ANATOMY & PHYSIOLOGY II
GHC 2013 / NMS 2012 / OHC 3013 / PTAP 1123

CHAPTER 4
ENDOCRINE SYSTEM

Topic Outlines

- 4.1 Introduction to Endocrine System
- 4.2 Hormones
- 4.3 Glands of Endocrine System
  - 4.3.1 Pituitary Gland
  - 4.3.2 Thyroid Gland
  - 4.3.3 Parathyroid Gland
  - 4.3.4 Adrenal Gland
  - 4.3.5 Pineal Gland
- 4.4 Pancreas
- 4.5 Gonads
- 4.6 Thymus
- 4.7 Negative Feedback Mechanisms
- 4.8 Positive Feedback Mechanisms

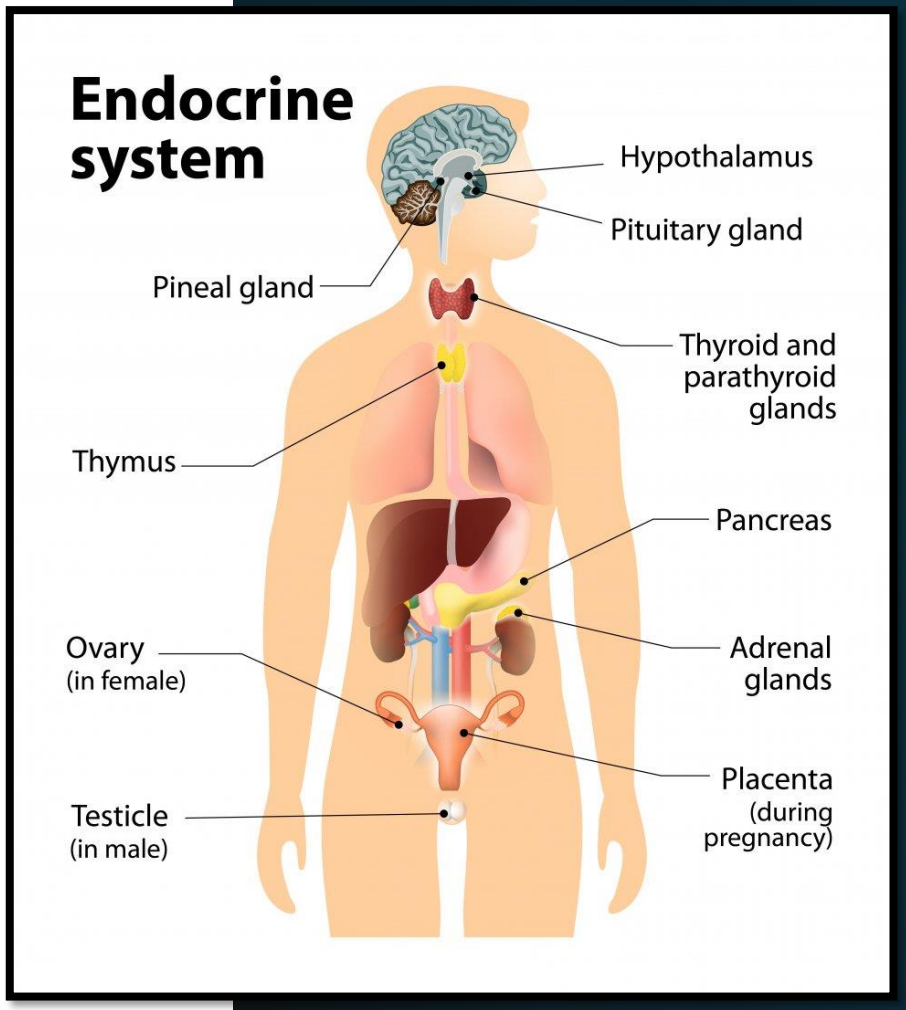
Learning Outcomes

At the end of this chapter, students should be able to:

- Identify the main glands of endocrine system
- Describe the main hormones secreted by the glands of endocrine system
- Describe the functions of each glands of endocrine system
- Explain the basic physiological process of endocrine system

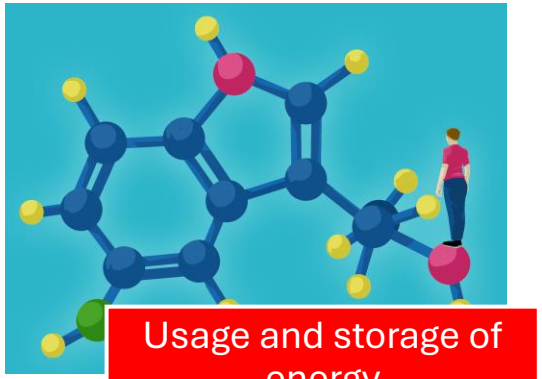
4.1 Introduction to Endocrine System

- A **gland** is an organ that produces a secretion.
- **Endocrine glands** are groups of tissues which use materials from blood or lymph to make hormones.
- Also called ductless glands
  - secrete hormones directly into blood streams to be transported to target organs in the body



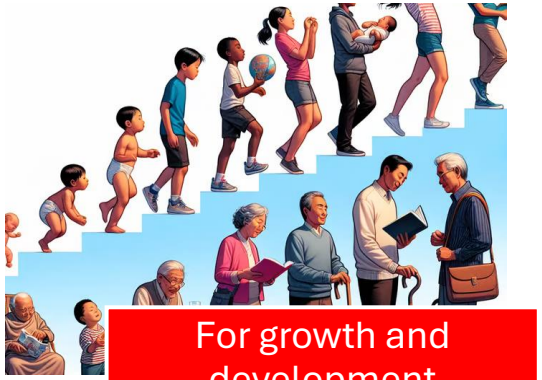
4.1.2 Main Functions of Endocrine System

Maintain homeostasis

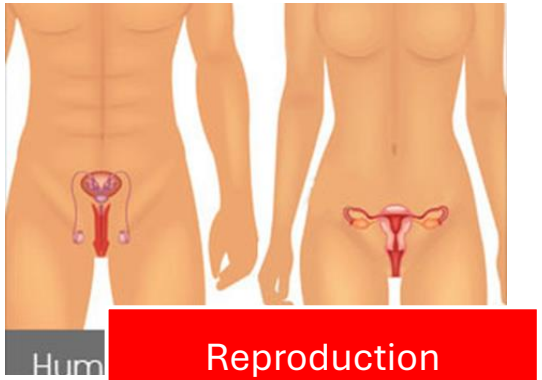


Usage and storage of energy

Regulates levels of fluid, salt and sugar in blood



For growth and development



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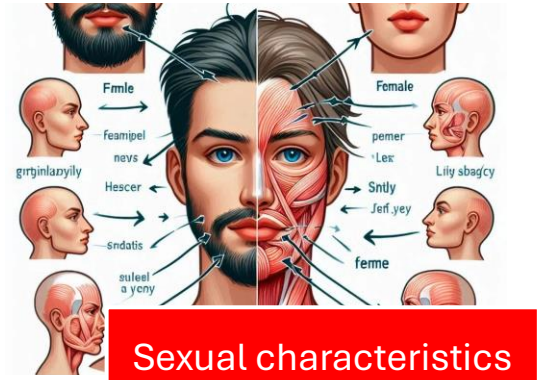
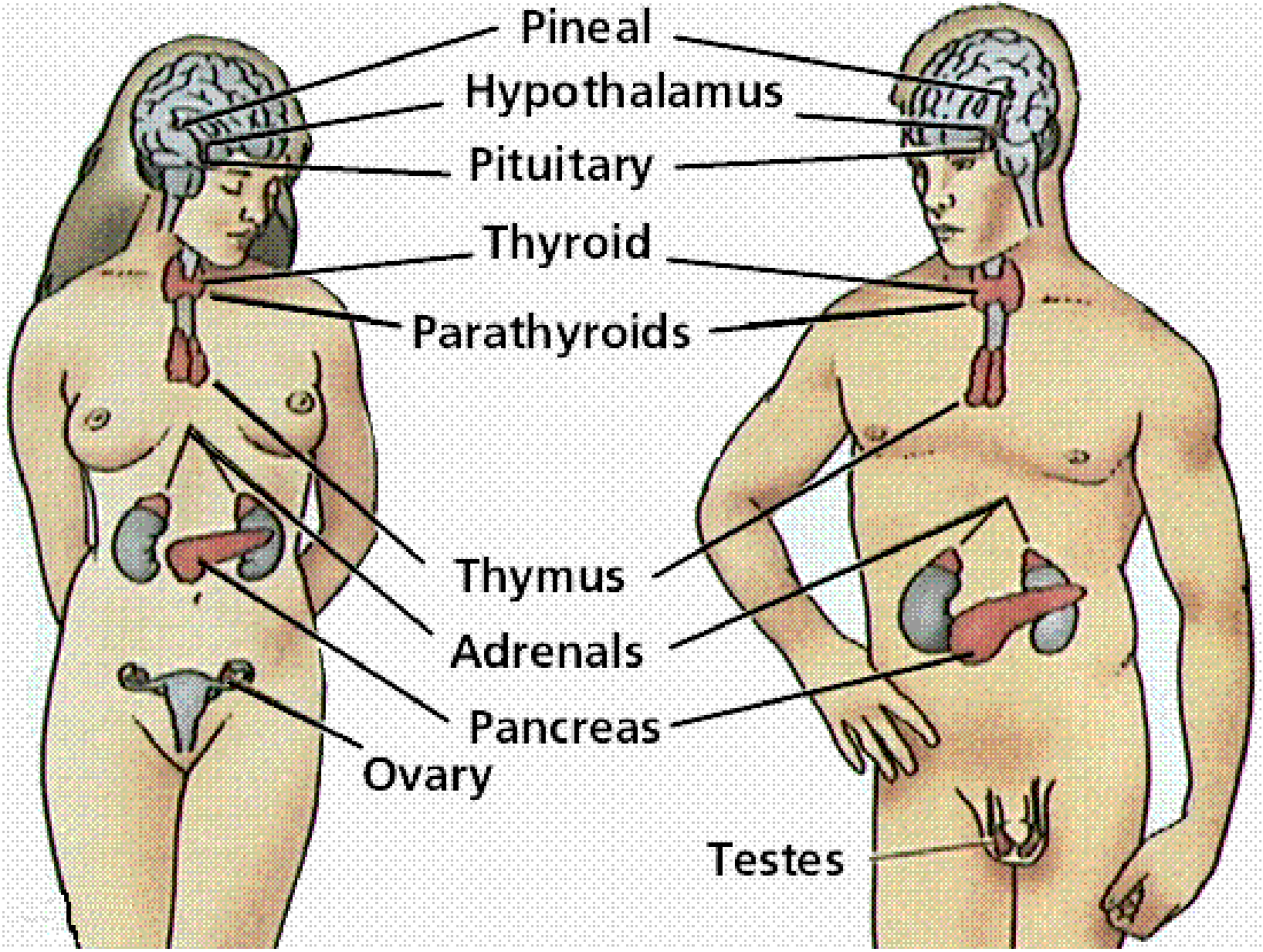


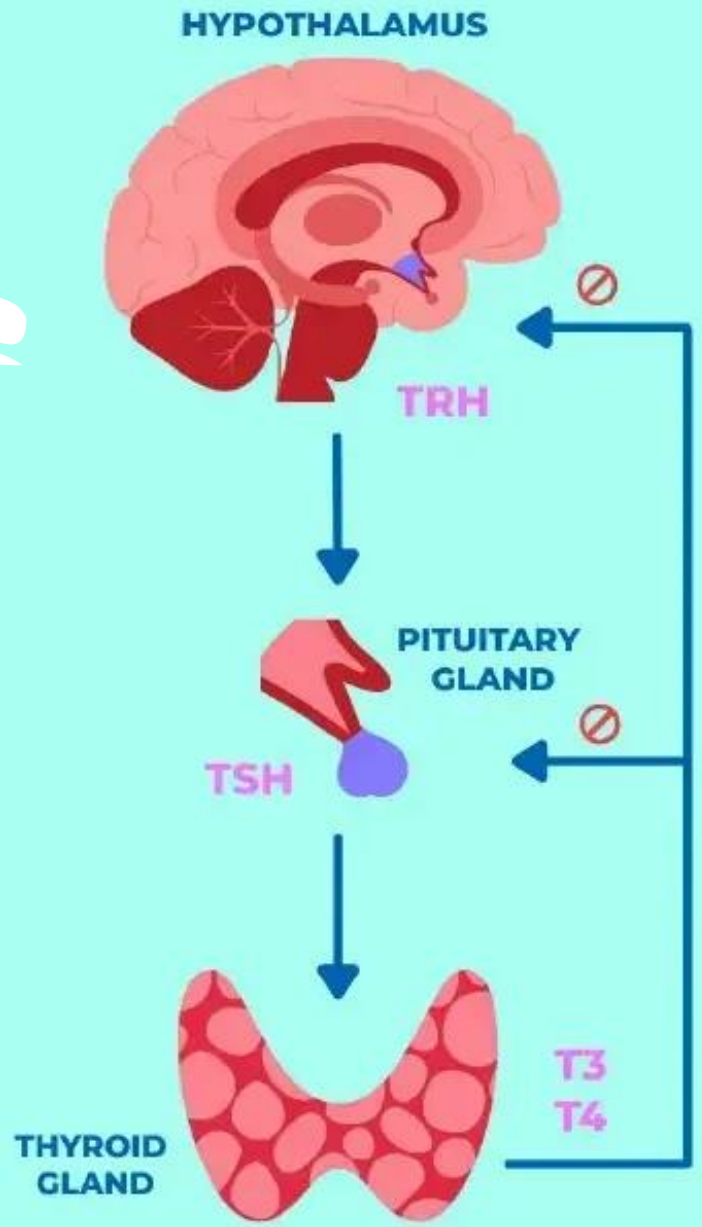
Sexual characteristics

Figure 4.1 Endocrine System



4.2 Hormones

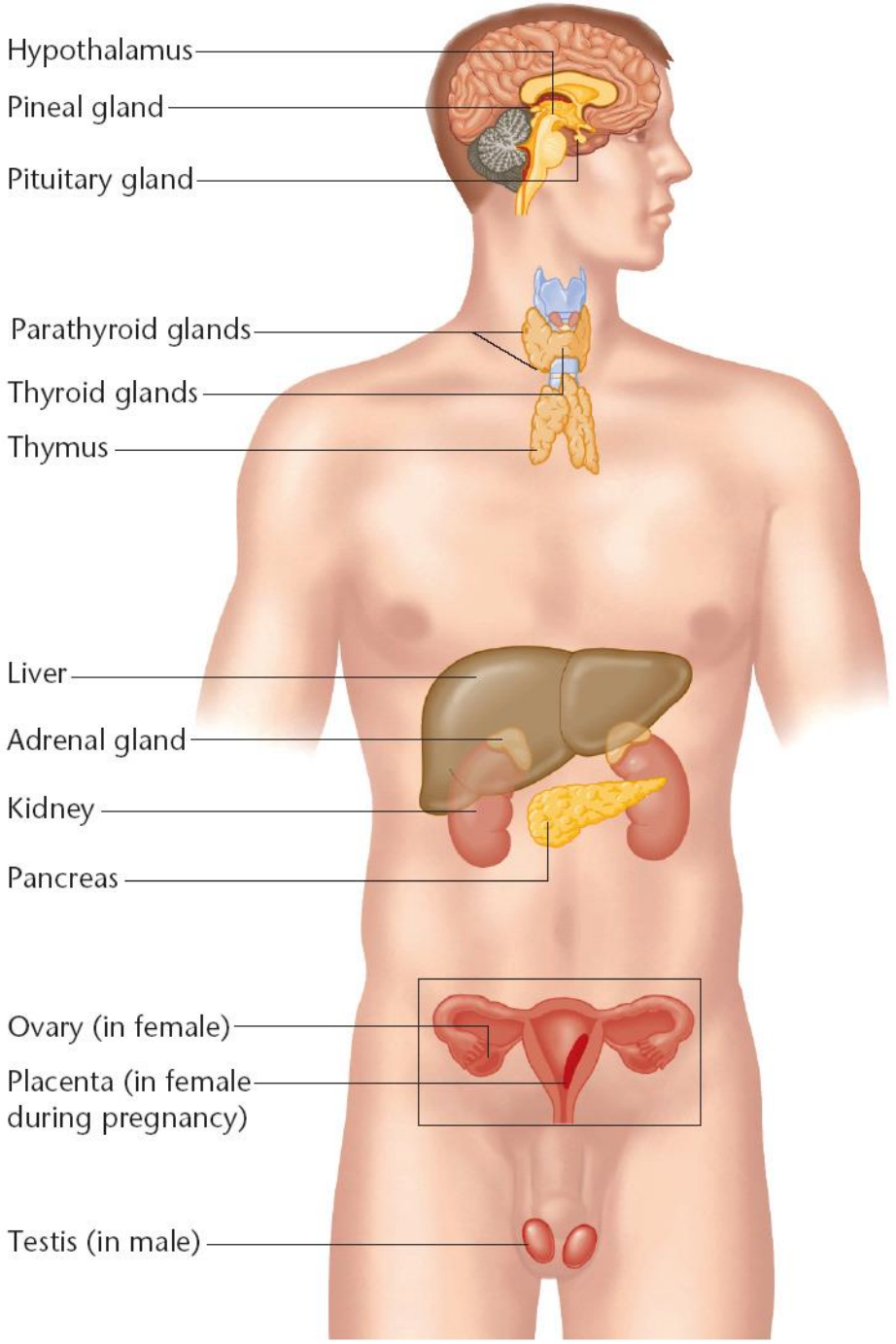
- A chemical messenger released by the glands which control and regulate many body functions
- Carried by blood to the specific target organs
- Act with negative feedbacks
- Types of hormones:
  - a) Fat / Lipid Soluble Hormones = *Steroids, Thyroid hormones*
  - b) Water Soluble Hormones = *Adrenaline, Noradrenaline, Insulin, Glucagon*



