the testes***.

Stimulus: **GnRH** from the hypothalamus.

6- LH

In women: ***stimulates ovulation, transforms mature follicle into corpus luteum and stimulates secretion of progesterone*.**

In men: *stimulates secretion of testosterone by the testes*.

Stimulus: **GnRH** from the hypothalamus.

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Table 10–2 HORMONES OF THE ANTERIOR PITUITARY GLAND

Hormone	Function(s)	Regulation of Secretion
Growth hormone (GH)	• Increases rate of mitosis • Increases amino acid transport into cells • Increases rate of protein synthesis • Increases use of fats for energy	GHRH (hypothalamus) stimulates secretion GHIH—somatostatin (hypothalamus) inhibits secretion
Thyroid-stimulating hormone (TSH)	• Increases secretion of thyroxine and T_3 by thyroid gland	TRH (hypothalamus)
Adrenocorticotropic hormone (ACTH)	• Increases secretion of cortisol by the adrenal cortex	CRH (hypothalamus)
Prolactin	• Stimulates milk production by the mammary glands	PRH (hypothalamus) stimulates secretion PIH (hypothalamus) inhibits secretion
Follicle-stimulating hormone (FSH)	*In women:* • Initiates growth of ova in ovarian follicles • Increases secretion of estrogen by follicle cells *In men:* • Initiates sperm production in the testes	GnRH (hypothalamus) stimulates secretion Inhibin (ovaries or testes) inhibits secretion
Luteinizing hormone (LH) (ICSH)	*In women:* • Causes ovulation • Causes the ruptured ovarian follicle to become the corpus luteum • Increases secretion of progesterone by the corpus luteum *In men:* • Increases secretion of testosterone by the interstitial cells of the testes	GnRH (hypothalamus)

Thyroid gland

The Thyroid gland is one of the largest endocrine glands in the body. It is positioned on the neck just below the Larynx and has two lobes with one on either side of the trachea. It is involved in the production of two very different hormones. The follicular cells produce **T3** (triiodothyronine) and **T4** (thyroxine), an amine hormone. **These hormones increase the metabolic activity of the body's cells.** The parafollicular cells produce **calcitonin, a peptide hormone**.

The thyroid **calcitonin (thyrocalcitonin)**

Calcitonin job to monitor the level of calcium and phosphorus in the blood, mainly responsible for the ***calcium metabolism processes***, and it has benefit in ***reducing the level of calcium in the blood very quickly*** by inhibiting the pulling process from the bones due to its ***counteracts the parathyroid hormone***.

Calcitonin decreases the plasma level of calcium through 3 main mechanisms:

1) Inhibition of ionized calcium absorption from intestines

2) Inhibition of calcium reabsorption in renal tubule

3) Inhibition of osteoclasts activity

The secretion of calcitonin is increased during hypercalcemia, a state of increased plasmatic calcium. The extent of its physiological impact is disputed, because the

above-mentioned effects occur in vitro only at concentrations that are not commonly found within the human body

- ✓ **The thyroid hormone consists of two components, thyroxine and iodine**.
- ✓ This hormone increases the metabolism of most body cells.
- ✓ A deficiency of iodine in the diet leads to the enlargement of the thyroid gland, known as a simple goiter.

Simple goiter

The signs and symptoms of **hypothyroidism** vary, depending on the severity of the hormone deficiency. Symptoms tend to appear slowly, often up to several years.

You may hardly notice symptoms of hypothyroidism at first, such as fatigue and weight gain. Or it may be due to age. But as your metabolism continues to slow, you may develop more obvious diseases.

Signs and symptoms of hypothyroidism may include:

Tired, Increased sensitivity to cold Constipation Dry skin overweight Facial puffiness Hoarseness Muscle weakness High cholesterol in the blood

Muscle aches, pains, and stiffness. Joint pain, stiffness or swellin

Sl.no	Effects of thyroid hormones	Hypersecretion	Hyposecretion
9.	Gastrointestinal tract	Increases the secretion of digestive juices. There is increased motility of GI tract. The person suffers from diarrhea.	Decreased secretion and decreased motility. The person suffers from constipation.
10.	CNS	Increase in cerebral activity. The person suffers from nervousness, anxiety.	Decrease in cerebral activity. He becomes less alert.
11.	Endocrine glands	Thyroid hormones stimulate the secretion of other endocrine glands because they create a need for their hormones such as insulin, parathyroid hormone & glucocorticoids.	No stimulation of other endocrine glands &there is decrease in secretion of their hormones.
12.	Sexual function	In men, there is increase in libido but excess can lead into impotence. In women, there is oligomennorrhea or reduced bleeding.	In men, there is a loss of libido. In women, loss of libido, excessive bleeding & frequent menstrual bleeding.
13.	Sleep	Though a person feels tired he is not able to sleep.	The person feels drowsy and can sleep for 12 to 14 hours a day.

1- Hypothyroidism: - ***results if there is an insufficient amount of thyroxine***.

