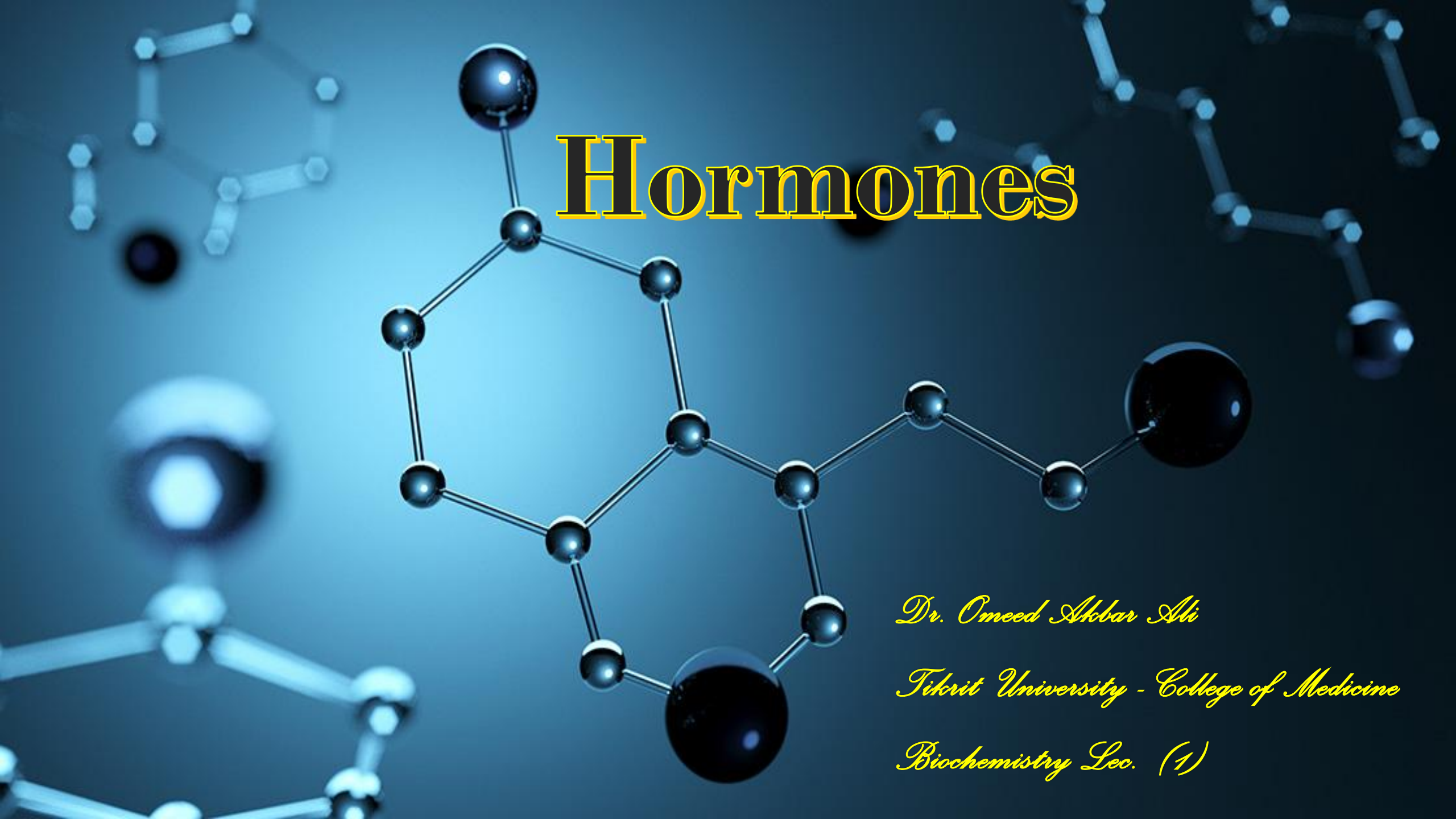

# Hormones

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*Biochemistry Lec. (1)*

# About this Lecture

- Expand on integration of chemical and nervous coordination
- Classification, structure and synthesis of hormones
- Form and function of key endocrine glands
- Pathways of nervous to endocrine regulation
- How target cells/tissues are impacted
- Some pathologies of the endocrine system

# What are Hormones?

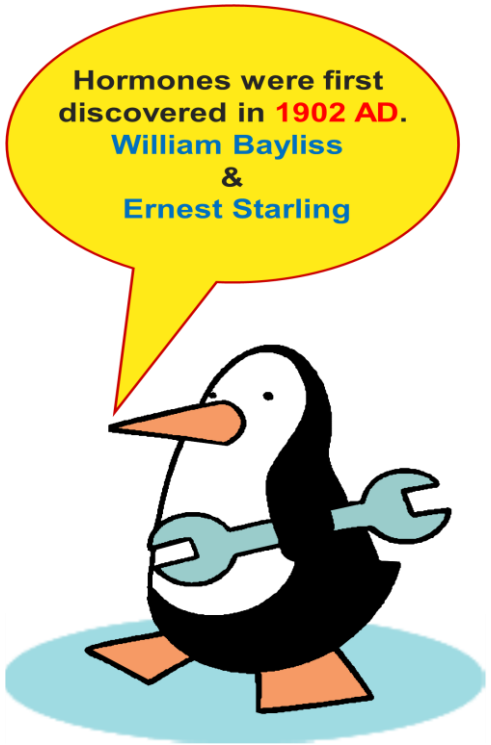
- Hormones are chemicals synthesized and produced by the specialized glands to control and regulate the activity of certain cells and organs.

  - such as: digestion, metabolism, breathing, sensory perception, sleep, output, breastfeeding, stress, growth, development, movement, reproduction, mood, tissue function and Homeostasis.

## Scientific Nomenclature:

- The word hormone originates from the **Greek language** and means to excite, which is to induce the effectiveness.

✓ The discovery of hormones and signs of the endocrine glands occurred during studies of how the digestive system regulates its activities where the hormone (Secretin) was observed.



# Mechanism of Action

✓- Our bodies depend entirely on the **hormone-secreting glandular system** and the **nervous system** that sends neurotransmitters to control various functions and organs.

❖ **By Cell Signaling**

The effects of hormones depend on how they are released. Hence, signaling effects can be classified into the following:

**Intracrine:** The hormone is produced in the cell and acts intracellularly means inside the cell.

**Autocrine:** The hormone act on the cell that secreted it.

**Paracrine:** The hormone act on a near by cell without having to enter the blood circulation.

**Endocrine:** The hormone act on the target cells once it is released from the respective glands into the bloodstream.

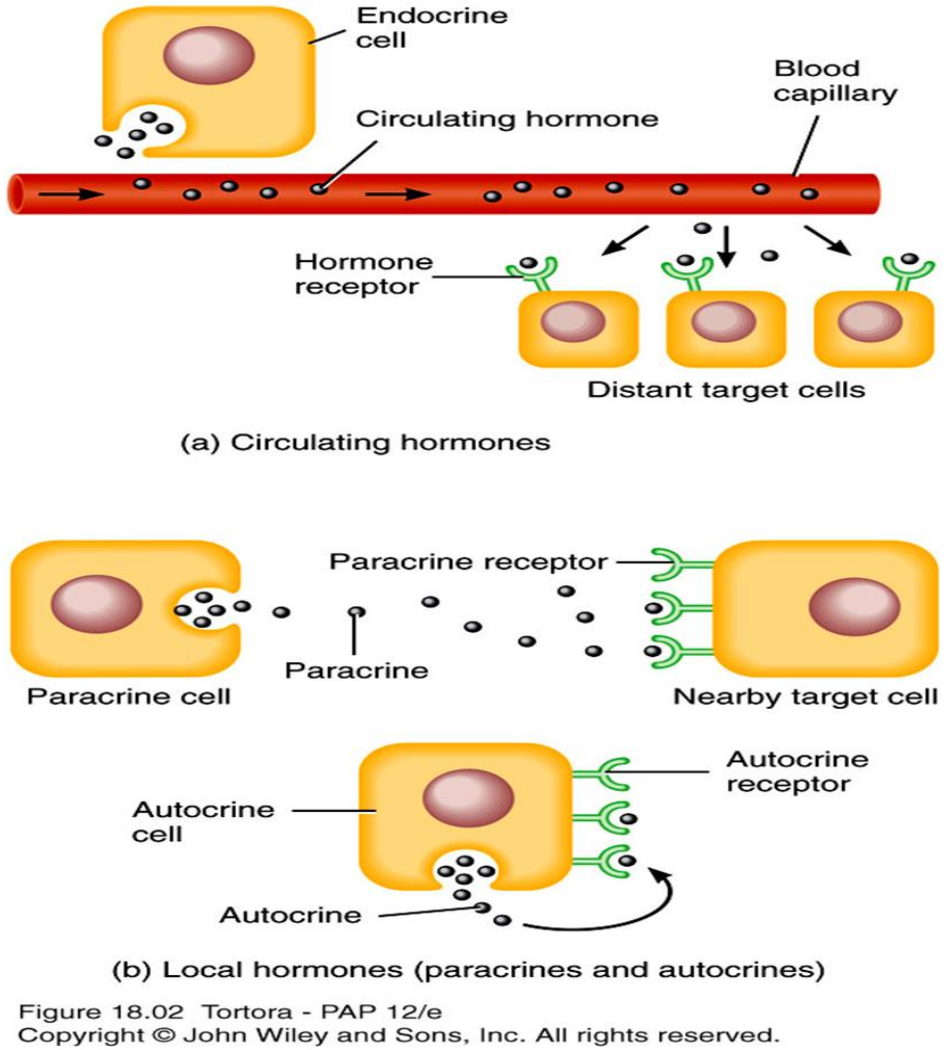
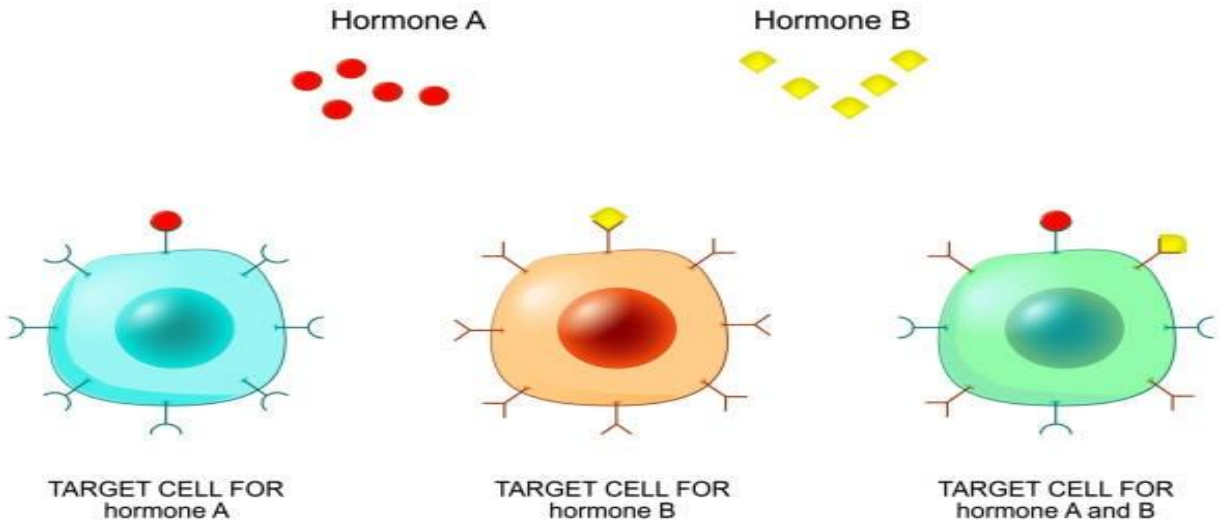
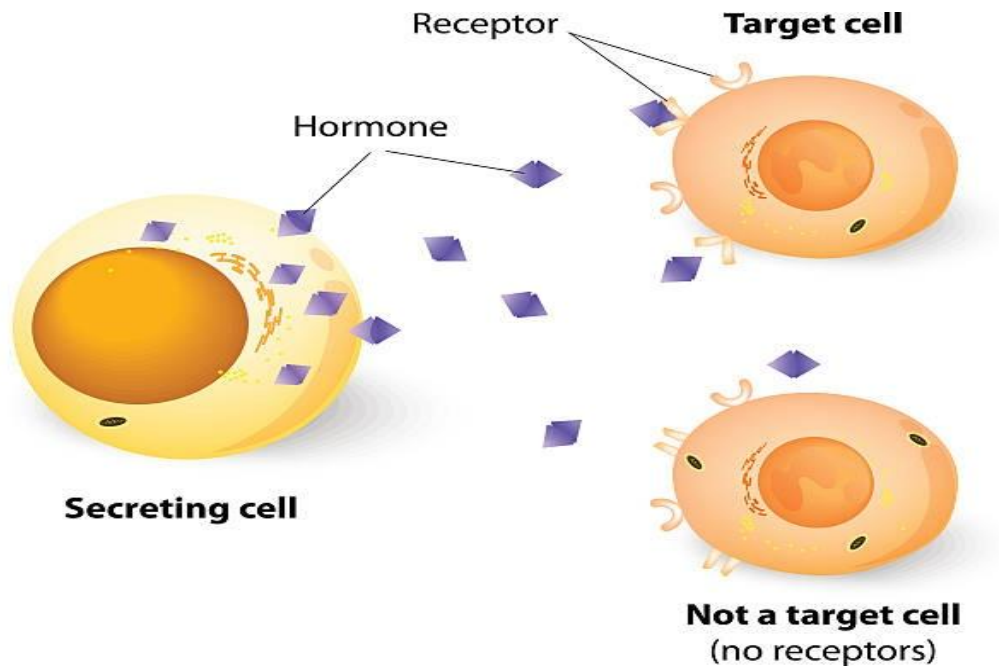