4.2 Hormones

- Recognize the location of the glands

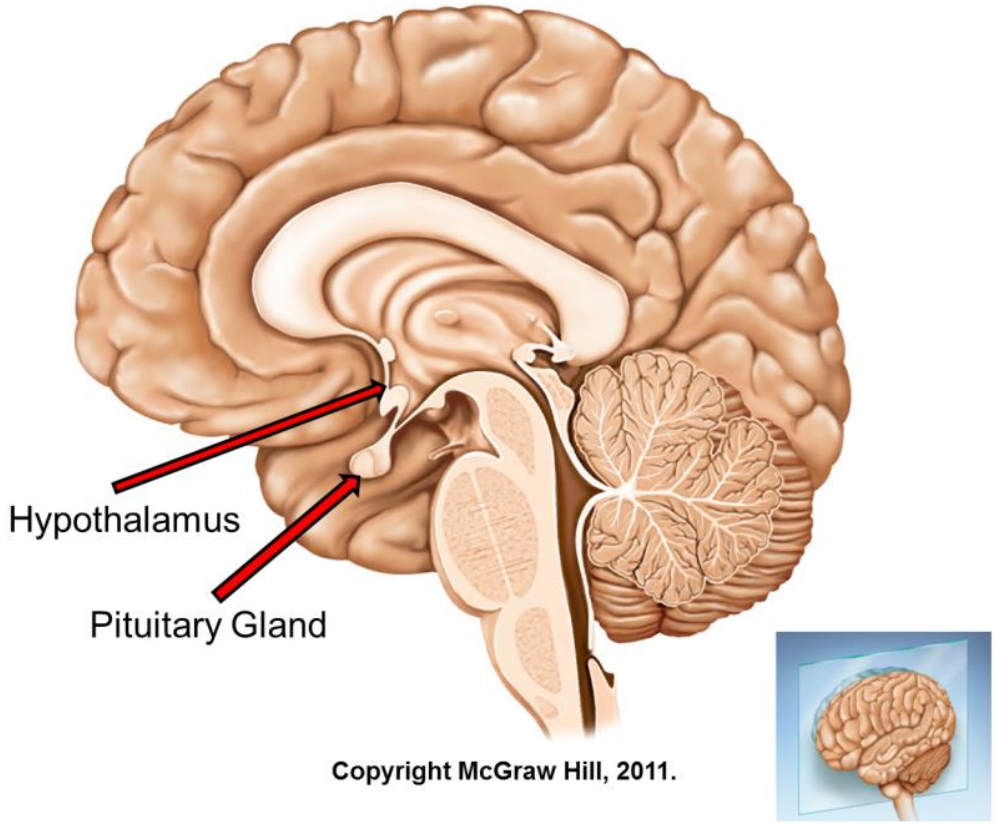
- Which glands locate at:
  - *Inside brain*
  - *Anterior neck*
  - *Superior both kidneys*
  - *Reproductive system*



4.3 Glands of Endocrine System

Hypothalamus

- Situated in the forebrain (between the thalamus and pituitary)
- A critical gland which **controls entire metabolic system**
- Secretes hormones that **control the pituitary and target organs**
- Collects information from other regions of the brain and blood vessels
- Sends neural and chemical signals to pituitary gland which directly or indirectly regulated the activity of all other glands
- Monitor metabolite and hormone levels in the blood



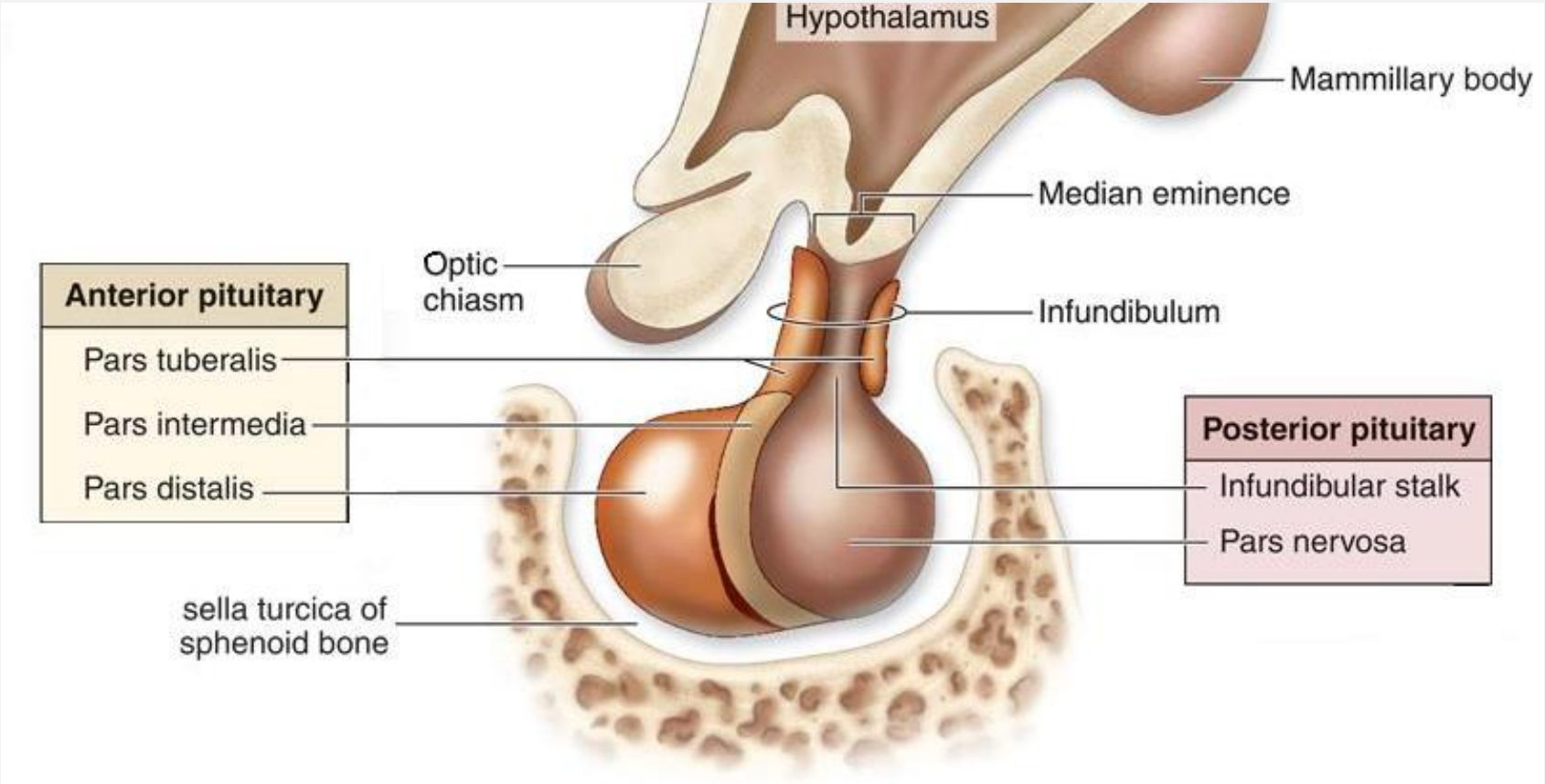
Pituitary & all Hormones are under the control of the Hypothalamus

4.3.1 Pituitary Gland

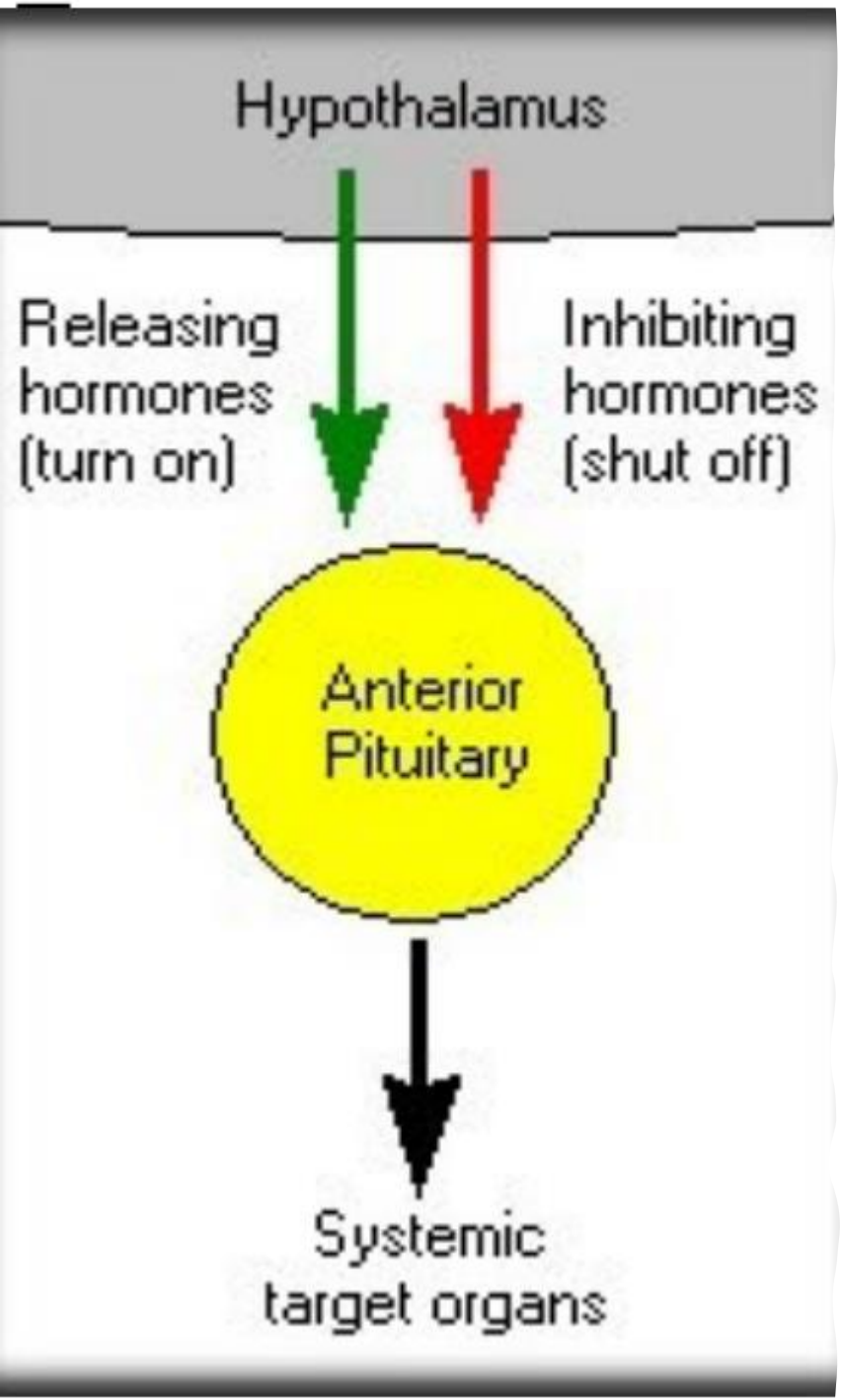
- Pear-shaped structure (1 → 1.5 cm)
- Situated below hypothalamus, attached to it by infundibulum
- Acts in response to stimuli from the hypothalamus
- Pituitary gland itself controlled by hypothalamus
- Also known as **"*Master of Endocrine Gland*"** because it **secretes several hormones that control other endocrine glands**
- Have 2 portions :

  → Anterior pituitary gland

  → Posterior pituitary gland



4.3.1 Pituitary Gland



4.3.1.1 Anterior Pituitary Gland

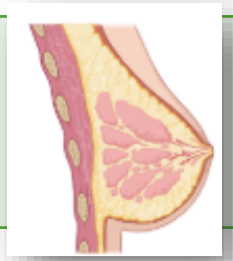
- Release of anterior pituitary gland hormones is stimulated by **releasing hormones** & suppressed by **inhibiting hormones** from hypothalamus
- Seven (7) major hormones secreted by anterior pituitary gland:
  - **[1] Human Growth Hormone (hGH)**
  - **[2] Thyroid – Stimulating Hormone (TSH)**
  - **[3] Follicle – Stimulating Hormone (FSH)**
  - **[4] Luteinizing Hormone (LH)**
  - **[5] Prolactin**
  - **[6] Adrenocorticotropic Hormone (ACTH)**
  - **[7] Melanocyte – Stimulating Hormone (MSH)**