Symptoms of hypothyroidism due to a reduction in the rate of oxidative energy-releasing reactions within the body cells (***low metabolic rate*** **LMR)**. Usually the patient shows

- ✓ ***Puffy skin***, ***sluggishness***, and ***lowered vitality***.
- ✓ Other symptoms of hypothyroidism include ***weight gain, decreased libido, inability to tolerate cold, muscle pain and spasm, sleeplessness and breakable nails.***

  Hypothyroidism in children, a condition known as **cretinism**, can result in ***mental retardation, dwarfism, and permanent sexual immaturity.***

  Hypothyroidism in adults, it produces myxedema, characterized by obesity and lethargy

2-Hyperthyroidism: - The thyroid gland produces too much thyroxine.

Hyperthyroidism is caused by an increase in the amount of hormones produced by the gland in the blood. Symptoms of this disease vary from person to person, and are usually linked to an increased metabolic rate in a person. Symptoms of hyperthyroidism are as follows:

Shaking in the hands. Difficulty breathing. Muscle weakness. Nervousness and mood swings, and the patient can suffer from a reduced ability to concentrate. Suffering from diarrhea. Increased appetite. Increased bowel movement and frequent urination. Excessive sensitivity to heat, increased sweating. General fatigue and difficulty sleeping. Neck swelling due to gland enlargement. Nail breakage. Increased chance of developing alopecia. Lack of fertility. Chronic itch. Accelerated heartbeat. Sudden weight loss or gaining. Redness of hands. Problems in the menstrual cycle in women, so that non - existent, or be menstruation

- ✓ This condition produces symptoms such as an ***abnormally high body temperature, profuse sweating, high blood pressure, loss of weight, irritability, and muscular pain and weakness.***
- ✓ ***It also causes the characteristic symptom of the eyeballs protruding from the skull called*** **(exopthalmic goiter**). Hyperthyroidism has been treated by partial removal or by partial radiation destruction of the gland. More recently, several drugs that inhibit thyroid activity have been discovered. Unfortunately, thyroid conditions require lifetime treatment and can take months or even years to regulate.

  The thyroid gland is a ***two-lobed gland*** that manifests a remarkably powerful active transport mechanism for up-taking iodide ions from the blood.
- ✓ As blood flows through the gland, iodide is converted to an active form of iodine. This iodine combines with an amino acid called tyrosine.
- ✓ Two molecules of iodinated tyrosine then combine to form thryroxine (T4).

- ✓ Following its formation, the thyroxine becomes bound to a polysaccharide-protein material called thyroglobulin.
- ✓ **The normal thyroid gland may store several weeks supply of thyroxine in this bound form**.
- ✓ An enzymatic splitting of the thyroxine from the thyroglobulin occurs when a specific hormone is released into the blood. This hormone, produced by the pituitary gland, is known as thyroid-stimulating hormone **(TSH).**
- ✓ **Thyroid gland produce two different types of hormones: -**

1- Thyroxine

(T4) and (**T3)** produced by thyroid follicles.

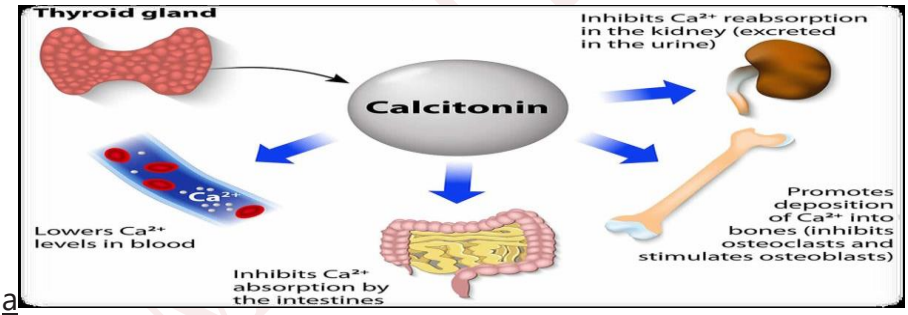
- **Increase use of all food types for energy and increase protein synthesis**.
- **Necessary for normal physical, mental, and sexual development.**

Stimulus: TSH from the anterior pituitary.

2- Calcitonin: - Produced by para-follicular cells.

- **Decreases resorption of calcium from bones and lowers blood calcium lev*el***.