Figure 18.02 Tortora - PAP 12/e

# Hormones and target cells



# Mechanism of Hormone Action

- **Hormones produce one or more of the following cellular changes in target cells**
  - Alter plasma membrane permeability
  - Stimulate protein synthesis
  - Activate or deactivate enzyme systems
  - Induce secretory activity
  - Stimulate mitosis

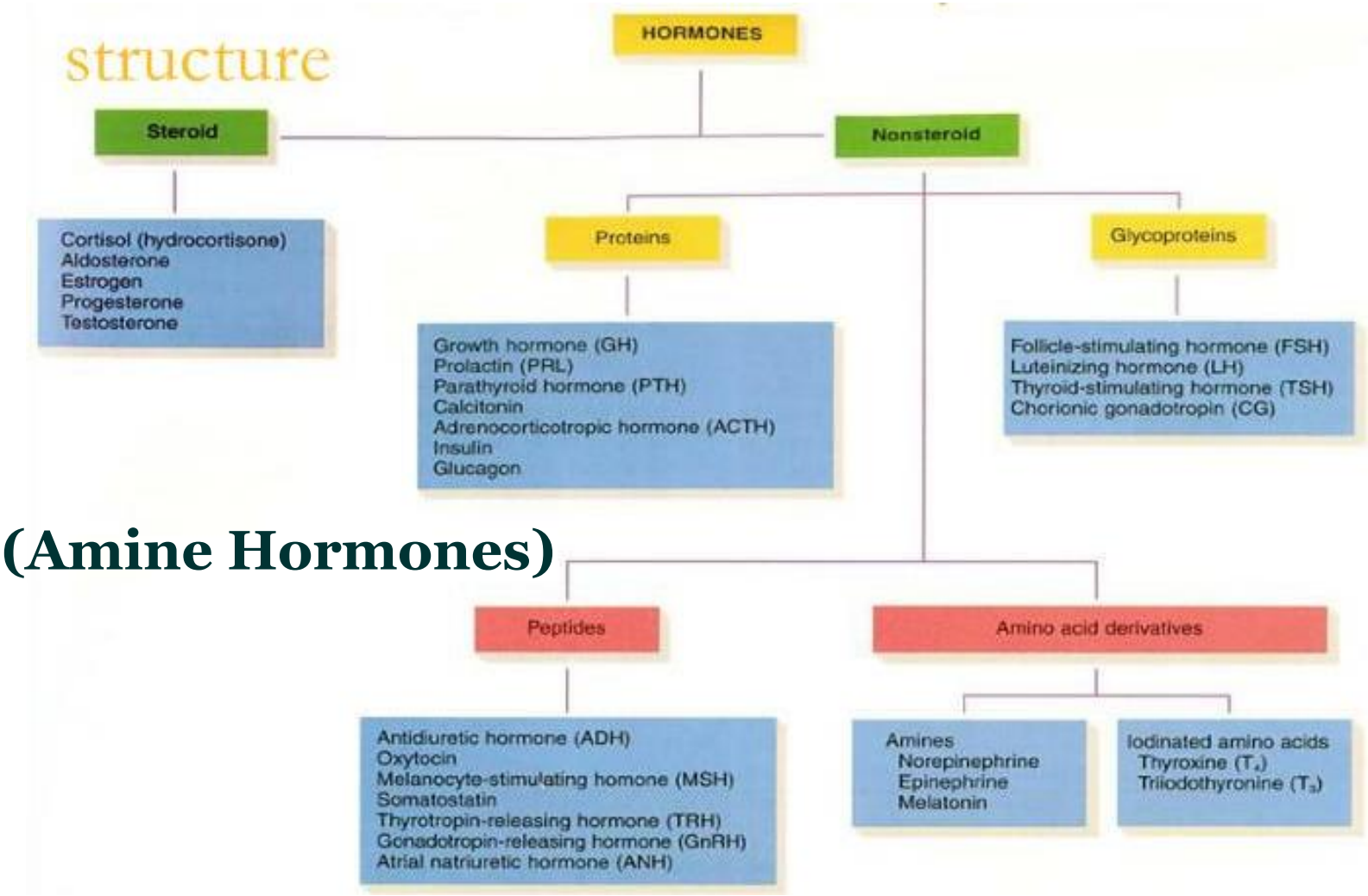
# Chemical Regulating Systems: Overview

- **Hormones:** Cell to cell communication molecules
  - Made in gland(s) or cells
  - Transported by blood
  - Distant target tissue receptors
  - Activates physiological response

# Classification hormones:

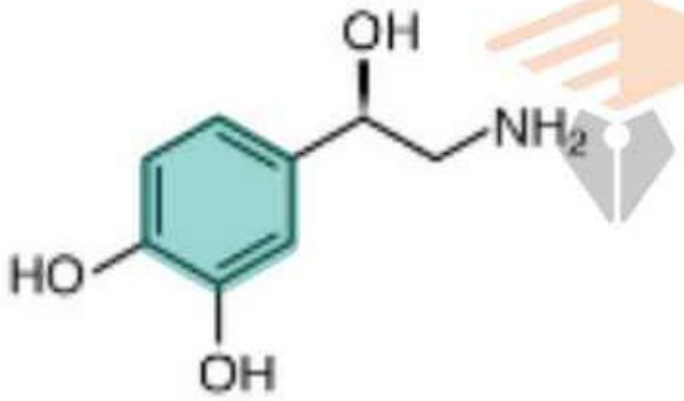
❖- **First:** **According to chemical structure**

- Three types
  - **Proteins (Nonsteroid)**
    - ✓ Glycoproteins
    - ✓ Small peptides
    - ✓ Large proteins
  - **Amino acid derivatives (Amine Hormones)**
  - **Lipids (Steroid)**
    - ✓ Cholesterol derivatives
    - ✓ Eicosanoids