4.3.1.1 Anterior Pituitary Gland

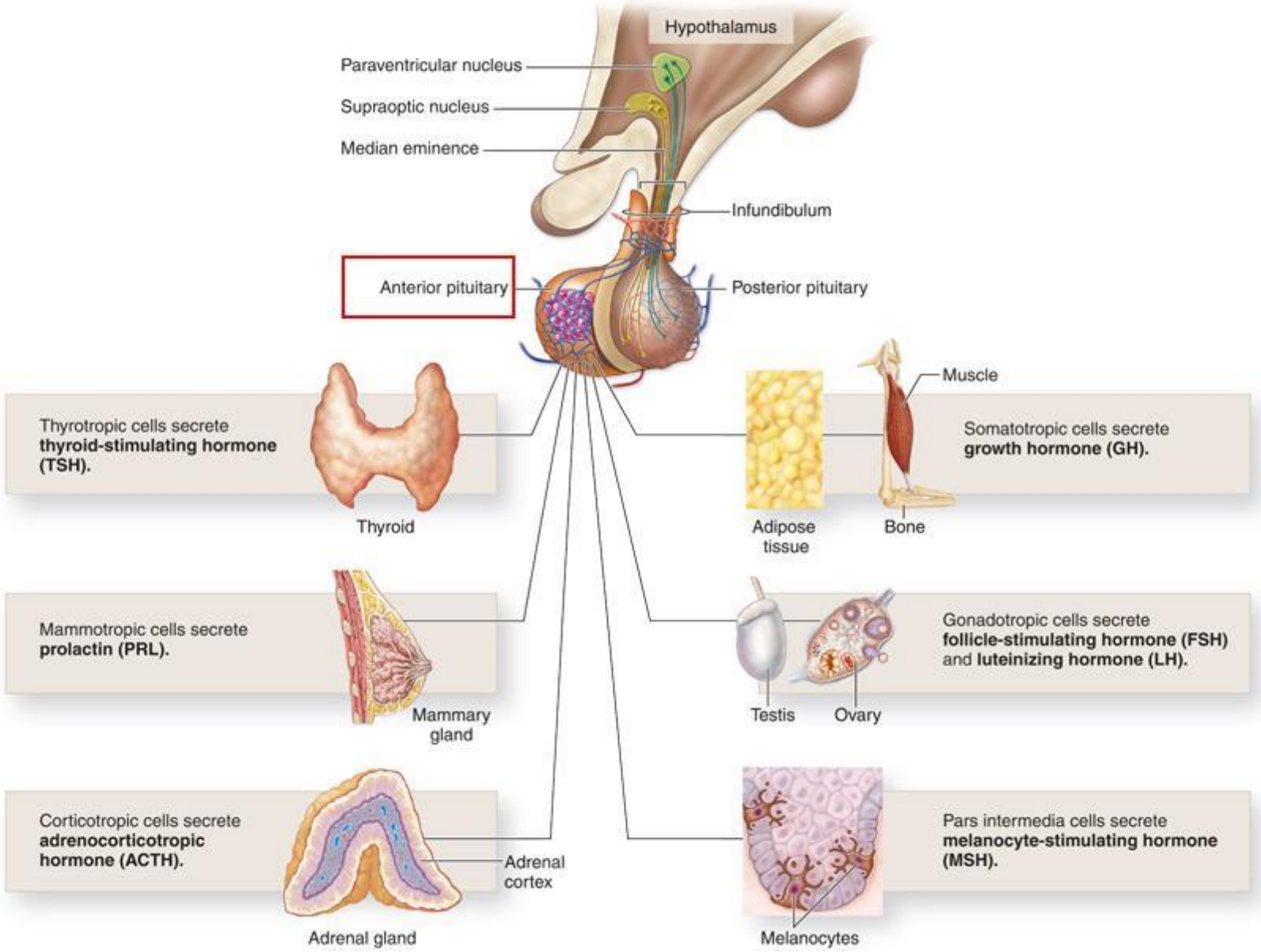
HORMONES	MAIN FUNCTIONS
hGh	• Controls growth of the body • Targets **bone, muscle** and **adipose tissue**
TSH	• Controls secretion of hormones by the thyroid gland • Targets **thyroid gland**
ACTH	• Controls the secretion of hormones by the adrenal cortex • Targets the outer portion of the **adrenal gland (cortex)**
MSH	• Increases production of melanin which cause darkening of the skin • Targets **melanocytes in skin**

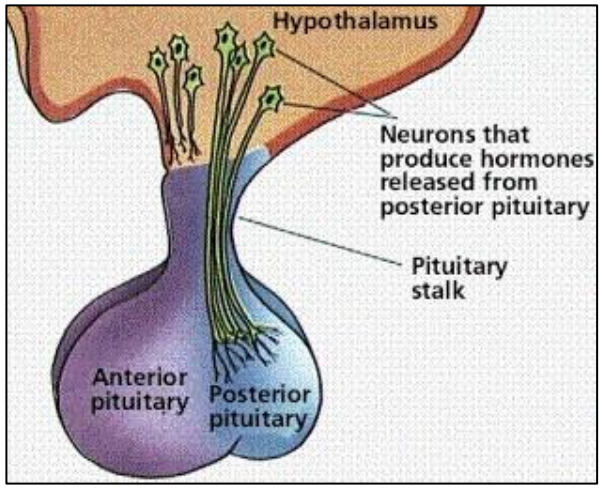
4.3.1.1 Anterior Pituitary Gland

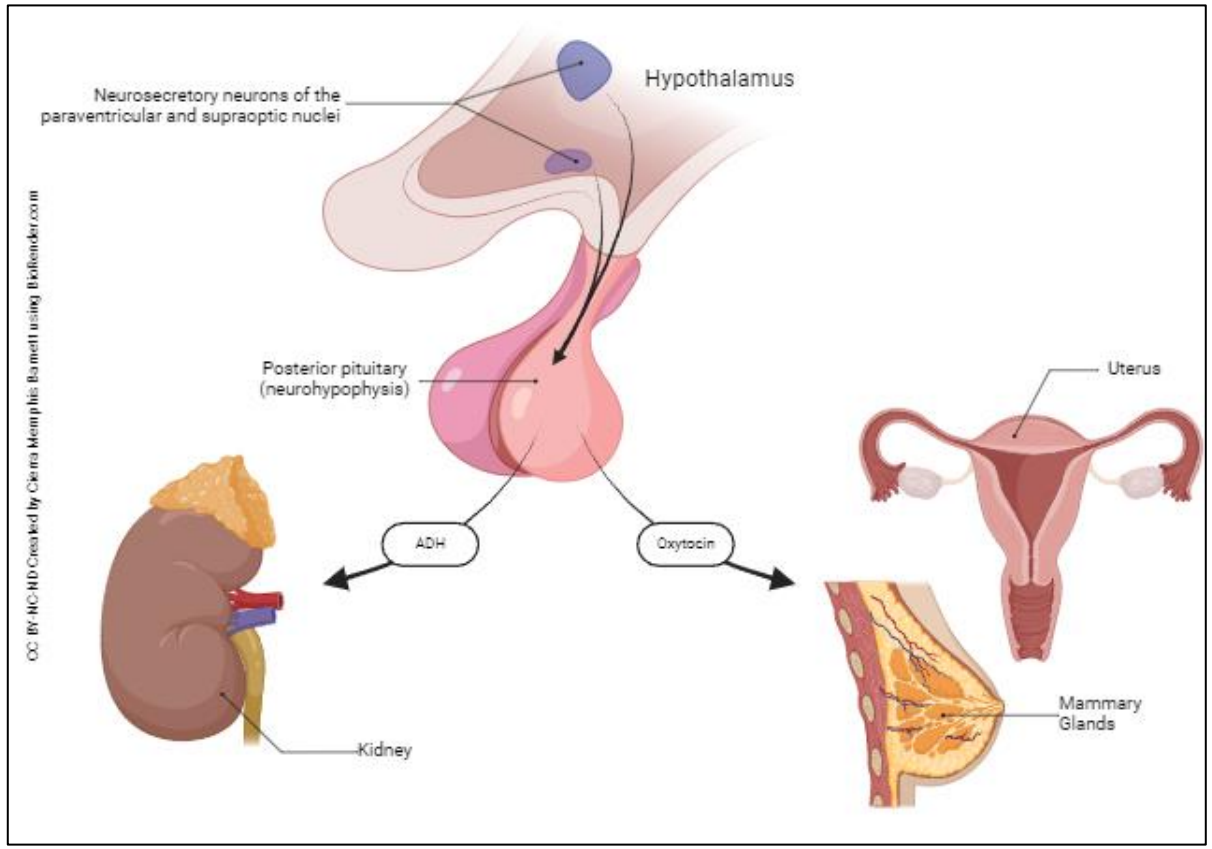
HORMONES	MAIN FUNCTIONS
FSH	• In females, stimulate development of follicles in the female egg & secretion of estrogens • In males, stimulate sperm production in testes • Targets the **ovaries** in female and **seminiferous tubules of testes**
LH	• In females, stimulate secretion of estrogens & progesterone, ovulation and formation of corpus luteum • In males, stimulate the synthesis of testosterone • Targets the **ovaries** and the **testes**
Prolactin	• Initiates and maintains milk production • Targets the **mammary glands**



4.3.1.1 Anterior Pituitary Gland







4.3.1.2 Posterior Pituitary Gland

- Posterior pituitary contain the axons and axons terminals of neurons
- The neurons bodies are in the hypothalamus
- Release of hormones into the capillaries of the posterior pituitary is stimulated by nerve impulses from hypothalamus
- Posterior pituitary **does not produce hormones**, it does **store, and release** two (2) hormones produced by the hypothalamus:
  - **i) Anti – Diuretic Hormone (ADH)**
  - **ii) Oxytocin**

i) Anti – Diuretic Hormone (ADH)

Main Functions

- Conserves body water by decreasing urine output
- Decreases water loss from sweating
- Increases blood pressure by constricting (narrowing) arterioles

i) Anti – Diuretic Hormone (ADH)

High blood osmotic pressure due to dehydration or **drop in blood volume** (hemorrhage, diarrhea or excessive sweating) in the body → stimulus → stimulate **osmoreceptors**

Will **activate the neurons** in hypothalamus to send nerve impulses to the posterior pituitary

Cause the **release of ADH** in the posterior pituitary

ADH then **diffuses into blood capillaries** of the posterior pituitary

The blood carries **ADH to three target tissues**: the kidneys, sweat glands and smooth muscle of blood vessel wall

- **Kidneys** : respond by retaining more water → absorb more water → decreasing urine output
- Secretion of sweat from **sweat gland** is decrease → reduce water loss by perspiration from the skin
- **Smooth muscle of arterial wall** contracts in response to high level of ADH → constrict the blood vessel → increase BP

Low blood osmotic pressure or increased blood volume stop the osmoreceptors

→ Stop ADH secretion

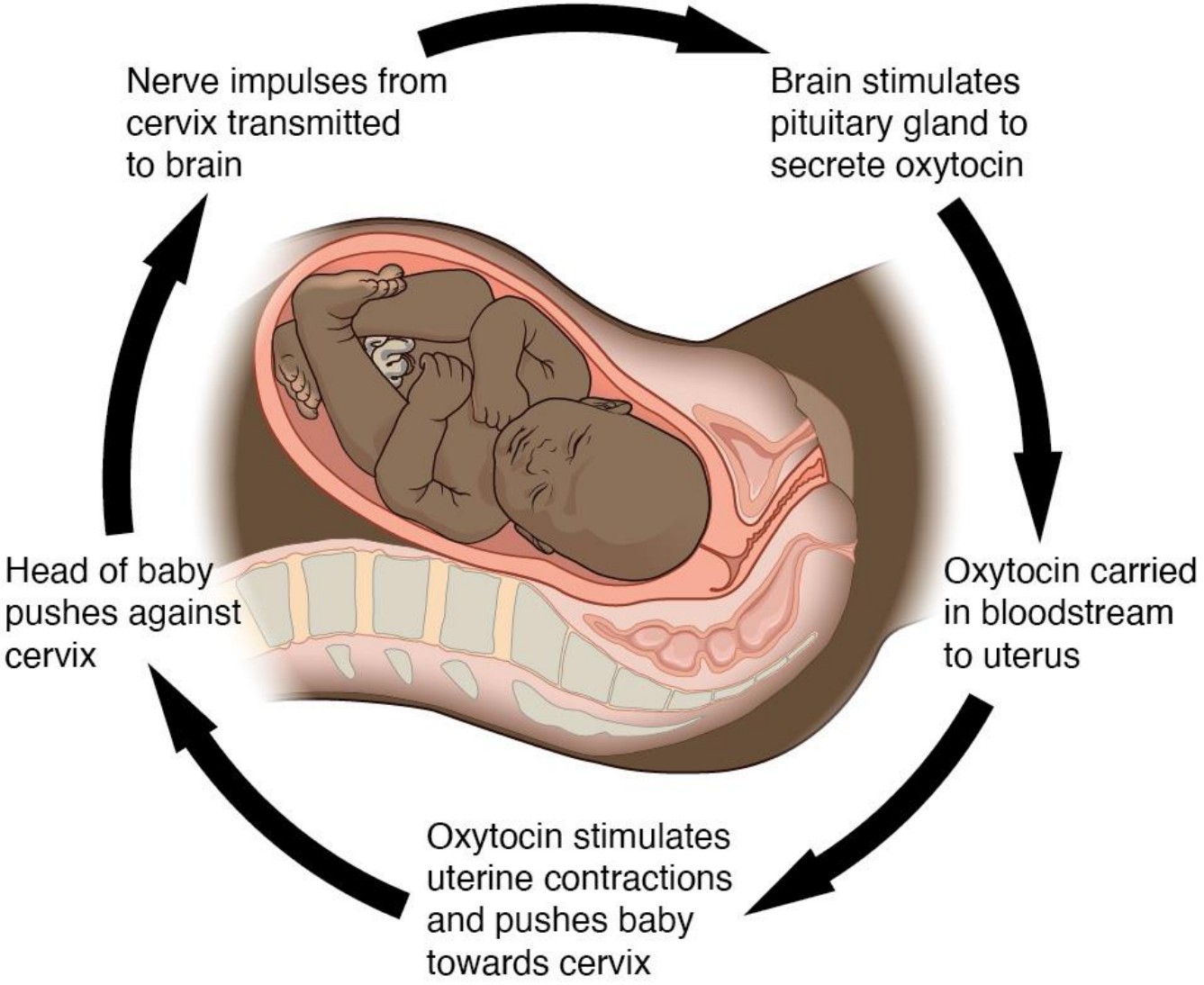
Stop all actions of target organs

→ return to normal activity → blood osmotic pressure & blood volume return to normal level

ii) Oxytocin

Main Functions

- Promotes contraction of myometrium of uterus during labour.
- Promotes release of milk (“let down” reflex) from mammary glands