Stimulus: hypercalcemia



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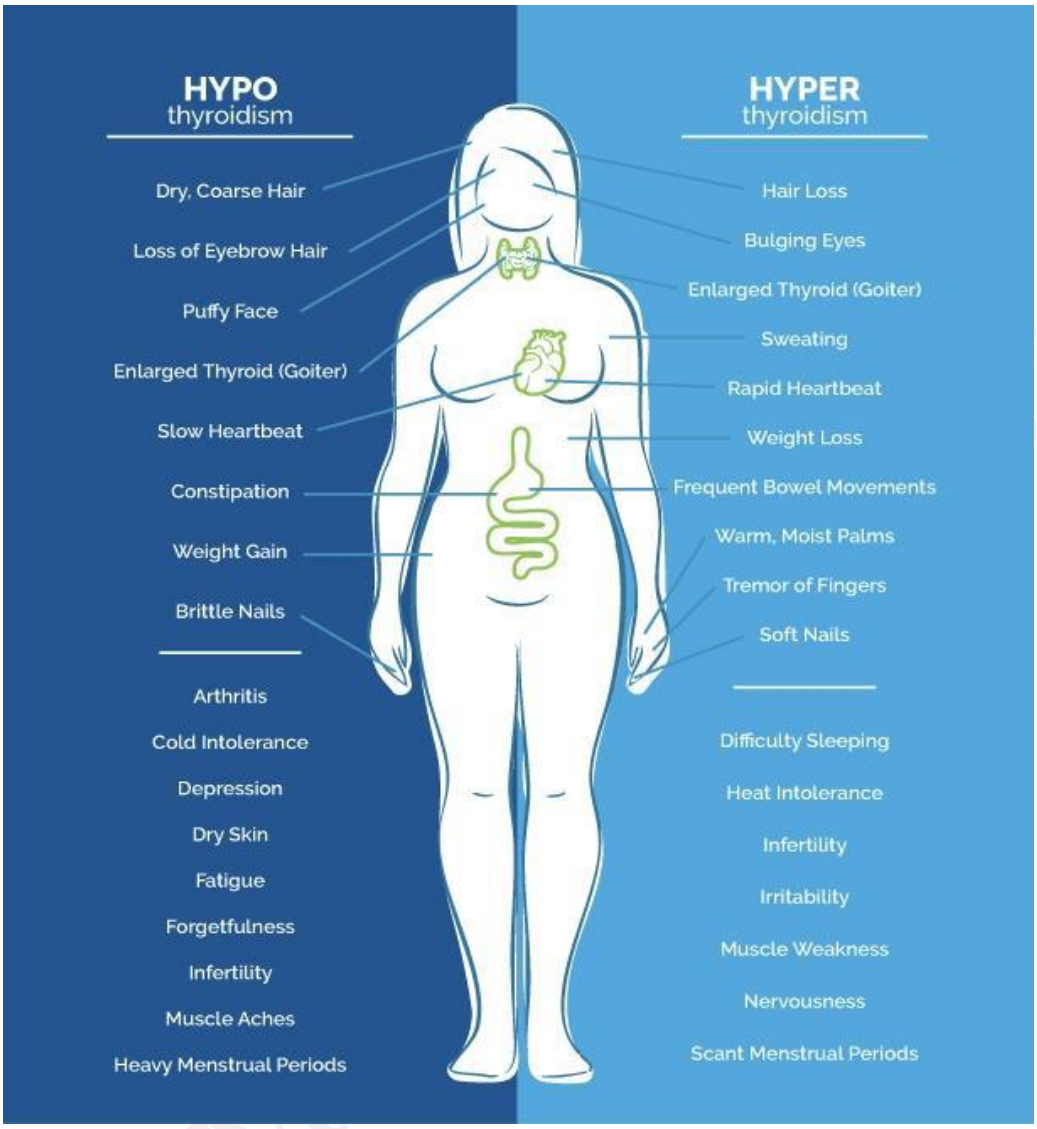

Fig 2. Functions of thyroxine and T3.

Parathyroid Glands

Four lobes; two on posterior of each lobe of thyroid

PTH: -

1- Increases resorption of calcium and phosphate from bones to the blood;

2-Increases absorption of calcium and phosphate by the small intestine;

3- Increases reabsorption of calcium and excretion of phosphate by the kidneys, & activates vitamin D.

Result: raises blood calcium and lowers blood phosphate levels.

Stimulus: *hypocalcemia*. ***Inhibitor:*** *hypercalcemia*.

Pancreas Lect.3

Pancreas extends from curve of duodenum to the spleen.

Islets of Langerhans contain **alpha cells** (**α**) and **beta cells** (**β**).

1- Glucagon: - Secreted by **alpha cells** (**α**).

Stimulates liver to change glycogen to glucose;

Increases use of fats and amino acids for energy.

Result: *raises blood glucose level.*

Stimulus: *hypo*glycemia.

2- Insulin: - secreted by **beta cells** (**β**).

Increases use of glucose by cells to produce energy; stimulates liver and muscles to change glucose to glycogen;

Increases cellular intake of fatty acids and amino acids to use for synthesis of lipids and proteins.

Result: *lowers blood glucose level.*

Stimulus: hyperglycemia.

3-Somatostatin: -

Inhibits secretion of insulin and glucagon.

Epinephrine & Glucagon *increases glyconeogeolysis (breakdown of glycogen).These hormones are the major counter-regulatory hormones for protection against hypoglycemia.These hormones are secreted in response to hypoglycemia, & increase blood glucose predominantly by increasing glycogenolysis.*

In fasting state: increase glucagon & increase epinephrine → stimulate adenylyl cylase → increase cAMP → increase protein kinase A → stimulate glycogen phosphorylase → break down glycogen for usage.

When the plasma glucose concentration is low, there is an increase in the body secretion of epinephrine, glucagon, and, to a lesser extent cortisol and growth hormone.

- ***Cortisol increases the transcription of enzymes involved in gluconeogenesis (formation of glucose from fat & protein substrate).***
- ***Insulin action is opposed by a glucagon, epinephrine, cortisol, and growth hormone.***
- ***Thus, cortisol decreases the action of insulin, thus, cortisol increases serum glucose.***

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In liver, epinephrine and glucagon inhibit glycogen synthase that produce glycogen from glucose. They also stimulate glycogen phosphorylase to break down glucagon and produces glucose. Epinephrine also work the same way in skeletal muscle glycogen synthase and phosphorylase.