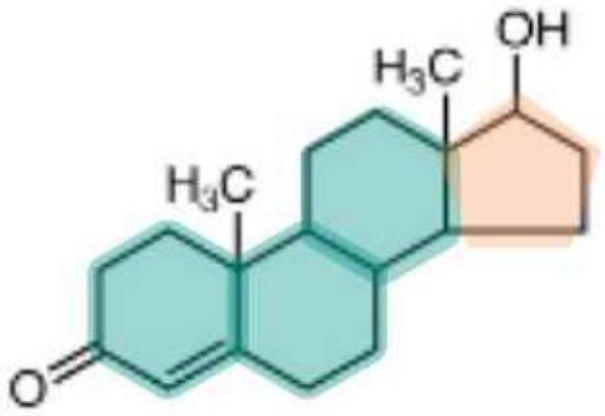


## ❖- Chemical Structure

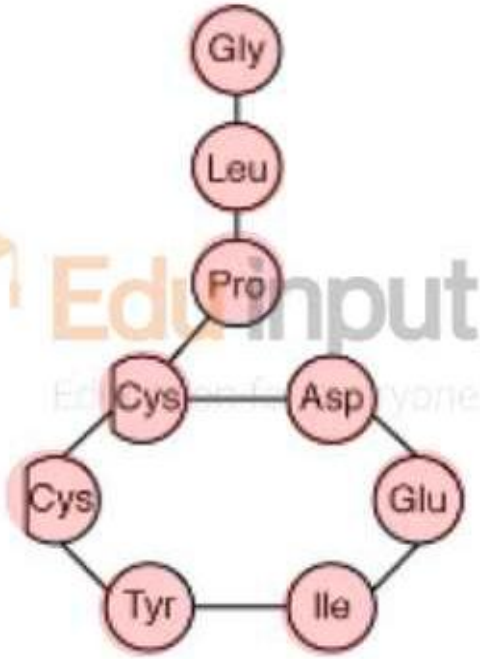
### Amine Harmone




### Steroid Harmone

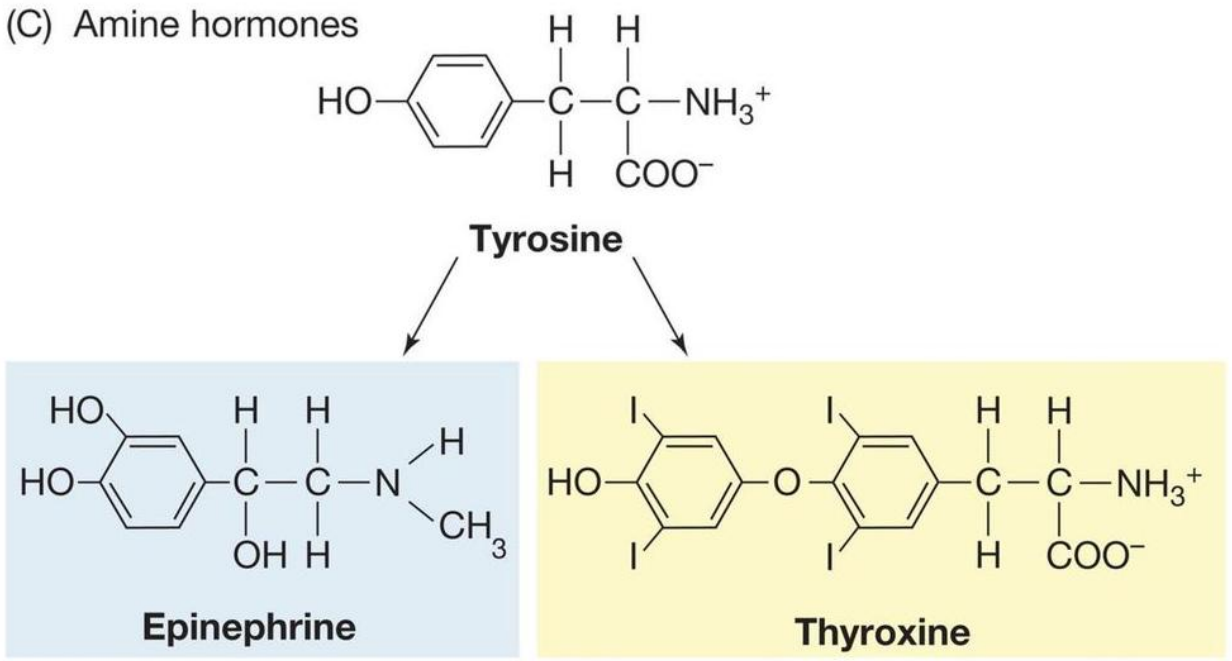



### Peptide Harmone

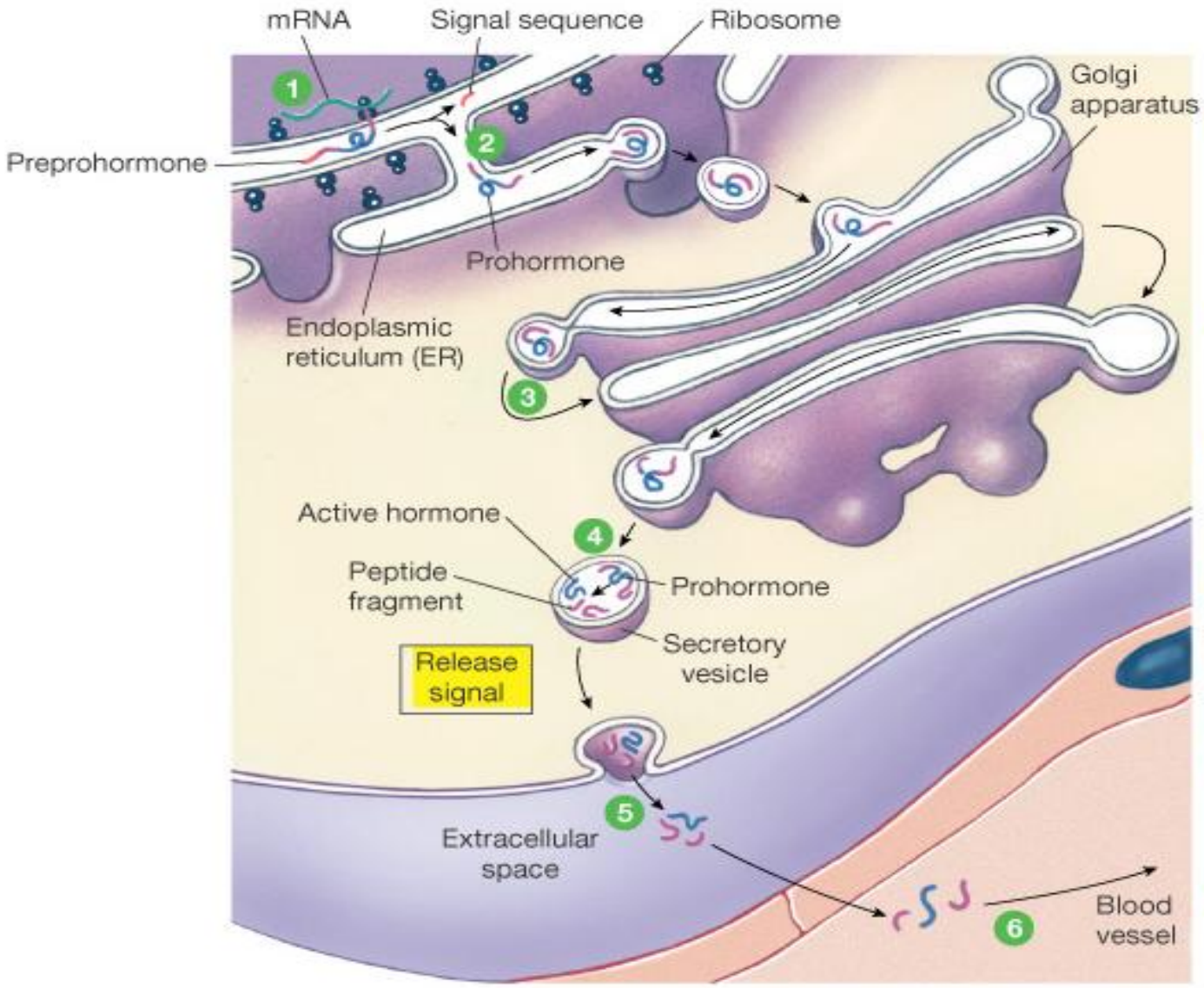


# Amine Hormone Structures and Functions

- Made of 1-2 amino acids, derived from **tyrosine** or **tryptophan**
- Receptors
  - Surface
  - Intracellular
- Small size, OH group
- Benzine ring
- Examples: Thyroxin , Epinephrine



# Protein and Polypeptide Hormones: Synthesis and Release




1. Messenger RNA on the ribosomes of the ER binds amino acids into a peptide chain called a **preprohormone**. The chain is directed into the ER lumen by a **signal sequence** of amino acids.
2. Enzymes in the ER chop off the signal sequence, creating an inactive **prohormone**.
3. The prohormone passes from the ER through the Golgi apparatus.
4. Secretory vesicles containing enzymes and prohormone bud off the Golgi. The enzymes chop the prohormone into one or more active peptides plus additional peptide fragments.
5. The secretory vesicle releases its contents by exocytosis into the extracellular space.
6. The hormone moves into the circulation for transport to its target.

Figure 7-3: Peptide hormone synthesis, packaging, and release

# Protein and Polypeptide Hormone Receptors

- Surface receptor
- Hormone binds
  - - Transduction
  - ✓ - Enzyme activation
  - ✓ - Open channels
  - - Second messenger systems
  - ✓ - Synthesis

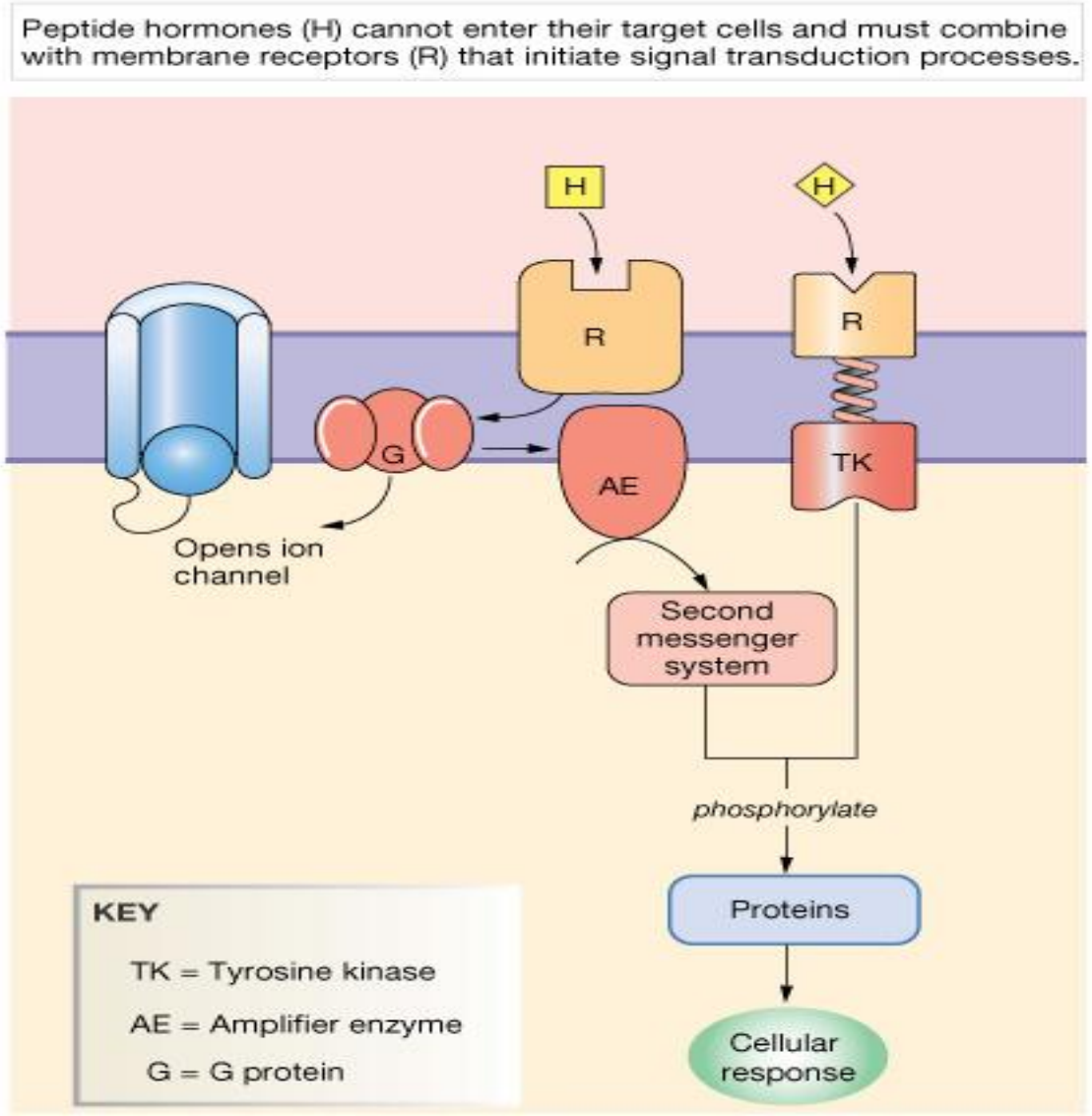
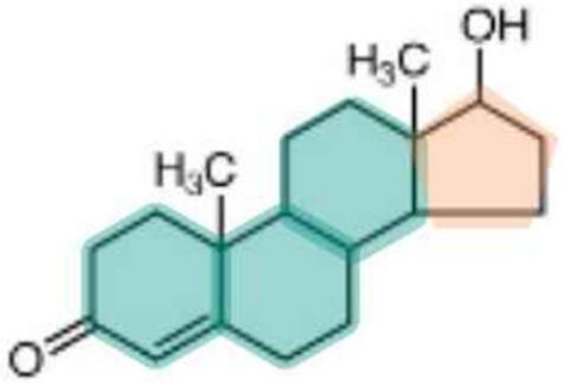



Figure 7-5: Membrane receptors for peptide hormones

# Steroid Hormones: Structure and Action

- From cholesterol, lipophilic, enter target cell,
  - ✓- Cytoplasmic or nuclear receptors (mostly)
  - ✓- Activate DNA for protein synthesis
- Examples: cortisol, estrogen & testosterone



# Steroid Hormones: Structure and Action

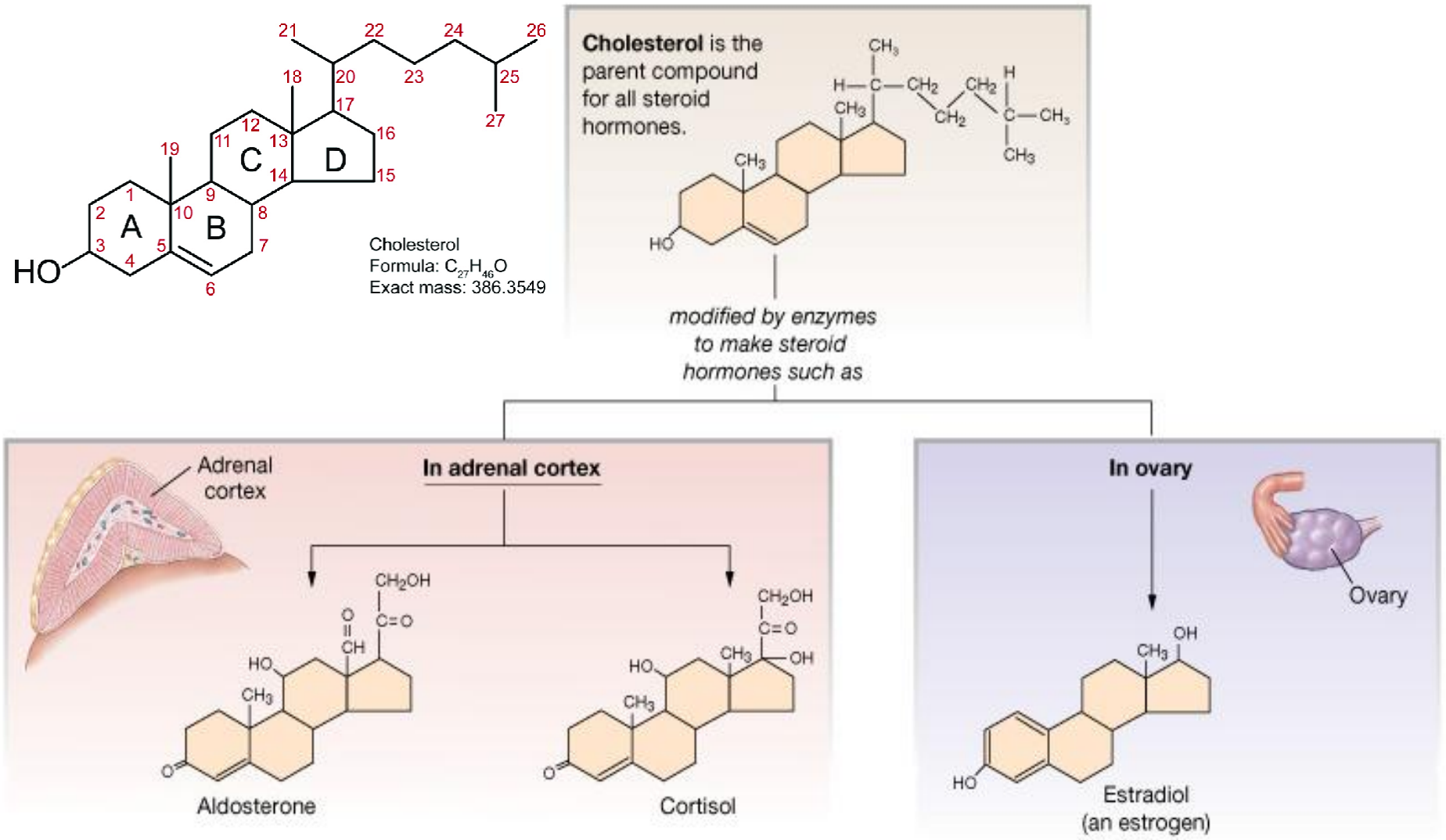
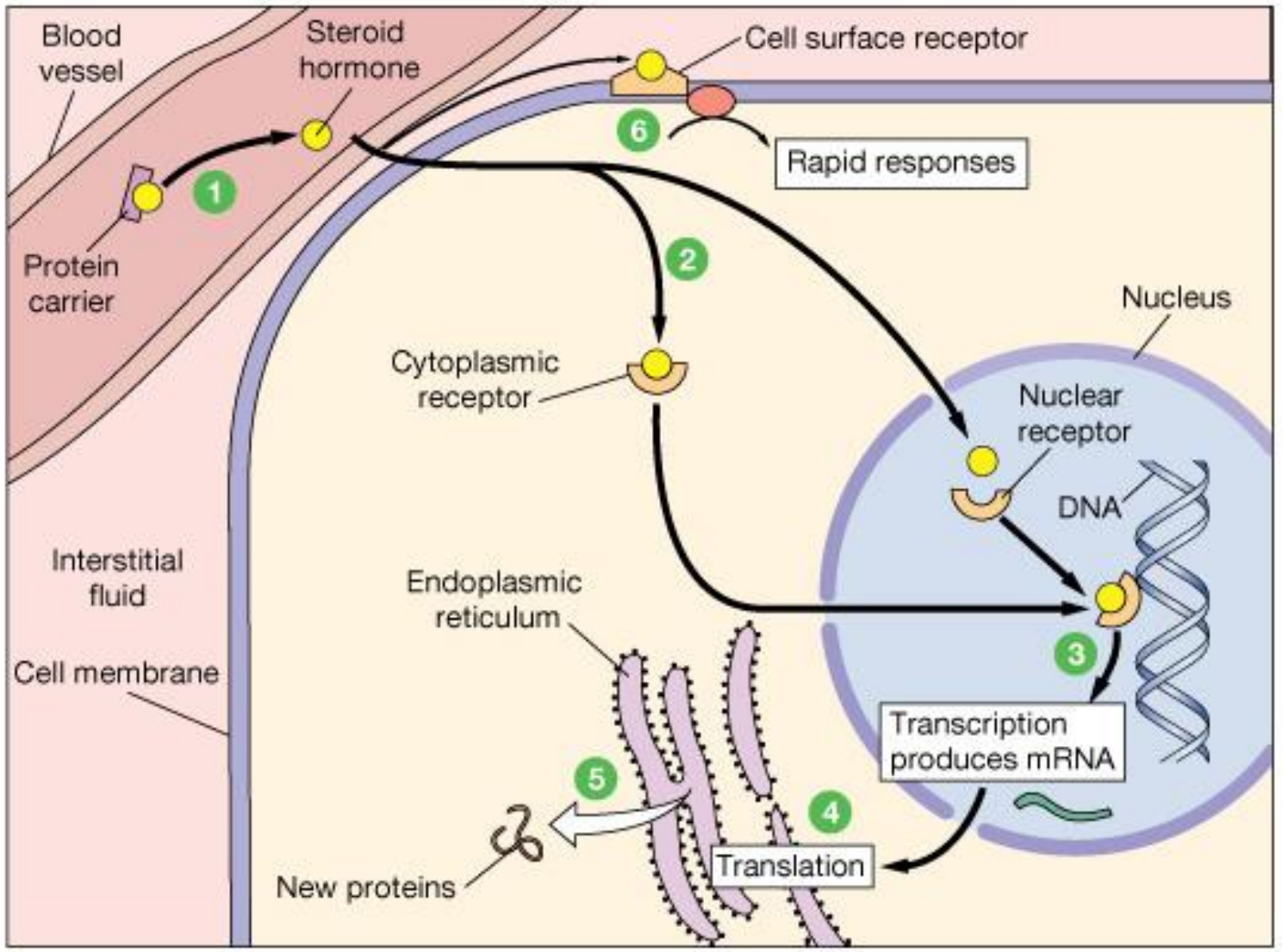