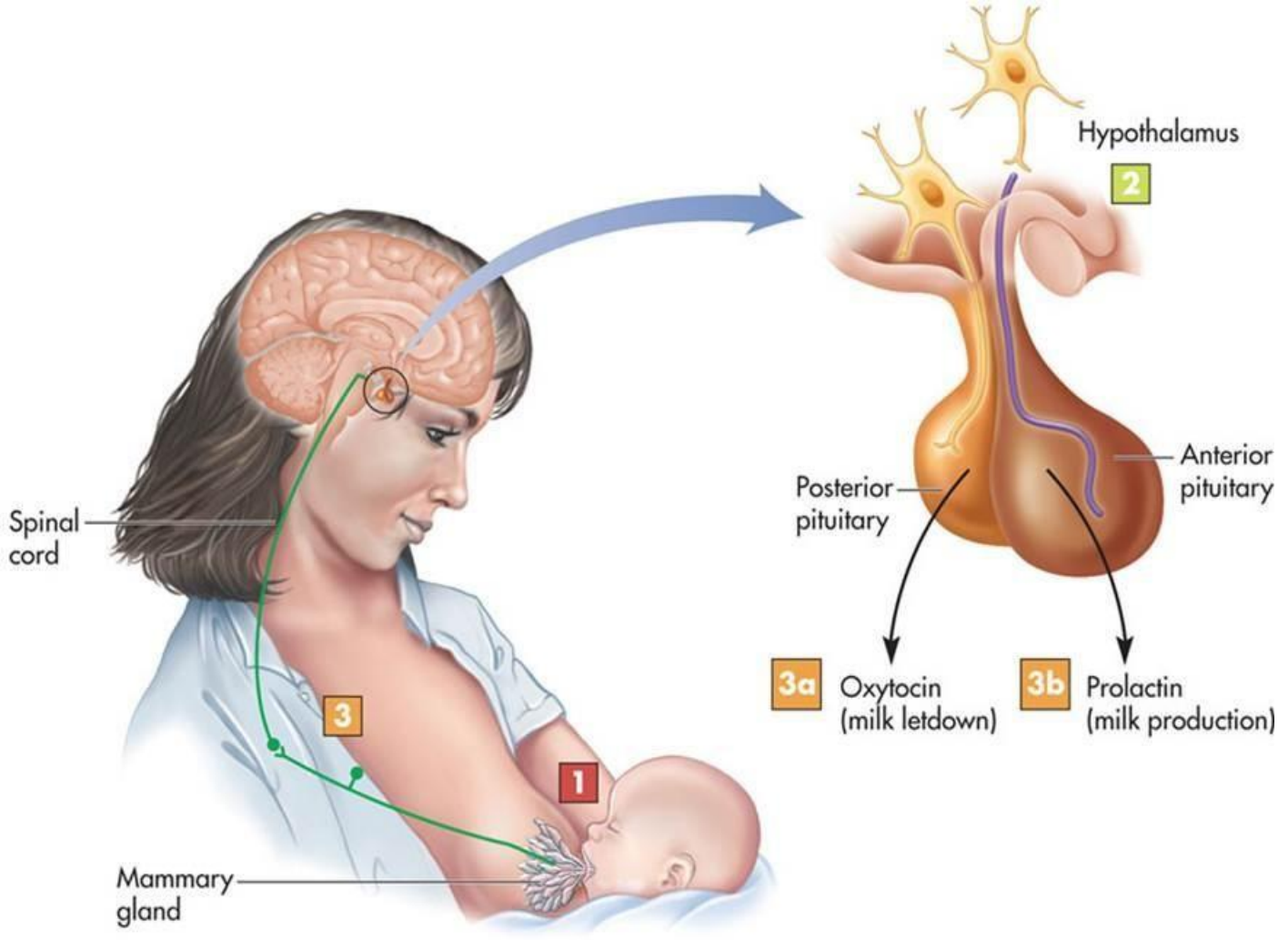


Lactation Process

1. Suckling stimulates nerves in the nipple and areola that travel to the hypothalamus.

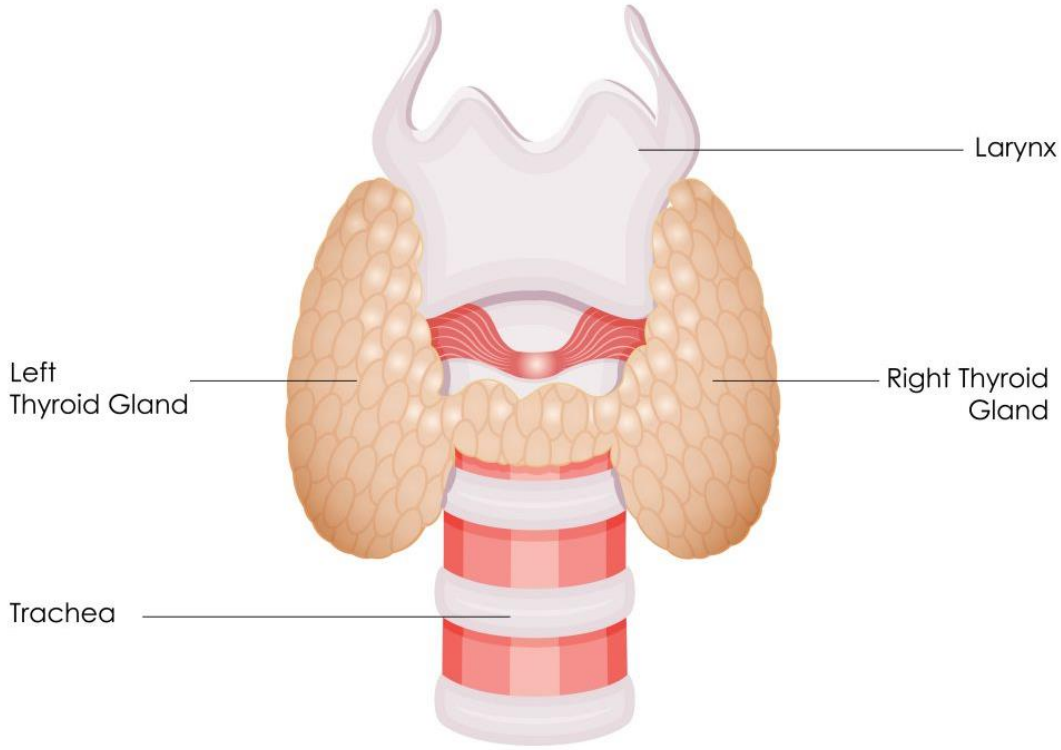
2. In response, the hypothalamus stimulates the posterior pituitary to release oxytocin and the anterior pituitary to release prolactin.

3. Oxytocin stimulates lobules in the breast to let down (release) milk from storage. Prolactin stimulates additional milk production.



4.3.2 Thyroid Gland

- Situated in the neck (in front of larynx & trachea)
- Highly vascular
- Weight about 25g
- Shape like a butterfly
- Consists of 2 lobes & joined by a narrow isthmus
- Lobes are cone-shaped, 5cm long & 3 cm wide

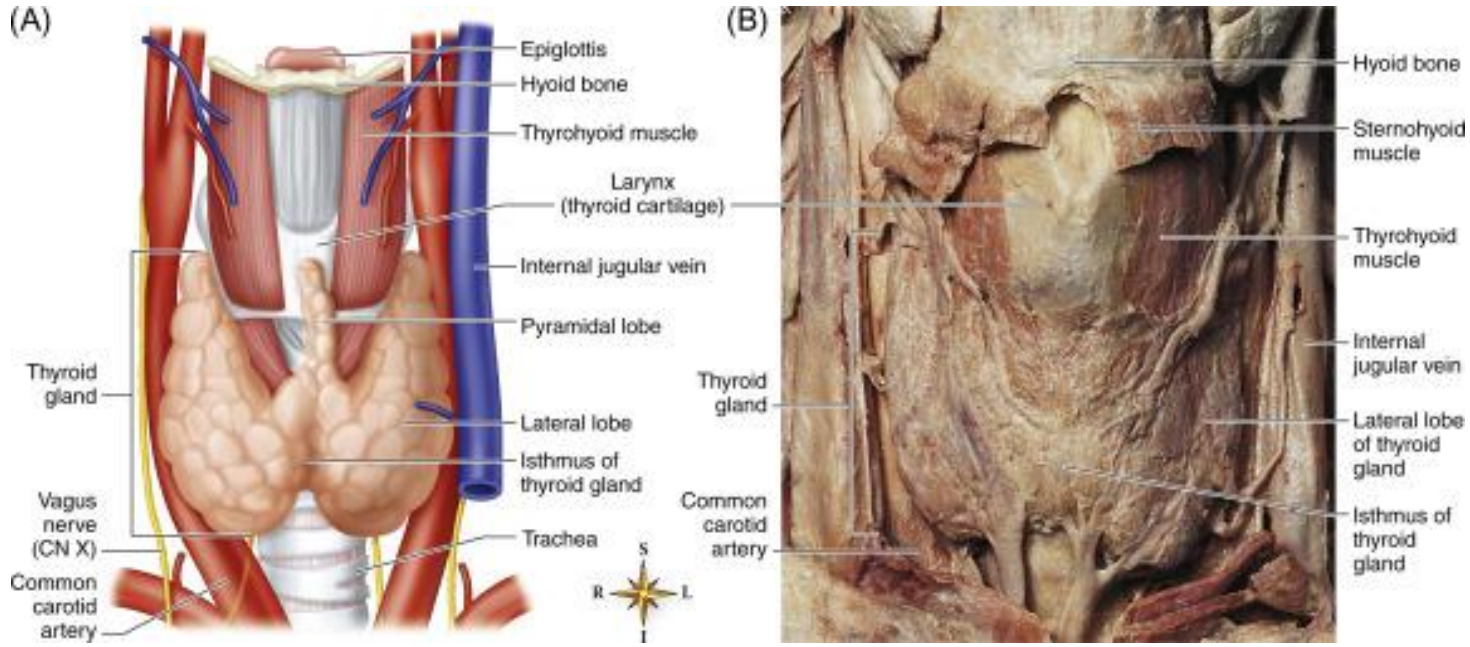


THYROID GLAND

4.3.2 Thyroid Gland

Function

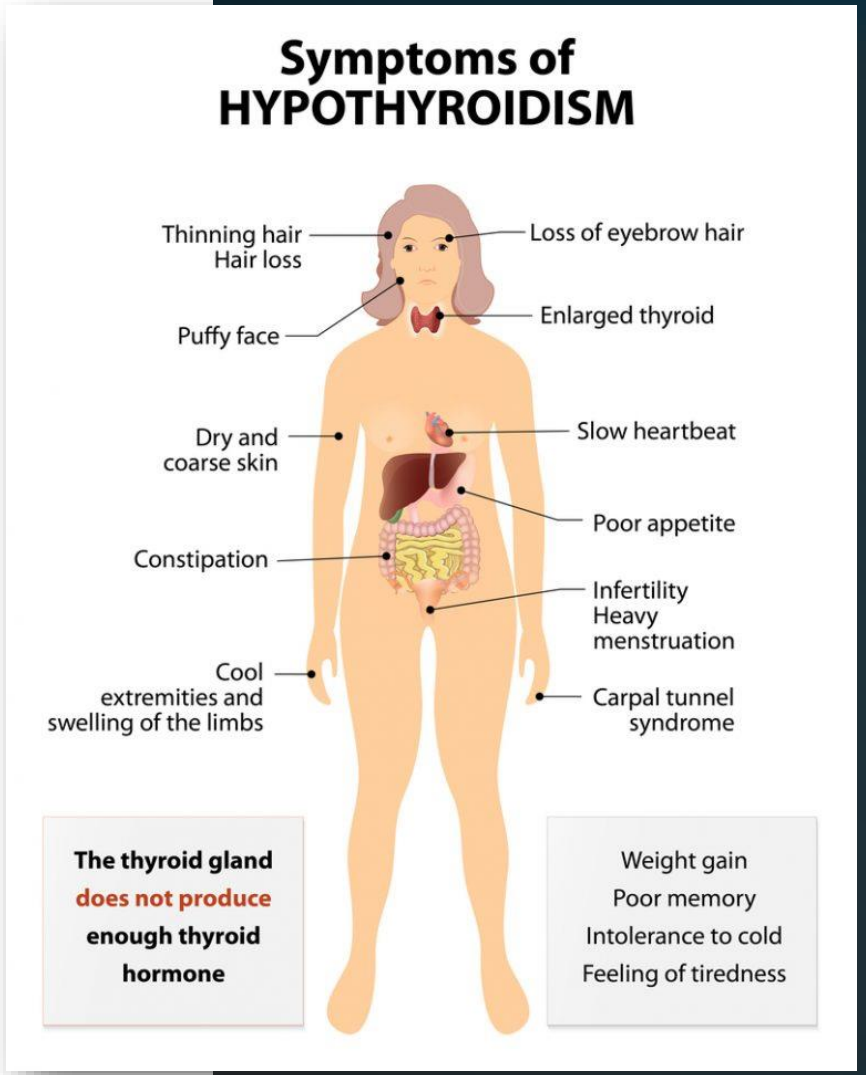
- Secretes **Thyroxine (T4)** and **Triiodothyronine (T3)**
  - *TSH promotes release of T3 & T4*
- Controls metabolism
  - *regulate the metabolism of carbohydrates, fats & proteins*
- Secretes **Calcitonin**
  - *regulate calcium level in blood by decreasing them*



Thyroid gland is the only endocrine gland that stores its secretory product in large quantity

4.3.2.1 Thyroid Dysfunction - Hypothyroidism

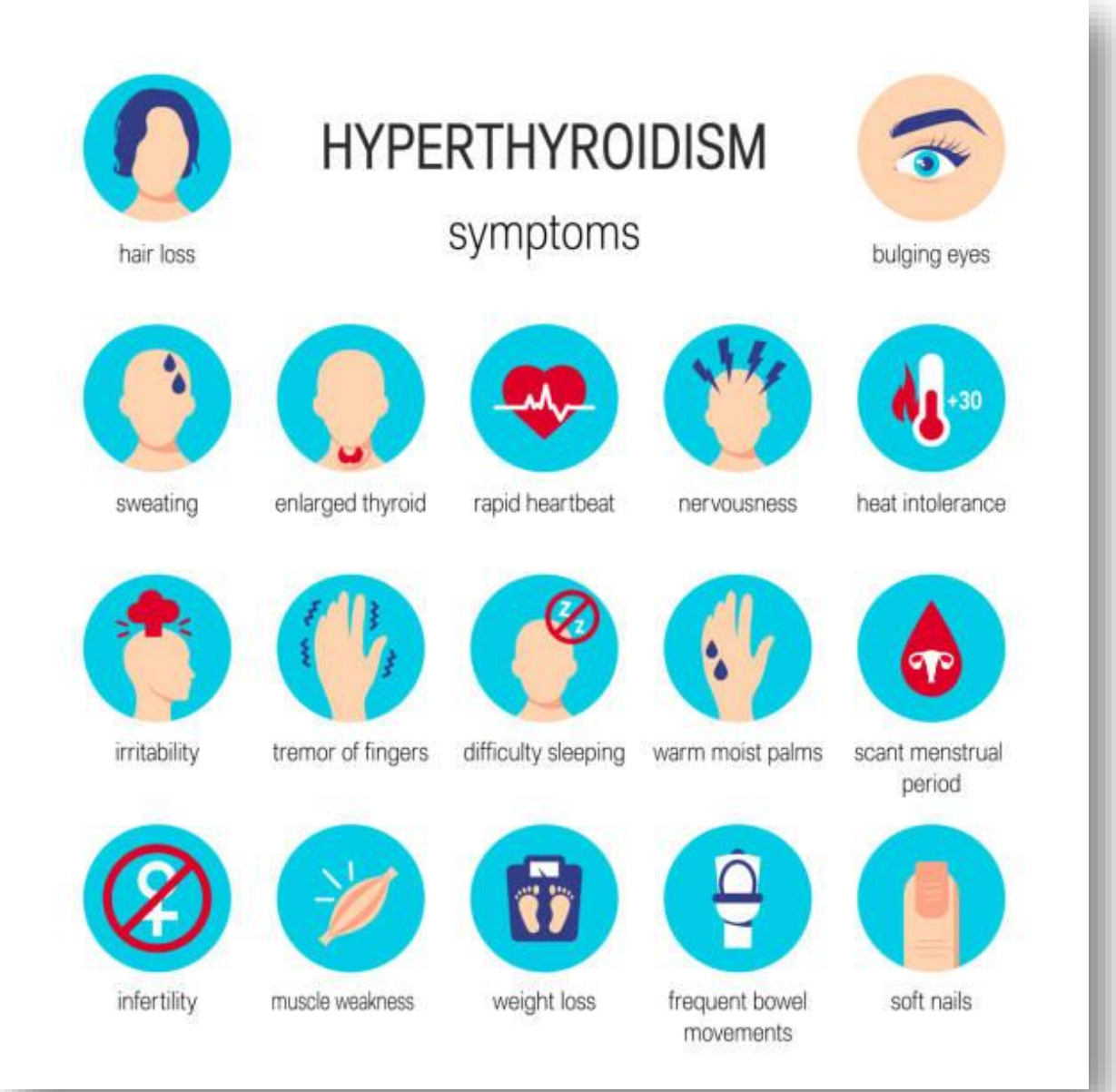
- A condition where the thyroid gland produces too little thyroid hormone, causing a slowing down of bodily functions
- Low level of T3 and T4 (*decreased*)
- Sign & symptoms:
- ***Dry skin, brittle hair***
- ***Bradycardia (slow heart rate)***
- ***Decreased metabolic rate***
- ***Depression, psychosis, mental slowness, lethargy***
- ***Dry cold skin, prone to hypothermia***
- ***Constipation***
- ***Weight gain or anorexia***