Corticosteroids increase insulin resistance thus allowing blood glucose levels to rise and remain higher. ***Steroid Diabetes***

Type 2 diabetes is more likely to develop following longer term usage of steroids, such as usage of oral corticosteroids for longer than 3 months

High blood glucose levels whilst taking steroids may subside after you stop taking steroids, however, some people may develop type 2 diabetes which will need to be managed for life.

Symptoms of Steroid Diabetes

1.Dry mouth ***2. Blurred vision***

3. Increased thirst ***4. Increased need to urinate***

5. Tiredness and lethargy

Adrenal Glands

One on top of each kidney; each has an inner adrenal medulla and an outer adrenal cortex.

Adrenal Medulla

Produce **catecholamines** in stress situations.

1- Norepinephrine: -

Stimulates vasoconstriction and raises blood pressure.

2- Epinephrine

- **Increases heart rate and force.**
- **Causes vasoconstriction in skin and viscera and vasodilation in skeletal muscles.**
- **Dilates bronchioles.**
- **Slows peristalsis.**
- **Causes liver to change glycogen to glucose;**
- **Increases use of fats for energy.**
- **Increases rate of cell respiration.**

Stimulus: sympathetic impulses from the hypothalamus.

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Adrenal Cortex

Produces;

1- Mineralocorticoids,

2-Glucocorticoids,

3- Androgens very small amounts of sex hormones: At puberty, the growth of body hair is stimulated by androgens. The typical pattern of hair growth in males is associated with the secretion of significant levels of testosterone.

In females, both the ovaries and adrenal glands produce small amounts of androgens that influence the development of hair (Fig 3).

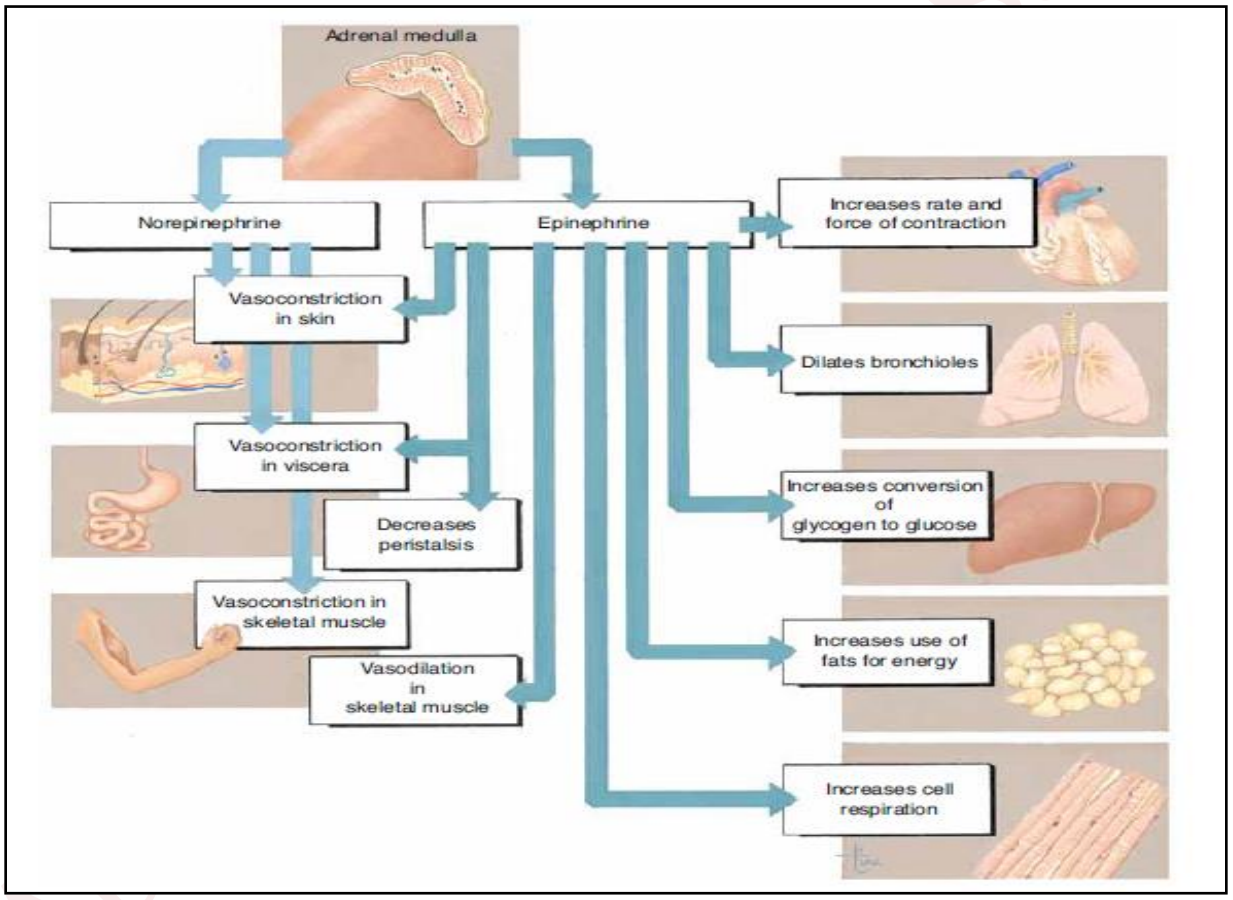

Figure 3. Functions of epinephrine and norepinephrine

1. Aldosterone (Mineralocorticoids):-

<u>Increases reabsorption of sodium and excretion of potassium by the kidneys</u>.

