

ENDOCRINE PHYSIOLOGY

PROF. ABDULMAJEED AL-DREES

OBJECTIVES

- **By the end of this lecture, students should be able to describe :**
- **Hormones**
 - Definition
 - Chemical structure
 - Paracrine and autocrine
- **Secretion and clearance of hormones**
- **Mechanism of action of hormones**
 - Hormone receptors, down-regulation and up-regulation
 - Intracellular signaling
 - Second messenger mechanism (cAMP, IP₃)

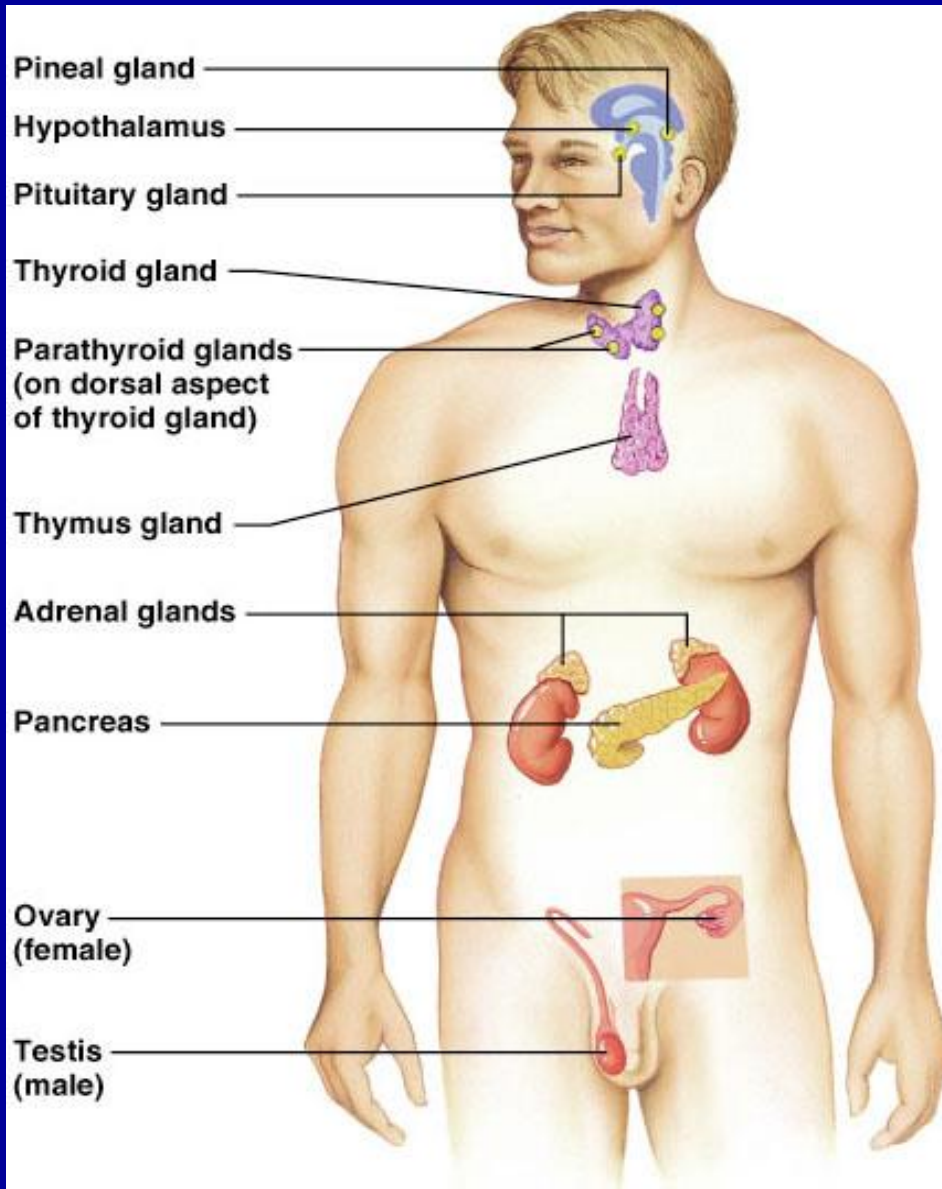
GLANDS

- **Exocrine gland.**
- **Endocrine gland.**

What is hormone?.

- **Chemical substance** secreted in a small amount from endocrine gland directly to the blood stream in response to **stimulus** to cause physiological responses at the **target tissues**.

ENDOCRINE GLANDS



HYPOTHALAMUS

TRH CRH GnRH GHRH Somatostatin Dopamine

ANTERIOR PITUITARY

TSH FSH LH ACTH MSH Growth hormone Prolactin

POSTERIOR PITUITARY

Oxytocin ADH

THYROID

T₃, T₄ Calcitonin

PARATHYROID

PTH

PANCREAS

Insulin Glucagon

ADRENAL MEDULLA

Norepinephrine Epinephrine

KIDNEY

Renin 1,25-Dihydroxycholecalciferol

ADRENAL CORTEX

Cortisol Aldosterone Adrenal androgens

TESTES

Testosterone

OVARIES

Estradiol Progesterone

CORPUS LUTEUM

Estradiol Progesterone

PLACENTA

HCG
Estriol Progesterone
HPL

Table 9-1 Commonly Used Abbreviations in Endocrine Physiology

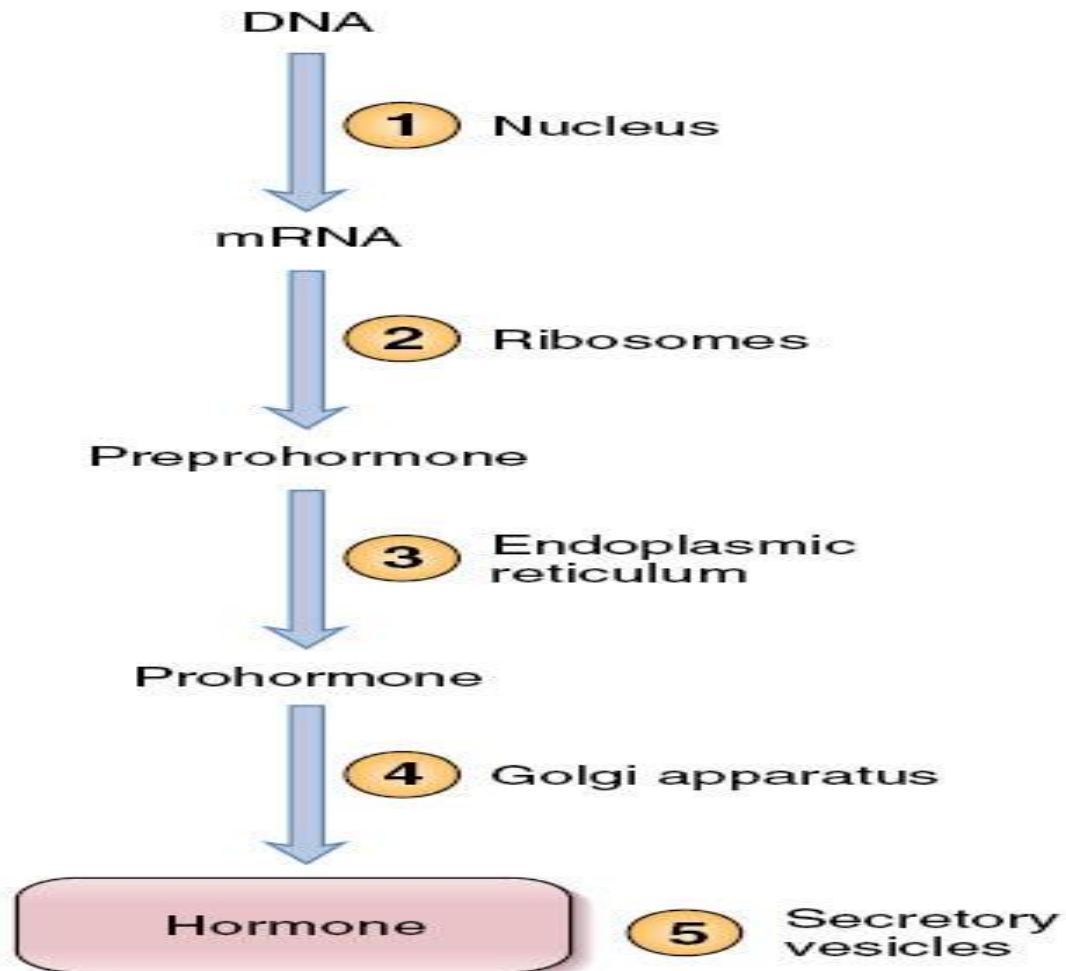
Abbreviation	Hormone	Abbreviation	Hormone
ACTH	Adrenocorticotrophic hormone	LH	Luteinizing hormone
ADH	Antidiuretic hormone	MIT	Monoiodotyrosine
CRH	Corticotropin-releasing hormone	MSH	Melanocyte-stimulating hormone
DHEA	Dehydroepiandrosterone	PIF	Prolactin-inhibiting factor
DIT	Diiodotyrosine	POMC	Pro-opiomelanocortin
DOC	11-Deoxycorticosterone	PTH	Parathyroid hormone
FSH	Follicle-stimulating hormone	PTU	Propylthiouracil
GHRH	Growth hormone-releasing hormone	SRIF	Somatotropin release-inhibiting factor
GnRH	Gonadotropin-releasing hormone	T ₃	Triiodothyronine
HCG	Human chorionic gonadotropin	T ₄	Thyroxine
HGH	Human growth hormone	TBG	Thyroxine-binding globulin
HPL	Human placental lactogen	TRH	Thyrotropin-releasing hormone
IGF	Insulin-like growth factor	TSH	Thyroid-stimulating hormone

CHEMICAL CLASSIFICATION OF HORMONES

- **Peptides or proteins hormones.**
- **Steroid hormones.**
- **Amine hormones.**

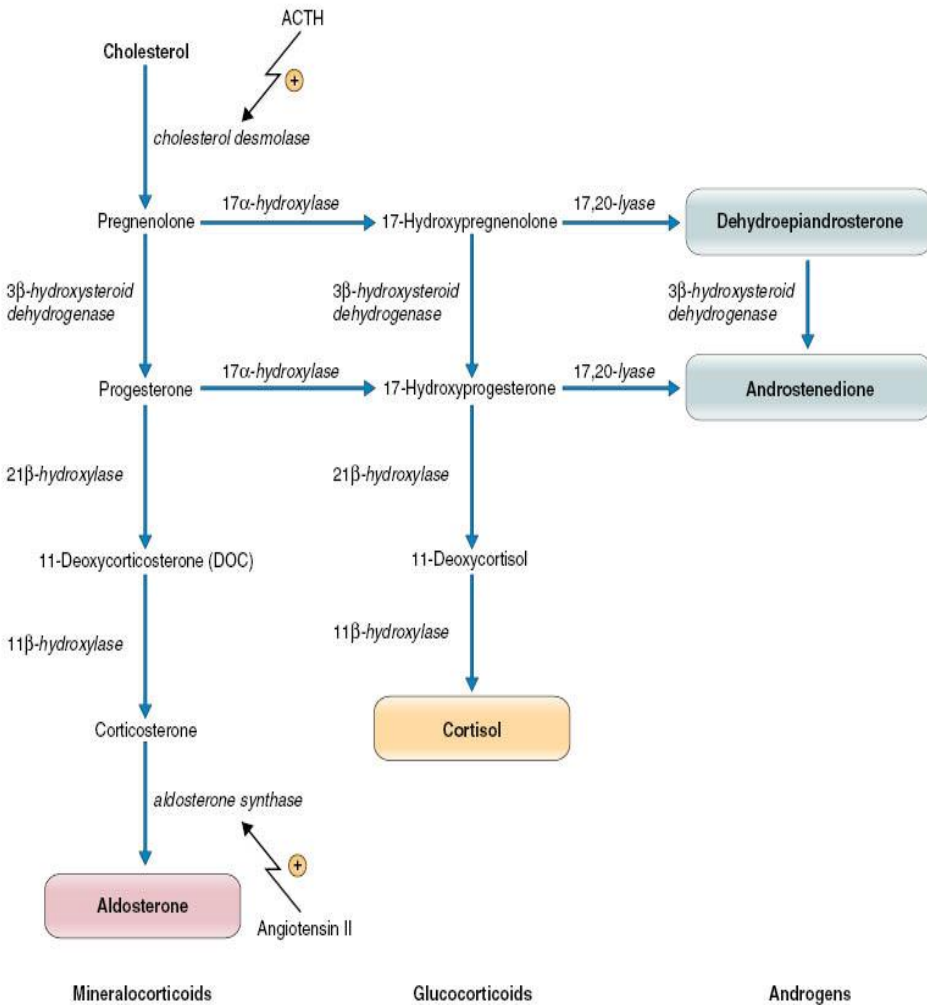
HORMONES SYNTHESIS

PEPTIDE HORMONE SYNTHESIS

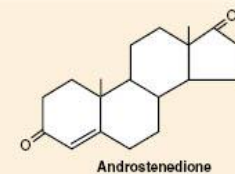
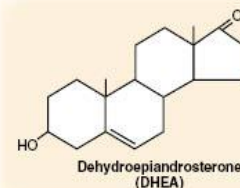
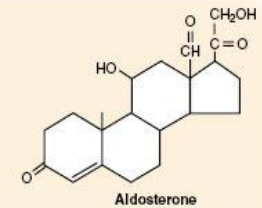
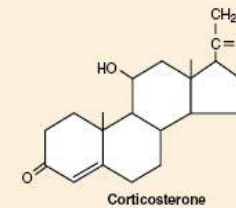
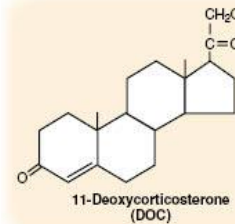
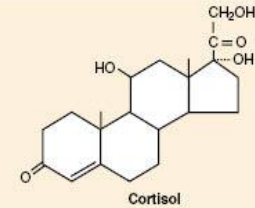
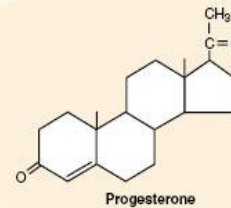
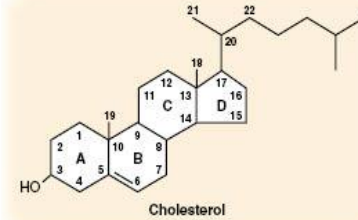


STEROIDS HORMONES

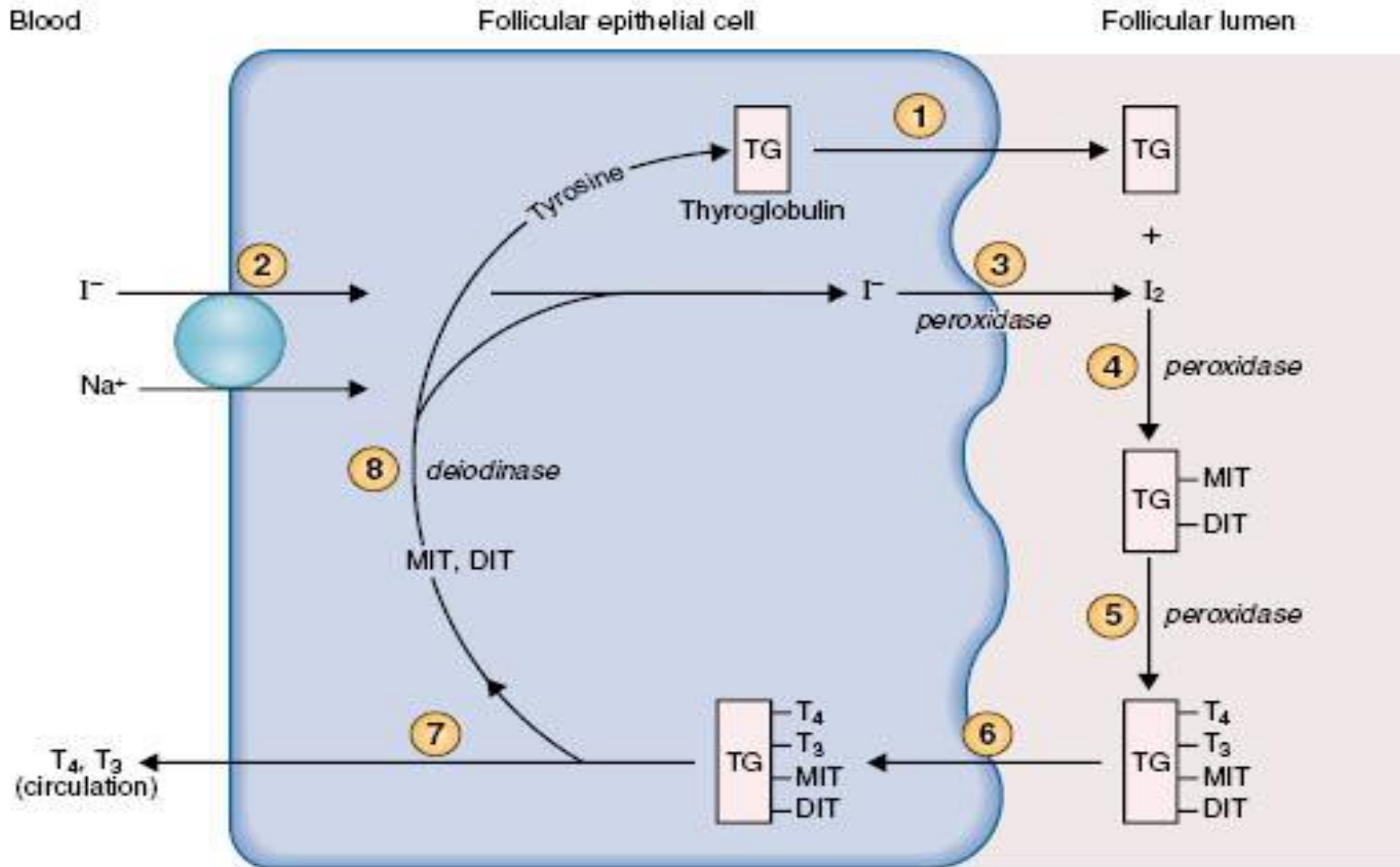
BIOSYNTHESIS OF ADRENOCORTICAL HORMONES



ADRENOCORTICAL STEROIDS



AMINE HORMONE

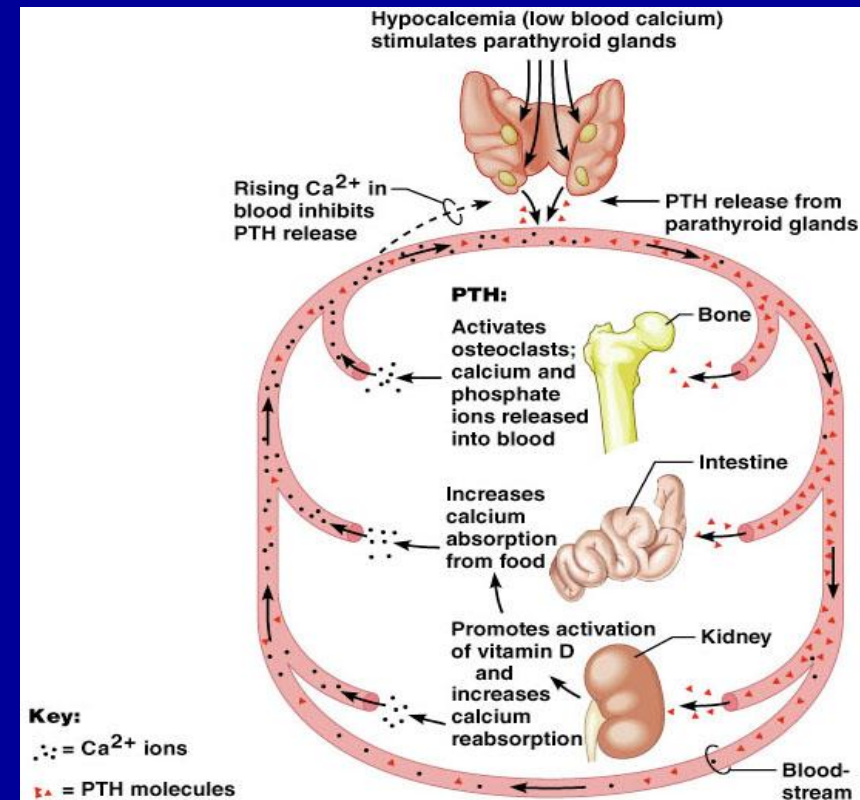
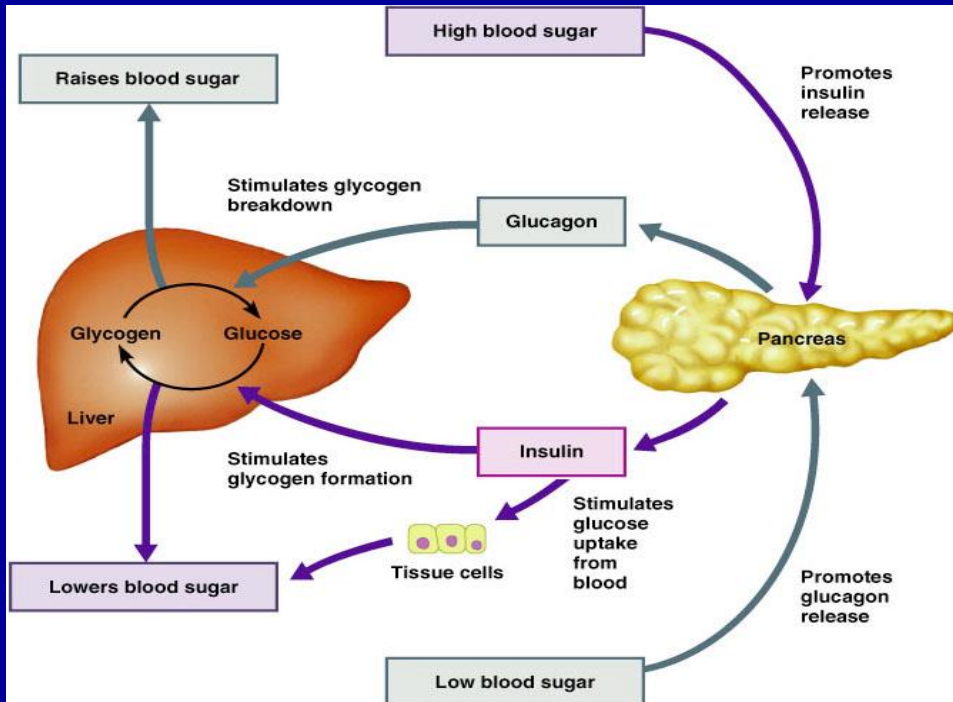