Figure 7-6: Steroid hormones are derived from cholesterol

# Steroid Hormones

- Steroid hormones diffuse easily into their target cells.
- Once inside, they bind and activate a specific **intracellular receptor**.
- The **hormone-receptor complex** travels to the nucleus and binds a DNA-associated receptor protein.
- This interaction prompts **DNA transcription** to **produce mRNA**.
- The mRNA is translated into proteins, which bring about a cellular effect.

# Steroid Hormones: Structure and Action




1. Most hydrophobic steroids are bound to plasma protein carriers. Only unbound hormones can diffuse into the target cell.
2. Steroid hormone receptors are in the cytoplasm or nucleus.
3. The receptor-hormone complex binds to DNA and activates or represses one or more genes.
4. Activated genes create new mRNA that moves back to the cytoplasm.
5. Translation produces new proteins for cell processes.
6. Some steroid hormones also bind to membrane receptors that use second messenger systems to create rapid cellular responses.

Figure 7-7: Steroid hormone action

# **Second:** According to categories.

1- **Water soluble Hormones:** Glycoproteins and Peptide

2- **Fat-soluble hormones :** Testosterone, Estrogen, Cortisol

❖ **- Water-based hormones tend to be more easily metabolized by the body than fat-based hormones.**

-This is because water-based hormones are more easily absorbed into the bloodstream, whereas fat-based hormones tend to be repelled by the fatty structures that surround cells.

Because of this, water-based hormones generally bind **to receptor sites on the outside** of the cell and signal from there.

# **Third:** According to the way of secretion:

- Some hormones are secreted directly into the blood through special glands called **endocrine glands**.

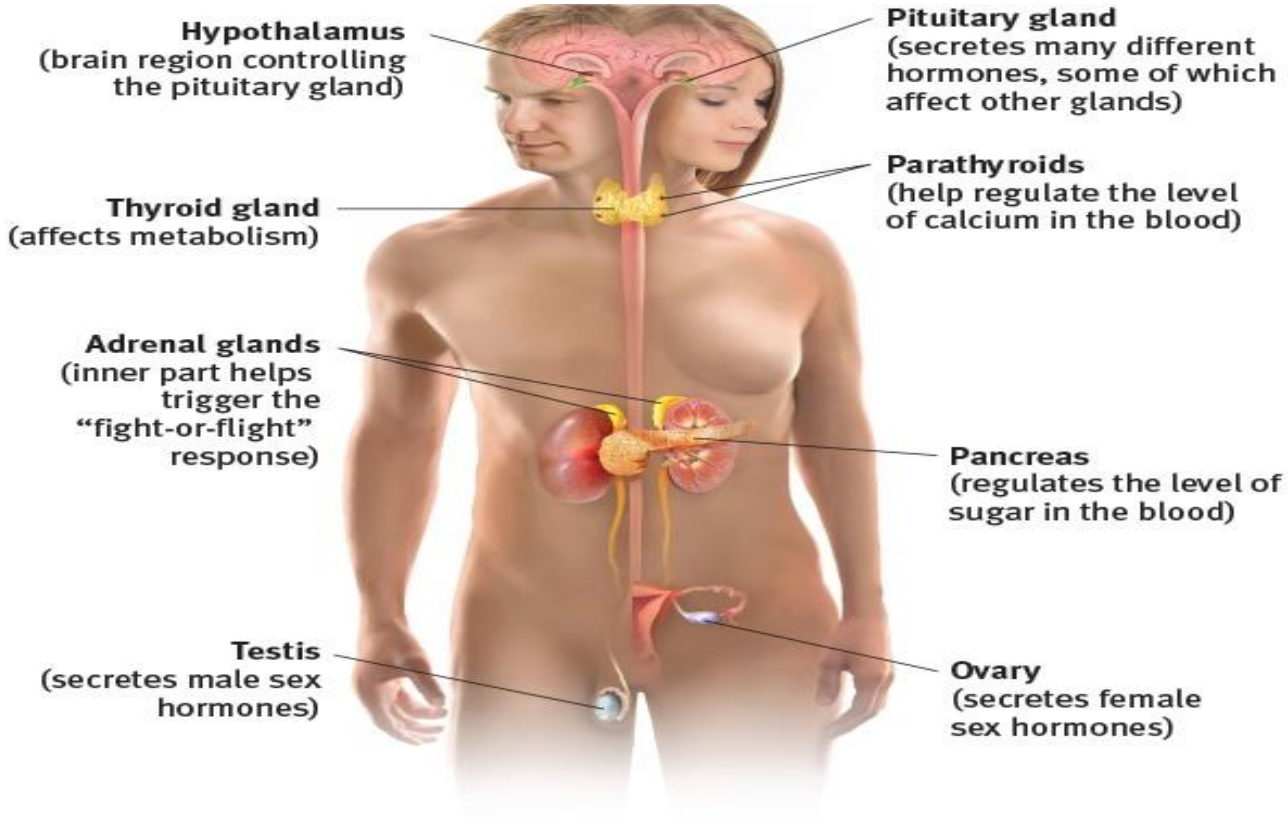
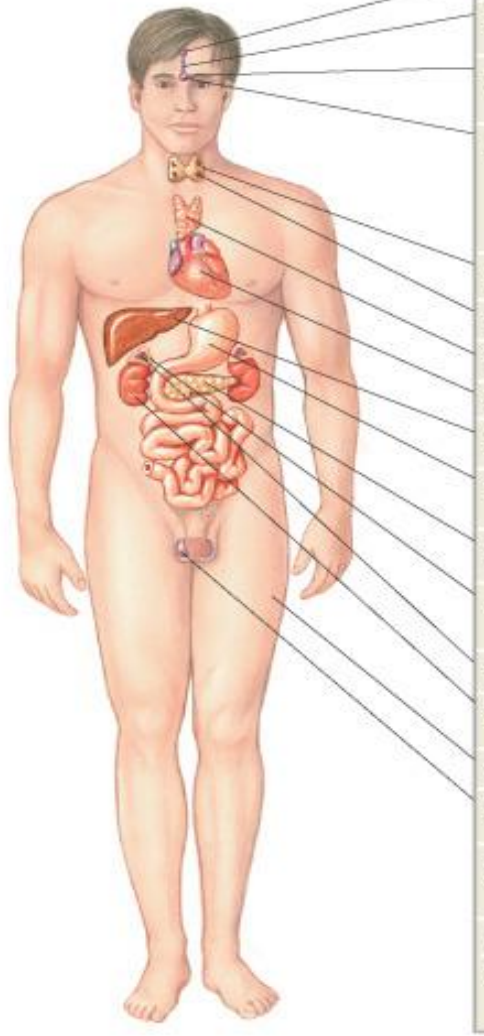



**Figure 2.8**
Myers/DeWall, *Psychology in Everyday Life*, 4e, © 2017 Worth Publishers

# Endocrine System

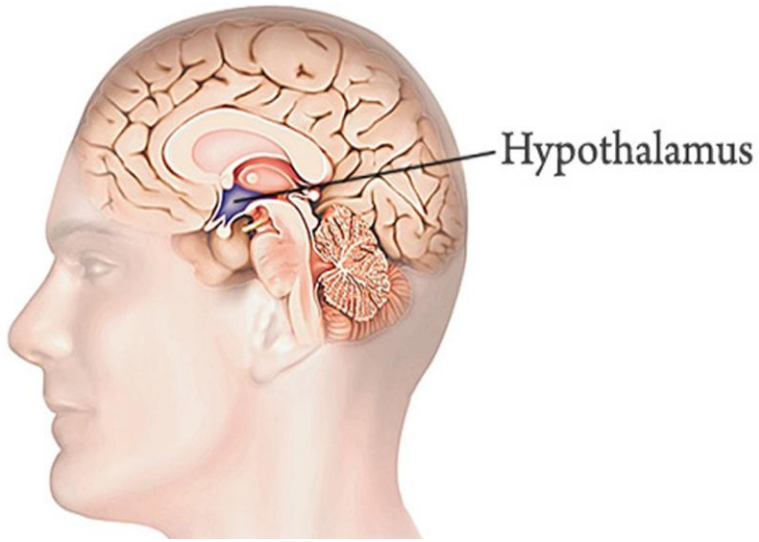


| Location | Gland or cell? | Chemical class |
|---|---|---|
| Pineal gland | Gland | Amine |
| Hypothalamus | Clusters of neurons | Peptides |
| Posterior pituitary | Extensions of hypothalamic neurons | Peptides |
| Anterior pituitary | Gland | Peptides |
| Thyroid | Gland | Iodinated amines<br>Peptide |
| Parathyroid | Gland | Peptide |
| Thymus | Gland | Peptides |
| Heart | Cells | Peptide |
| Liver | Cells | Peptides |
| Stomach and small intestine | Cells | Peptides |
| Pancreas | Gland | Peptide |
| Adrenal cortex | Gland | Steroids |
| Adrenal medulla | Gland | Amines |
| Kidney | Cells | Peptide<br>Steroid |
| Skin | Cells | Steroid |
| Testes (male) | Glands | Steroids<br>Peptide |
| Ovaries (female) | Glands | Steroids<br>Peptide |
| Adipose tissue | Cells | Peptide |
| Placenta (pregnant females only) | Gland | Steroids<br>Peptide |

Figure 7-2-1: ANATOMY SUMMARY: Hormones

# • Hypothalamus Gland

- Part of the diencephalon of the brain.
- Located inferior to the thalamus.
- ***It's a major link between the nervous and the endocrine systems.***
- It's connected to the pituitary gland by blood vessels and nerve fibers.
- It secretes a number of hormones that control the secretions of the pituitary gland.