Results: hydrogen ions are excreted in exchange for sodium; chloride and bicarbonate ions and water follow sodium back to the blood; maintains normal blood pH, blood volume, and blood pressure.

Stimulus: decreased blood sodium or elevated blood potassium; decreased blood volume or blood pressure (activates the renin-angiotensin mechanism of the kidneys).

2-Cortisol (Glucocorticoids):-

- **Increase the use of fats and amino acids for energy;**
- **Decreases use of glucose to conserve glucose for the brain;**
- **Anti-inflammatory effect:** blocks effects of histamine and stabilizes lysosomes to prevent excessive tissue damage.

Stimulus: ACTH from hypothalamus during physiological stress.

Ovaries

In pelvic cavity on either side of uterus

1- Estrogen

Estrogens are steroid hormones present in both males and females but in significantly higher quantities in females where they are the primary female sex hormone.

- They are produced primarily by ***developing follicles*** *in the* ***ovaries****, the* ***corpus luteum*** *and* ***the placenta.***
- **Promotes maturation of ovum**;
- **Stimulates growth of blood vessels in endometrium;**
- **Stimulates development of secondary sex characteristics.**
- **Growth of duct system of mammary glands.**
- **Growth of uterus.**
- **Fat deposition.**
- **Promotes closure of epiphyses of long bones.**
- **Lowers blood levels of cholesterol and triglycerides.**

Stimulus: FSH from anterior pituitary.

2- Progesterone: -

Produced by the **corpus luteum**.

- **Promotes storage of glycogen and further growth of blood vessels in the endometrium.**
- **Promotes growth of secretory cells of mammary glands.**

Stimulus: LH from anterior pituitary.

3-Inhibin:-

Inhibits secretion of **FSH.**

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Testes

In scrotum between the upper thighs

1- Testosterone: -

Produced by interstitial cells.

- **Promotes maturation of sperm in testes;**
- **stimulates development of secondary sex characteristics: growth of reproductive organs, facial and body hair, larynx, skeletal muscles;**
- **Promotes closure of epiphyses of long bones.**

Stimulus: LH from anterior pituitary.

2- Inhibin: -

Produced by sustentacular cells.

Inhibits secretion of FSH to maintain a constant rate of sperm production.

Stimulus: increased testosterone.

Antagonistic Hormones Lect.4

Maintaining homeostasis often requires conditions to be limited to a narrow range. ***The two glands that are the most responsible for homeostasis is the thyroid and the parathyroid.*** The regulation of blood glucose concentration (***through negative feedback***) illustrates how the endocrine system maintains homeostasis by the action of antagonistic hormones. Bundles of cells in the pancreas ***called the islets of Langerhans*** contain two kinds of cells, *alpha cells* **(α)** and *beta cells* **(β). *These cells control blood glucose concentration by producing the antagonistic hormones insulin and glucagon***.

When the concentration of blood glucose rises after eating, **beta cells** secret **insulin** into the blood. Insulin stimulates the liver and most other body cells to absorb glucose. ***Liver and muscle cells convert glucose to glycogen***, for short term storage, and ***adipose cells convert glucose to fat.*** In response, glucose concentration decreases in the blood, and insulin secretion discontinues through negative feedback from declining levels of glucose. ***When the concentration of blood glucose drops such as during exercise***, **alpha cells** secrete **glucagon** into the blood.

- ✓ **Glucagon** stimulates the liver to release glucose.
- ✓ The glucose in the liver originates from the breakdown of glycogen.
- ✓ Glucagon also stimulates the production of ketone bodies from amino acids and fatty acids. Ketone bodies are an alternative energy source to glucose for some tissues.

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When blood glucose levels return to normal, glucagon secretion discontinues through **negative feedback.**

Another example of antagonistic hormones occurs in the maintenance of **Ca2+** ion concentration in the blood.

- ✓ **Parathyroid hormone (PTH**) from the parathyroid glands increases **Ca2+** in the blood by ***increasing Ca2+ absorption in the intestines and reabsorption in the kidneys and stimulating Ca2+ release from bones.***
- ✓ **Calcitonin (CT)** ***produces the opposite effect*** by ***inhibiting the breakdown of bone matrix and decreasing the release of calcium in the blood***.

Endocrine Tissue Hormones

The *pineal, heart, gastrointestinal tract, Thymus, the placenta, the kidneys and the skin*, whose major function is not the secretion of hormones, also contain some specialized cells that produce hormones, they are known as endocrine tissues. In addition, all cells, except red blood cells secrete a class of hormones called eicosanoids. These hormones are paracrine, or local hormones, that primarily affect neighboring cells. Two groups of eicosanoids, the prostaglandins (PGs) and the leukotrienes (LTs), have a wide range of varying effects that depend upon the nature of the target cell. Eicosanoid activity, for example, may impact blood pressure, blood clotting, immune and inflammatory responses, reproductive processes, and the contraction of smooth muscles.