CLASSIFICATION OF STIMULI

- **Humoral Stimuli.**
- **Neural Stimuli.**
- **Hormonal Stimuli.**

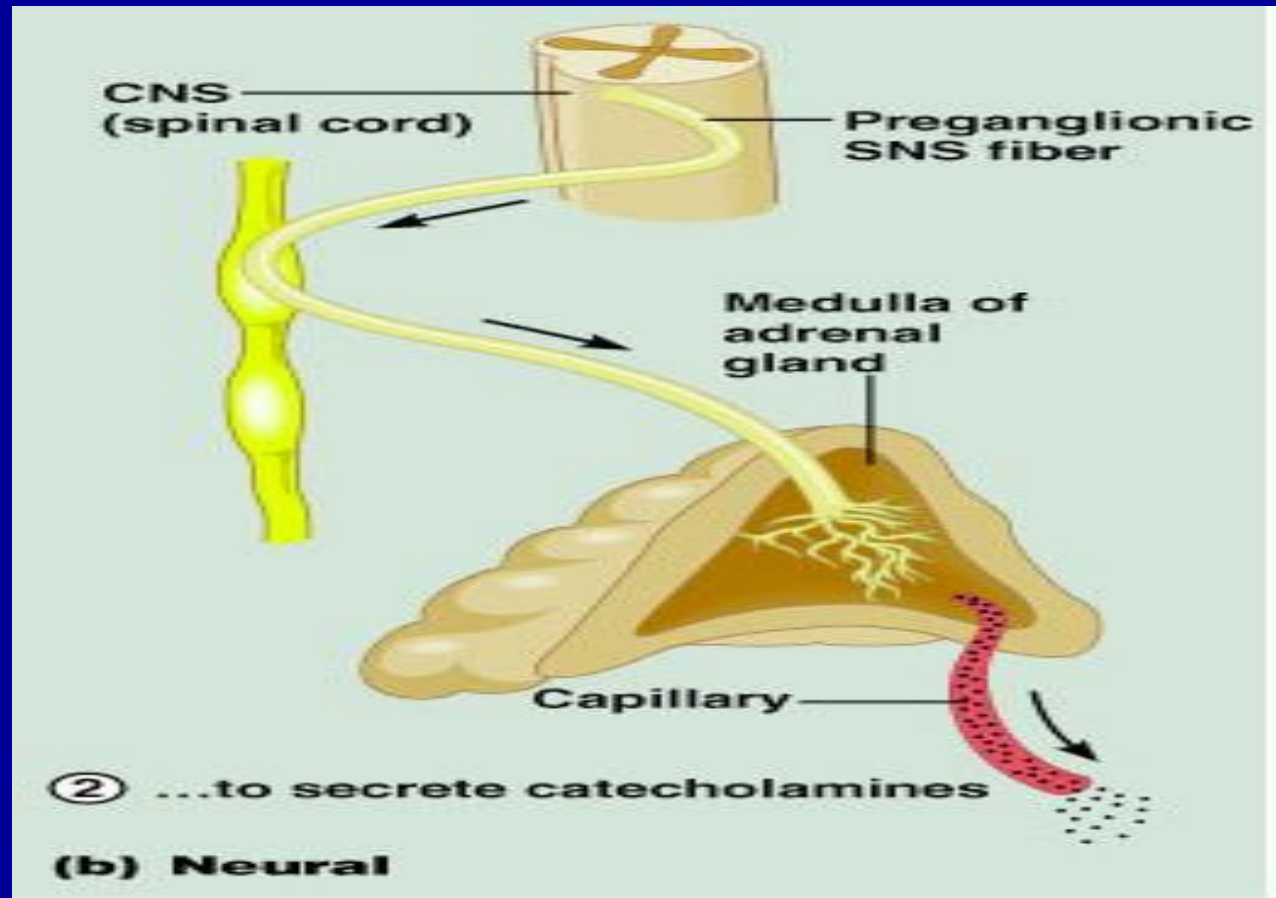
Humoral Stimuli

- Secretion of **hormones** in direct response to **changing** in blood levels of **ions** and **nutrients**



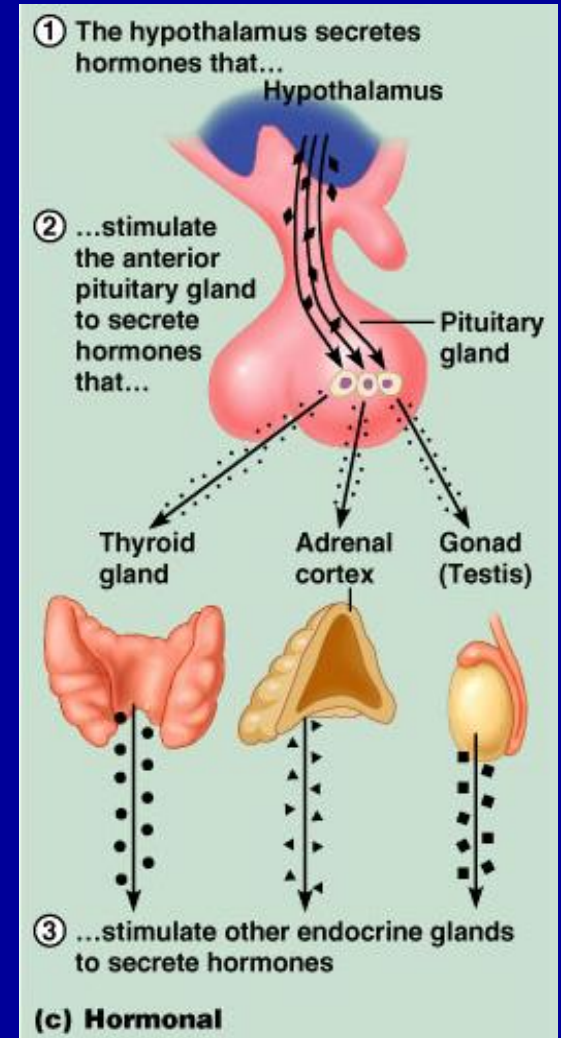
Neural Stimuli

- **Nerve** fibers stimulate **hormone** release.



Hormonal Stimuli

- Release of **hormones** in response to **hormones** produced by other endocrine gland.

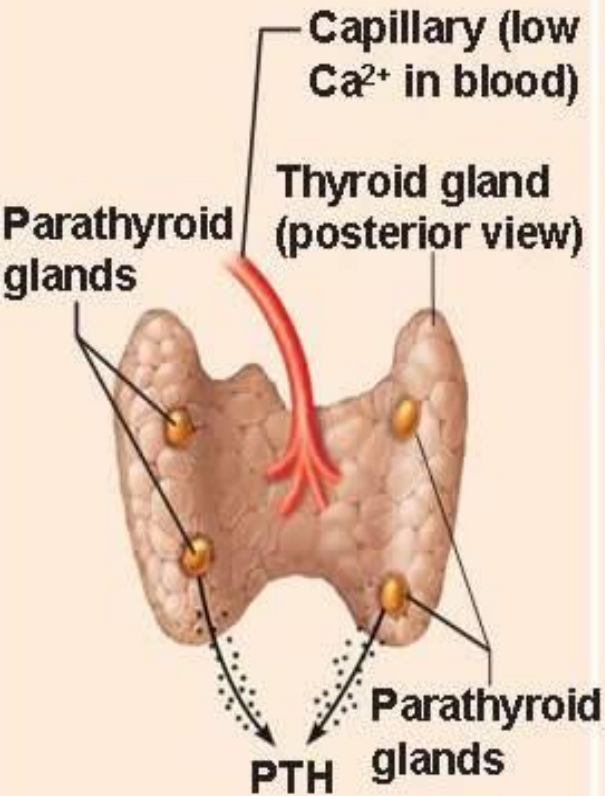


(a) Humoral Stimulus

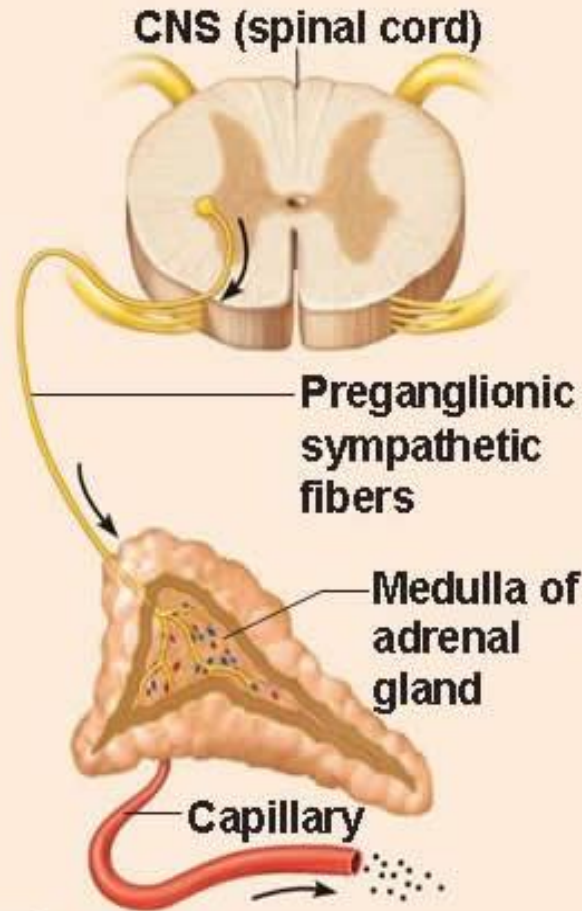
(b) Neural Stimulus

(c) Hormonal Stimulus

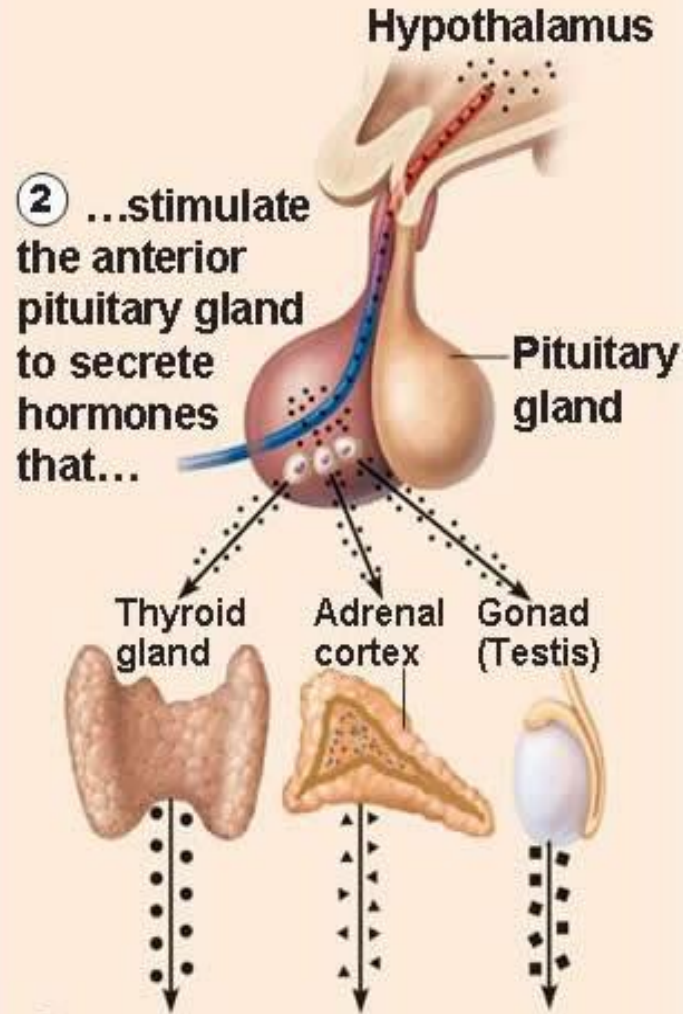
① Capillary blood contains low concentration of Ca^{2+} , which stimulates...



① Preganglionic sympathetic fibers stimulate adrenal medulla cells...



① The hypothalamus secretes hormones that...



② ...secretion of parathyroid hormone (PTH) by parathyroid glands*

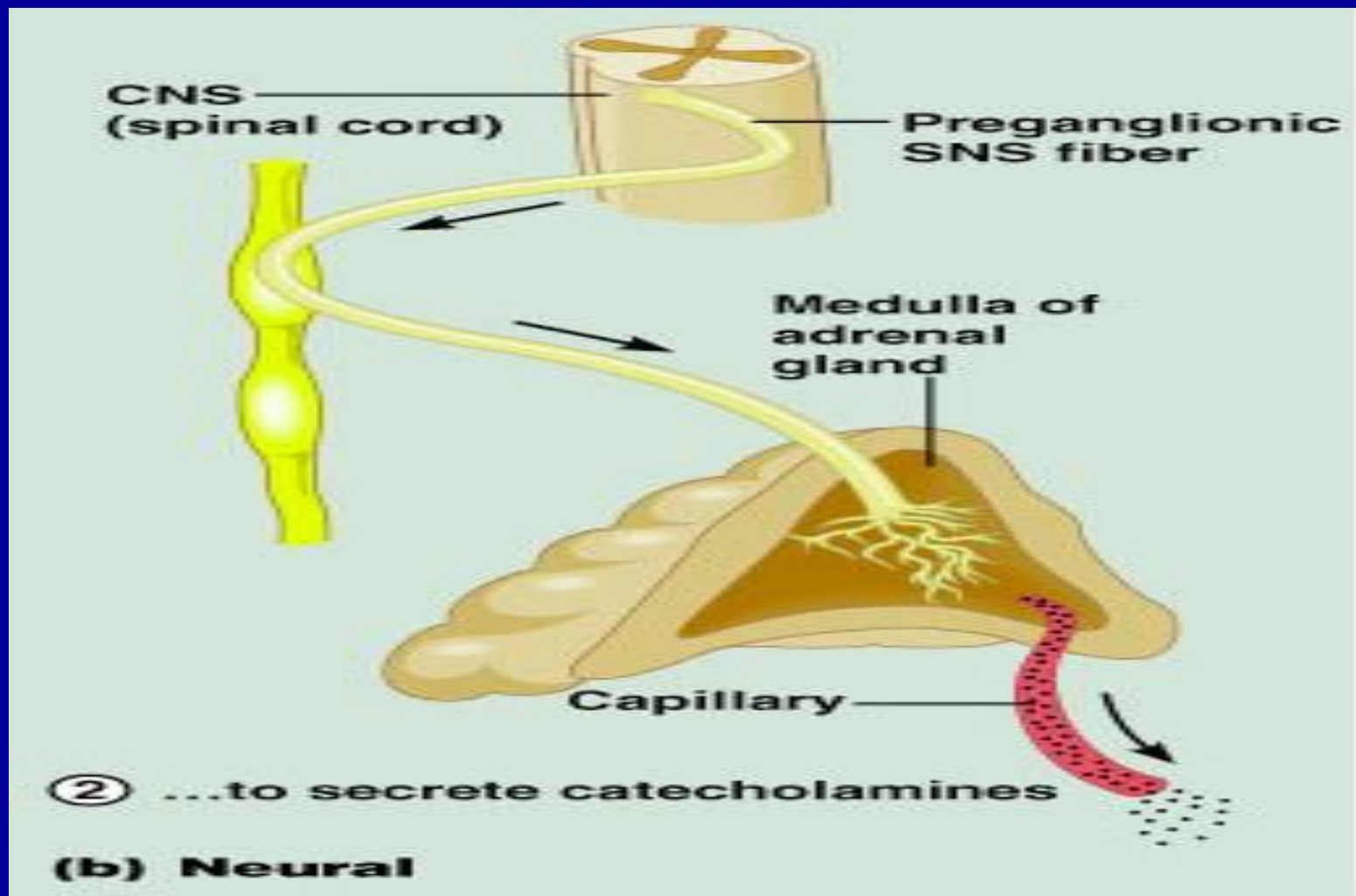
② ...to secrete catecholamines (epinephrine and norepinephrine)

③ ...stimulate other endocrine glands to secrete hormones

REGULATION OF HORMONE SECRETION

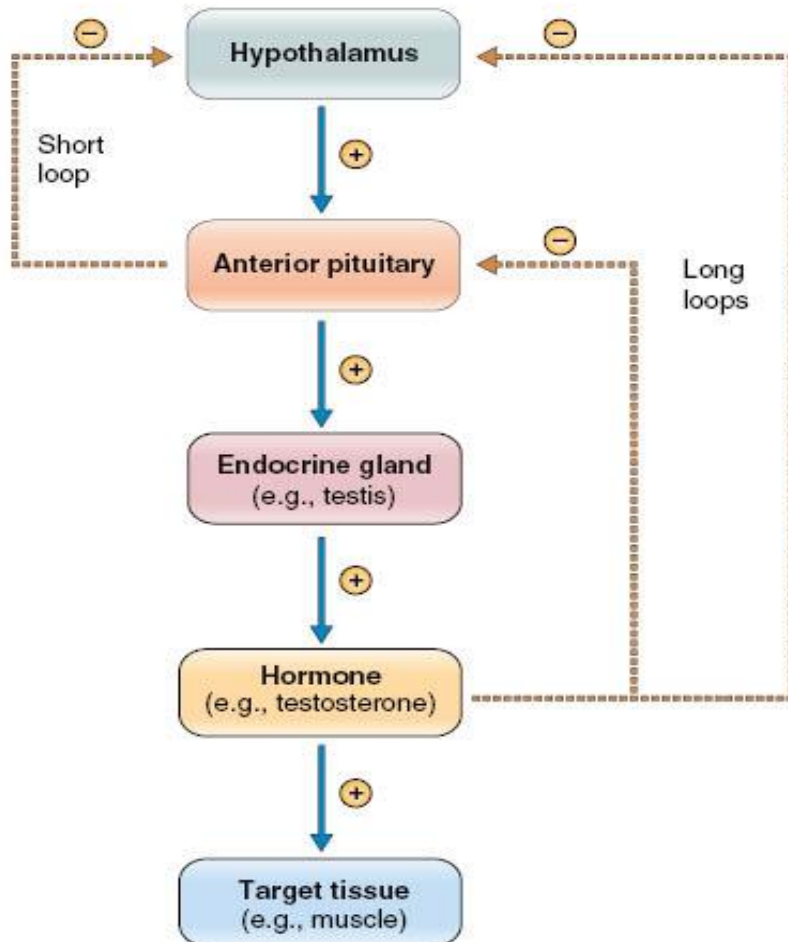
- **Neural mechanism.**
- **Feedback mechanism.**

NEURAL MECHANISM

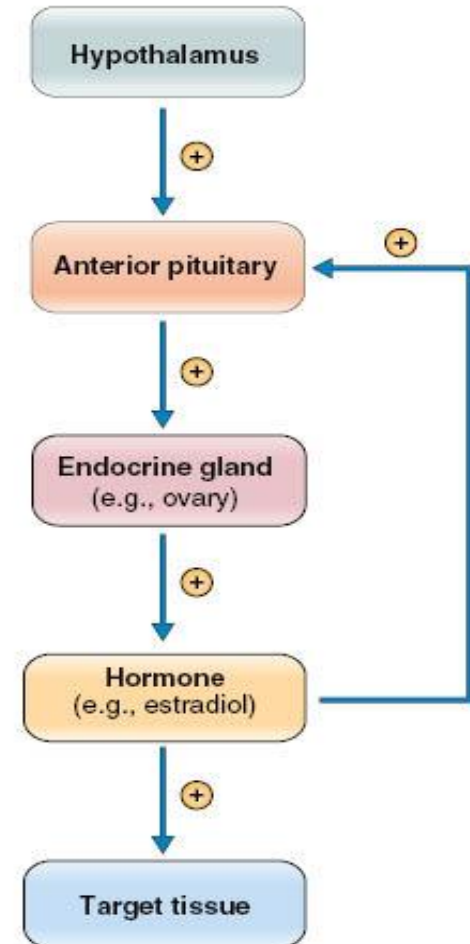


FEEDBACK MECHANISM

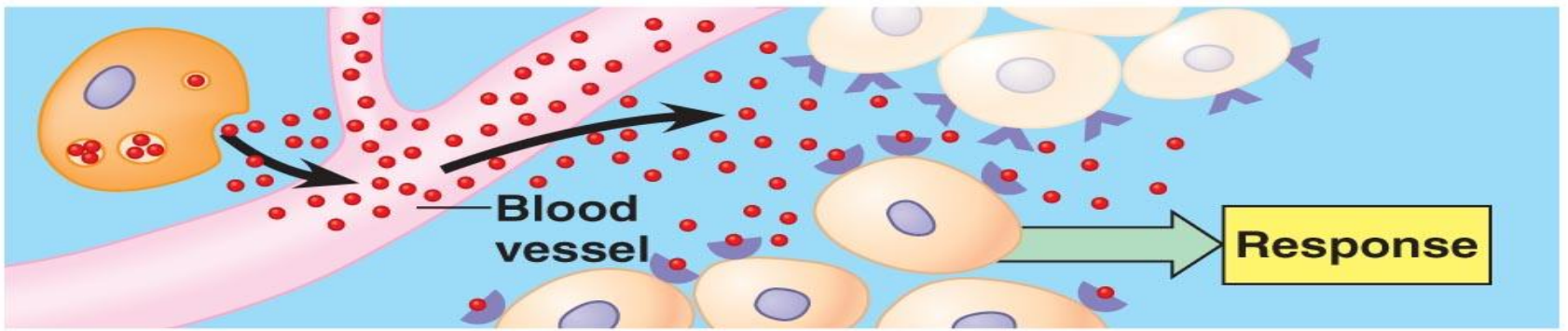
NEGATIVE FEEDBACK



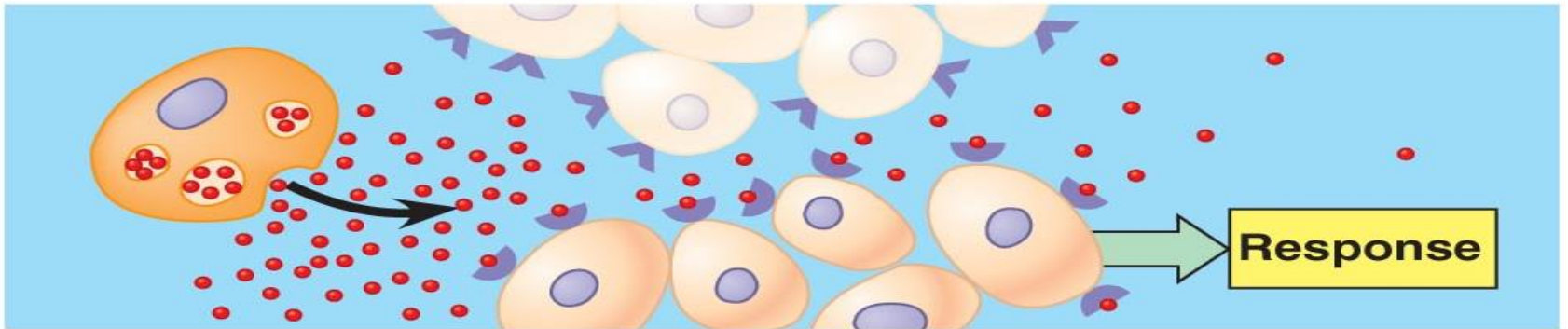
POSITIVE FEEDBACK



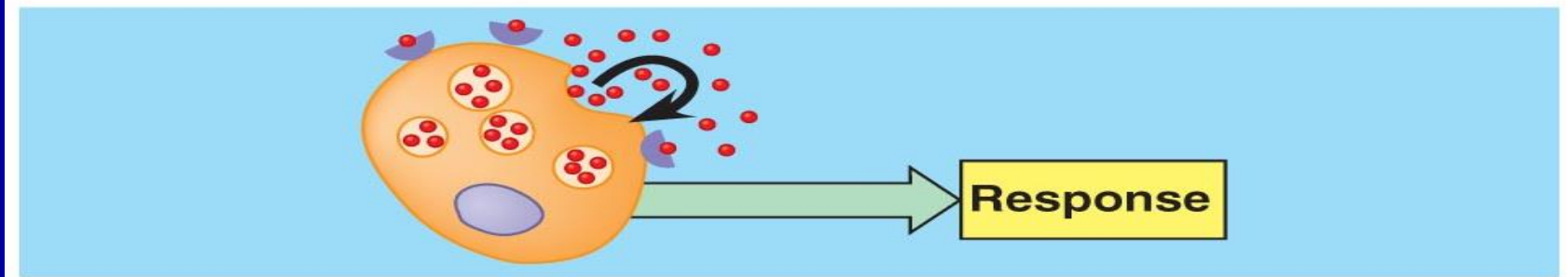
- **Autocrines** – chemicals that exert their effects on the same cells that secrete them.
- **Paracrines** – locally acting chemicals that affect cells other than those that secrete them.