4.3.2.2 Thyroid Dysfunction - Hyperthyroidism

- A condition where the thyroid gland produces too much thyroid hormone, causing a speeding up of bodily functions
- High level of T3 & T4 (*increased*)
- Sign & symptoms:

- ***Increased metabolic rate***
- ***Anxiety, physical restlessness, mental excitability***
- ***Hair loss***
- ***Tachycardia, palpitations, atrial fibrillation***
- ***Warm sweaty skin, heat intolerance***
- ***Diarrhea***
- ***Weight loss, good appetite***
- ***Exophthalmos in Graves' disease***



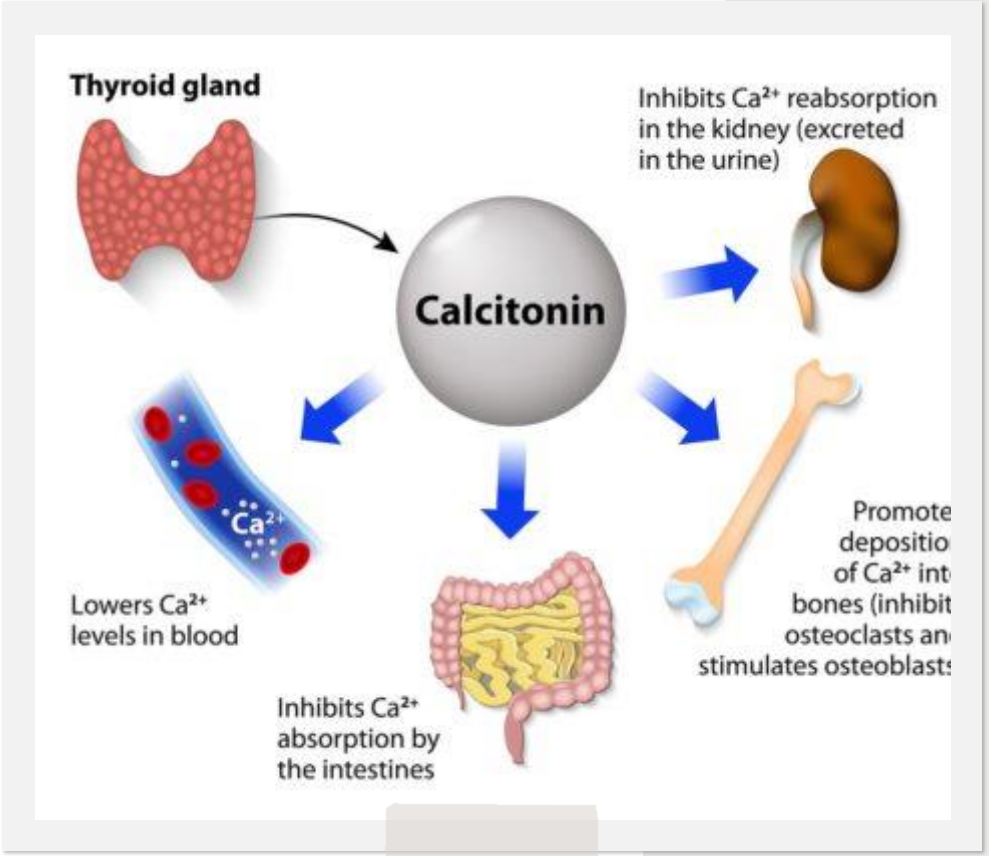
4.3.2.3 Calcitonin

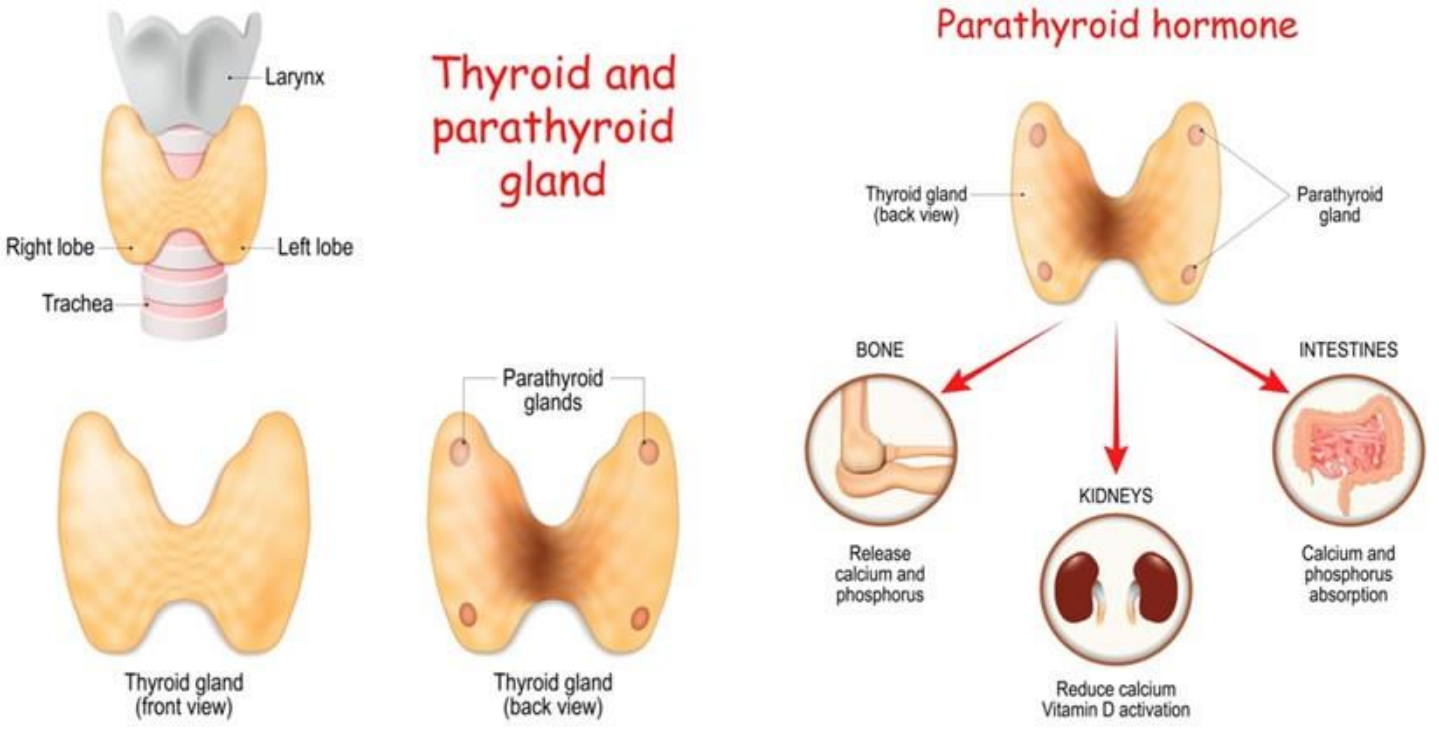
- Release is triggered by an **increase in blood calcium levels**

  a) Target **bone cells** (*stimulates osteoblast - cell that makes bone activity and inhibits osteoclasts cell that break down old bone activity*)

  b) Target **distal convoluted tubules** (*causes secretion of excess calcium into urine*)

- Therefore, causes a **decrease in blood calcium (and phosphate) levels back to normal**





4.3.3 Parathyroid Gland

- Consists of 4 small glands *(2 embedded in the posterior surface of each lobe of the thyroid gland)*
- Secretes **parathyroid hormone (PTH)**
- Main function:
  - **Regulates the amount of calcium and phosphorus in the blood by increasing them**

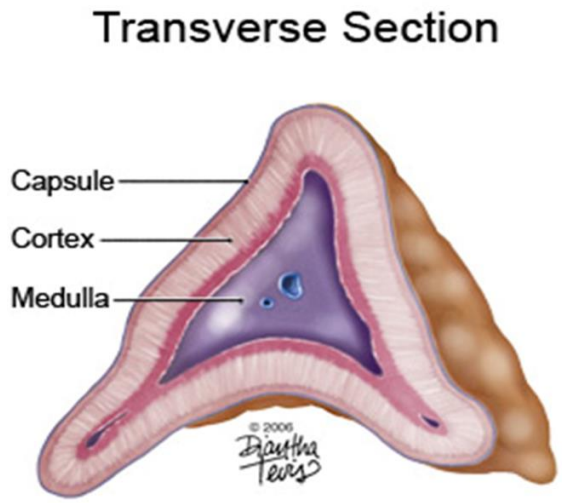
4.3.3.1 Physiology of Parathyroid Gland

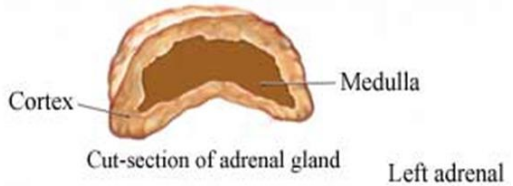
Release of PTH is stimulated by **decreased blood calcium levels**

PTH targets bone cells *(activates osteoclasts to reabsorb calcium back into bloodstream)*, and small intestine *(promotes calcium absorption)*

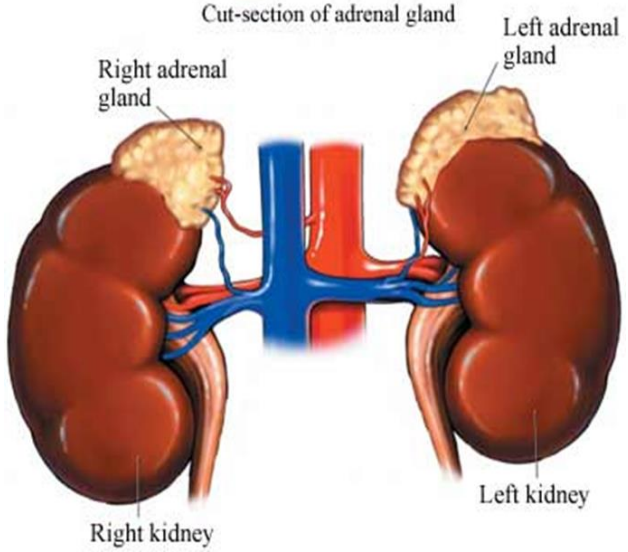
Therefore, PTH causes an **increase in blood calcium and phosphate levels back to normal**

PTH and calcitonin together maintain the homeostasis of Ca++ in the blood





Cut-section of adrenal gland



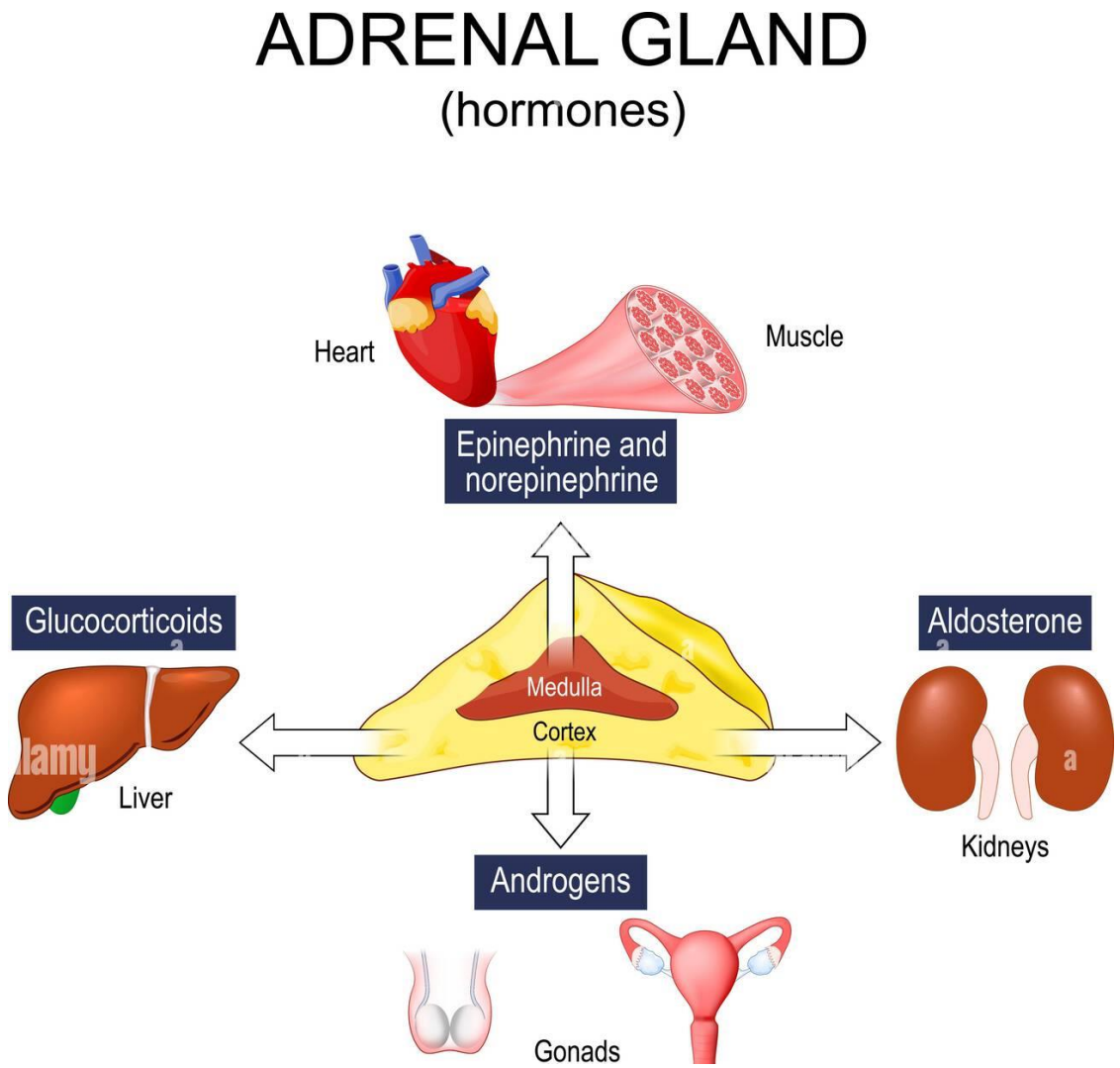
4.3.4 Adrenal Gland

- Lies **superior** to each kidney.
- 4 cm long & 3 cm thick
- Flattened **pyramidal shape**
- 3 main parts:
  - → *capsule (outer)*
  - → *adrenal cortex (middle)*
  - → *adrenal medulla (inner)*