Pineal Gland

Pineal gland is located above the hypothalamus. Pineal gland has two types of cells:

1. Large epithelial cells called *parenchymal* cells

2. Neuroglial *cells*. In adult's pineal gland is **calcified**. But, the epithelial cells exist and secrete the hormonal substance.

Functions of pineal gland:-

1. It controls the sexual activities in animals by regulating the seasonal fertility. Pineal gland plays little role in regulating the sexual functions in human being

2. It secretes the hormonal substance called melatonin.

Melatonin is secreted by the parenchymal cells of pineal gland.

Melatonin: -

(N-acetyl-5-methoxytryptamine).

Actions of melatonin

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- **Melatonin acts mainly on gonads**.
- **In humans, it inhibits the onset of puberty by inhibiting the gonads.**

Melatonin secretion is more in darkness than in daylight.

In animals, the secretion of melatonin varies according to activities in different periods of the day, i.e. circadian rhythm. Hypothalamus is responsible for the circadian fluctuations of melatonin secretion.

Thymus gland

Thymus is situated in front of trachea, below the thyroid gland. Thymus is small in newborn infants and gradually enlarges till puberty and then decreases in size. Thymus has two functions:

1- Thymus has lymphoid function processing the T lymphocytes. It plays an important role in development of immunity in the body.

The lymphocytes which are produced in bone marrow are processed in thymus into T lymphocytes. It occurs during the period between **3** months before birth and **3** months after birth.

2. Thymus secretes two hormones:

A) Thymosin

B) Thymin.

Thymosin is a peptide. It accelerates lymphopoiesis and increase of T lymphocytes. Thymin is also called **thymopoietin.** It suppresses the neuromuscular activity by inhibiting acetylcholine release. **Hyperactivity of thymus causes myasthenia gravis**.

Kidney Hormones

Kidneys secrete five hormonal substances:

1. Erythropoietin

2. Thrombopoietin

3. Renin

4. 1, 25-dihydroxycholecalciferol (calcitriol)

5. Prostaglandins.

Recently discovered that kidney secretes small quantity of ***C-type natriuretic peptide*** **(CNP).**

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1- ERYTHROPOIETIN: Endothelial cells of peritubular capillaries in the kidney secrete erythropoietin. The stimulant for its secretion is hypoxia. Erythropoietin is a glycoprotein with **165 amino acids**. ***Erythropoietin stimulates the bone marrow and causes erythropoiesis.***

2- THROMBOPOIETIN is a glycoprotein secreted by kidneys and liver. ***It stimulates the production of platelets.***

3- RENIN: The granular cells of juxtaglomerular apparatus of the kidney secrete renin. When renin is released into the blood, it acts on a specific plasma protein called **alpha-2 globulin.** It is also called angiotensinogen or **renin substrate.** Renin converts **angiotensinogen** into **angiotensin I,** which is converted into **angiotensin II** by a converting enzyme.

4- Calcitriol 1, 25-Dihydrocalciferol

1, 25-dihydroxycholecalciferol is otherwise known as **calcitriol** or **activated vitamin D.** It is formed from cholecalciferol, which is present in skin and intestine. The cholecalciferol **(vitamin D3)** from skin or intestine is converted into **25-**hydroxycholecalciferol in liver. This in turn, is activated into **1, 25-dihydroxycholecalciferol** by parathormone in kidney. **The activated vitamin D plays an important role in the maintenance of blood calcium level. It acts on the intestinal epithelium and enhances absorption of calcium from intestine into the blood.**

5-Prostaglandiens

Synthesized by juxtaglomerular cells and **type I** interstitial cells present in medulla of kidney cells from the phospholipids of their cell membranes; **exert their effects locally**. **Involved in inflammation and pain, reproduction, nutrient metabolism, changes in blood vessels, blood clotting**, **diuresis and natriuresis.**

HEART

Heart secretes the hormones **atrial natriuretic peptide**, recently, another peptide called **C-type natriuretic peptide** is found in heart.

Atrial Natriuretic Peptide

Atrial natriuretic peptide **(ANP)** is a polypeptide with **28** amino acids. It is secreted by **atrial musculature** of the heart. Recently, it is found in hypothalamus of brain also.

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However, its action in brain is not known. ANP is secreted during overstretching of atrial muscles in conditions like increase in blood volume. ANP, in turn increases excretion of sodium (followed by water excretion) through urine and helps in the maintenance of extracellular fluid (ECF) volume and blood volume. It also lowers blood pressure.

Atrial natriuretic peptide increases excretion of sodium ions through urine by:

1. Increasing glomerular filtration rate by relaxing **mesangial cells** and dilating afferent arterioles.

2. Inhibiting sodium reabsorption from distal convoluted tubules and collecting ducts in kidneys.

3. Increasing the secretion of sodium into the renal tubules. *Escape phenomenon* Thus, ANP is responsible for escape phenomenon and prevention of edema in **primary hyperaldosteronism,** in spite of increased ECF volume.

ANP decreases the blood pressure by:

1. Vasodilatation by relaxing the smooth muscle fibers, mainly in arterioles and venules

2. Inhibiting renin secretion from juxtaglomerular apparatus of kidney

3. Inhibiting vasoconstrictor effect of angiotensin II

4. Inhibiting vasoconstrictor effects of catecholamine's.

BRAIN

Brain Natriuretic Peptide

Brain natriuretic peptide (BNP) is also called B-type natriuretic peptide. It is a polypeptide with **32** amino acids. It is secreted by the cardiac muscle. It is also secreted in some parts of the brain. The stimulant for its secretion is not known. BNP has same actions of ANP. On brain, its actions are not known.