(a) Endocrine signaling



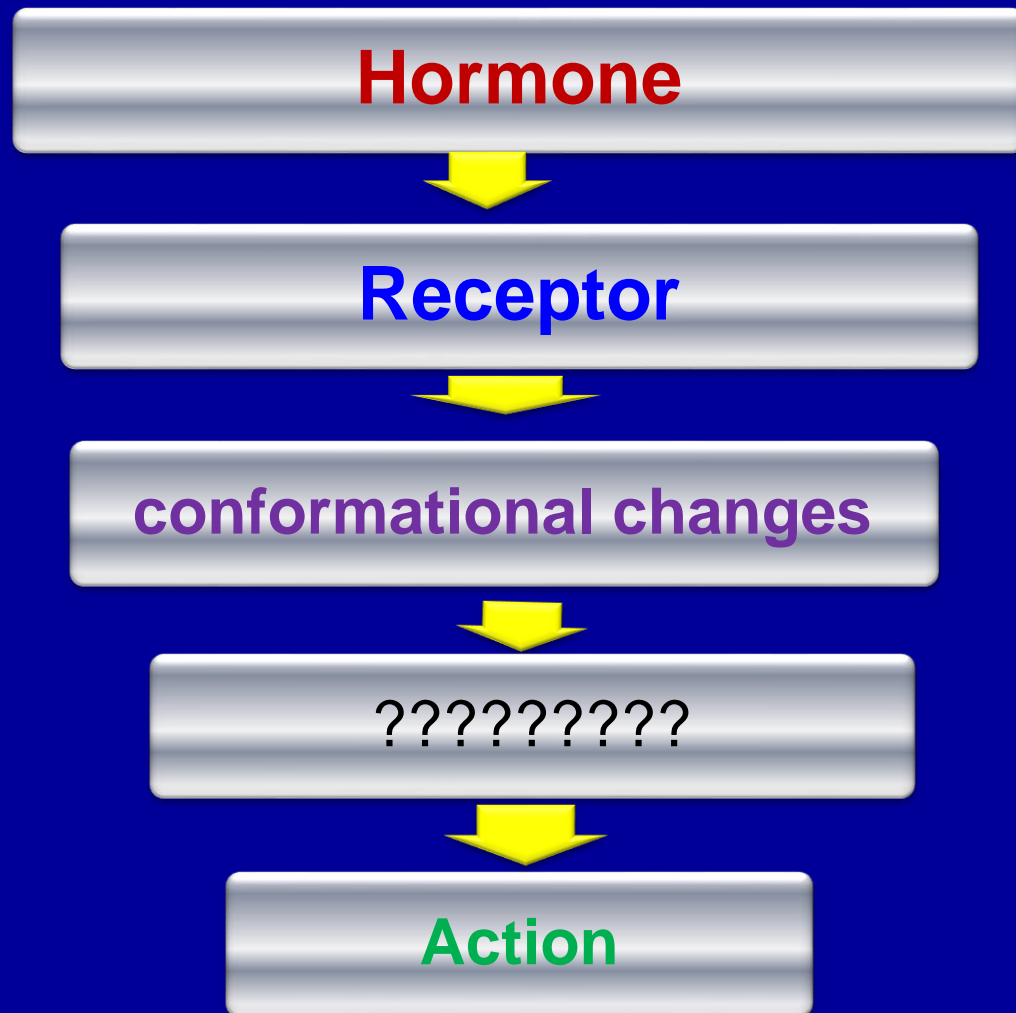
(b) Paracrine signaling



(c) Autocrine signaling

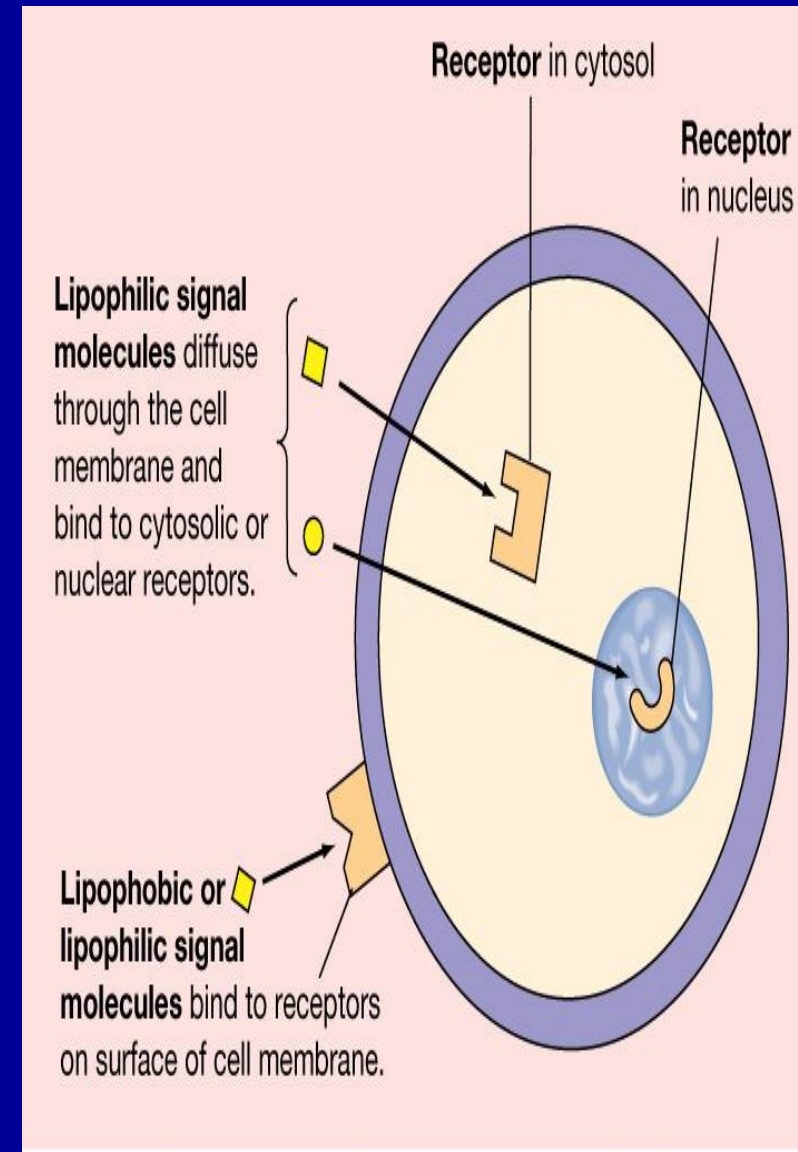
TARGET TISSUE

MECHANISM OF ACTION



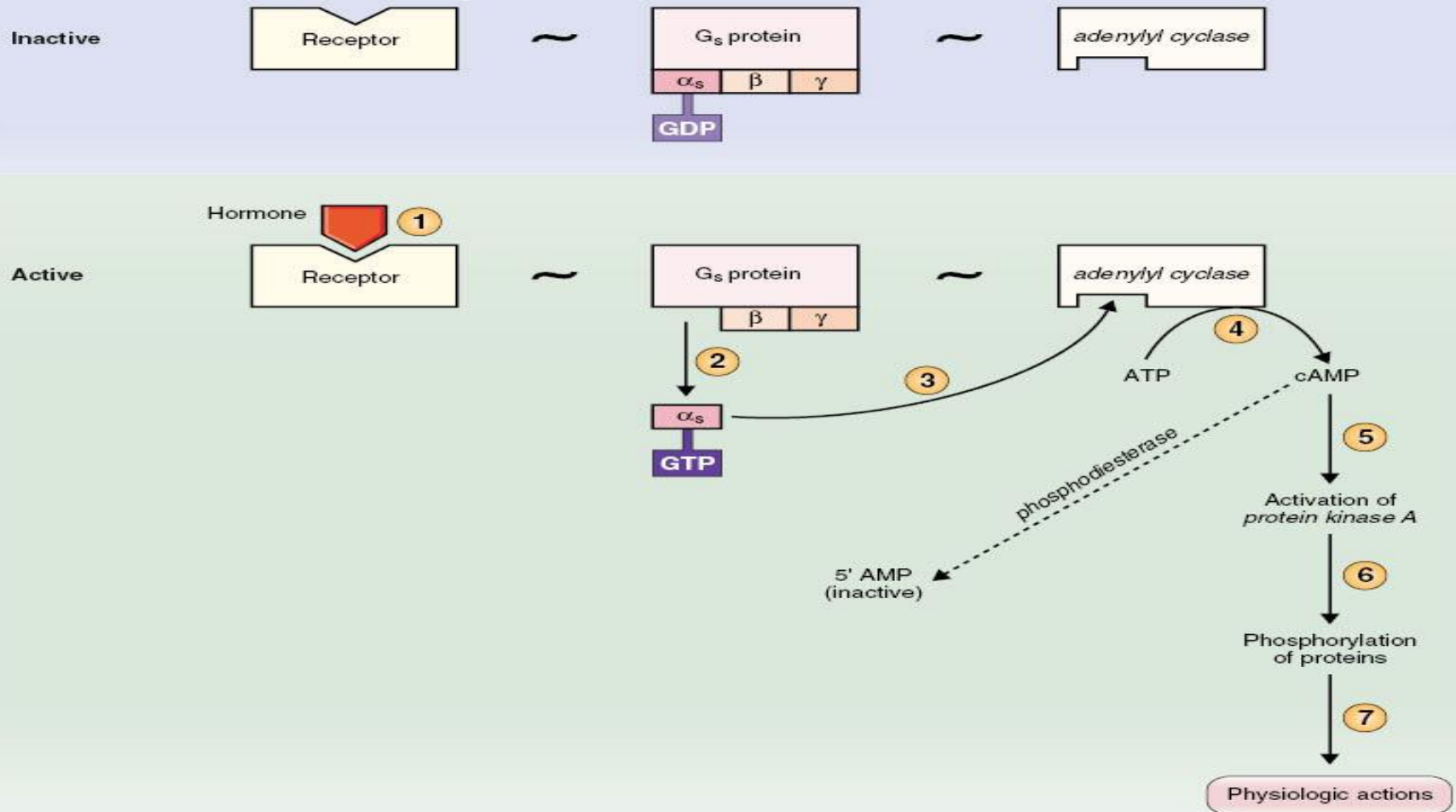
RECEPTOR LOCATIONS

- **Cytosolic or Nuclear**
 - **Lipophilic ligand enters cell**
 - **Often activates gene**
 - **Slower response**
- **Cell membrane**
 - **Lipophobic ligand can't enter cell**
 - **Outer surface receptor**
 - **Fast response**

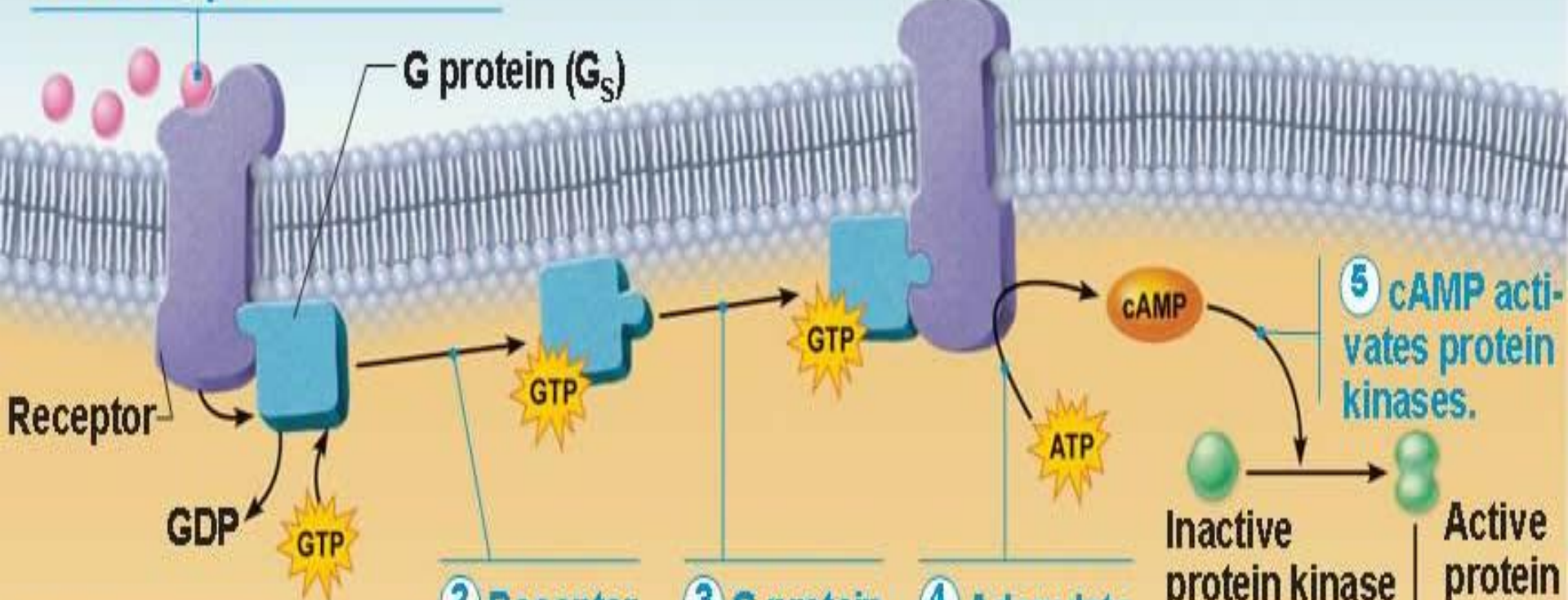


SECOND MESSENGER

ADENYLYL CYCLASE MECHANISM



1 Hormone (1st messenger) binds receptor.



2 Receptor activates G protein (G_s)

3 G protein activates adenylate cyclase.

4 Adenylate cyclase converts ATP to cAMP (2nd messenger).

5 cAMP activates protein kinases.

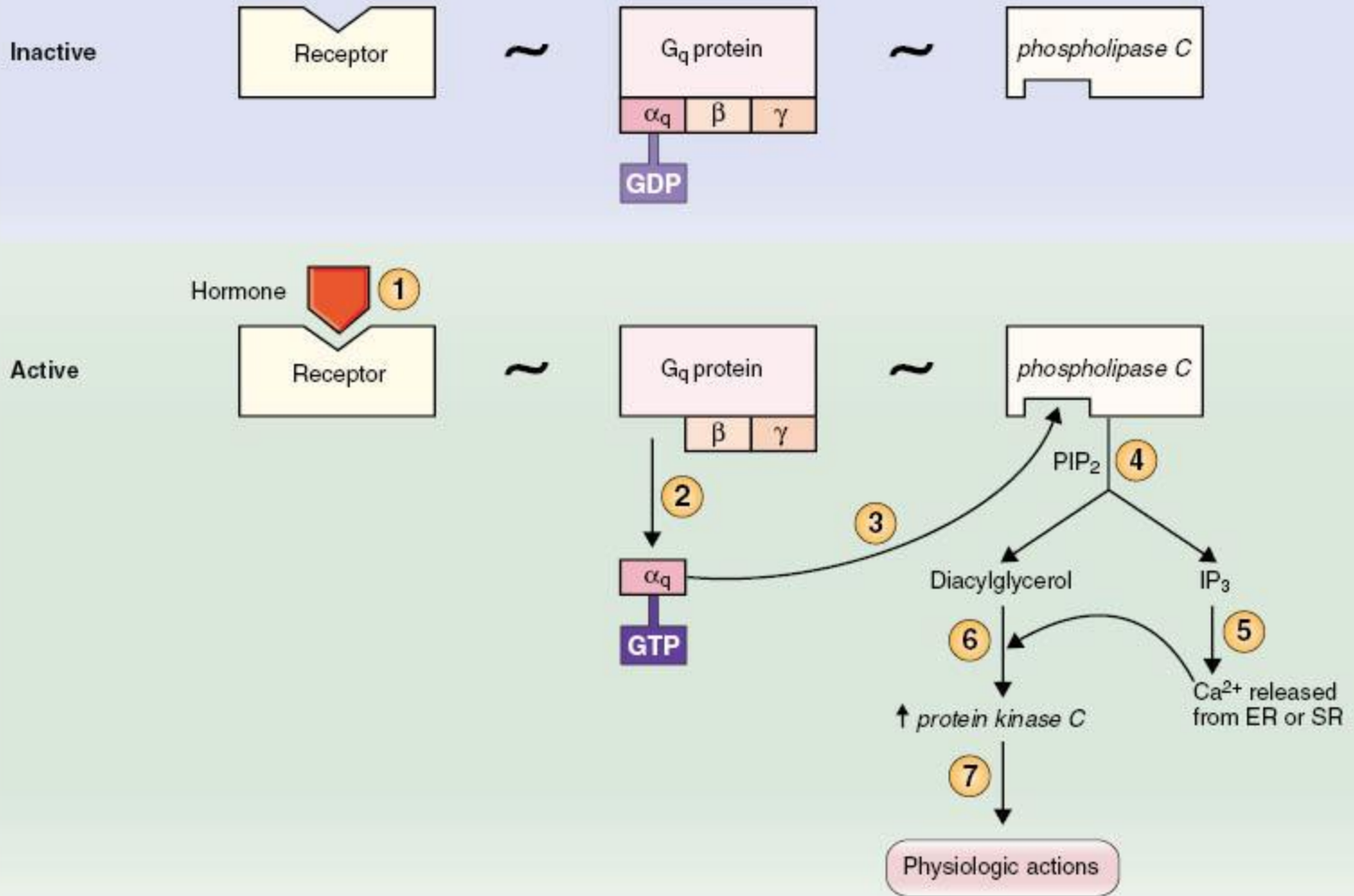
Inactive protein kinase → Active protein kinase

Triggers responses of target cell (activates enzymes, stimulates cellular secretion, opens ion channel, etc.)

Cytoplasm

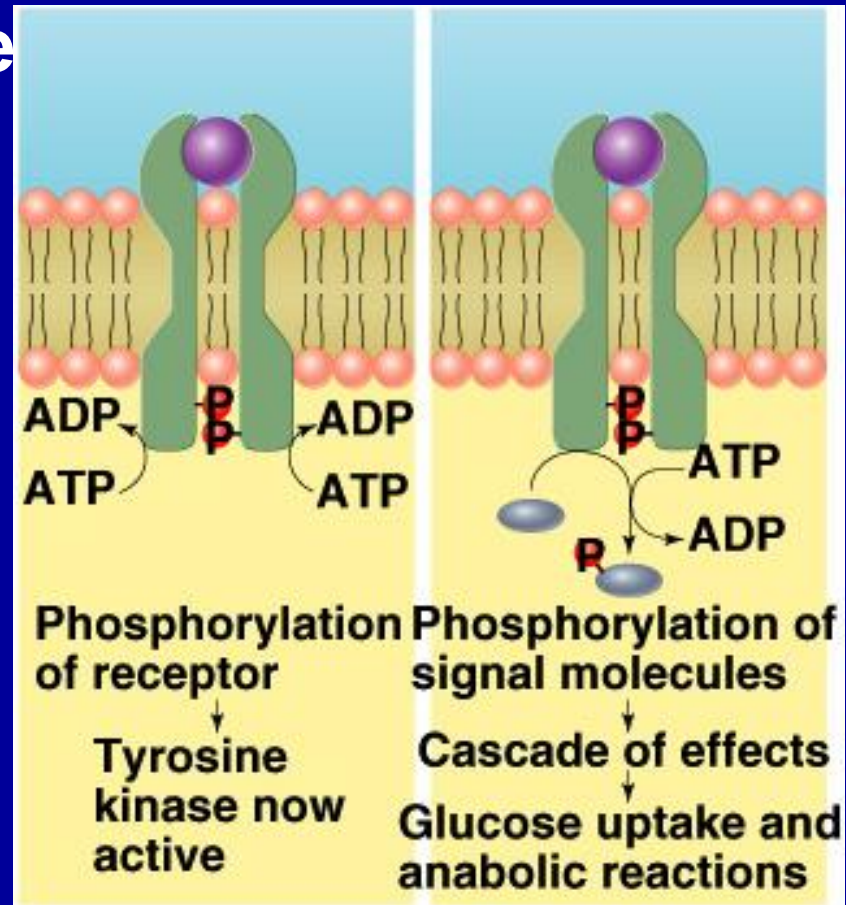
- Hormones that act via cAMP mechanisms:**
- | | |
|-------------|------------|
| Epinephrine | Glucagon |
| ACTH | PTH |
| FSH | TSH |
| LH | Calcitonin |