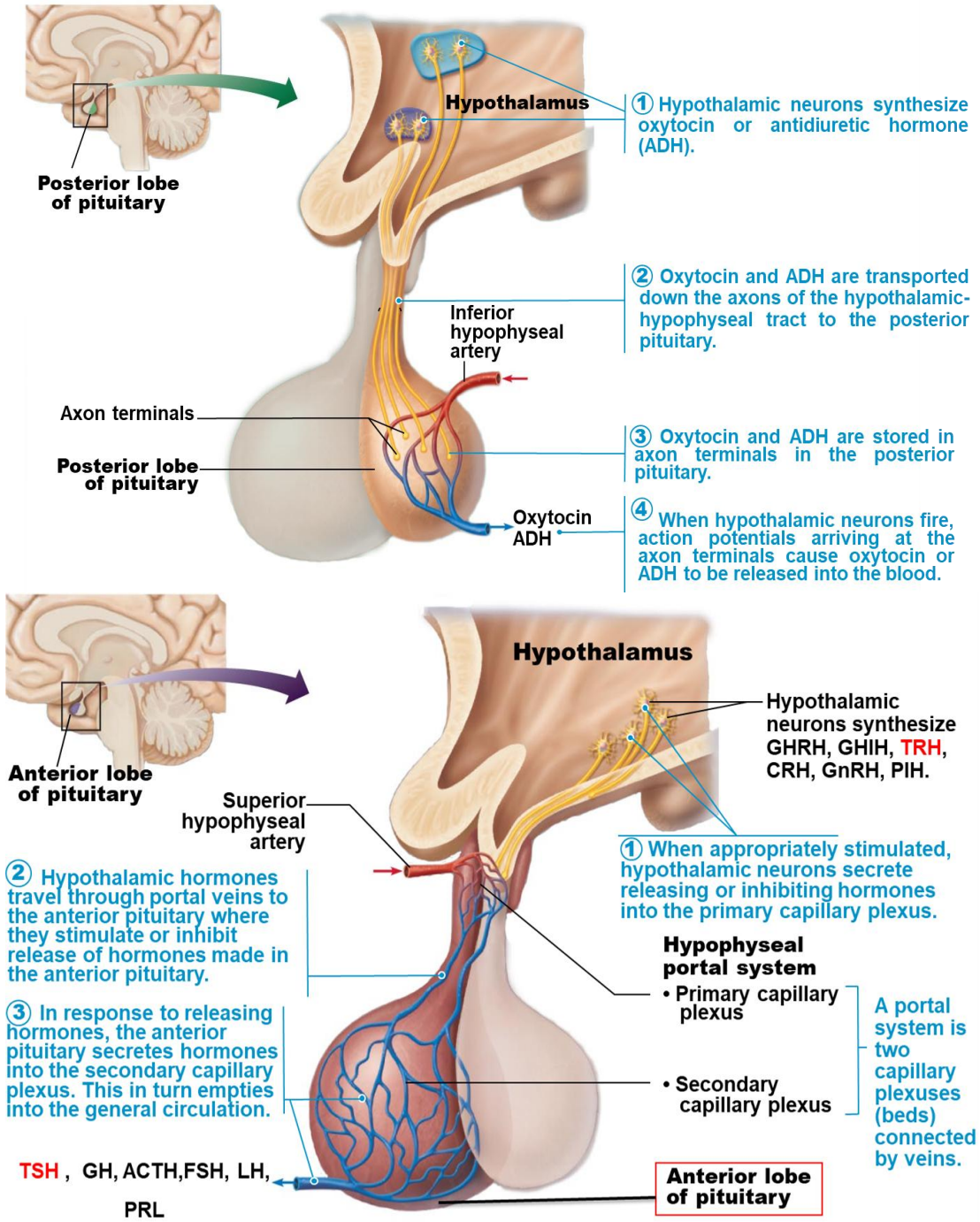




Figure 16.5b The hypothalamus controls release of hormones from the pituitary gland in two different ways.

## ●- Hypothalamus gland:

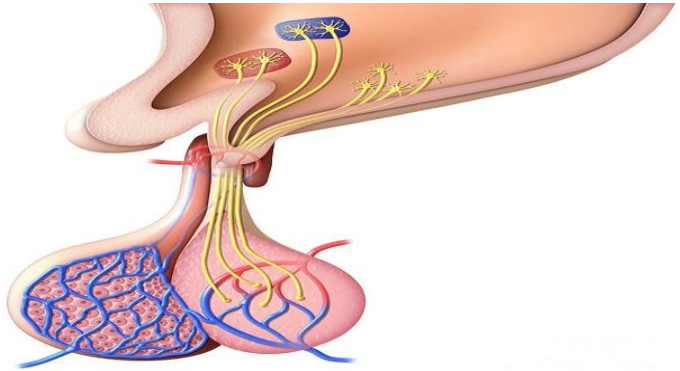
### A- Releasing Hormones

- ✓ **Thyrotropin releasing hormone (TRH):** **stimulates** the secretion of the Thyroid-Stimulating Hormone.
- ✓ **Prolactin- releasing hormone (PRH):** stimulates Prolactin it promotes the development of the breasts and the secretion of "milk"
- ✓ **Gonadotropin-releasing hormone (GnRH):** **stimulates** Follicle-Stimulating Hormone and Luteinizing Hormone.
- ✓ **Corticotropin-releasing hormone (CRH):** **stimulates** the secretion of the hormone directed to the Adrenocortex.
- ✓ **Growth hormone-releasing hormone(GHRH)** : **stimulates** Growth Hormone secretion.

### B- inhibiting hormones

- ✓ **Prolactin- inhibiting hormone (PIH):** Dopamine **inhibits** prolactin secretion.
- ✓ **Growth hormone-inhibiting hormone (GHIH):** Somatostatin **inhibits** the secretion of Growth Hormone and Thyroid-Stimulating Hormone.

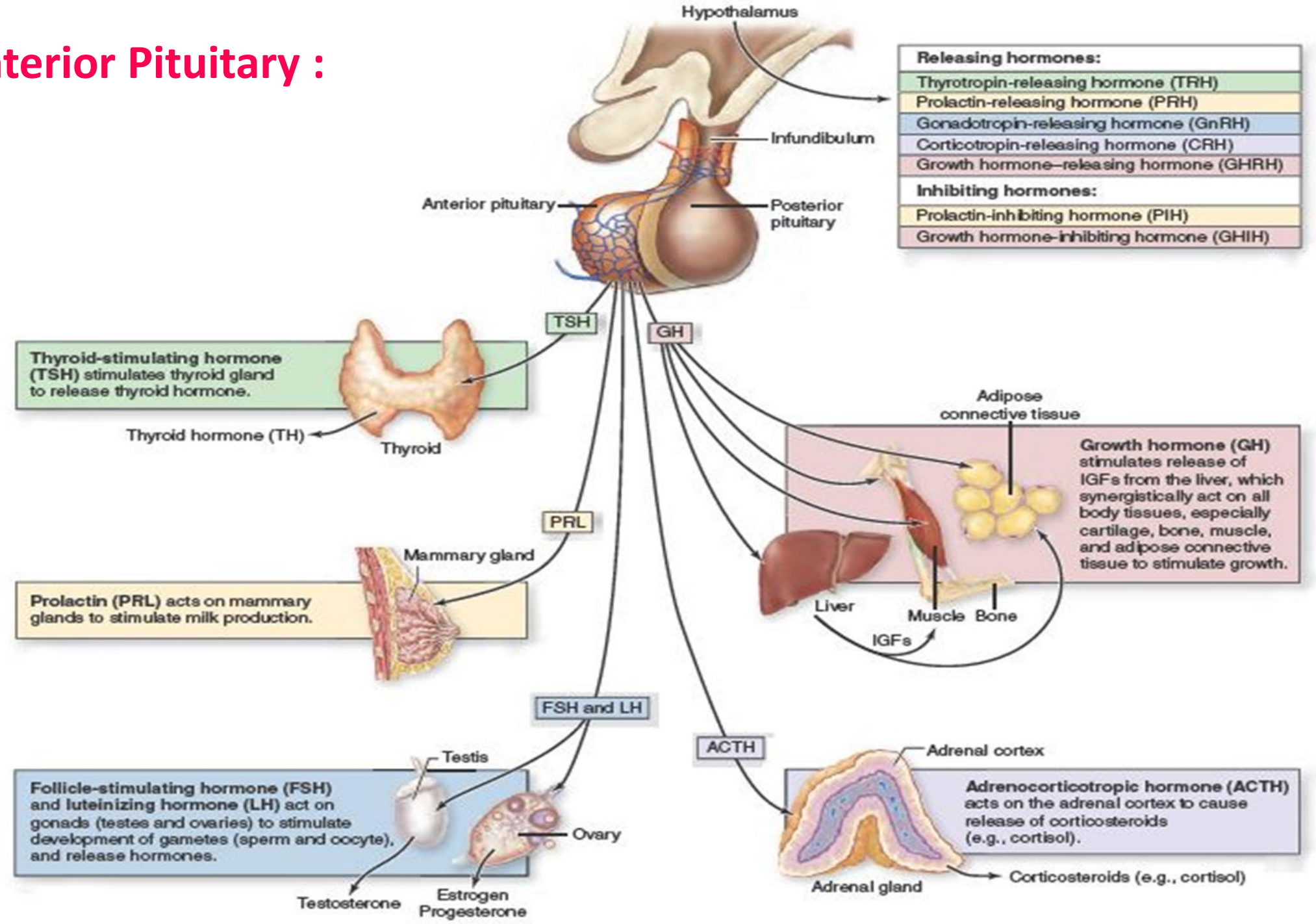
❖ - **Pituitary gland divides into:**



## A- Anterior pituitary hormones:

- **Growth Hormone (GH)** which generates the growth of almost all cells and tissues of the body.
- **Adrenocorticotropic Hormone (ACTH)** it causes the adrenal cortex to secrete adrenocorticotropic hormones.
- **Thyroid Stimulating Hormone (TSH)** which causes the thyroid gland to secrete "thyroxine and triiodothyronine“
- **Follicle Stimulating Hormone (FSH)** which stimulat **growth of follicles in the ovaries** prior to ovulation causes ovulation , and promotes spermatogenesis in the testis .
- **Luteinizing Hormone (LH)** it plays an important role in causing ovulation , and it also causes the release of **female sex hormones** from the ovaries and testosterone from the testicles.
- **Prolactin** it promotes the development of the breasts and the secretion of "milk"

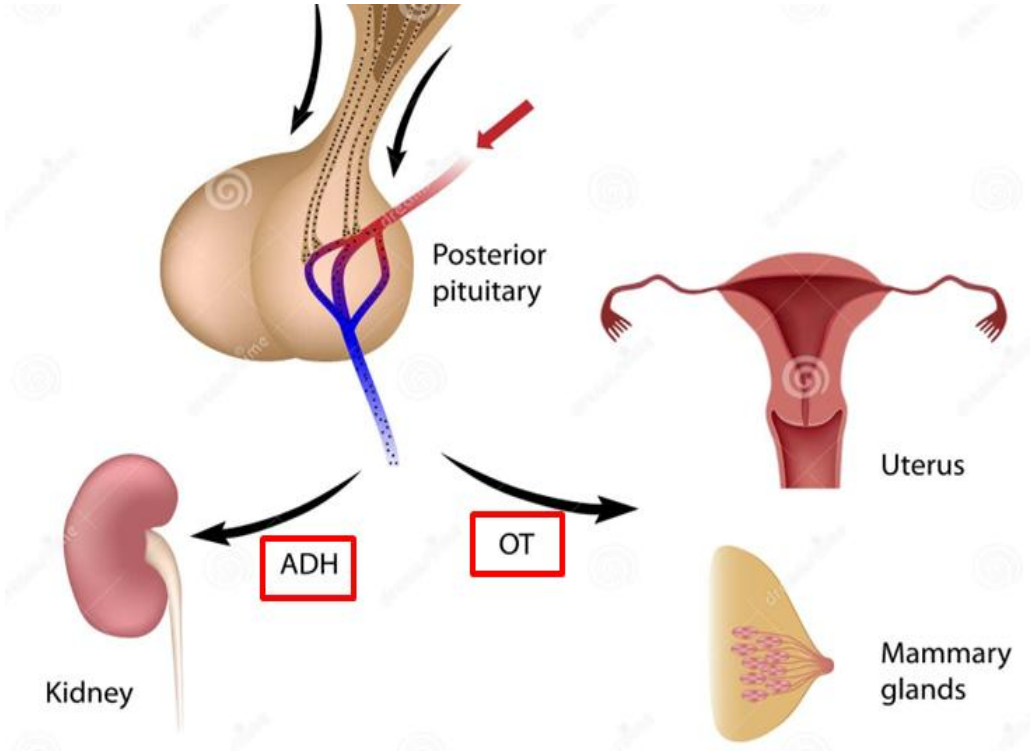
# ●- Anterior Pituitary :



## B- Posterior pituitary:

•- **Antidiuretic Hormone (ADH) :** (vasopressin) it **causes the kidneys to retain water** , thus increasing its content in the body , and at a high concentration it causes blood vessels to narrow throughout the body and raises blood pressure.