4.3.4 Adrenal Gland

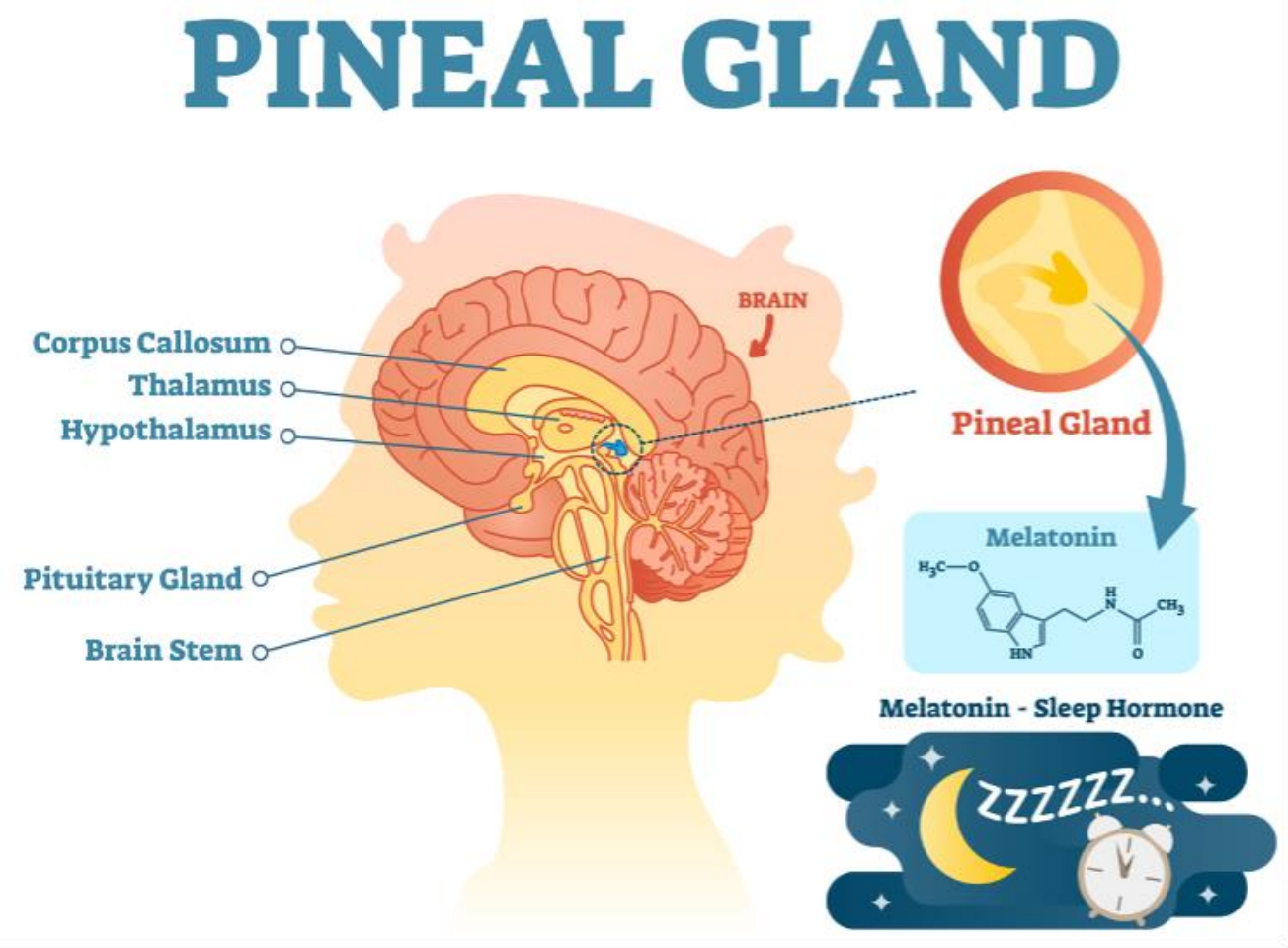
Hormones secrete by adrenal glands

- Adrenal cortex hormones
  - **- Aldosterone**
  - **- Cortisol**
  - **- Androgen**
- Adrenal medulla hormones
  - **- Epinephrine**
  - **- Norepinephrine**



4.3.4 Adrenal Gland

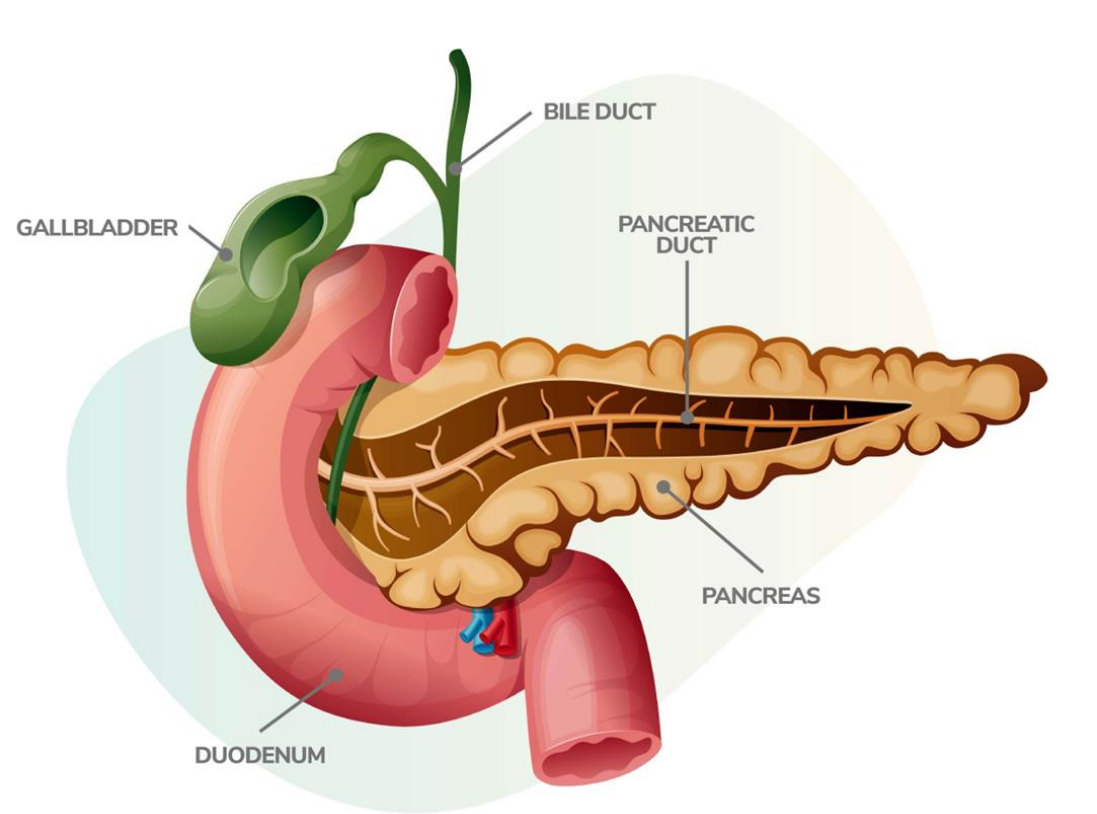
HORMONES	FUNCTIONS
Aldosterone	• Regulates the level of sodium and potassium in the body • Helps maintain blood volume and blood pressure
Cortisol	• Increase protein breakdown • Stimulate gluconeogenesis (synthesis of glucose from amino acids or lactic acids) • Provide resistance to stress
Androgen	• Assist early growth of axillary & pubic hair • For female = contribute to libido (sexual desire)
Epinephrine **Norepinephrine**	• Helps the body to respond to a stressful situation by increasing the heart rate and force of heart contractions *(sympathetic)* • Facilitates blood flow to the muscles and brain • Causes relaxation of smooth muscles • Helps with conversion of glycogen to glucose in the liver, and other activities



4.3.5 Pineal Gland

- Attached to the thalamus of the brain stem
- Secretes hormone called **melatonin**
- Hormones secretory cells called = Pinealocytes
- Function: **In darkness, secretion of melatonin is increase & promotes sleepiness**
- Being exposed to light at night can block melatonin production

4.4 Pancreas



- Flattened organ measures 12.5 → 15 cm
- Posterior & slightly inferior gaster
- Consist 3 parts (head, body & tail)
- Pancreatic cells:

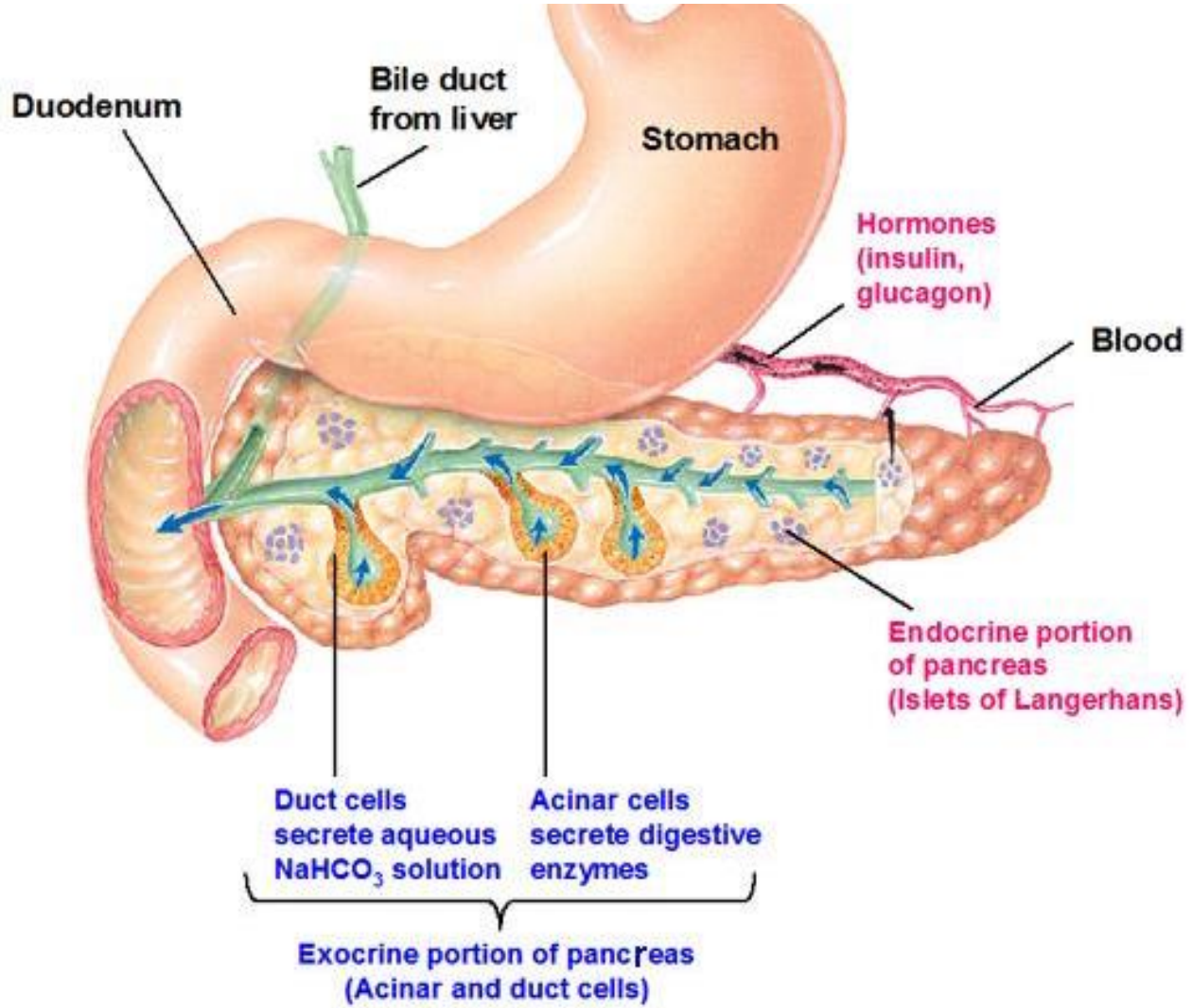
  [1] Acini (exocrine) ---- (99%)

  → produce digestive enzymes = *Amylase, Trypsin & Lipase*

  [2] Pancreatic islets (endocrine)

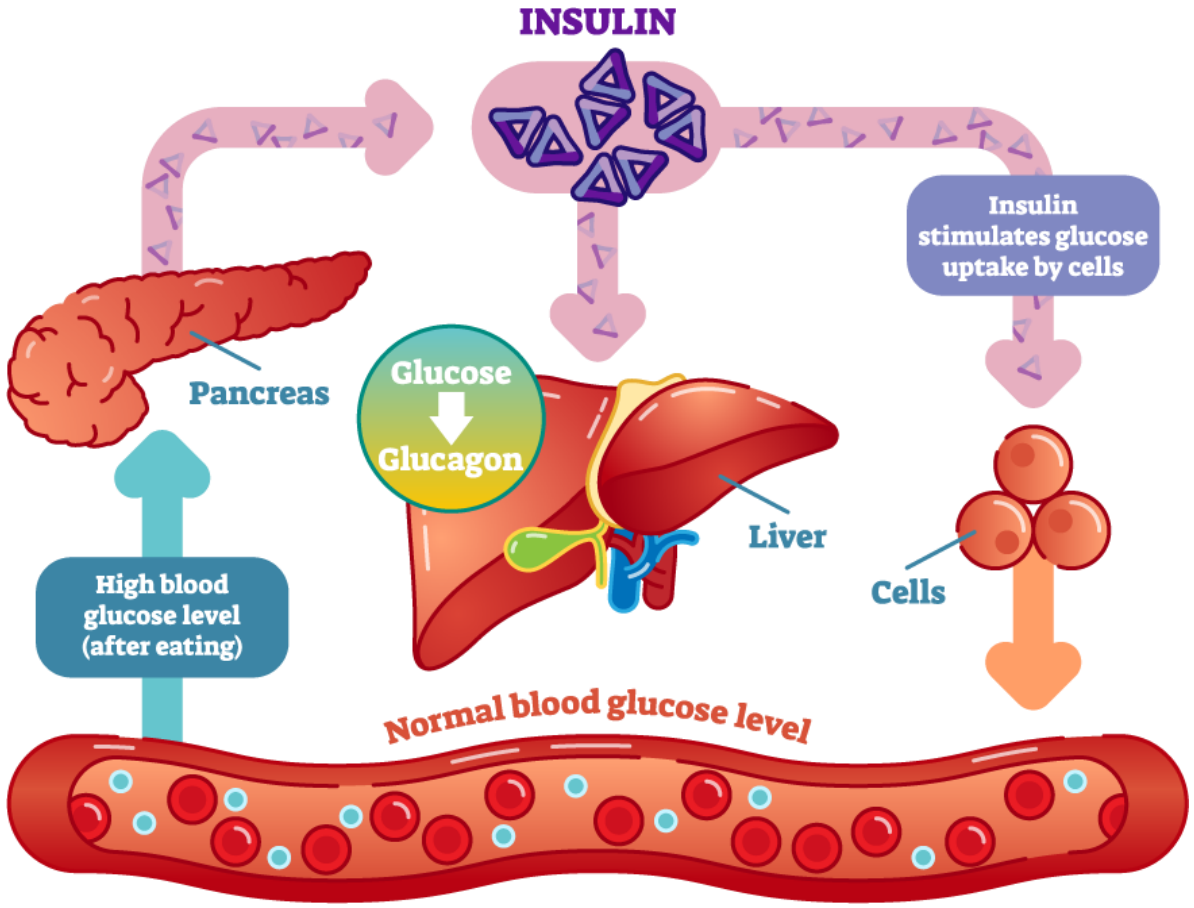
  → hormones = *Glucagon, Insulin, Somatostatin & Pancreatic polypeptide*
- Secretes **insulin** and **glucagon** that regulates the blood glucose level

4.4 Pancreas


Duodenum
Bile duct from liver
Stomach
Hormones (insulin, glucagon)
Blood
Endocrine portion of pancreas (Islets of Langerhans)
Duct cells secrete aqueous $NaHCO_3$ solution
Acinar cells secrete digestive enzymes
Exocrine portion of pancreas (Acinar and duct cells)