PHOSPHOLIPASE C MECHANISM

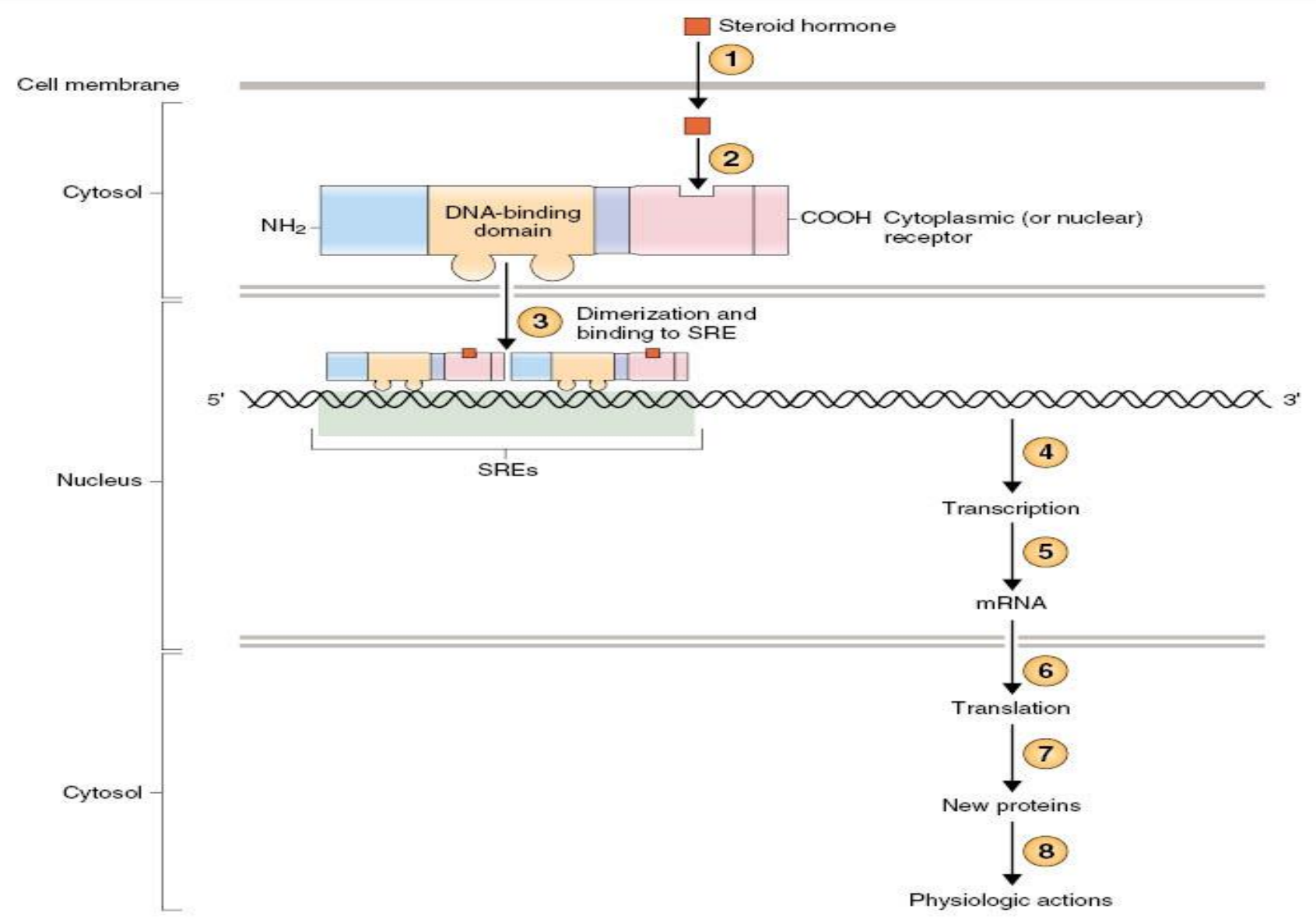


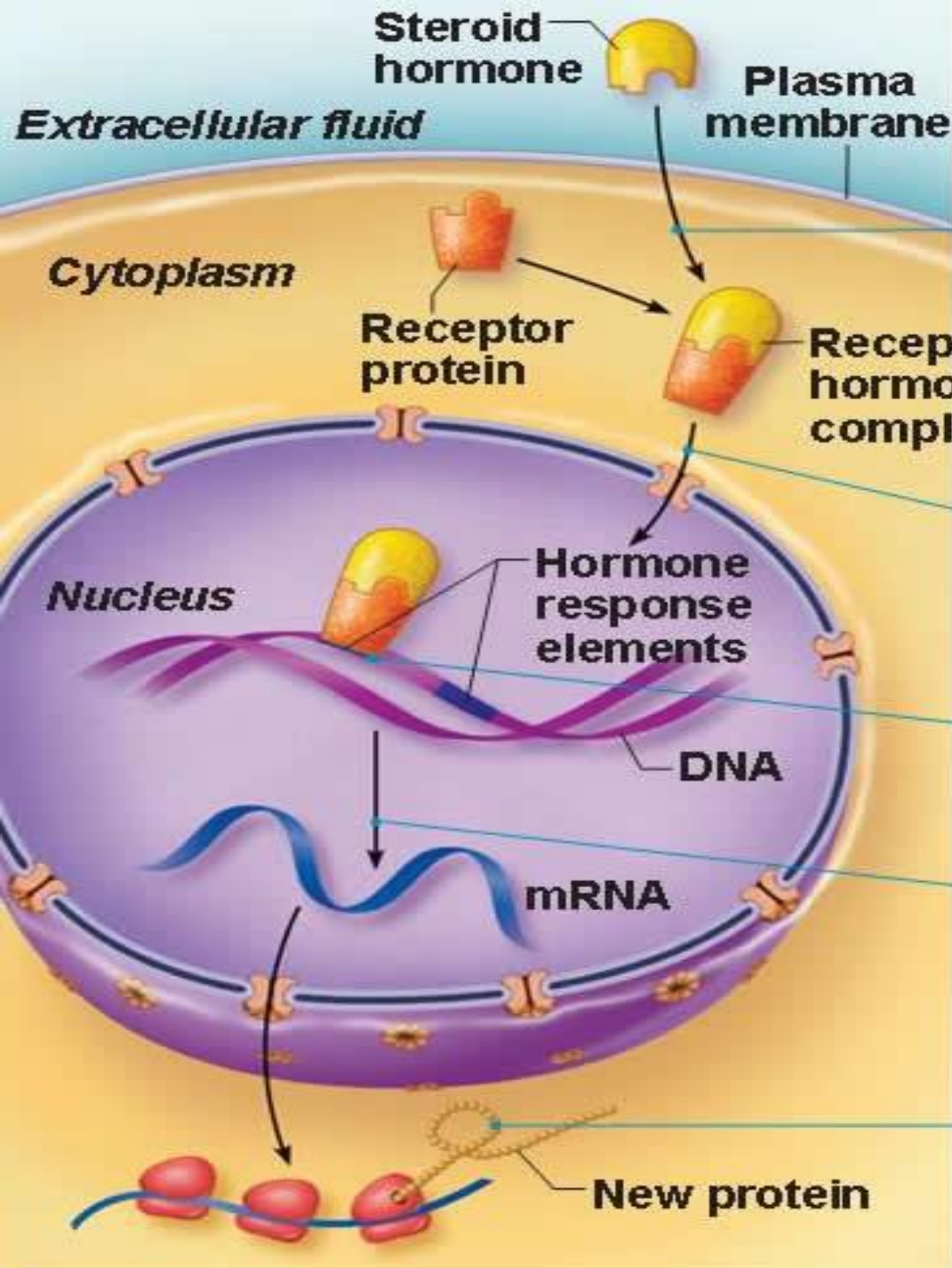
Tyrosine Kinase System

- Activated tyrosine kinase phosphorylates signaling molecules
- Induction of hormone/growth factor effects



STERIOD AND THYROID HORMONE MECHANISM





① The steroid hormone diffuses through the plasma membrane and binds an intracellular receptor.

② The receptor-hormone complex enters the nucleus.

③ The receptor-hormone complex binds a hormone response element (a specific DNA sequence).

④ Binding initiates transcription of the gene to mRNA.

⑤ The mRNA directs protein synthesis.

Table 9-3 Mechanisms of Hormone Action

Adenylyl Cyclase Mechanism (cAMP)	Phospholipase C Mechanism (IP_3/Ca^{2+})	Steroid Hormone Mechanism	Tyrosine Kinase Mechanism	Guanylate Cyclase Mechanism (cGMP)
ACTH	GnRH	Glucocorticoids	Insulin	Atrial natriuretic peptide (ANP)
LH	TRH	Estrogen	IGF-1	Endothelial-derived relaxing factor (EDRF)
FSH	GHRH	Progesterone		Nitric oxide (NO)
TSH	Angiotensin II	Testosterone		
ADH (V_2 receptor)	ADH (V_1 receptor)	Aldosterone		
HCG	Oxytocin	1,25-Dihydroxycholecalciferol		
MSH	α_1 Receptors	Thyroid hormones		
CRH				
Calcitonin				
PTH				
Glucagon				
β_1 and β_2 receptors				

REGULATION OF HORMONE RECEPTORS

- **Dose-response relationship.**
- **Sensitivity.**
- **Number.**
- **Affinity.**

DOWN-REGULATION

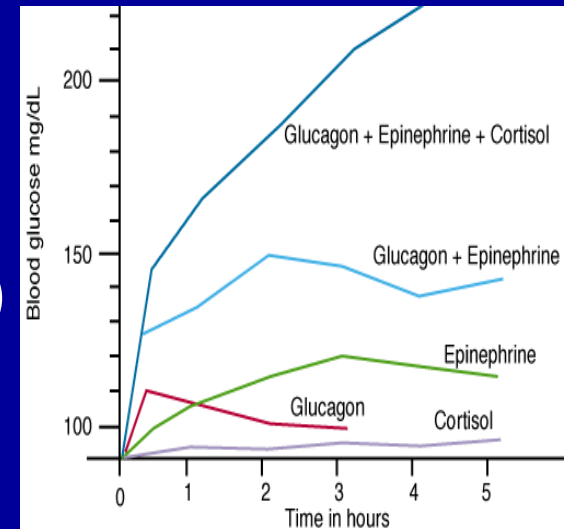
- **Decrease synthesis.**
- **Increase degradation.**
- **Inactivation .**
- **T3.**

UP-REGULATION

- **Increase synthesis.**
- **Decrease degradation.**
- **Activation .**
- **GH, prolactin.**

INTERACTION OF HORMONES AT TARGET CELLS

- **Permissiveness** (Thyroid hormone have permissive effect on growth hormone action)
- **Synergism** (glucagon, cortisol and epinephrine)
- **Antagonism** (Glucagon /insulin)



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

Thank you

HYPOTHALAMIC-PITUITARY AXIS

OBJECTIVES

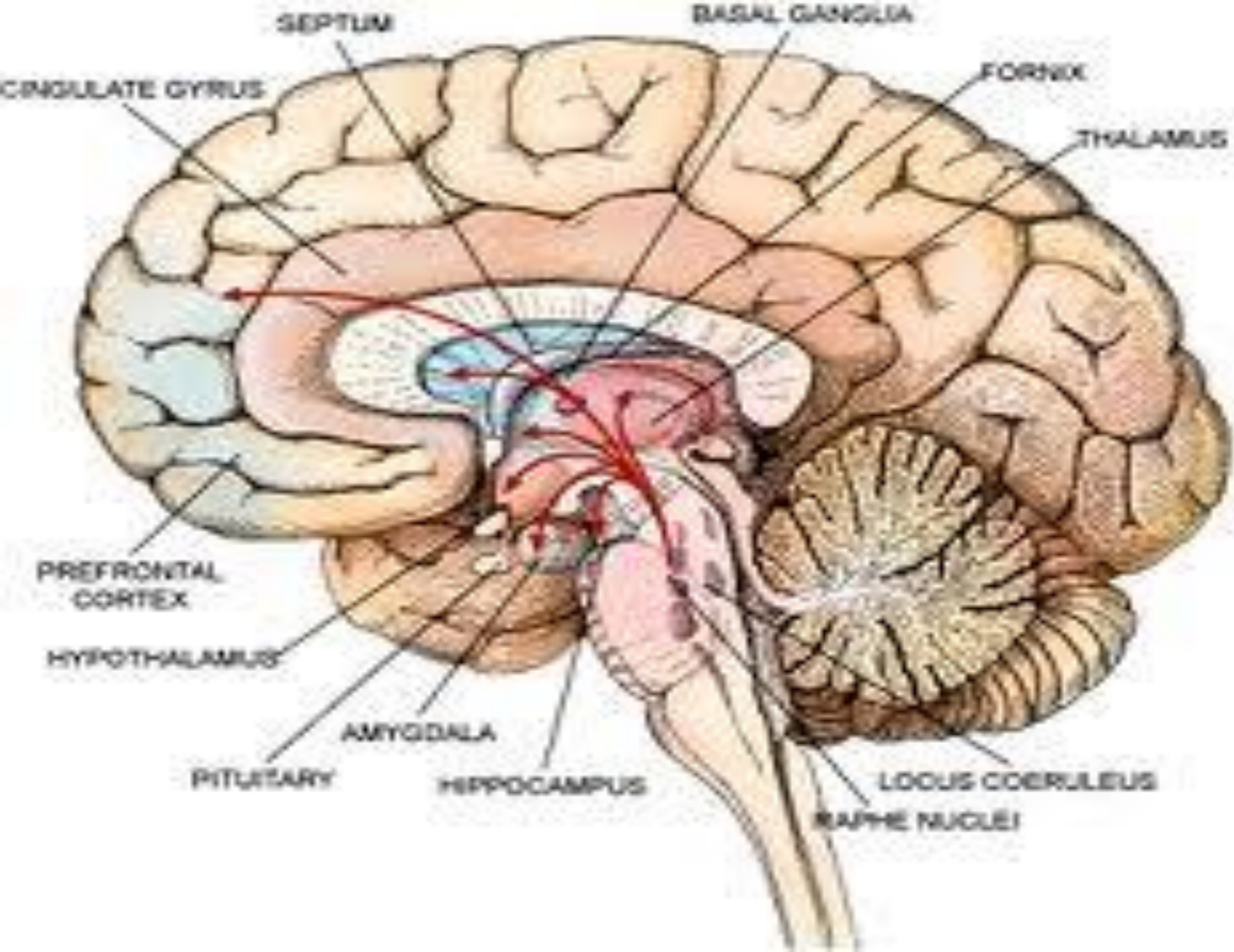
- **By the end of this lecture, students should be able to describe:**
- **Structure of pituitary gland (hypophysis)**
 - Anterior pituitary (adenohypophysis) cell types and hormones
 - Posterior pituitary (neurohypophysis) cell types and hormones
- **Control of pituitary gland by hypothalamus**
 - Hypothalamo-hypophysial portal blood vessels (Hypothalamic releasing and inhibiting hormones and median eminence)
 - Hypothalamo-hypophysial tract
- **Feedback mechanisms: positive and negative feedback**

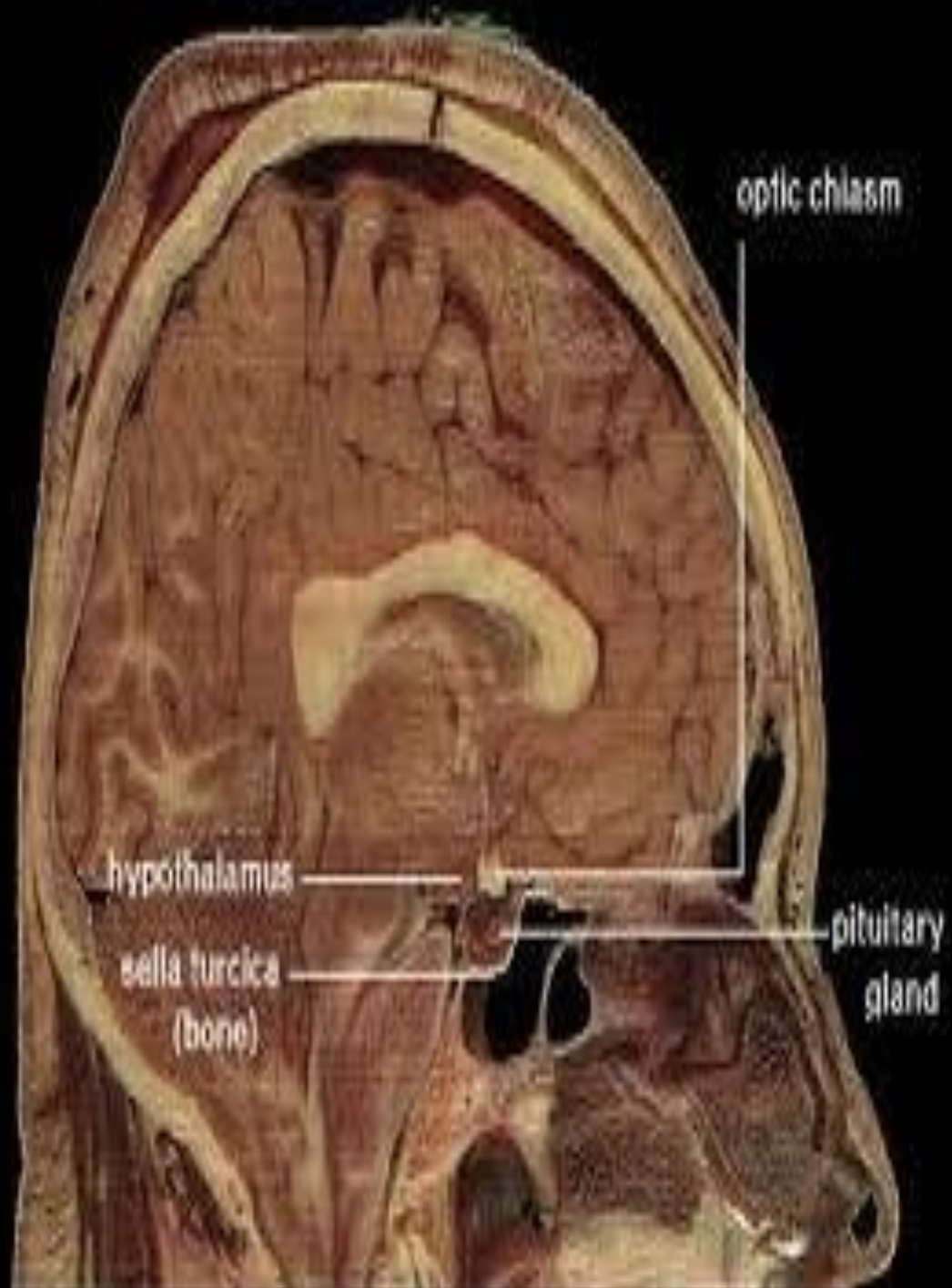
HYPOTHALAMIC-PITUITARY AXIS

- **Coordinate.**
- **Thyroid gland, adrenal gland, reproductive gland, control growth, milk production, osmoregulation.**

HYPOTHALAMUS

- **Control pituitary gland secretion.**
- **Composed of number of nerve cells.**





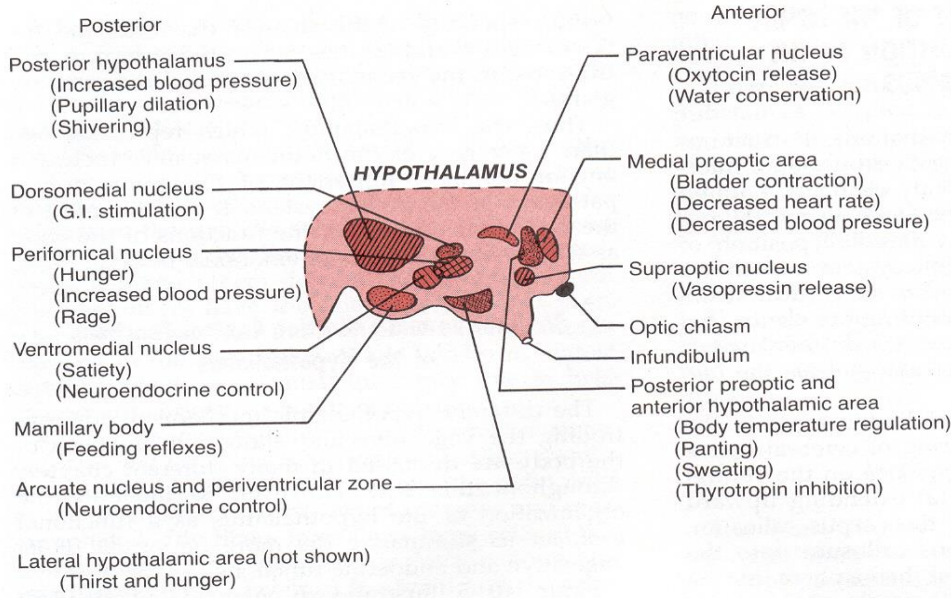
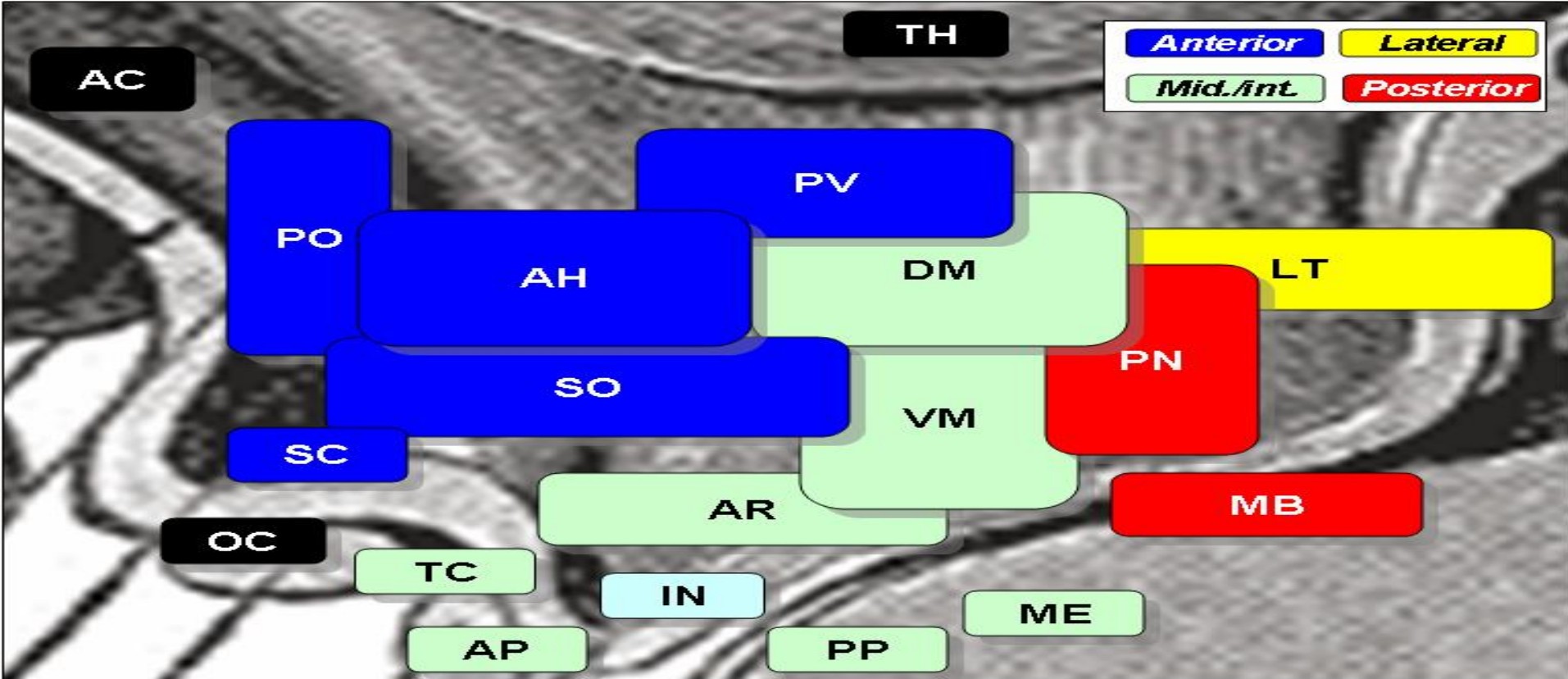


Figure 40-5 Control of the hypothalamus.

Homeostasis

The hypothalamus is the brain's control center for homeostasis. It receives information from the body and the environment and sends out signals to other parts of the brain and the body to maintain a stable internal environment.

Temperature Regulation

The hypothalamus acts as the body's thermostat. It receives information from temperature sensors in the body and the environment and sends out signals to the brain and the body to maintain a stable internal temperature. This includes shivering, sweating, and adjusting blood flow.

Hunger and Thirst

The hypothalamus controls hunger and thirst. It receives information from the body about energy levels and fluid balance and sends out signals to the brain and the body to initiate eating and drinking behaviors.

Circadian Rhythms

The hypothalamus controls the body's circadian rhythms, which are the 24-hour cycles of activity and rest. It receives information from the body and the environment and sends out signals to the brain and the body to regulate these rhythms.

Neuroendocrine Control

The hypothalamus controls the release of hormones from the pituitary gland. It sends out signals to the pituitary gland to release hormones that regulate growth, metabolism, and other body functions.