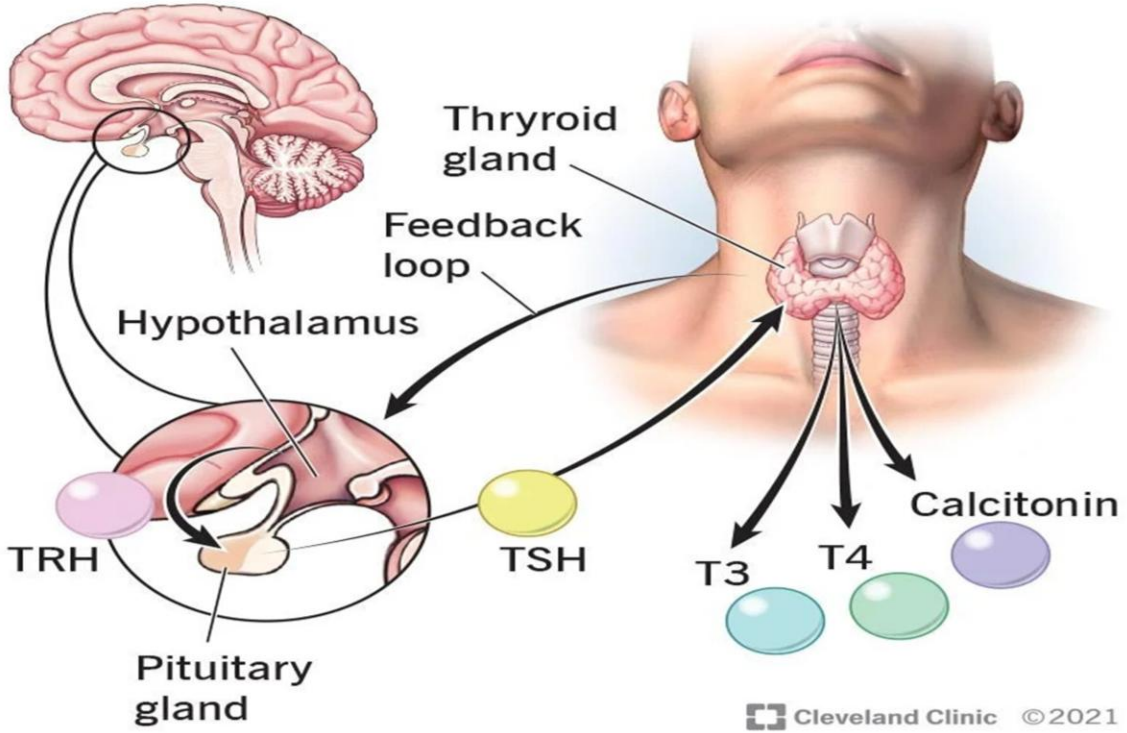
•- **Oxytocin (OT)** it causes the uterus to contract during the birth process and thus helps to expel the newborn from the uterus. It also shrinks the **epithelial muscular cells in the breasts** , thus expelling milk from them when the infant sucks it.



# ❖- Thyroid gland:

• **The Thyroid Hormones Thyroxine** and **Triiodothyronine** they **increase the speed of chemical reactions** in almost all cells of the body , which **increases the general level of body metabolism.**

• **Calcitonin:** Promotes the accumulation of **calcium** in the bones , thus reducing its concentration in the fluid outside the cells.



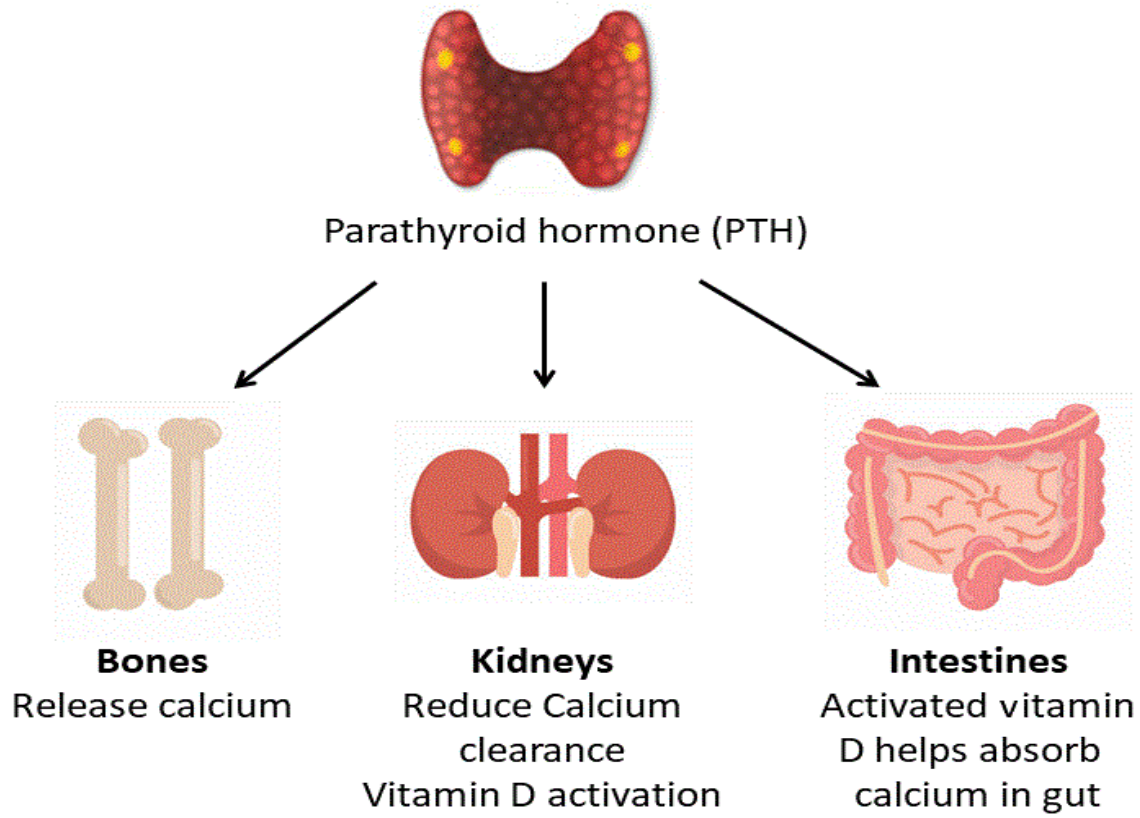
## ❖ Parathyroid gland:

- **parathyroid hormone:**

✓ -Controls the concentration of calcium ions in the extracellular fluid by controlling Calcium absorption from the intestin.

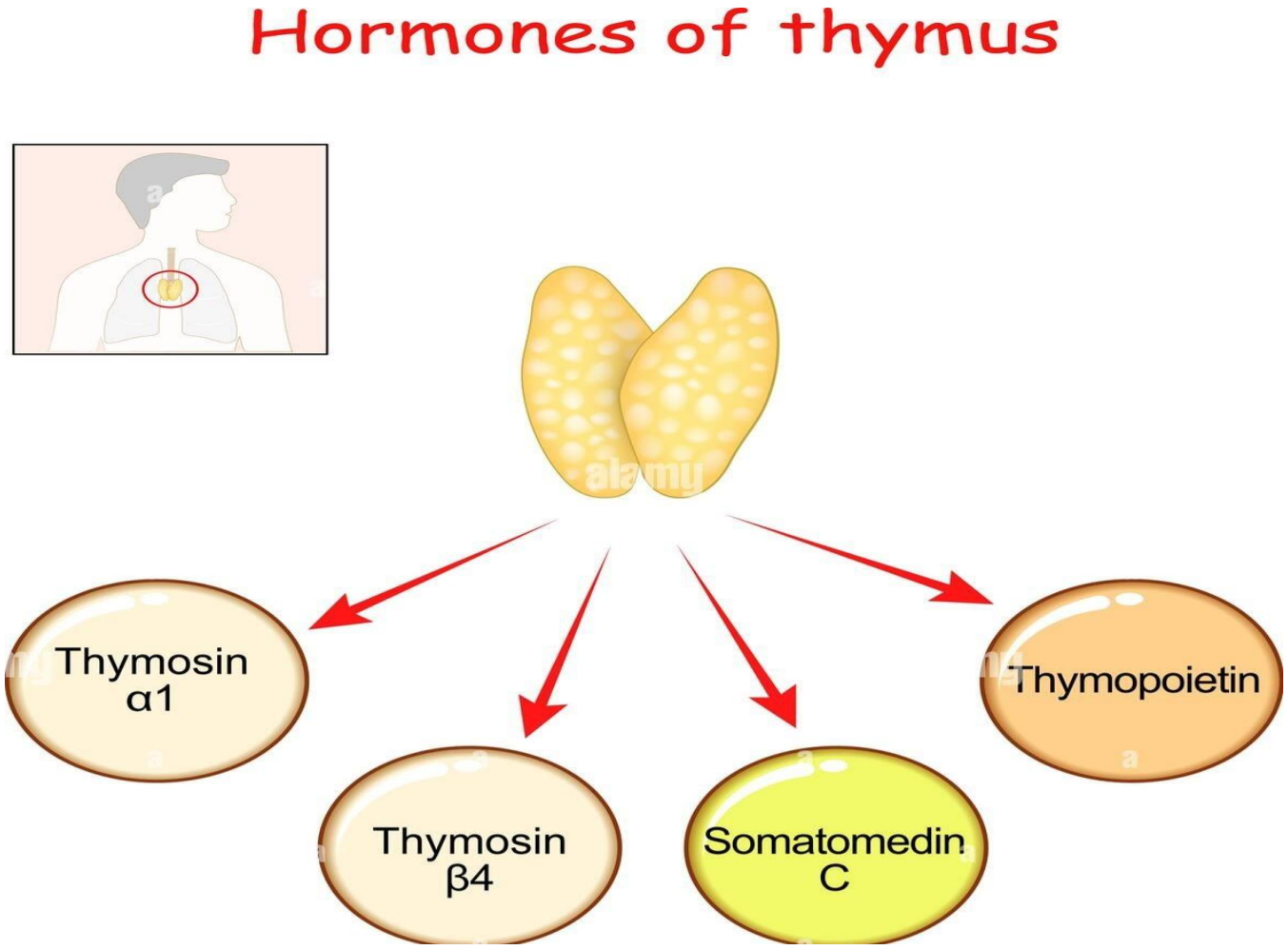
✓ -Excretion of calcium from the kidneys.

✓ -Release calcium from bones.



## ❖ Thymus gland:

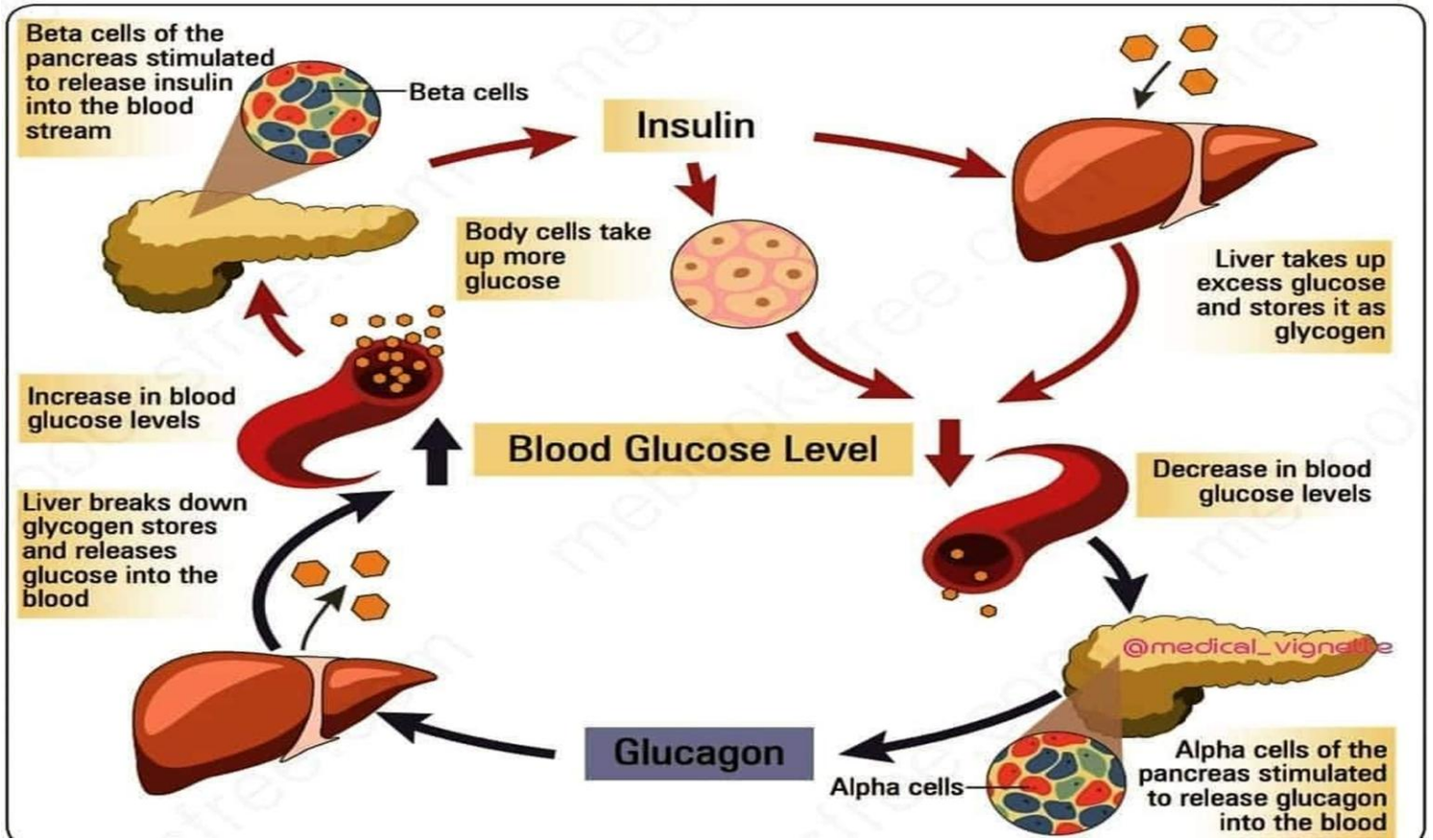
This gland secretes the **hormone thymosin**, which regulates and oversees the immunity in the body, helps produce lymphocytes.