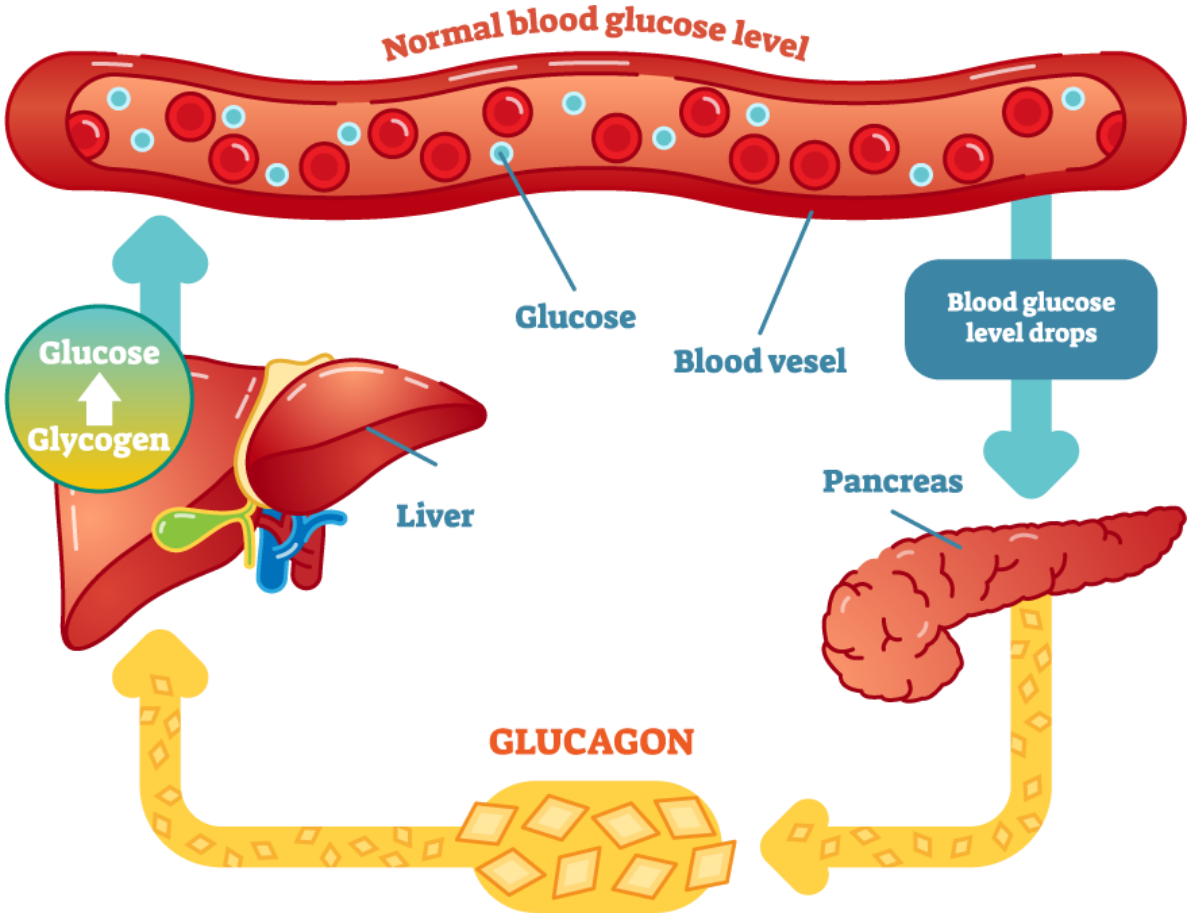
4.4.1 Insulin

- Produced by Beta cells (β-cells) in Islets of Langerhans
- Secretion is stimulated by **increased blood glucose levels** (eg. after eating)
- **Insulin will decreases blood glucose** levels to normal level

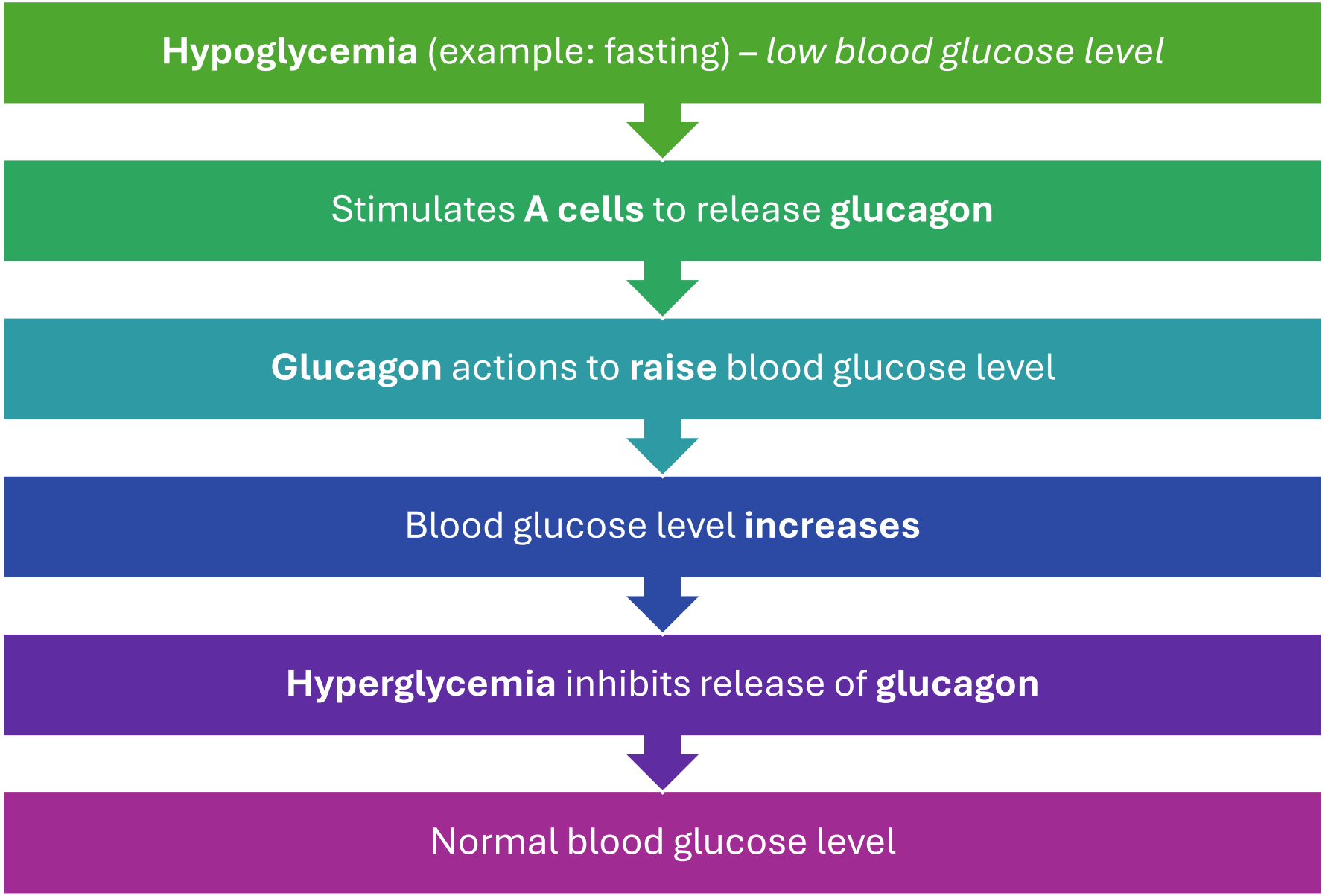


4.4.2 Glucagon

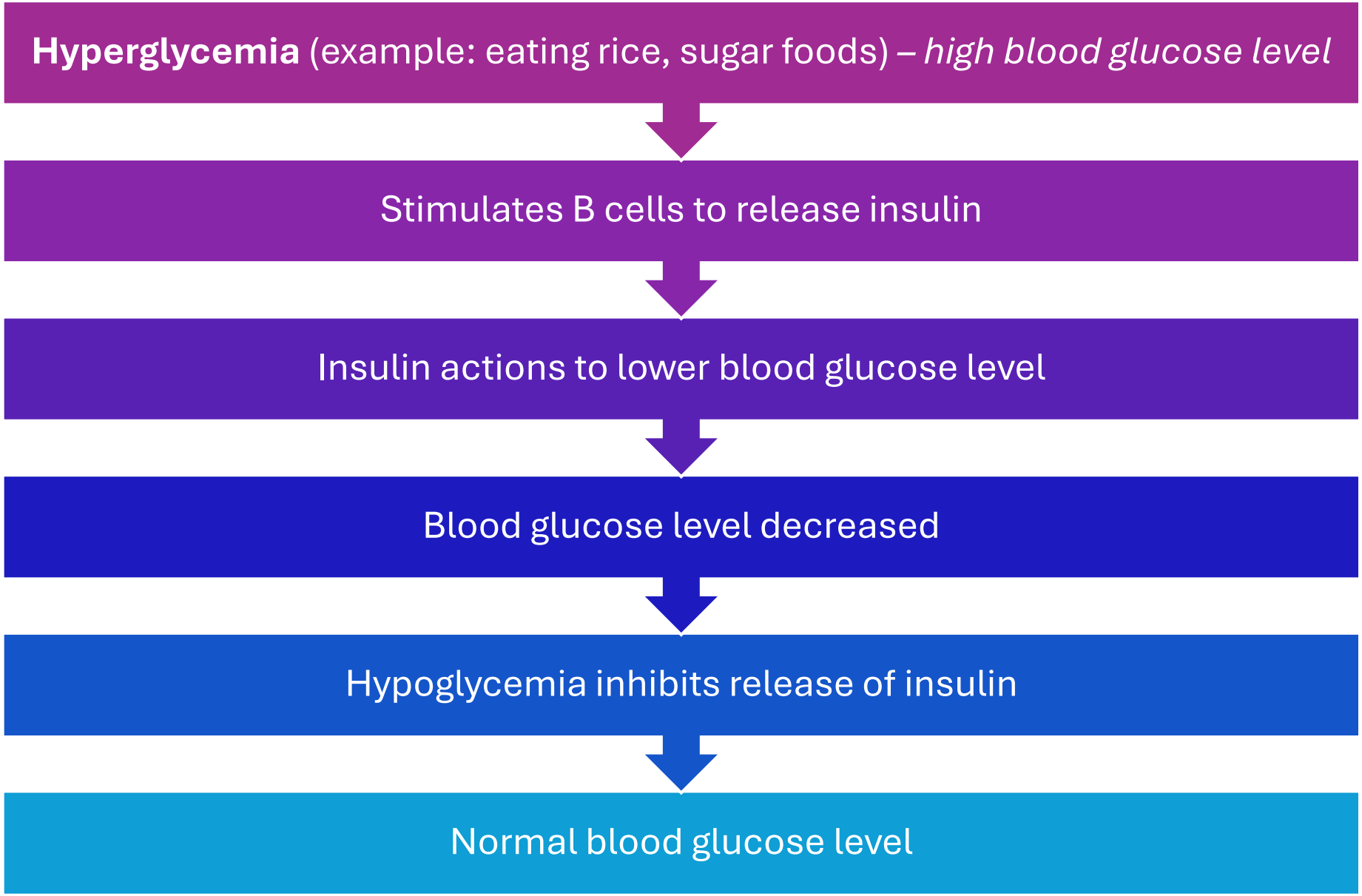
- Produced by Alpha cells (α-cells) in Islets of Langerhans
- Secretion is stimulated by **decreased blood glucose levels** (eg. fasting)
- **Glucagon will increases blood glucose** levels to normal level



4.4.3 Mechanism of Action: Hypoglycemia

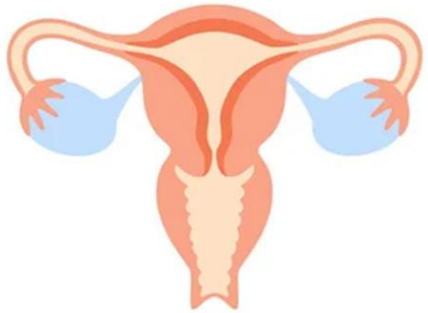


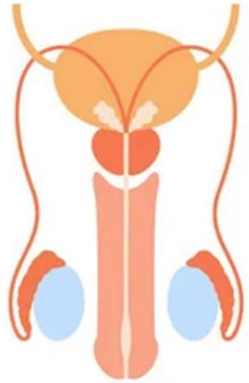
4.4.3 Mechanism of Action: Hyperglycemia

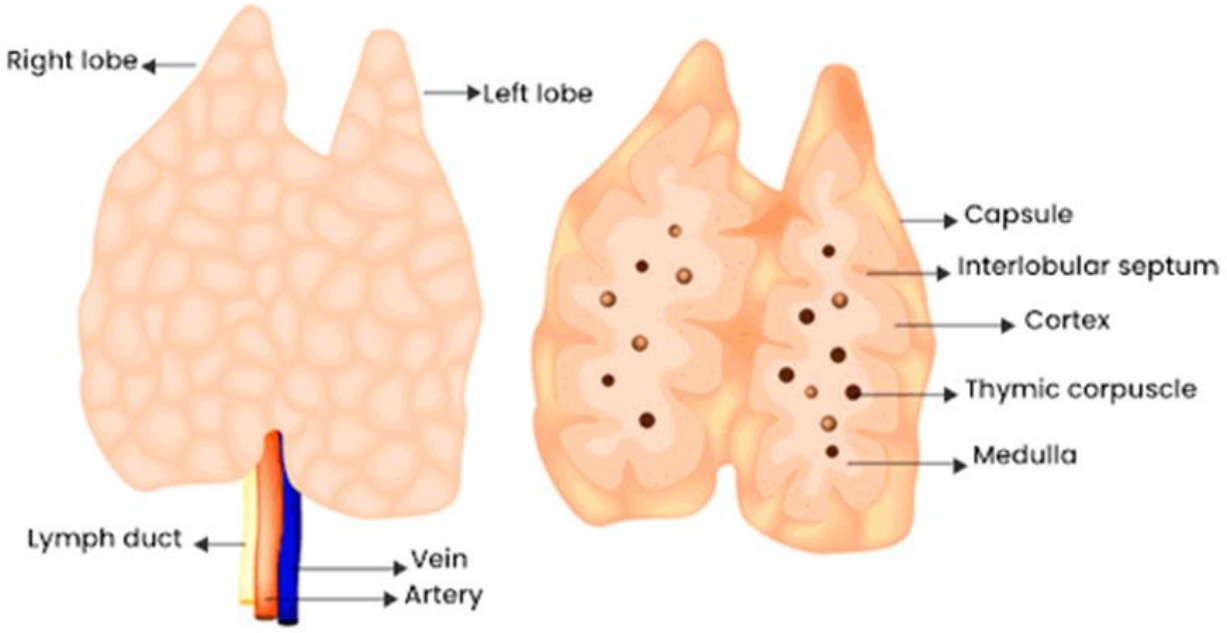


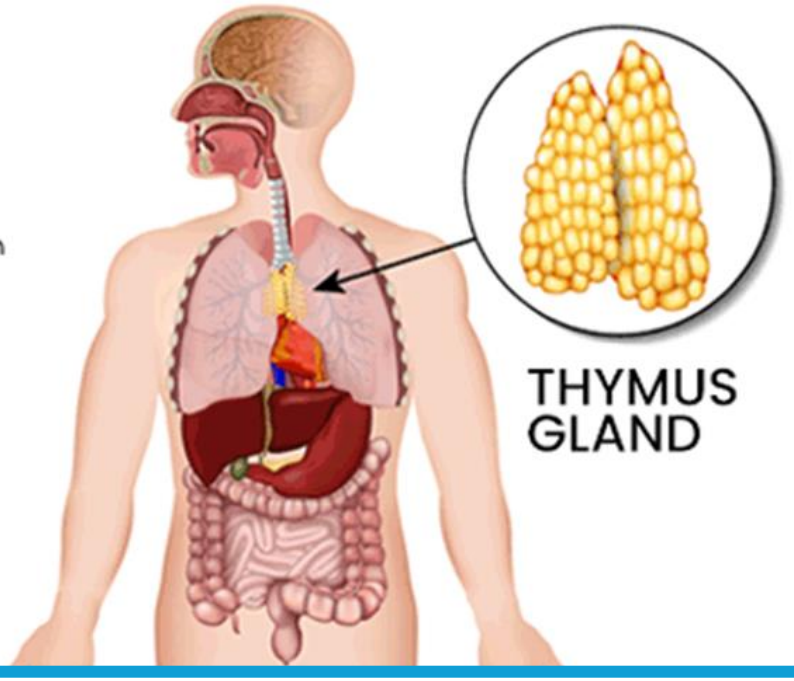
4.5 Gonads (Ovary & Testes)