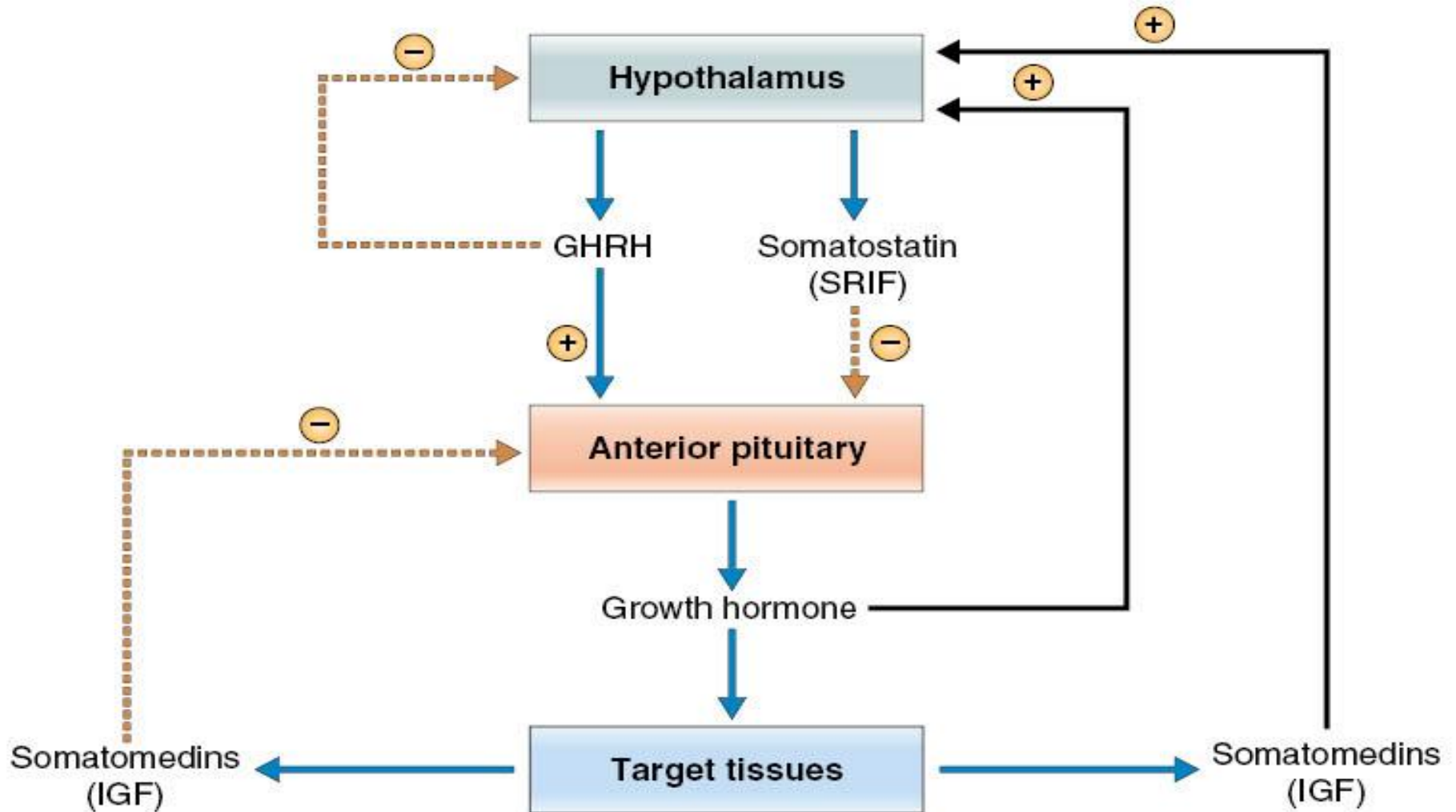
HORMONES

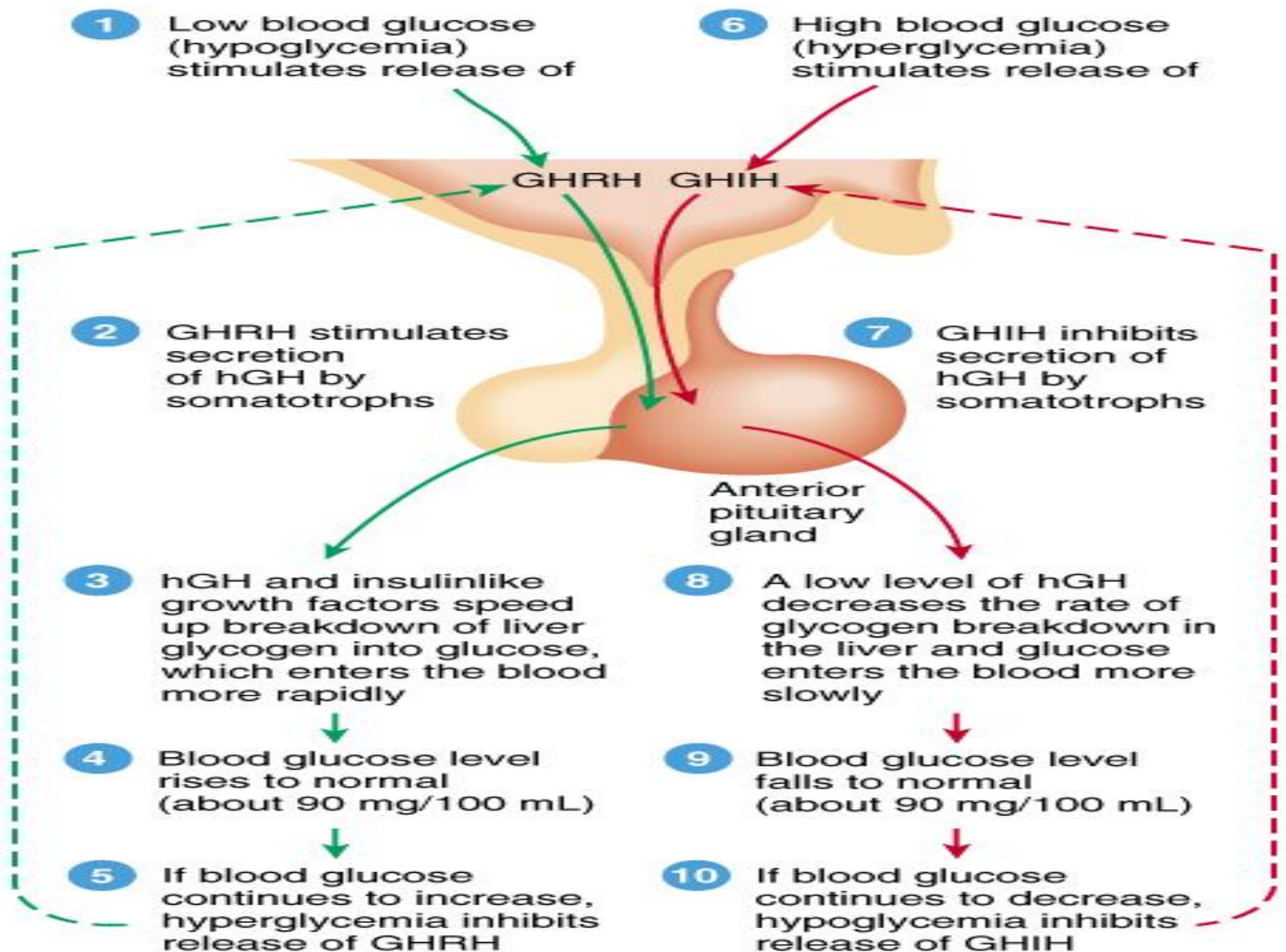
- TRH.
- CRH.
- GnRH.
- PIF.
- GHRH.

Table 9-2 Summary of Endocrine Glands and Actions of Hormones

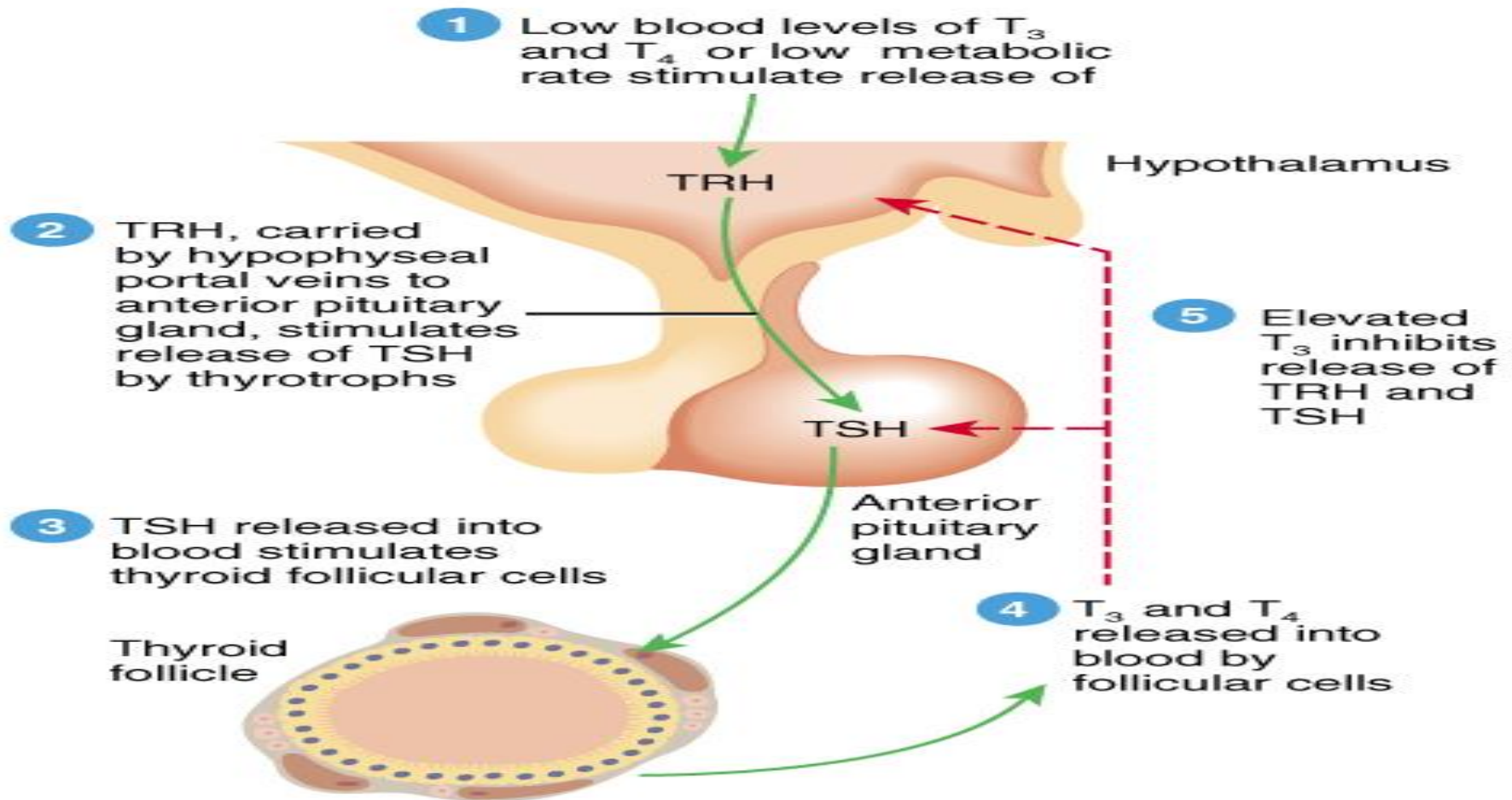
Gland of Origin	Hormones*	Chemical Classification [†]	Major Actions
Hypothalamus	Thyrotropin-releasing hormone (TRH)	Peptide	Stimulates secretion of TSH and prolactin
	Corticotropin-releasing hormone (CRH)	Peptide	Stimulates secretion of ACTH
	Gonadotropin-releasing hormone (GnRH)	Peptide	Stimulates secretion of LH and FSH
	Somatostatin or somatotropin release-inhibiting hormone (SRIF)	Peptide	Inhibits secretion of growth hormone
	Dopamine or prolactin-inhibiting factor (PIF)	Amine	Inhibits secretion of prolactin
	Growth hormone-releasing hormone (GHRH)	Peptide	Stimulates secretion of growth hormone

GHRH/GHIH(SRIF)



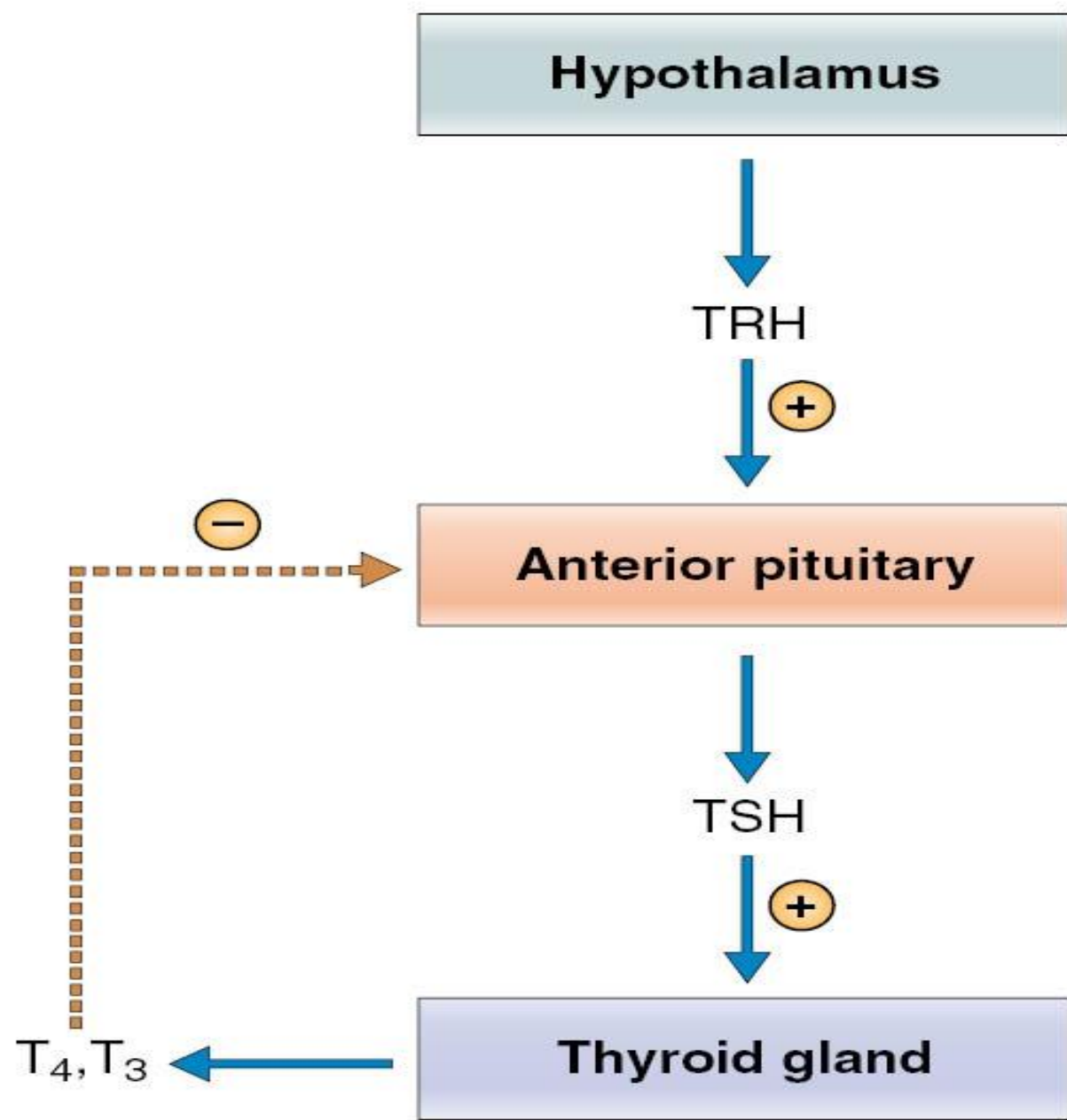


TRH

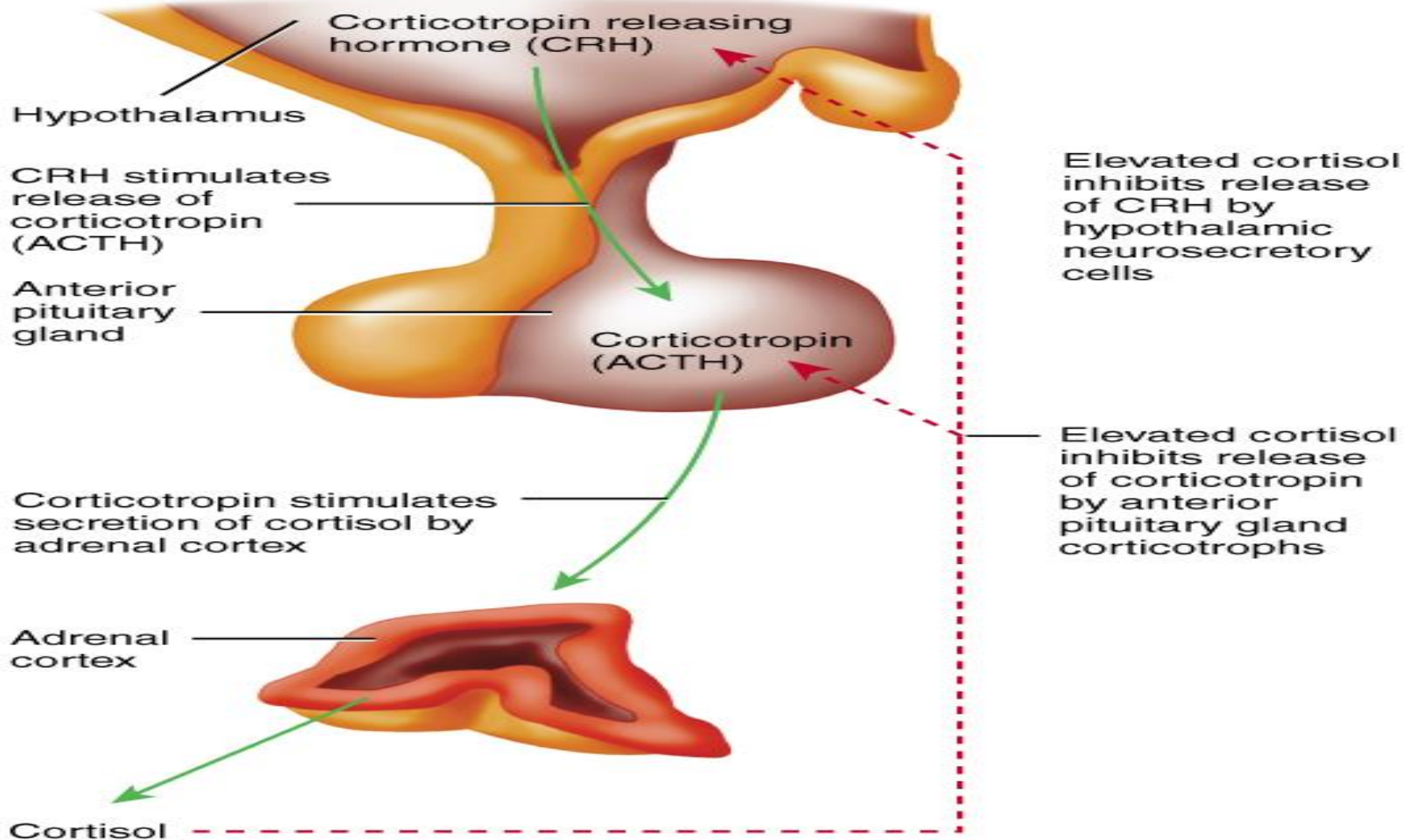


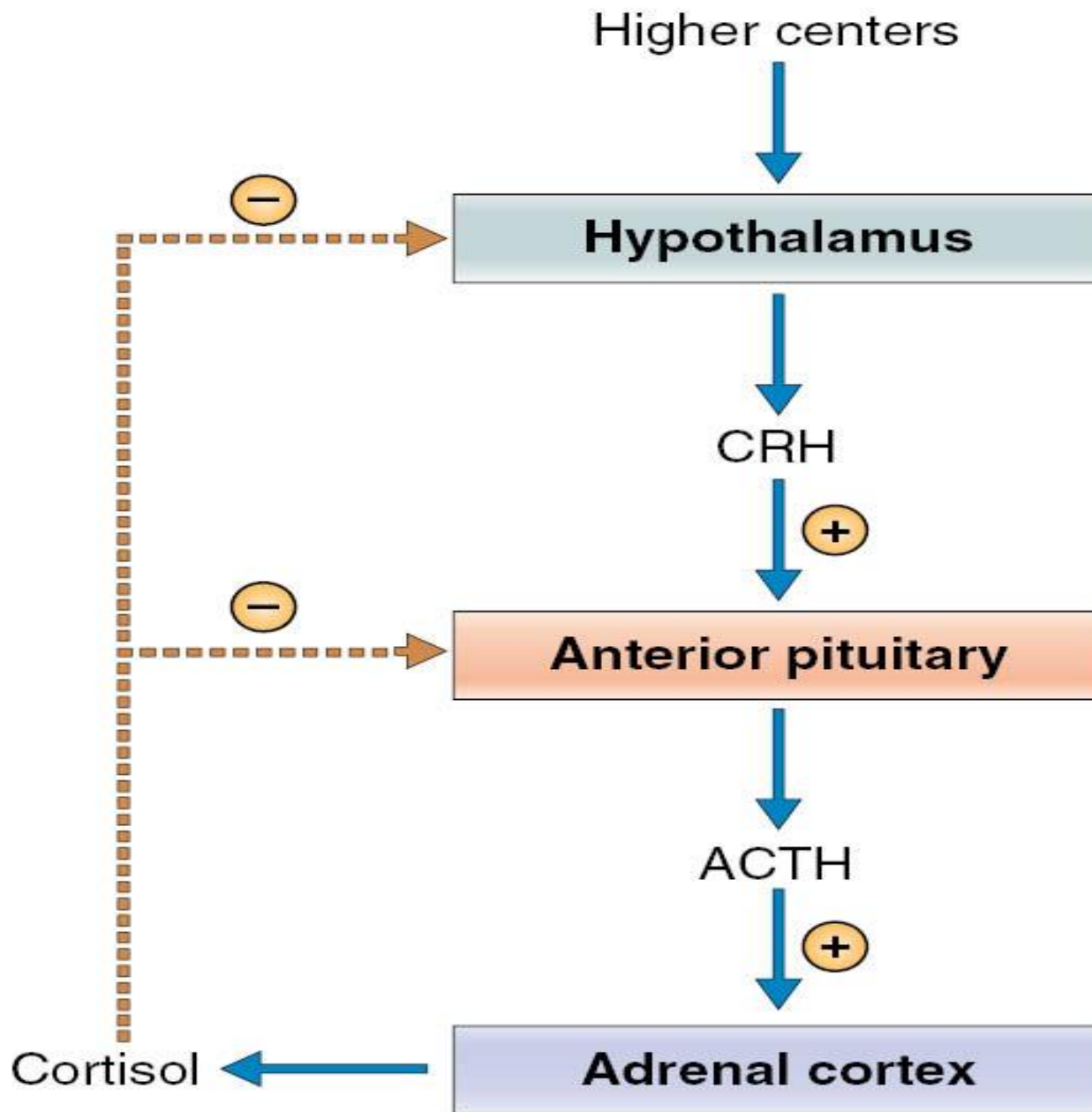
Key:

TRH = Thyrotropin releasing hormone
TSH = Thyroid-stimulating hormone
T₃ = Triiodothyronine
T₄ = Thyroxine (Tetraiodothyronine)