## ❖ - Pancreas:

•**Insulin** promotes the entry of glucose into most cells of the body and in this way controls the rate of metabolism of most sugars.

•**Glucagon** increases the synthesis and release of glucose from the liver into the body 's circulating fluids.



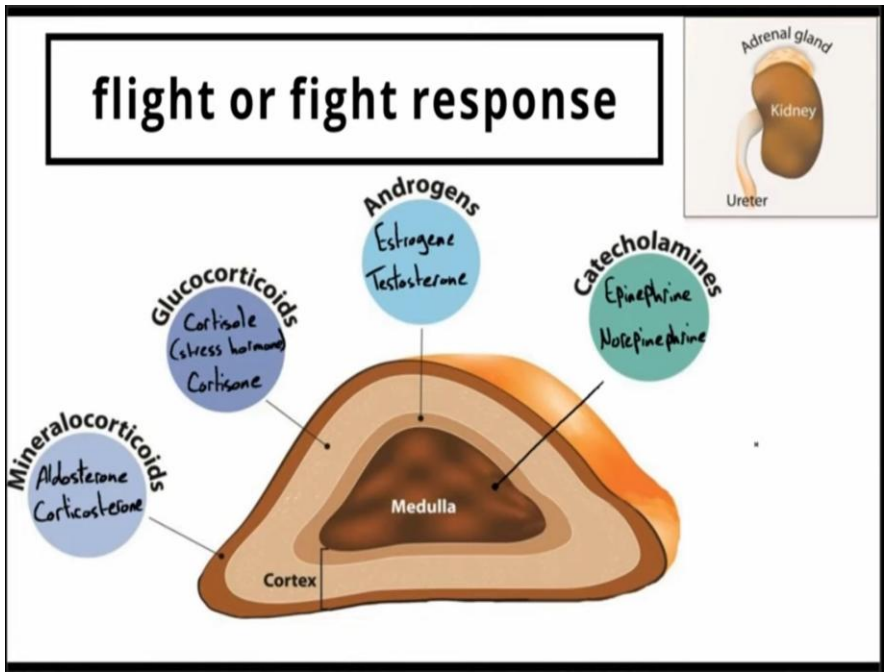
# ❖ Adrenal Gland

## ❖ Adrenal cortex:

- **Aldosterone:** reduces the excretion of sodium by the kidneys and increases the excretion of potassium , thereby increasing the sodium content of the body and reducing potassium in it.
- **Cortisol:** It has several metabolic functions to control the **metabolism of sugars** , **proteins and fat**.

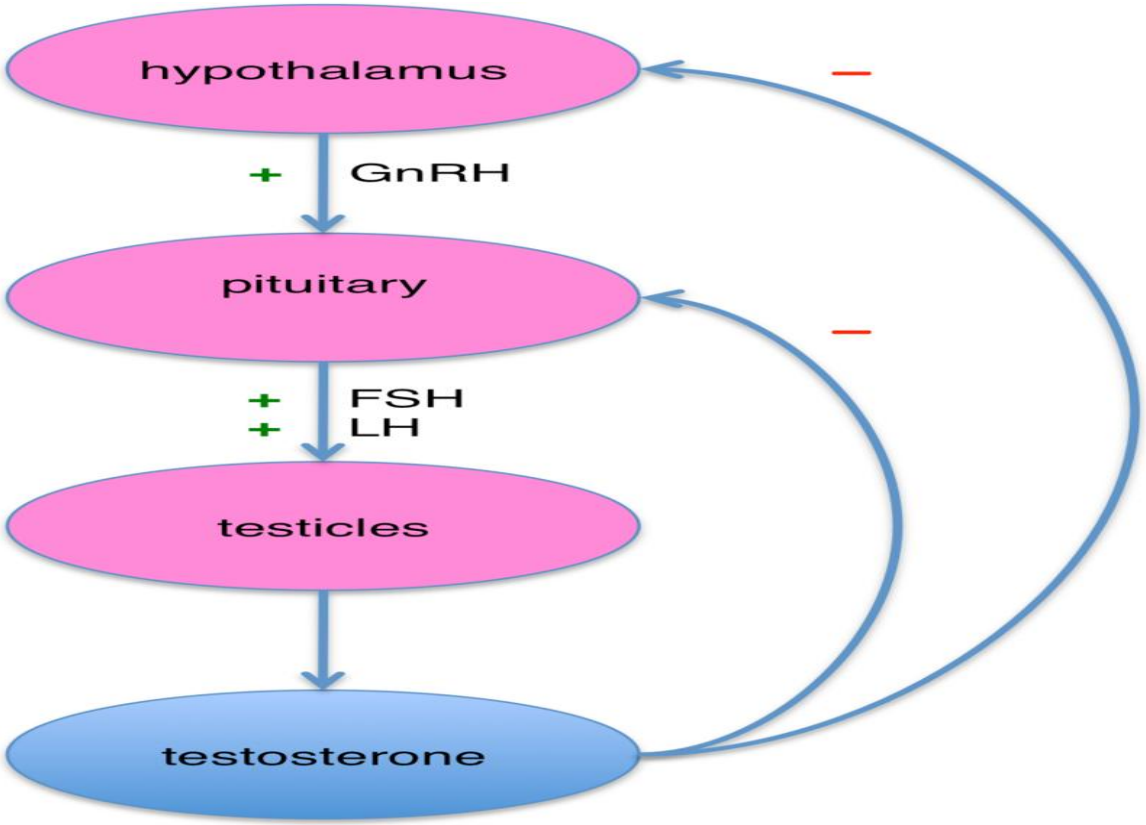
## ❖ Adrenal medulla:

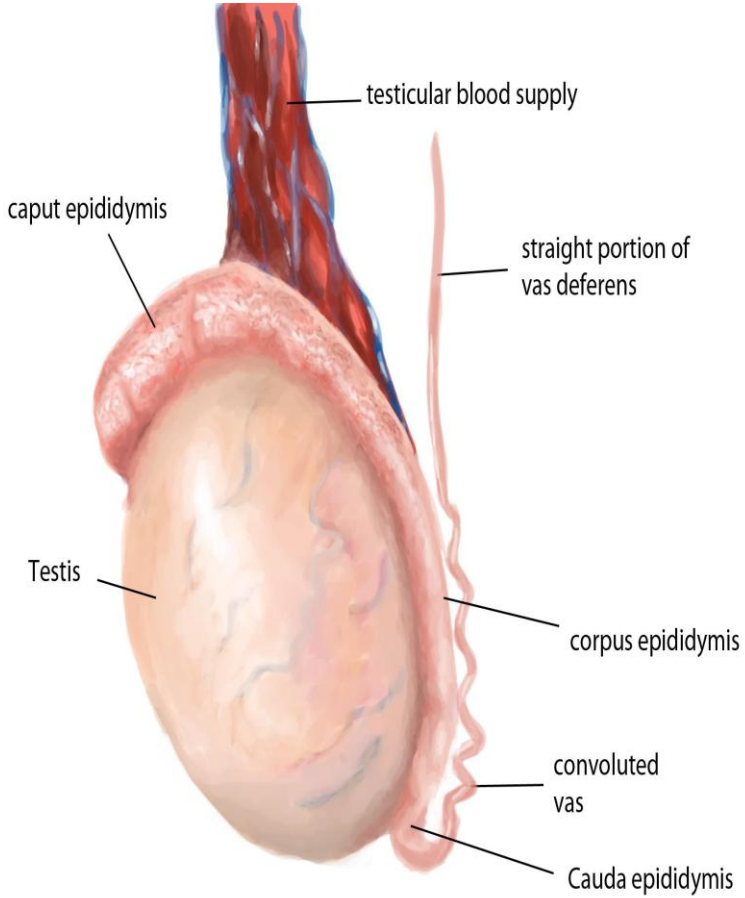
**Catecholamines:** participate in the response of escaping or fighting, such as expansion of eye increased heartbeat, high pressure, increased respiratory rate, or increased blood sugar.



## ❖ - Testicles:

•**Testosterone** it stimulates the growth of the **male sex organs** , and promotes the development of secondary male sexual characteristics.