C--type natriuretic peptide

C-type natriuretic peptide (CNP) it was identified in brain. Now, it is known to be secreted by several tissues which include myocardium, endothelium of blood vessels, gastrointestinal tract and kidneys. The functions of this hormone are not fully studied. It is believed that it has similar action of atrial natriuretic peptide.

Gastrointestinal hormones

GIT can be divided into following groups based upon their chemical structure.

1-<u>Gastrin:-</u> cholecystokinin family: **Gastrin** and **cholecystokinin**

2-<u>Secretin family</u>: **secretin**, **glucagon**, **vasoactive intestinal peptide and gastric inhibitory peptide**

3-<u>Somatostatin family</u>

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4-Motilin family

Mechanisms of Hormone Action

Hormones activate target cells by one of two methods, depending upon the chemical nature of the hormone.

Hormone affects cells that have specific receptors for it.

Receptors are proteins that may be part of the cell membrane, or within the cytoplasm or nucleus of the target cell.

1-Lipid-soluble hormones
(Steroid hormones and hormones of the thyroid gland)

Diffuse through the cell membranes of target cells. The lipid-soluble hormone then binds to a receptor protein that, in turn, activates a DNA segment that turns on specific genes. The proteins produced as result of the transcription of the genes and subsequent translation of mRNA act as enzymes that regulate specific physiological cell activity.

2-Water-soluble hormones

(Polypeptide, protein, and most amino acid hormones)

Bind to a receptor protein on the plasma membrane of the cell. The receptor protein, in turn, stimulates the production of one of the following second messengers:

A) - **Cyclic AMP (cAMP)** is produced when the receptor protein activates another membrane bound protein called a **G** protein. The **G** protein activates **adenylate cyclase,** the enzyme that catalyzes the production of **cAMP** from ATP. Cyclic AMP then triggers an enzyme that generates specific cellular changes.

B) - Inositol triphosphate (IP3) is produced from membrane phospholipids. **IP3**, in turn, triggers the release of Ca_2^+ from the endoplasmic reticulum, which then activates enzymes that generate cellular changes.