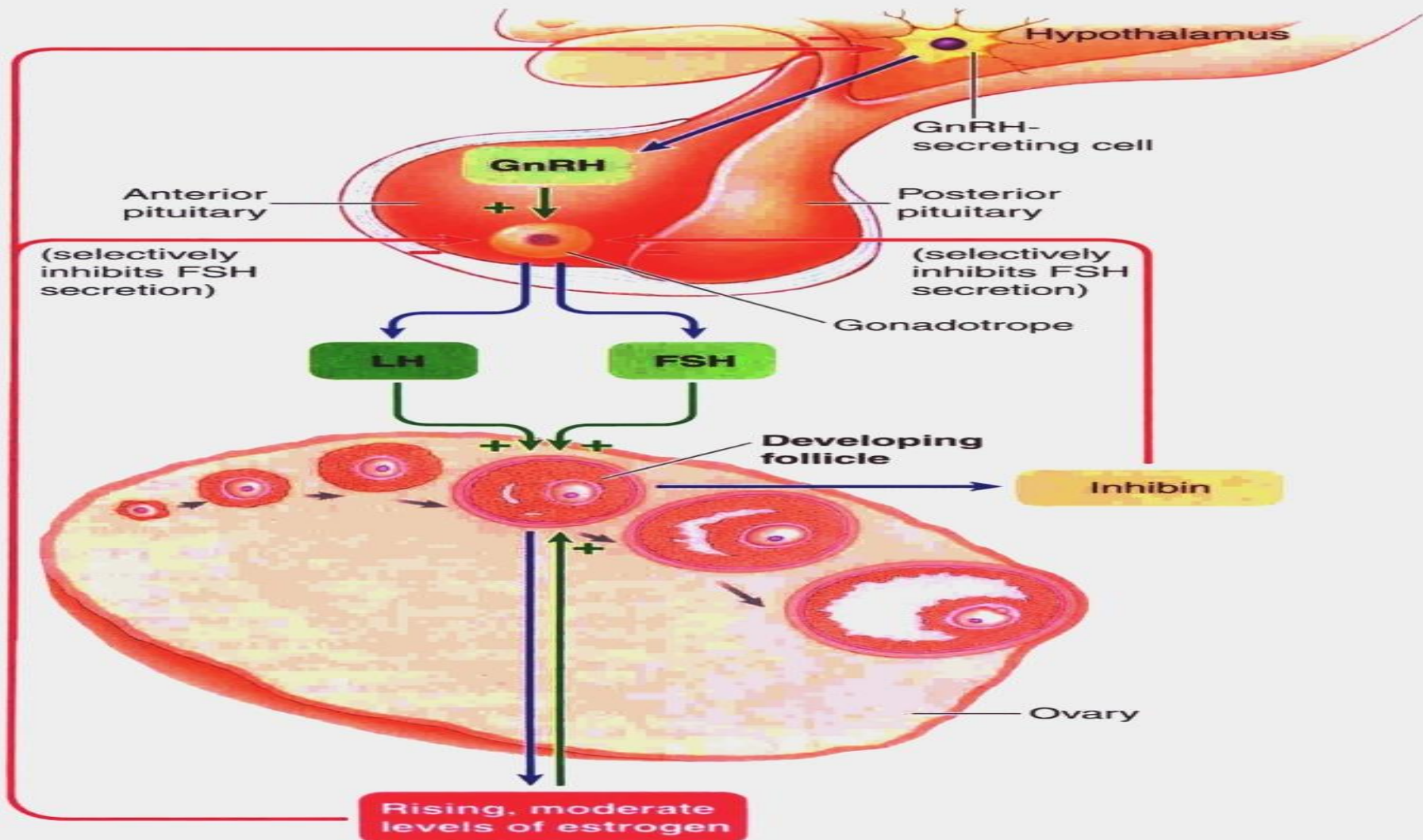


CRH

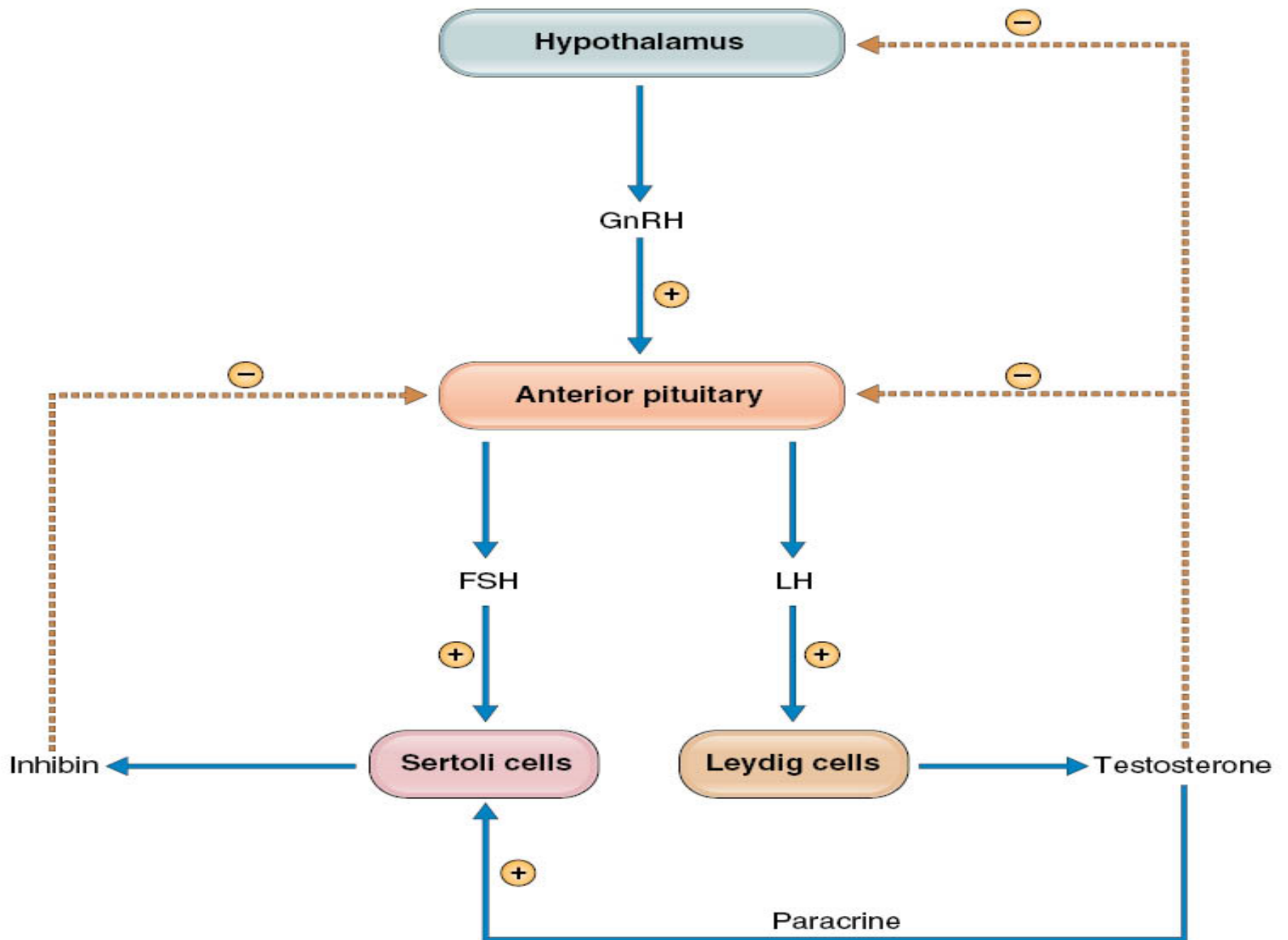


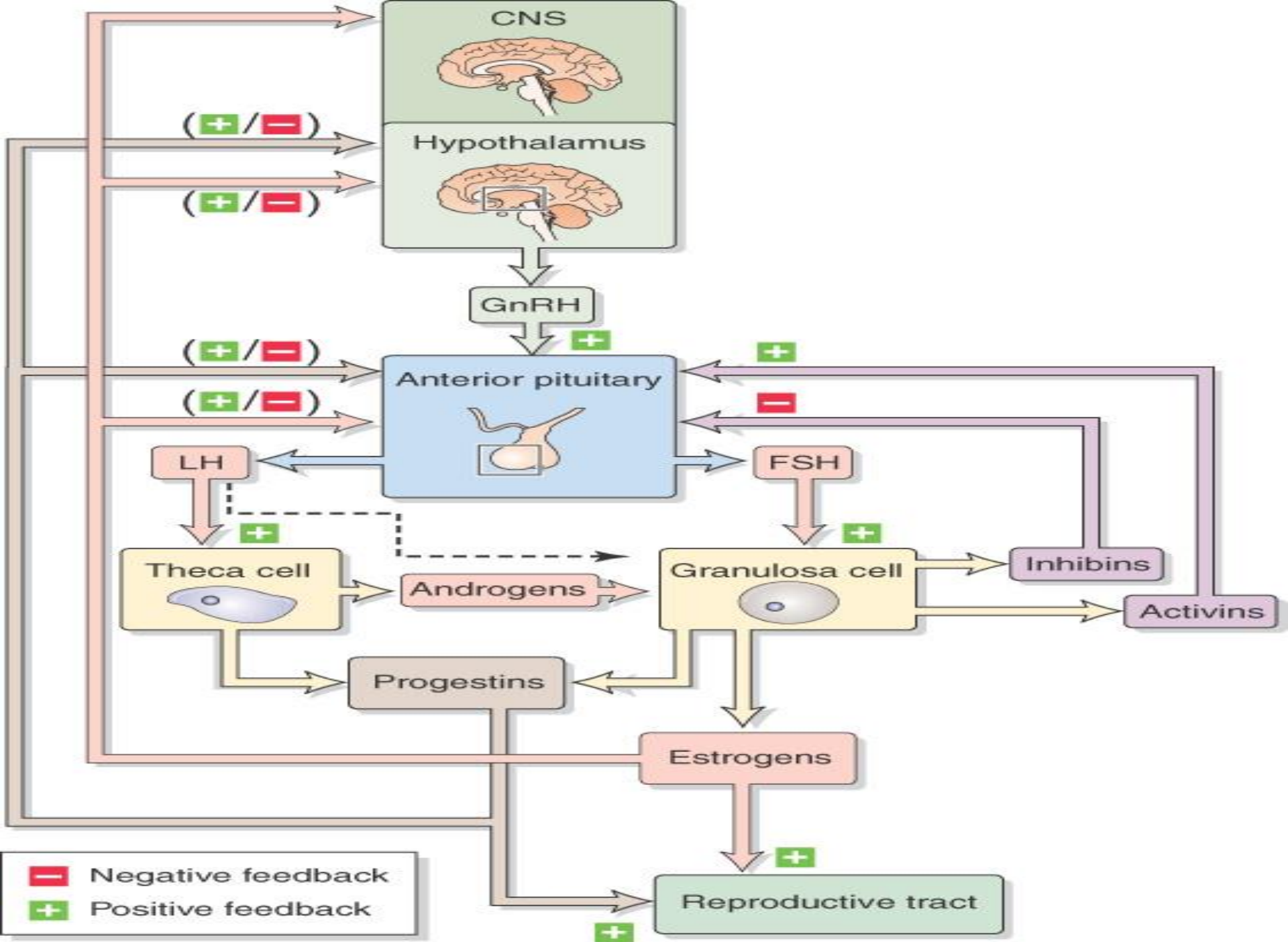


GnRH



● **FIGURE 20-20** Feedback control of FSH and tonic LH secretion during the follicular phase.





PIH

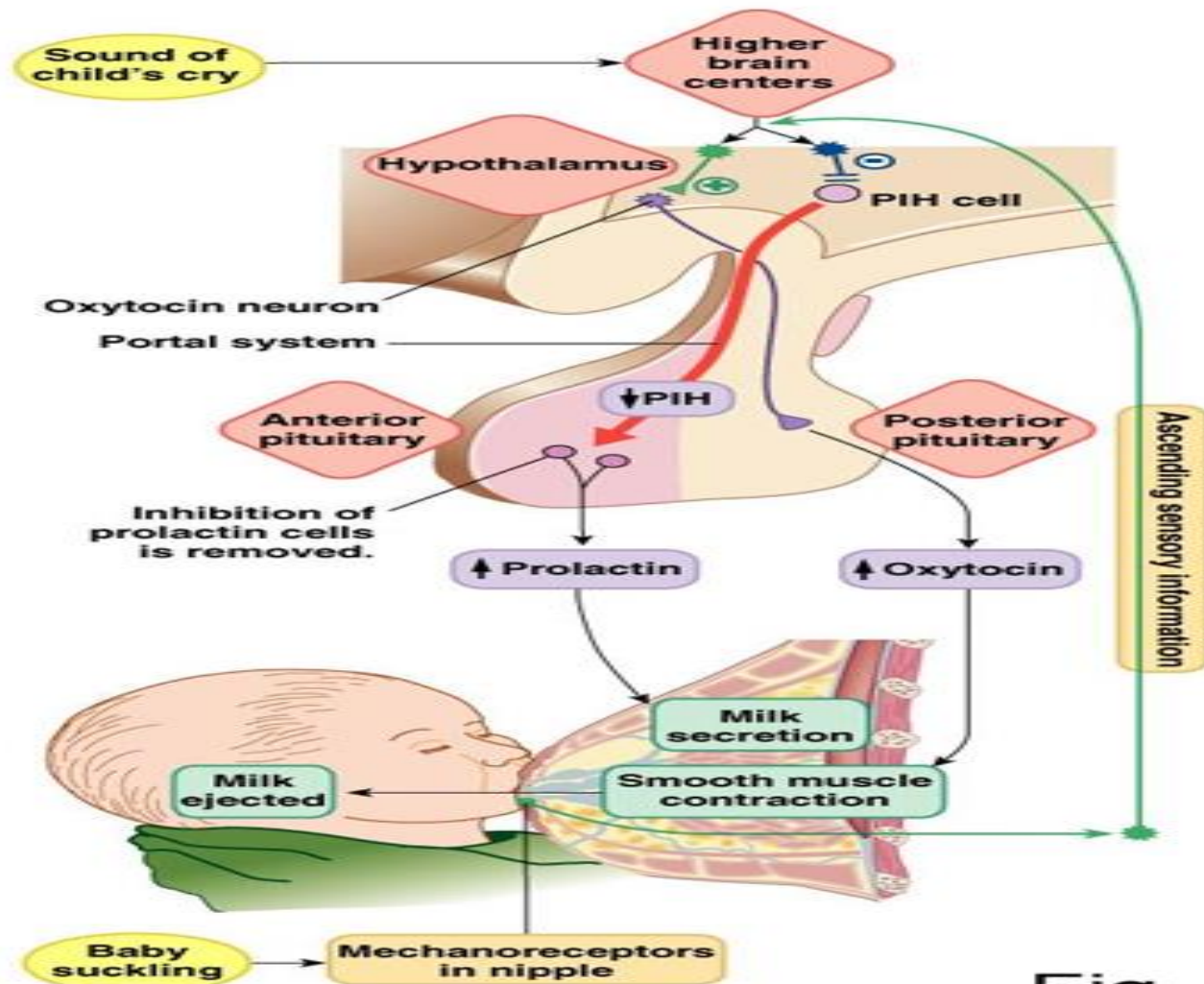
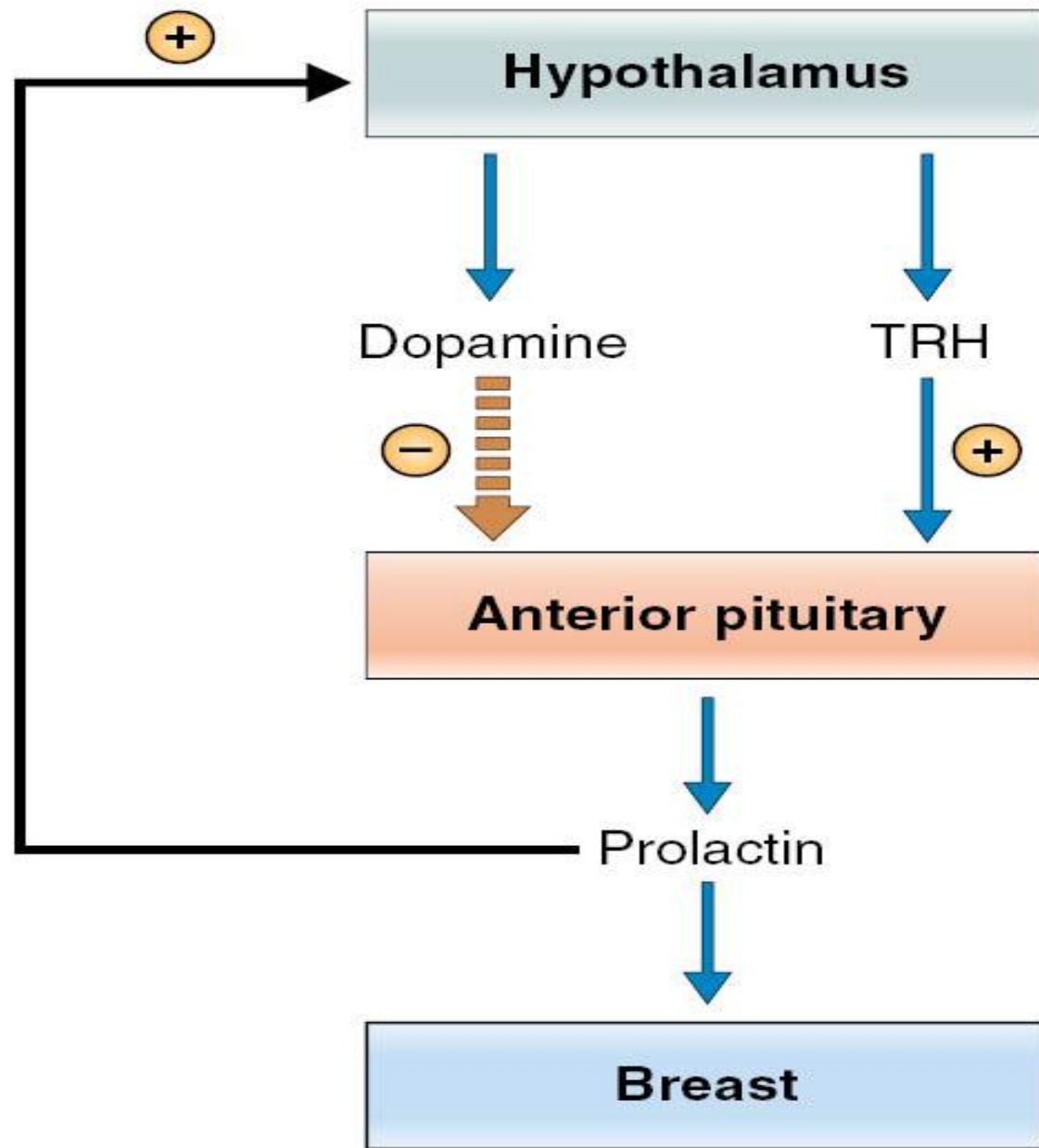
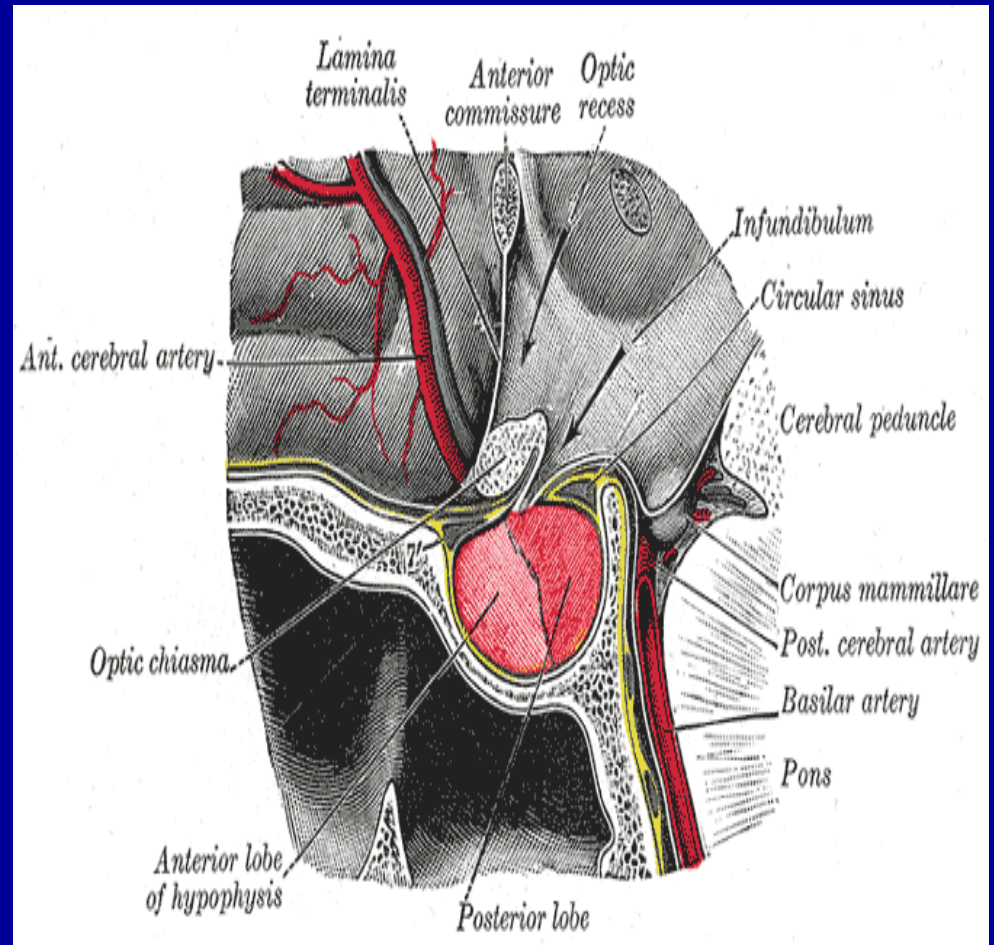