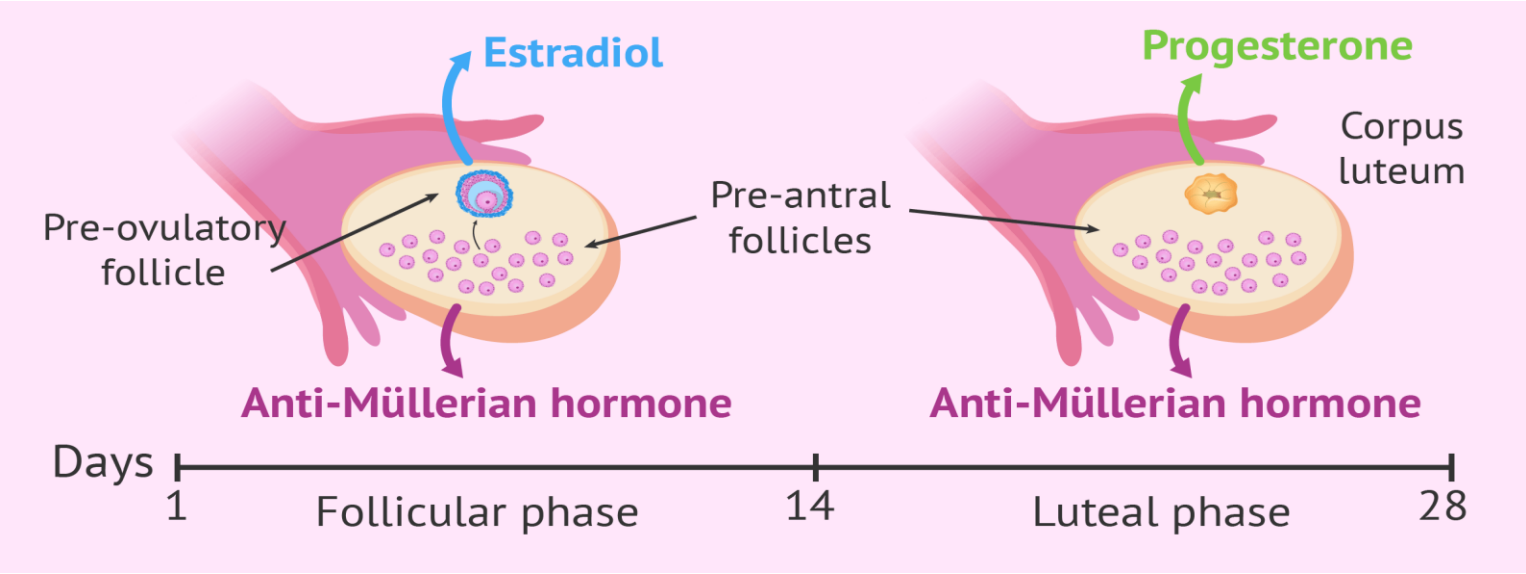


## ❖ - The Ovaries:

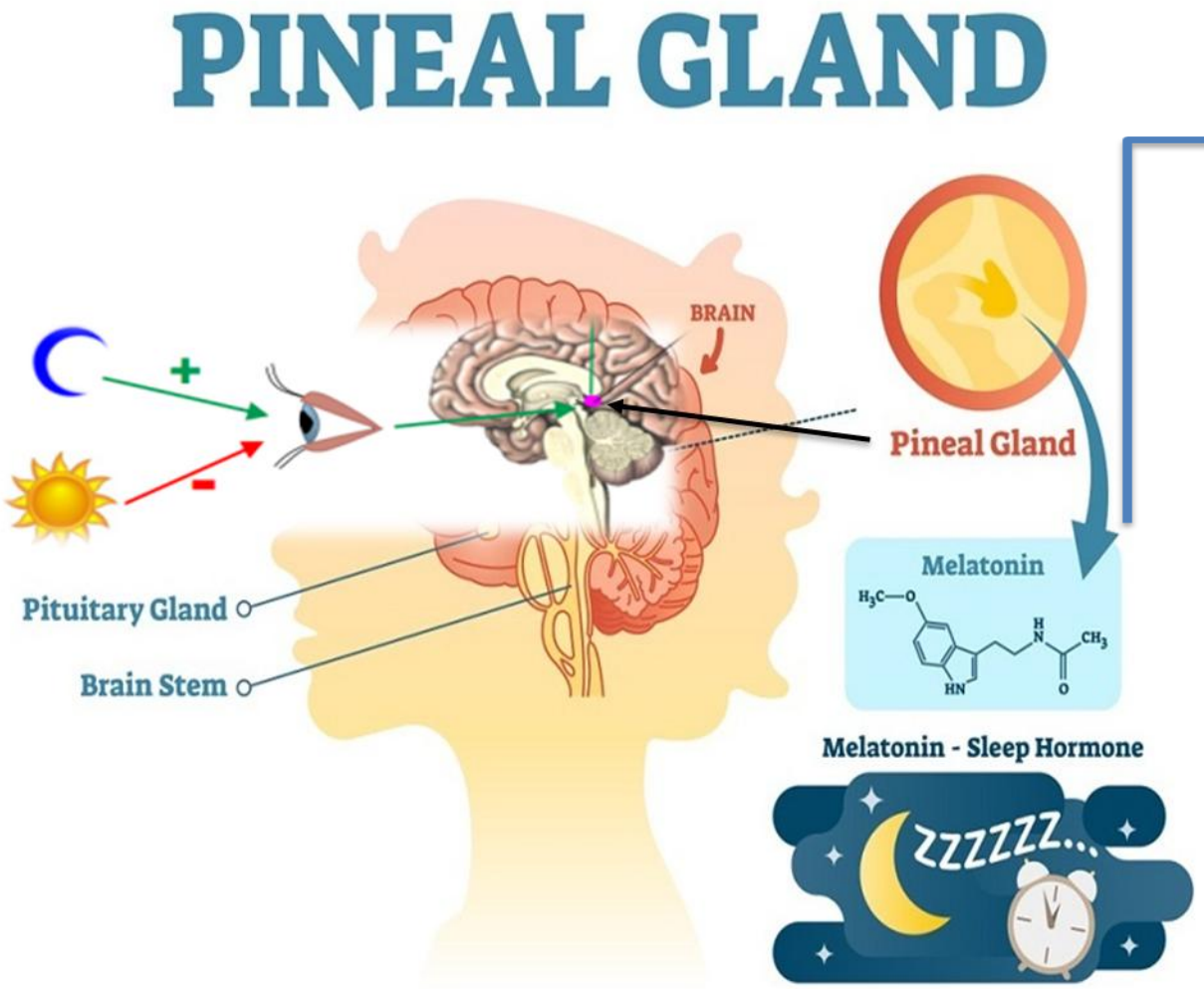
•**Estrogens** stimulates the development of **female sexual organs**, **breasts** , and **various** secondary sexual characteristics.

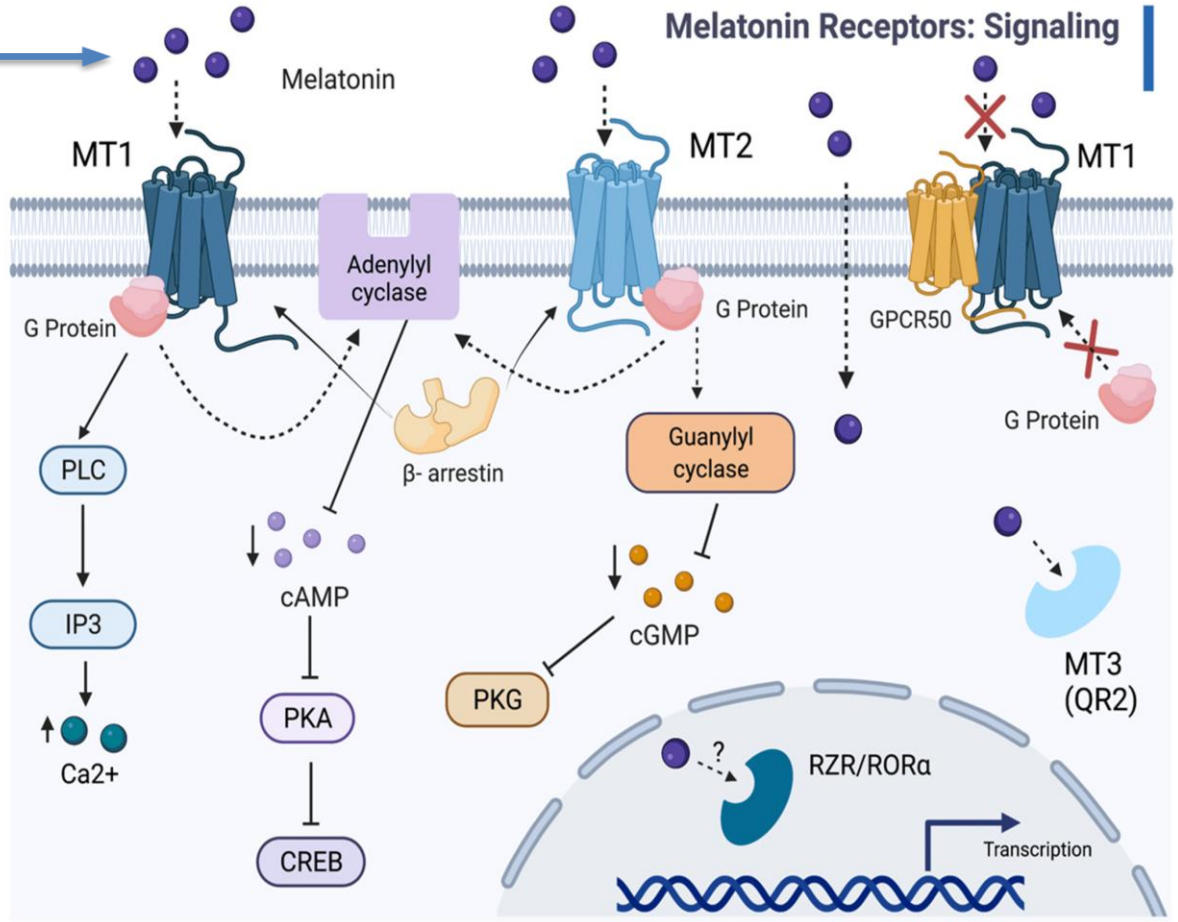
•**Progesterone** stimulates the secretion of the endometrial glands , and helps promote the development of the secretory system of the breasts.



# ❖ - Pineal gland:

It produces the hormone “**Melatonin**" which regulates the sleep and wake pattern in humans.



# Target Cell Specificity

- Hormones circulate to all tissues but only activate cells referred to as target cells
- Target cells must have **specific receptors to which the hormone binds**
- These receptors may be **intracellular** or located on the **plasma membrane**

# Target Cell Activation

- **Target cell activation depends on three factors:**
  - ✓ - **Blood levels** of the hormone
  - ✓ - Relative **number of receptors** on the target cell
  - ✓ - The **affinity of those receptors** for the hormone
- Up-regulation – target cells form **more receptors in response** to the hormone
- Down-regulation – target cells **lose receptors** in response to the hormone

# Hormone Concentrations in the Blood

- **Concentrations of circulating hormone reflect:**
  - ✓ Rate of release
  - ✓ Speed of **inactivation** and **removal** from the body
- **Hormones are removed from the blood by:**
  - ✓ Degrading enzymes
  - ✓ The kidneys
  - ✓ Liver enzyme systems

# Control of Hormone Release

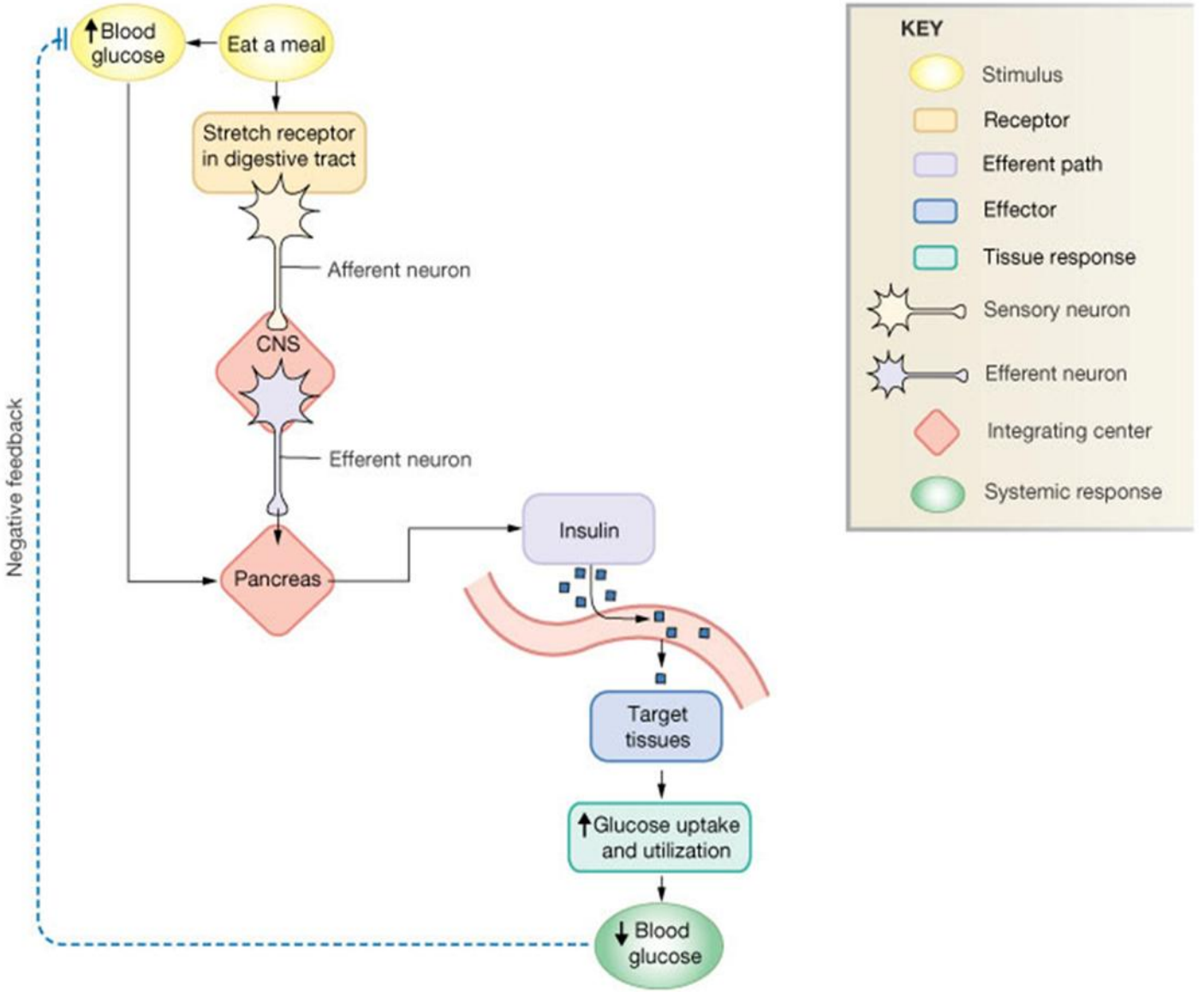
- Blood levels of hormones:
  - ✓Are controlled by negative feedback systems
- Hormones are synthesized and released in response to humoral, neural, and hormonal stimuli

# Endocrine Reflex Pathways: Overview

- **Stimulus**
- **Afferent signal**
- **Integration**
- **Efferent signal (the hormone)**
- **Physiological action**
- **Negative feedback**

# Multiple Stimuli for Hormone Release: Nervous & Endocrine

- Stimuli
  - Stretch
  - Glucose
  - Insulin levels
- Reflex
  - Lower blood glucose
  - Reduces stimulus
  - Reduces insulin release




Thanks For Listening …