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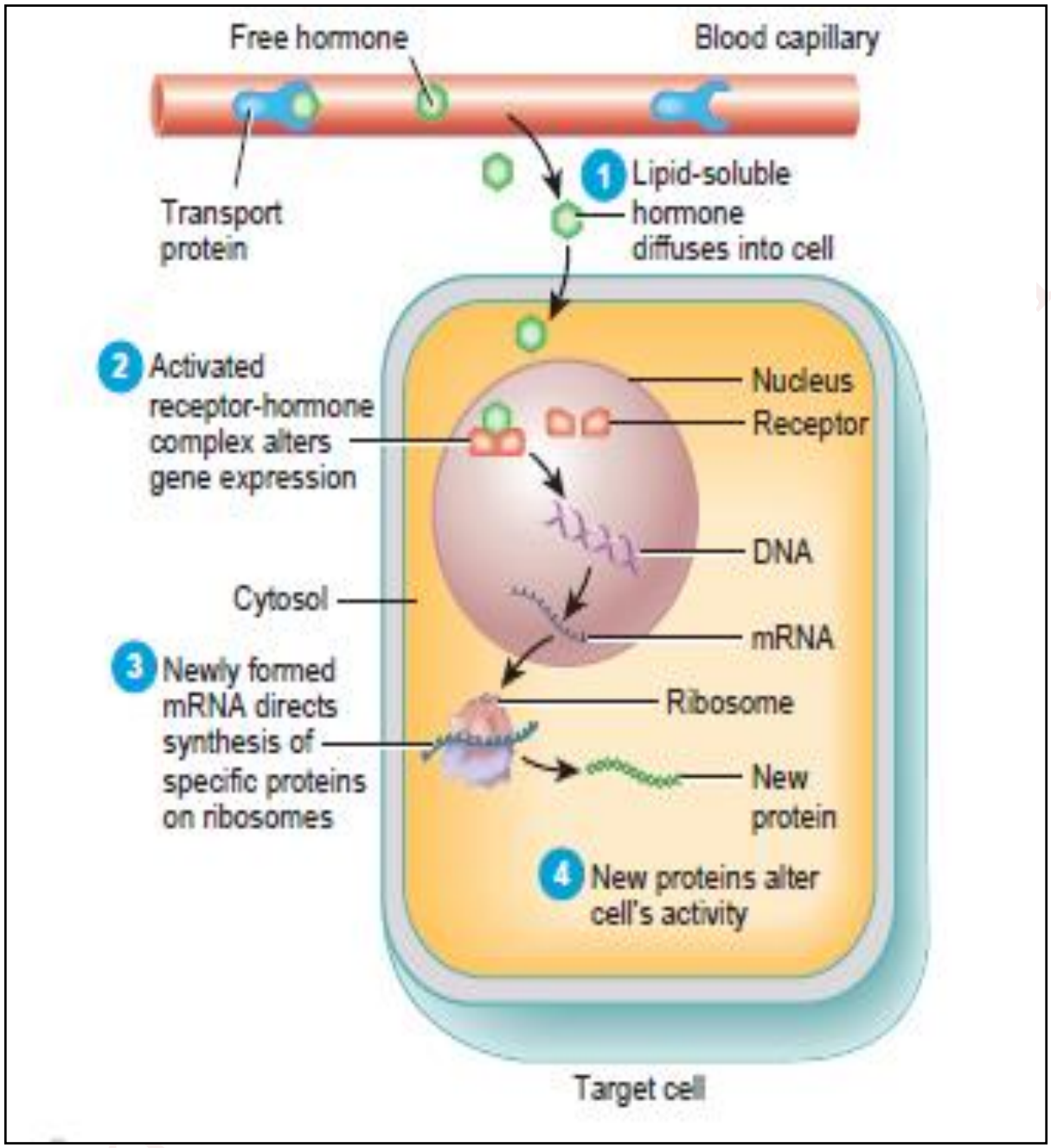
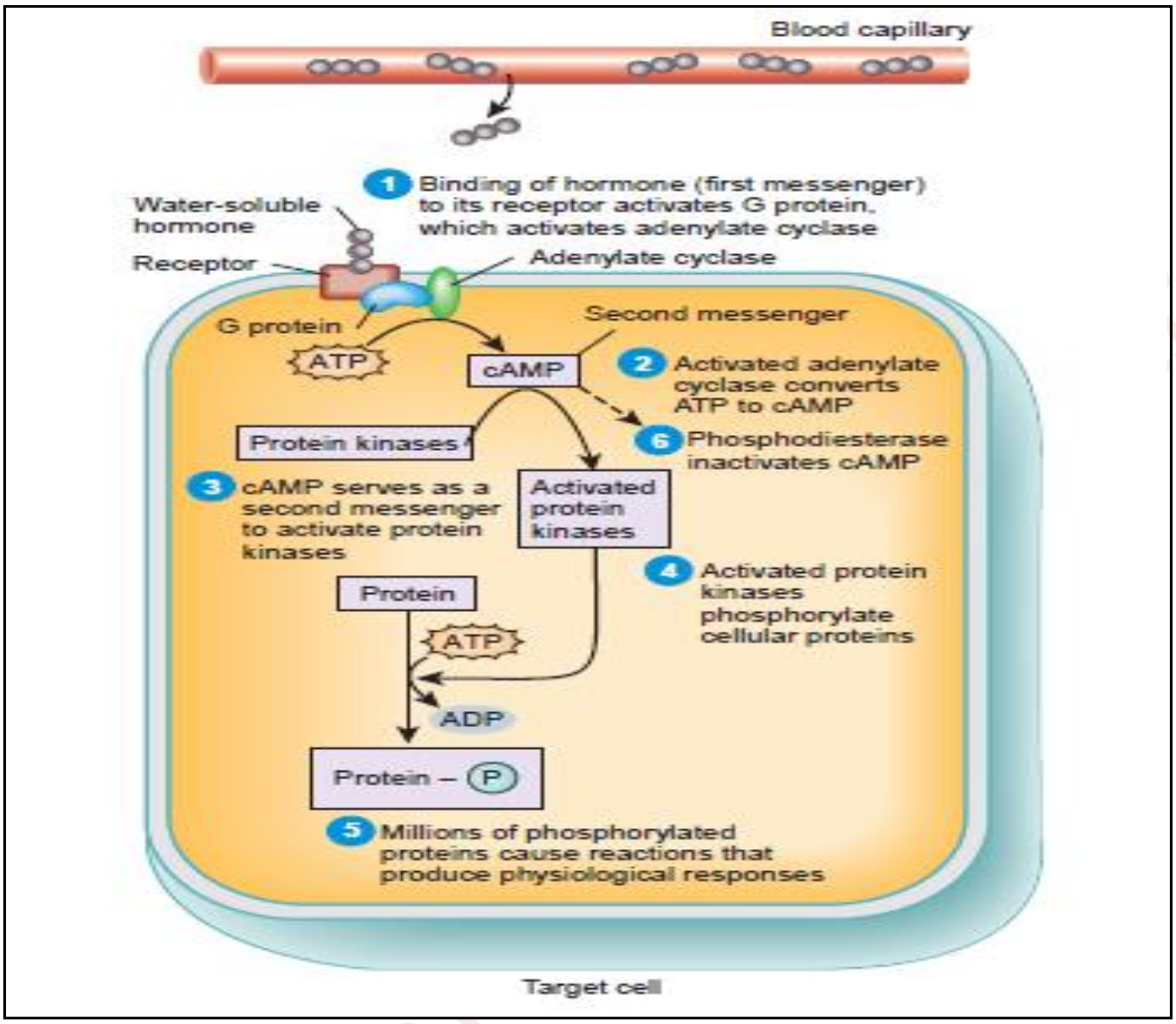


Mechanism of action of the lipid-soluble steroid hormones and thyroid hormones

Lipid-soluble hormones bind to receptors inside target cells



Mechanism of action of the water-soluble hormones (Amines, peptides, proteins).

Water-soluble hormones bind to receptors embedded in the plasma membranes of target cells.

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