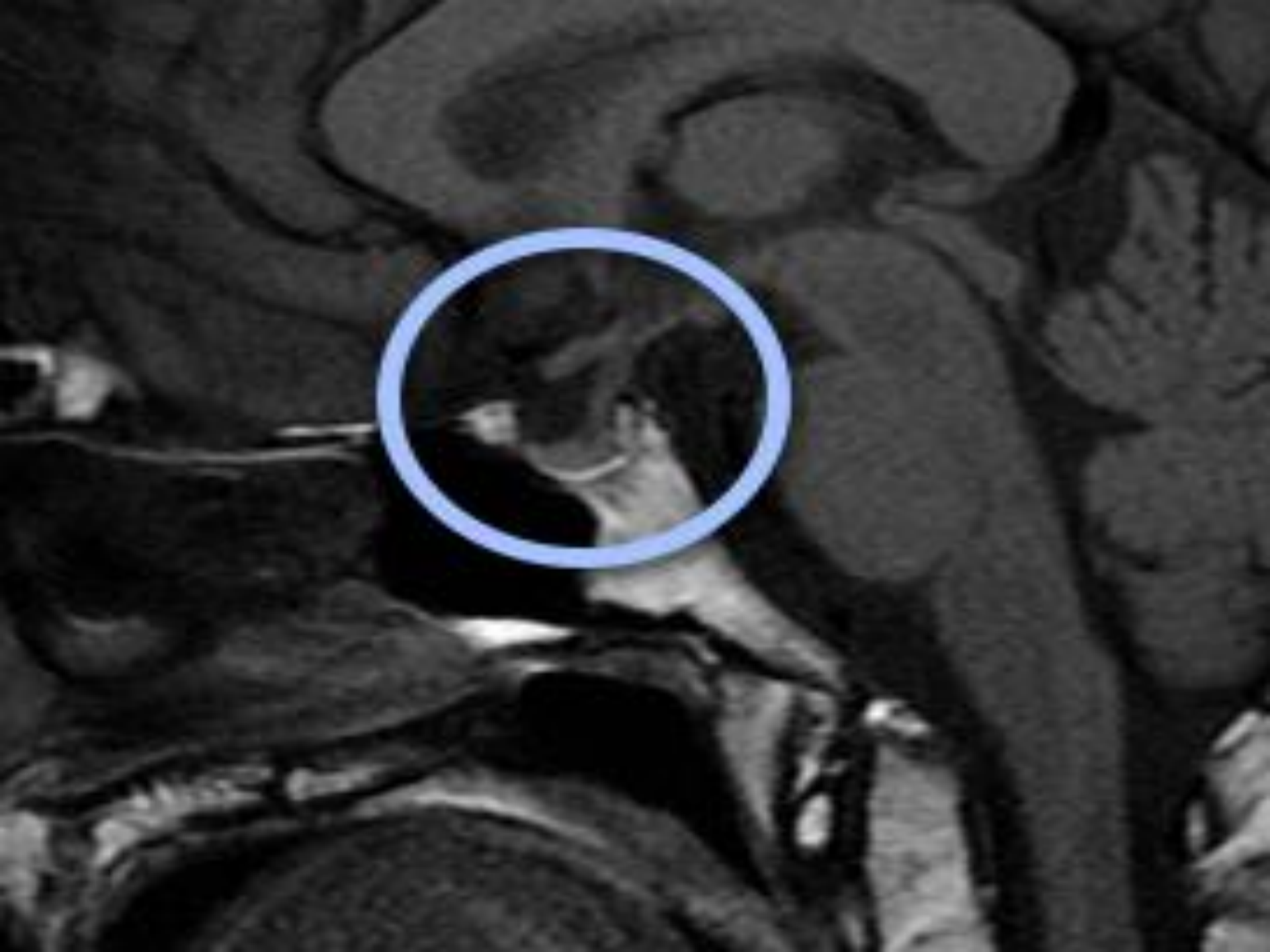
Fig. 26-23

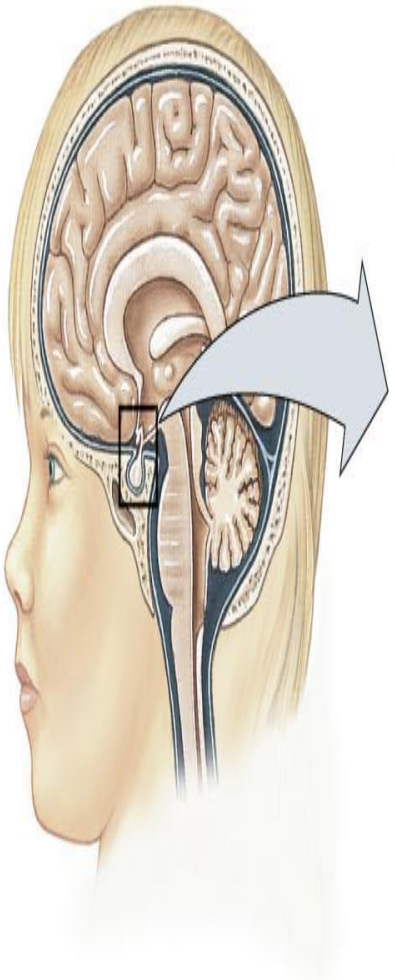


PITUITARY GLAND

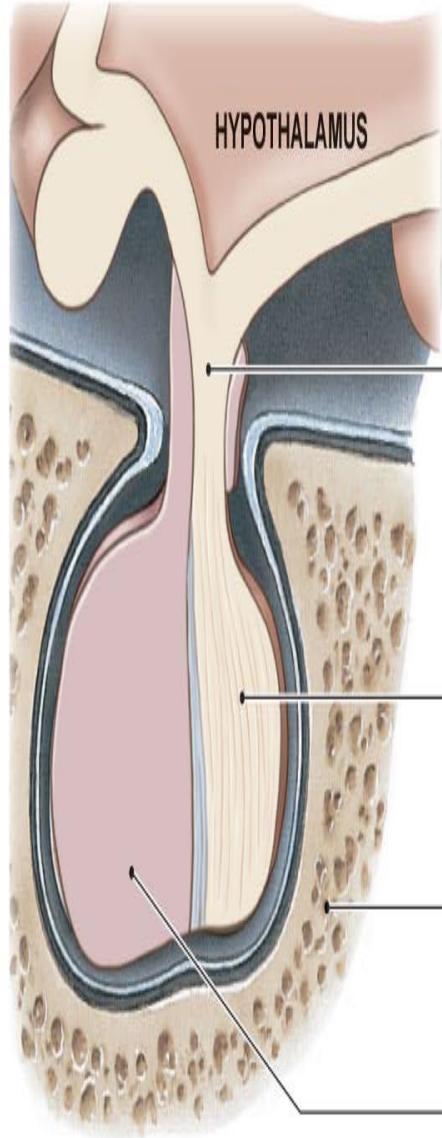
- Hypophysis.
- 1cm .
- 0.5-1 gram.







ANTERIOR ← → POSTERIOR



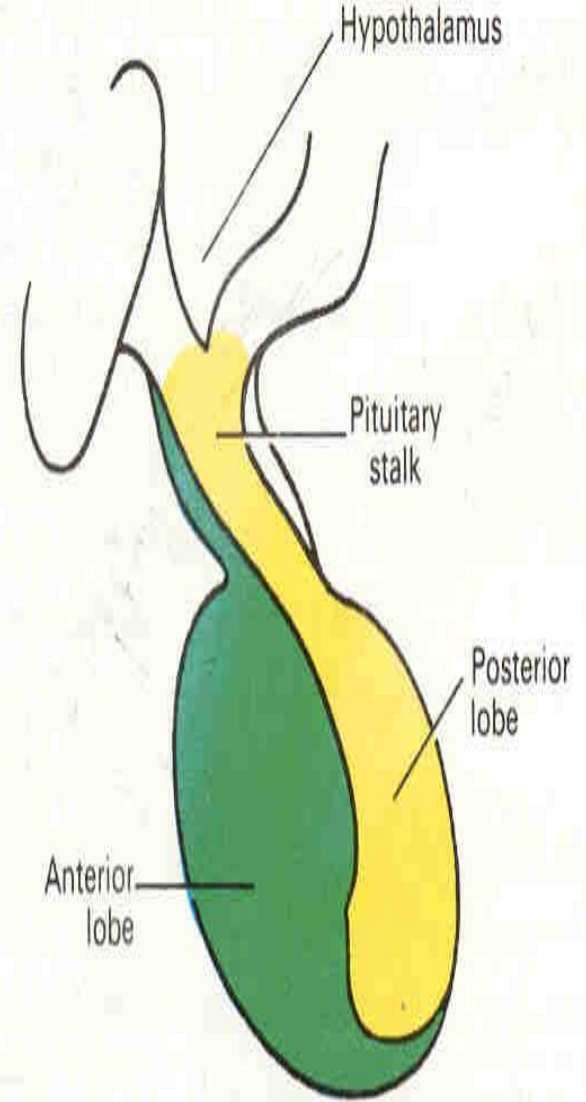
HYPOTHALAMUS

Infundibulum is the stalk that connects the pituitary to the brain.

Posterior pituitary is an extension of the neural tissue.

Sphenoid bone

Anterior pituitary is a true endocrine gland of epithelial origin.



Hypothalamus

Pituitary stalk

Posterior lobe

Anterior lobe

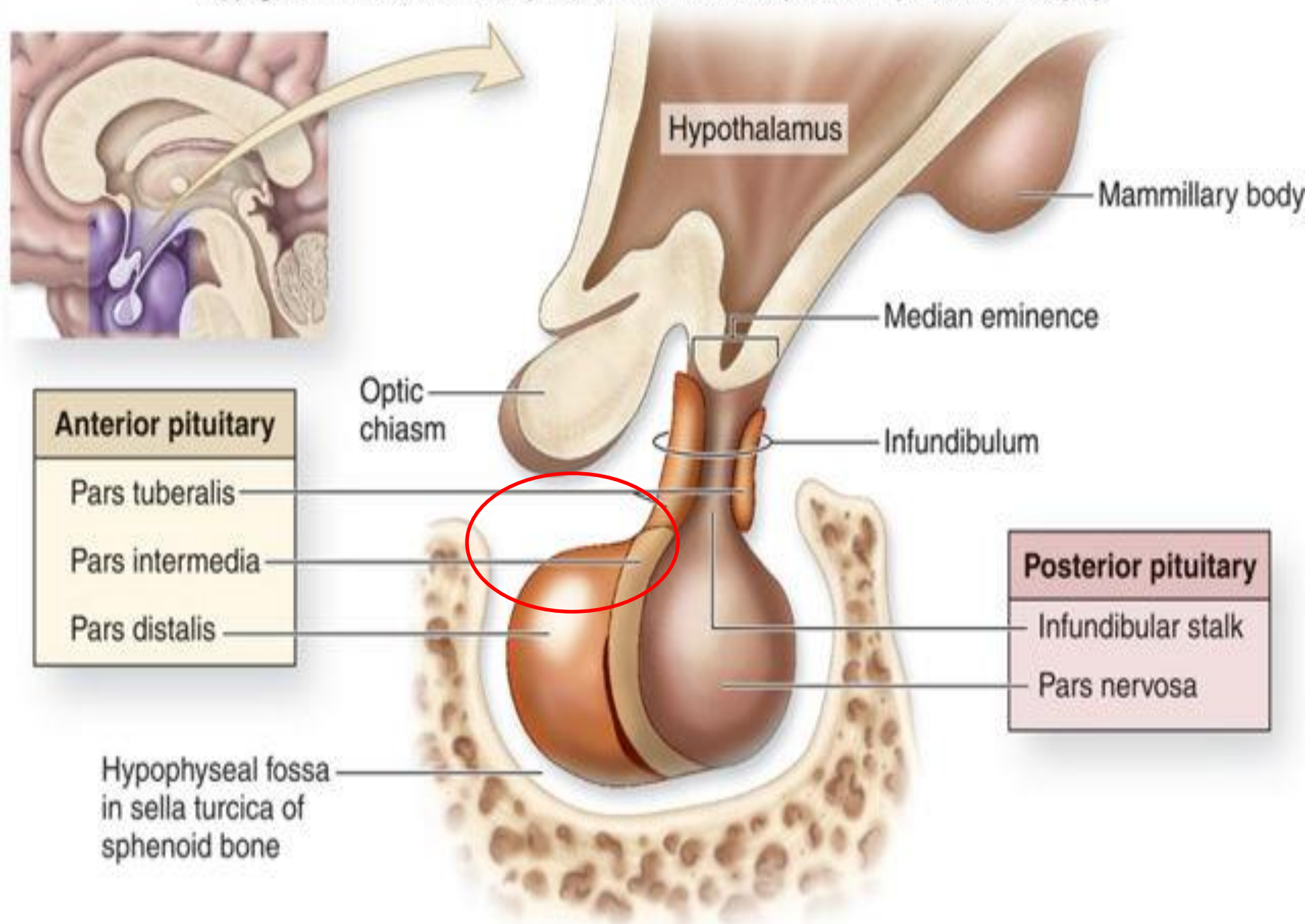
Figure 14:3 The parts of the pituitary gland and its relation to the hypothalamus.

STRUCTURE

Anterior lobe (adenohypophysis).

Posterior lobe (neurohypophysis).

Infundibulum.



RELATIONSHIP OF THE HYPOTHALAMUS TO THE POSTERIOR PITUITARY

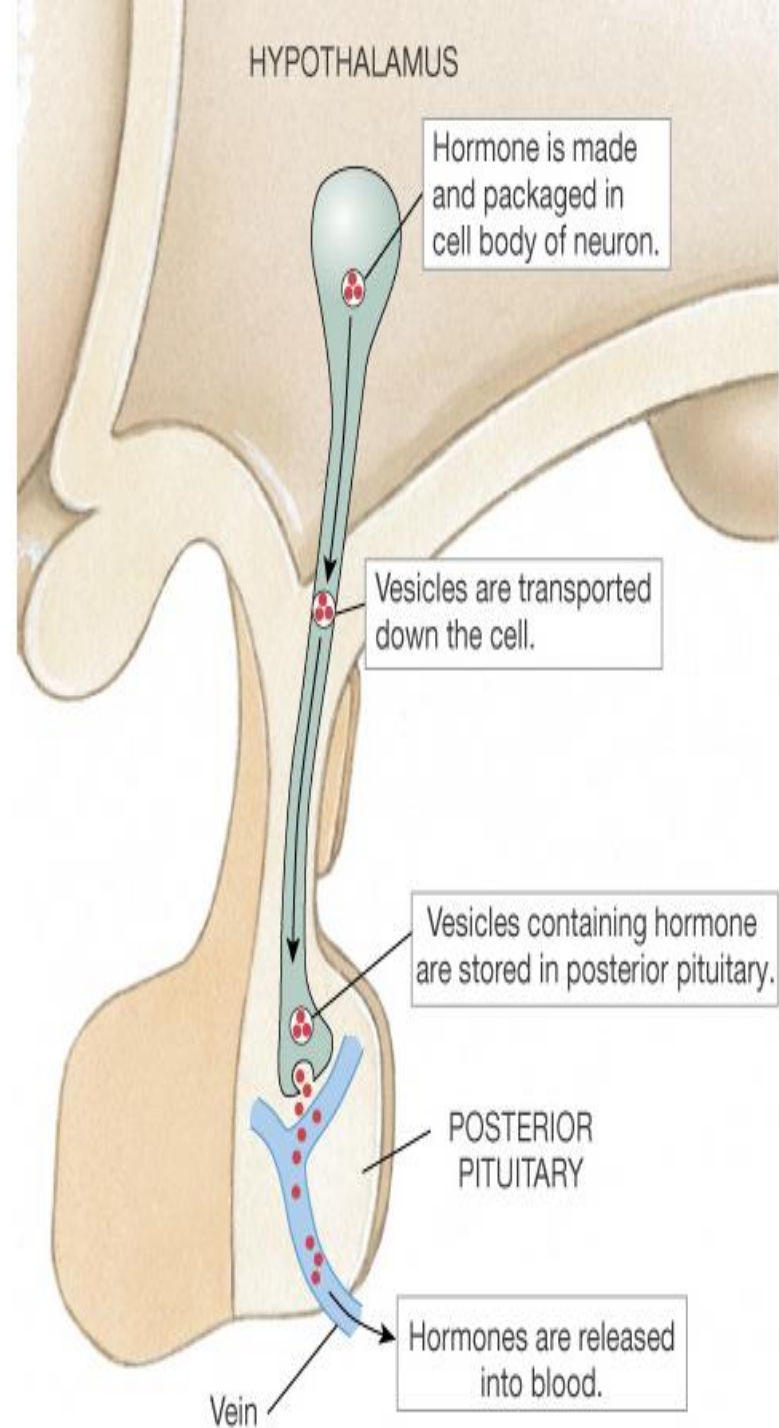
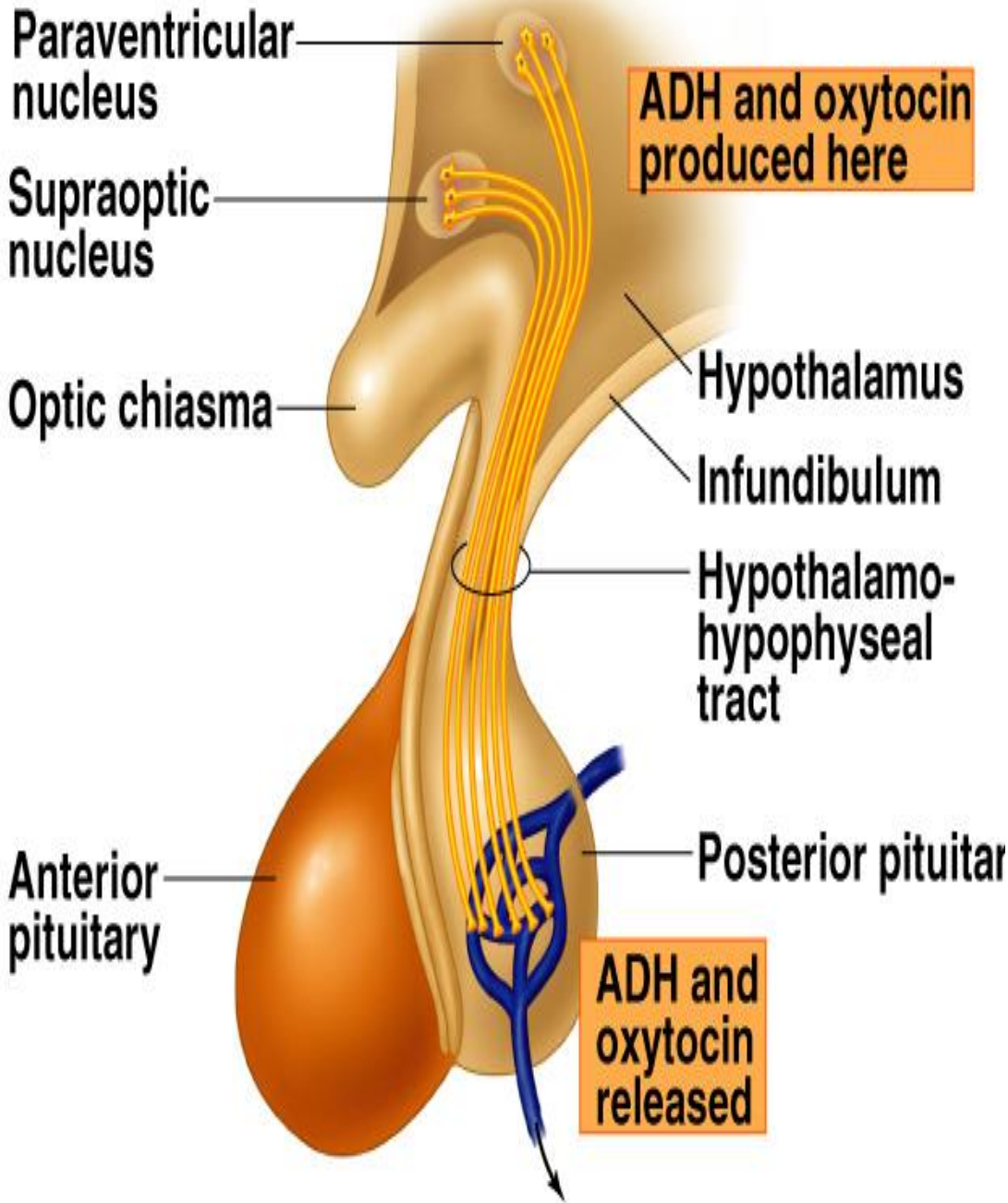
- Collection of nerve axons +supporting cells.

1- Antidiuretic hormone (ADH).

Supraoptic nuclei.

2- Oxytocin.

Paraventricular nuclei.



HYPOTHALAMO-NEURO HYPOPHYSIAL TRACT

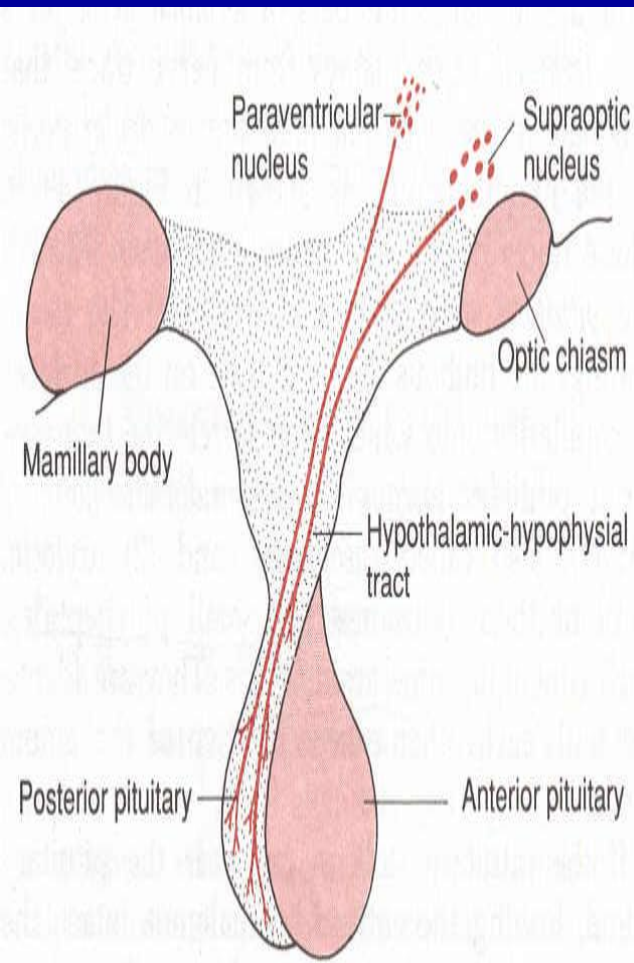
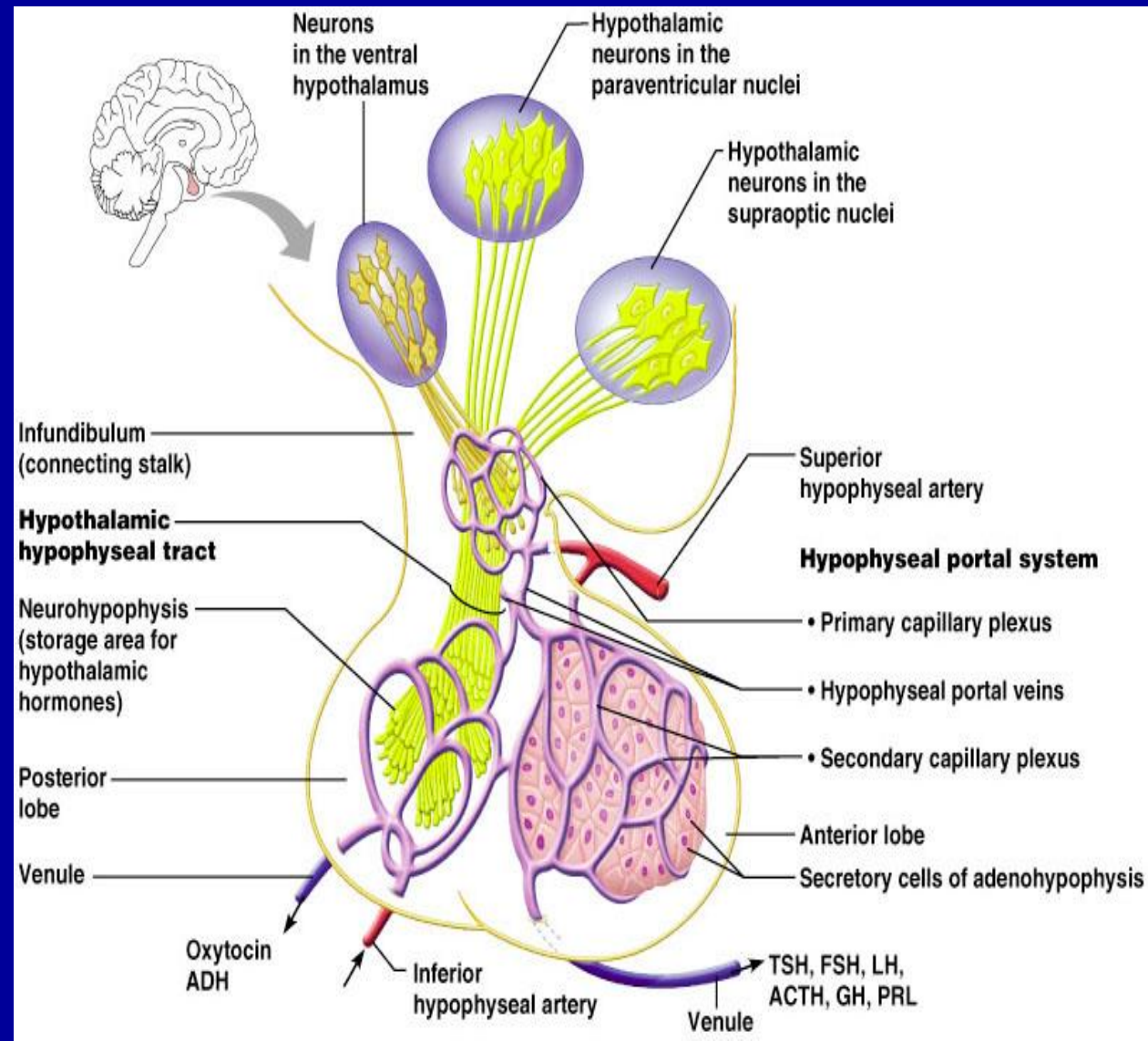


Figure 49-9 Hypothalamic control of the posterior pituitary.