Ovary	Testes
Female reproductive organ	Male reproductive organ
Produce ovum	Produce sperm
Secrete estrogen & progesterone	Secrete testosterone







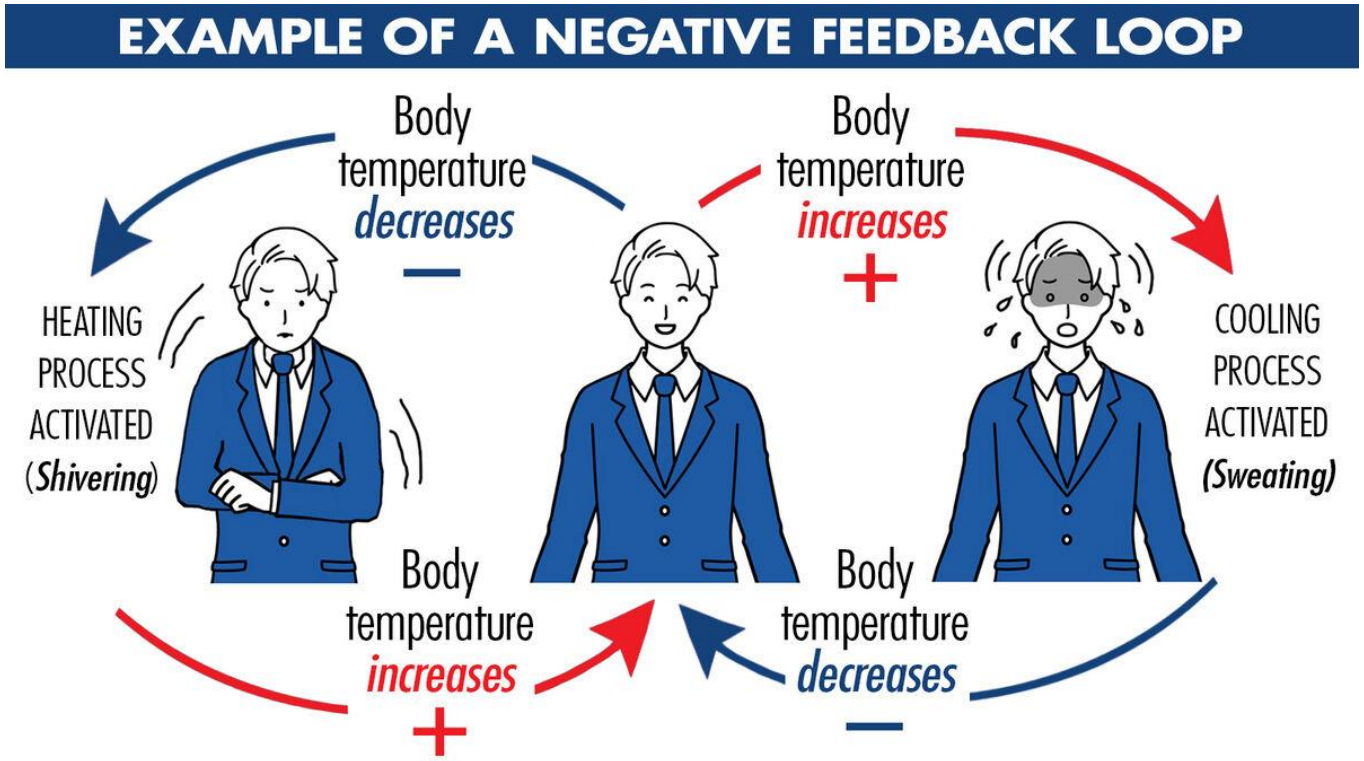


4.6 Thymus

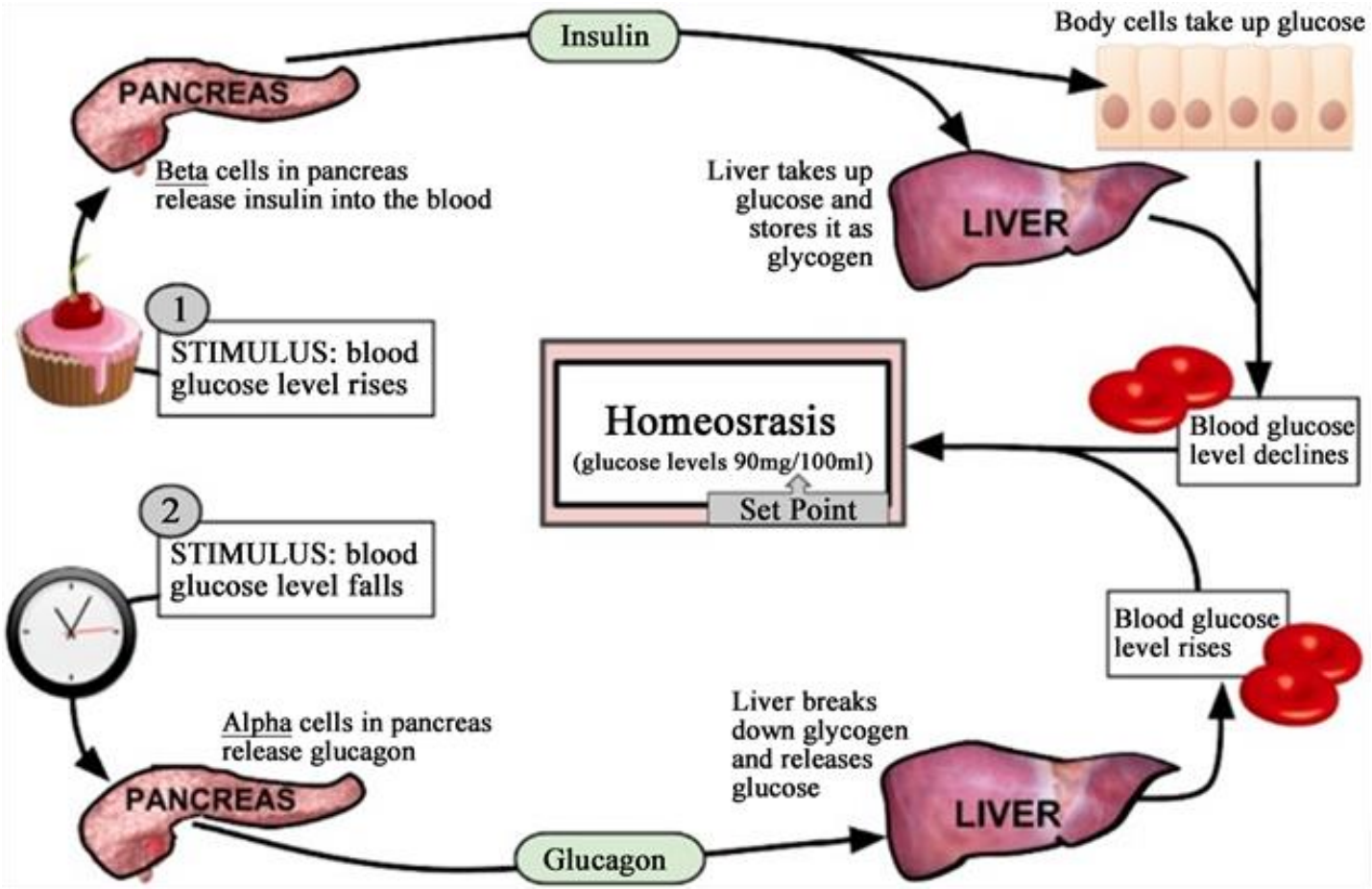
- Play a role in lymphatic system and immunity
- Produces **thymosin**
- Promote proliferation and maturation of white blood cells which destroy microbes and foreign substances.
- Decrease in size as we age

4.7 Negative Feedback Mechanisms

- Feedback mechanisms are interactions between endocrine glands, blood levels of various hormones, and certain activities of target organ
- Occurs when there is a drop in level of hormone
- The drop trigger a response to increase amount of hormone in blood
- The gland responds to blood levels of substances (by increasing hormone secretion) and stop producing more hormones when substance reach normal level again

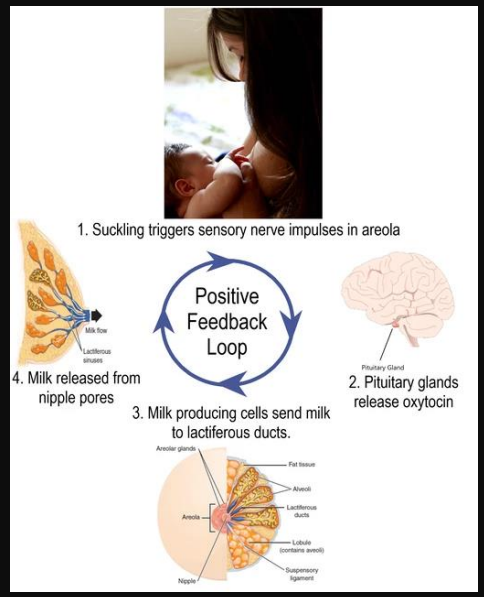


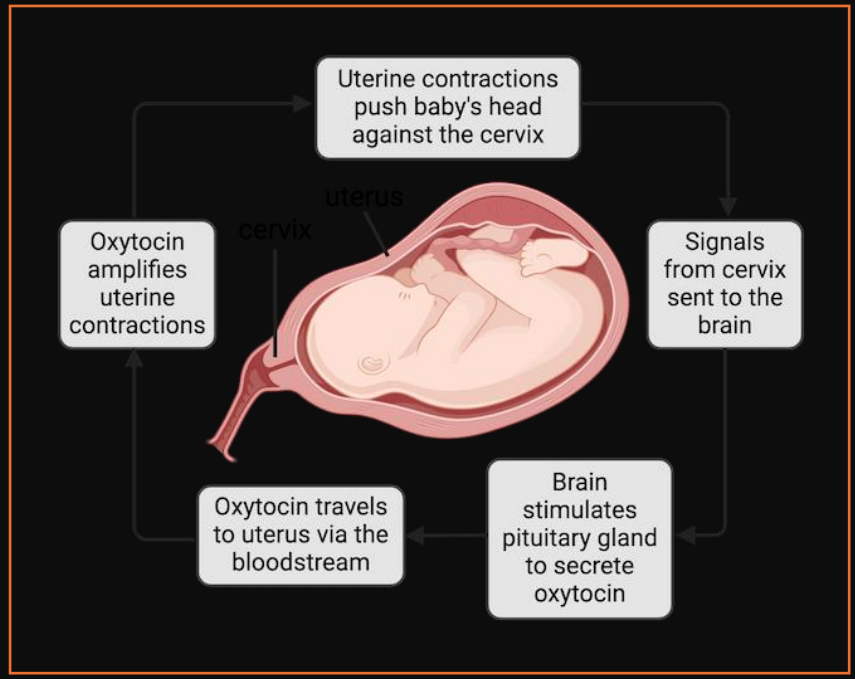
4.7 Negative Feedback Mechanisms

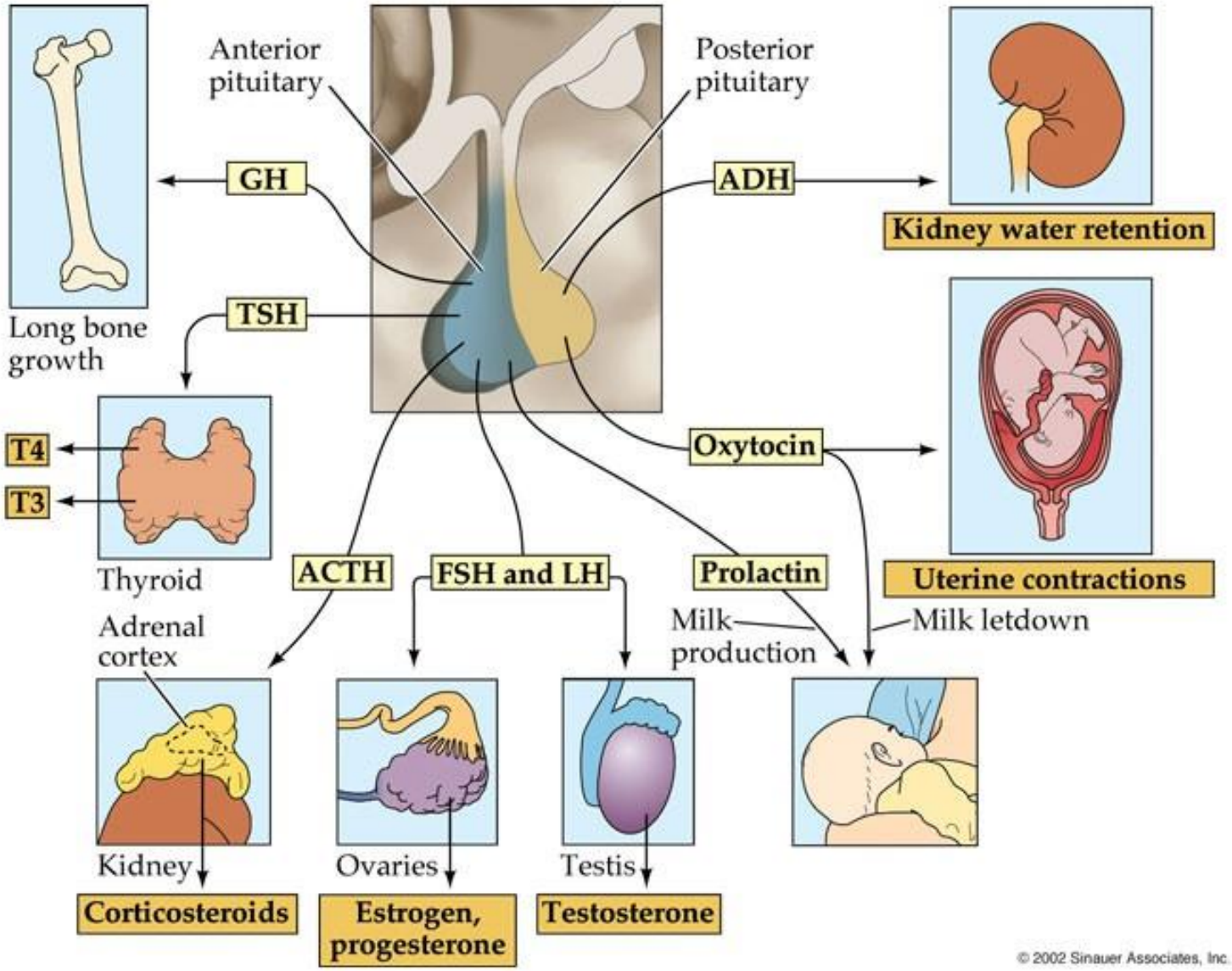


4.8 Positive Feedback Mechanisms

- As long as stimulus is present, action of hormone continues. Example:
  - Infant nursing at mother's breast →stimulates hypothalamus → stimulates posterior pituitary
  - Oxytocin released → stimulates milk ejection from mammary glands
  - Milk release continues as long as infant continues to breast feed






Anterior pituitary
Posterior pituitary
GH
ADH
Kidney water retention
Long bone growth
TSH
T4
T3
Thyroid
Oxytocin
Uterine contractions
ACTH
FSH and LH
Prolactin
Milk production
Milk letdown
Adrenal cortex
Kidney
Ovaries
Testis
Corticosteroids
Estrogen, progesterone
Testosterone
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REFERENCES

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THANK YOU