RELATIONSHIP OF THE HYPOTHALAMUS TO THE ANTERIOR PITUITARY

collection of endocrine glands.

1- TSH

2- FSH

3- LH

4- GH

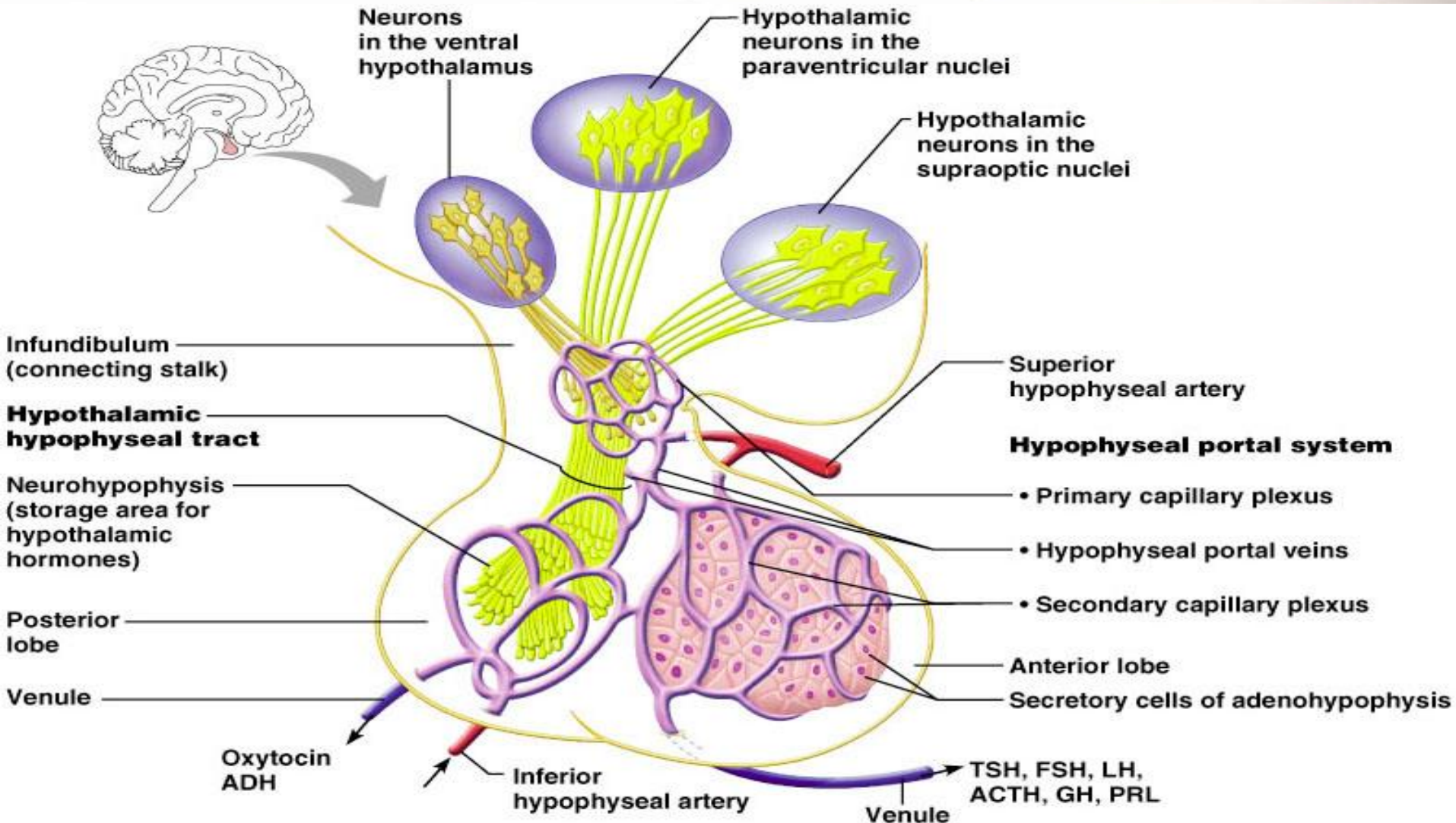
5- PROLACTIN

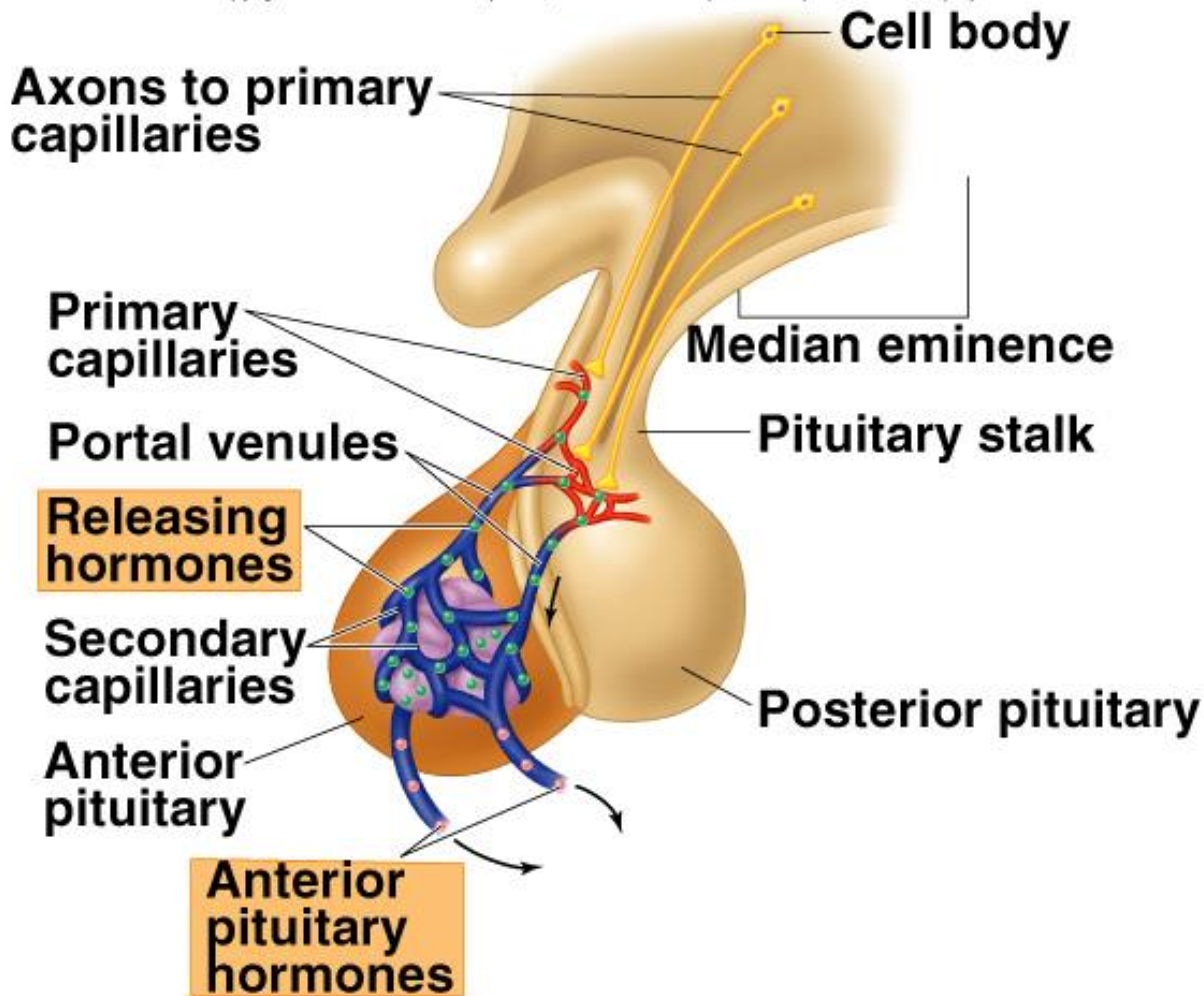
6- ACTH.

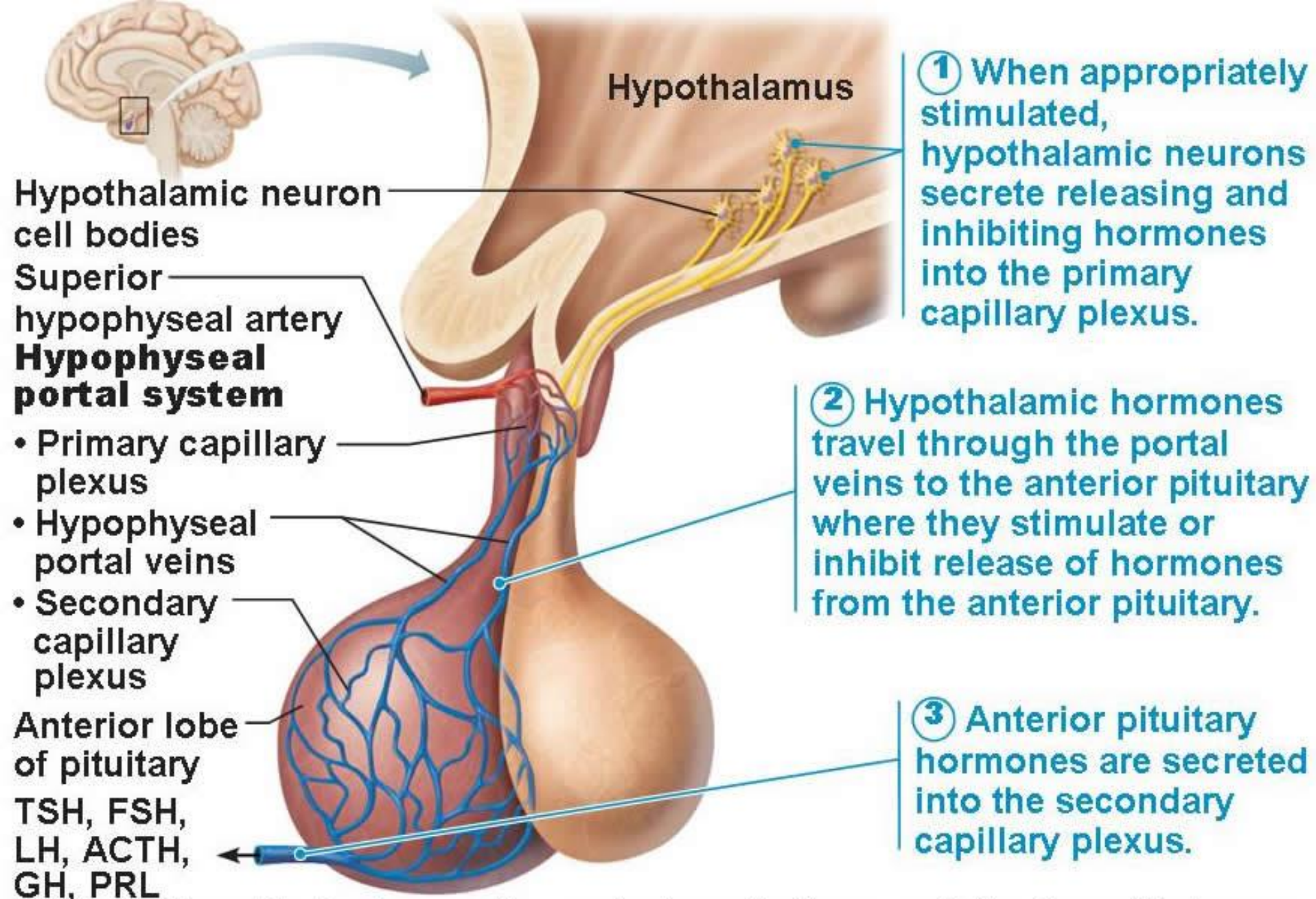
Table 11.6 | Anterior Pituitary Hormones

Hormone	Target Tissue	Principal Actions	Regulation of Secretion
ACTH (adrenocorticotrophic hormone)	Adrenal cortex	Stimulates secretion of glucocorticoids	Stimulated by CRH (corticotropin-releasing hormone); inhibited by glucocorticoids
TSH (thyroid-stimulating hormone)	Thyroid gland	Stimulates secretion of thyroid hormones	Stimulated by TRH (thyrotropin-releasing hormone); inhibited by thyroid hormones
GH (growth hormone)	Most tissue	Promotes protein synthesis and growth; lipolysis and increased blood glucose	Inhibited by somatostatin; stimulated by growth hormone-releasing hormone
FSH (follicle-stimulating hormone)	Gonads	Promotes gamete production and stimulates estrogen production in females	Stimulated by GnRH (gonadotropin-releasing hormone); inhibited by sex steroids and inhibin
PRL (prolactin)	Mammary glands and other sex accessory organs	Promotes milk production in lactating females; additional actions in other organs	Inhibited by PIH (prolactin-inhibiting hormone)
LH (luteinizing hormone)	Gonads	Stimulates sex hormone secretion; ovulation and corpus luteum formation in females; stimulates testosterone secretion in males	Stimulated by GnRH; inhibited by sex steroids

HYPOTHALAMIC-HYPOPHYSIAL PORTAL SYSTEM



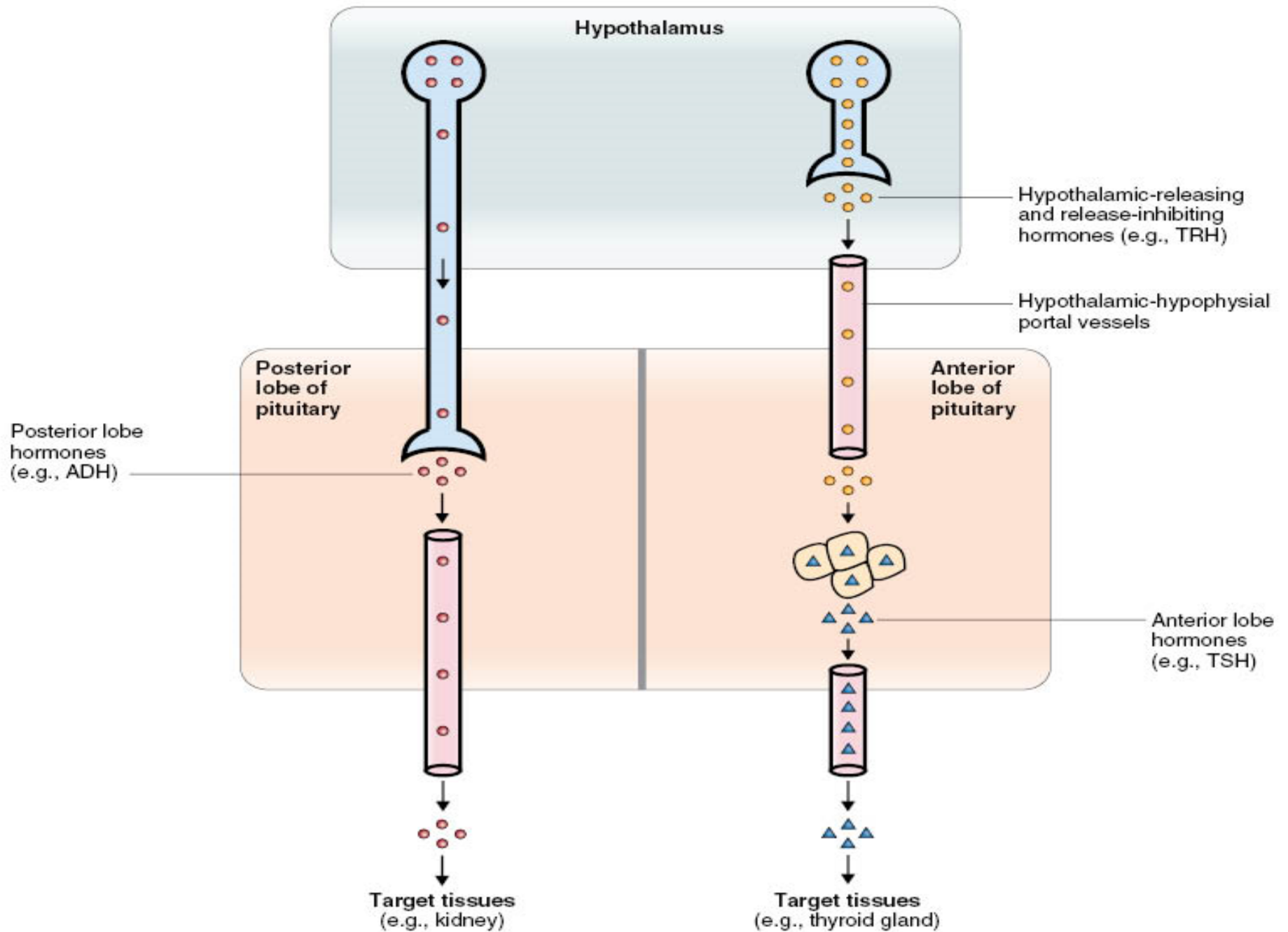




(b) Relationship between the anterior pituitary and the hypothalamus

- **Both neural and endocrine.**

HYPOTHALAMIC-PITUITARY RELATIONSHIPS



NEGATIVE FEEDBACK MECHANISM

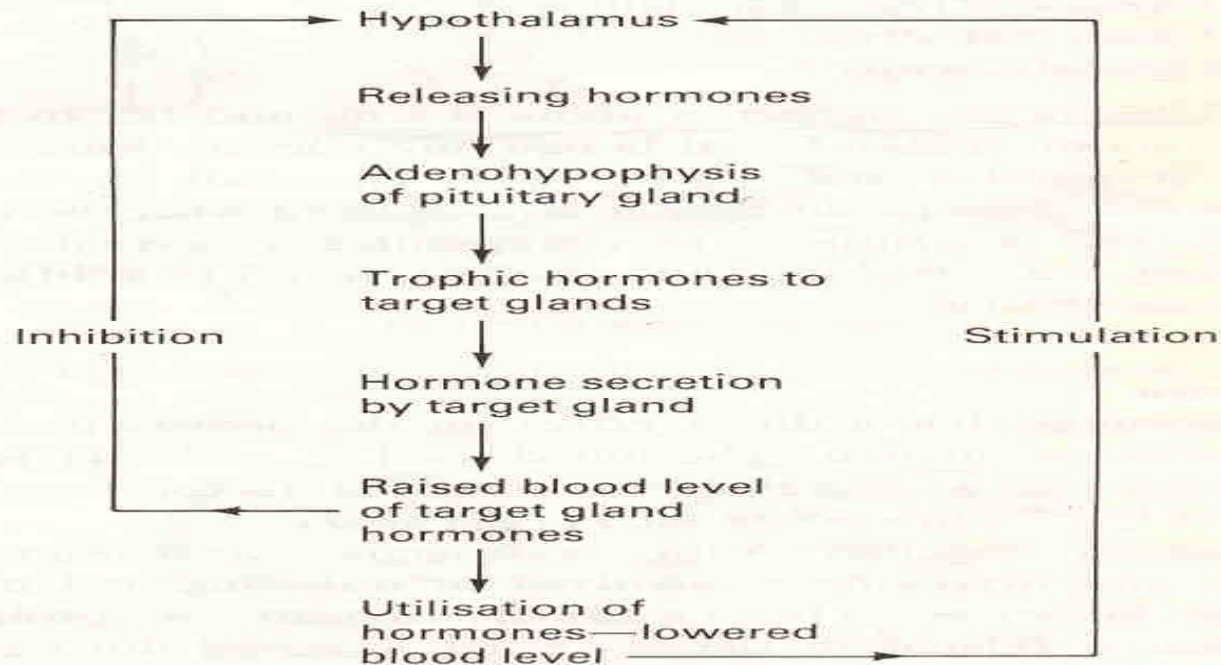
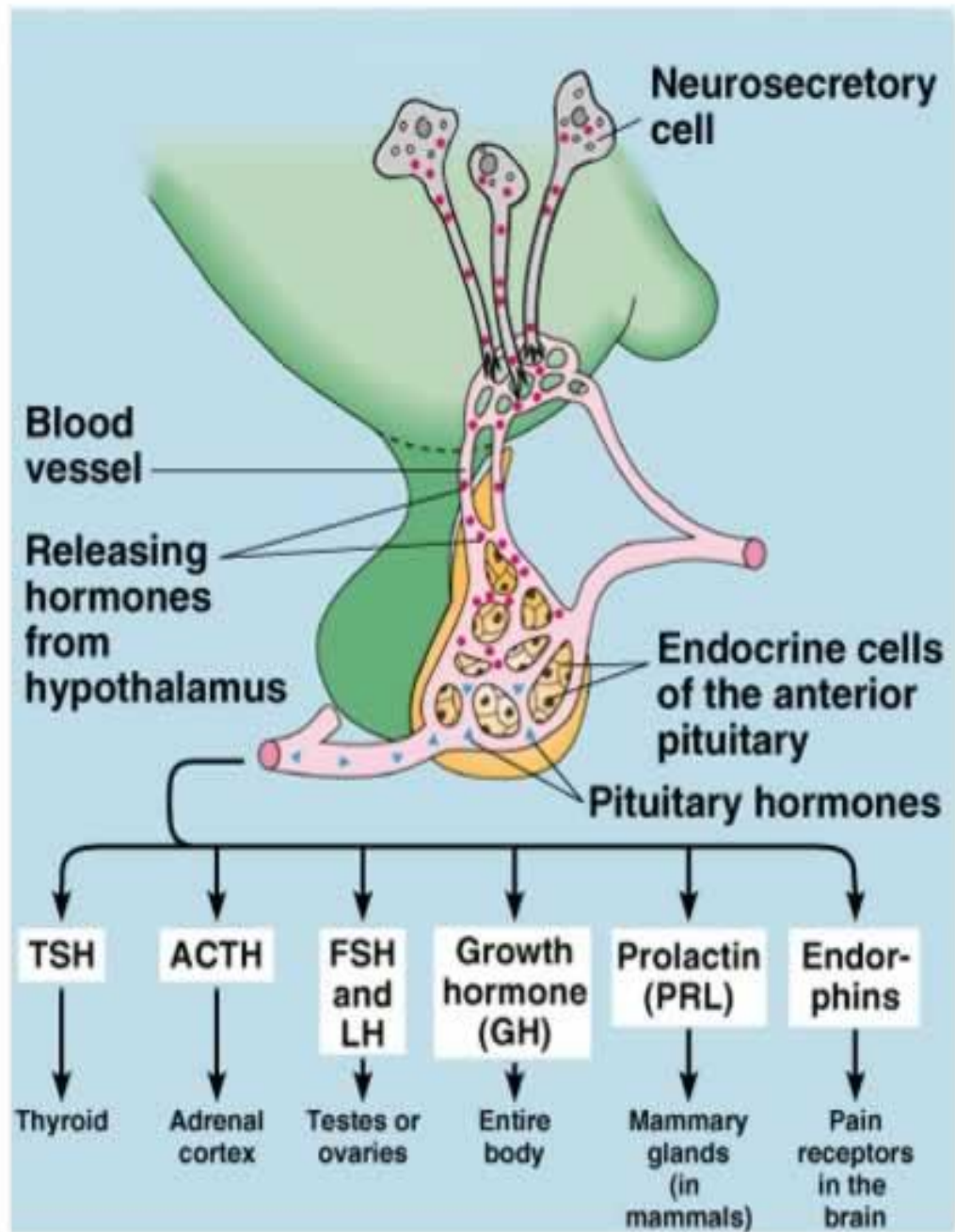
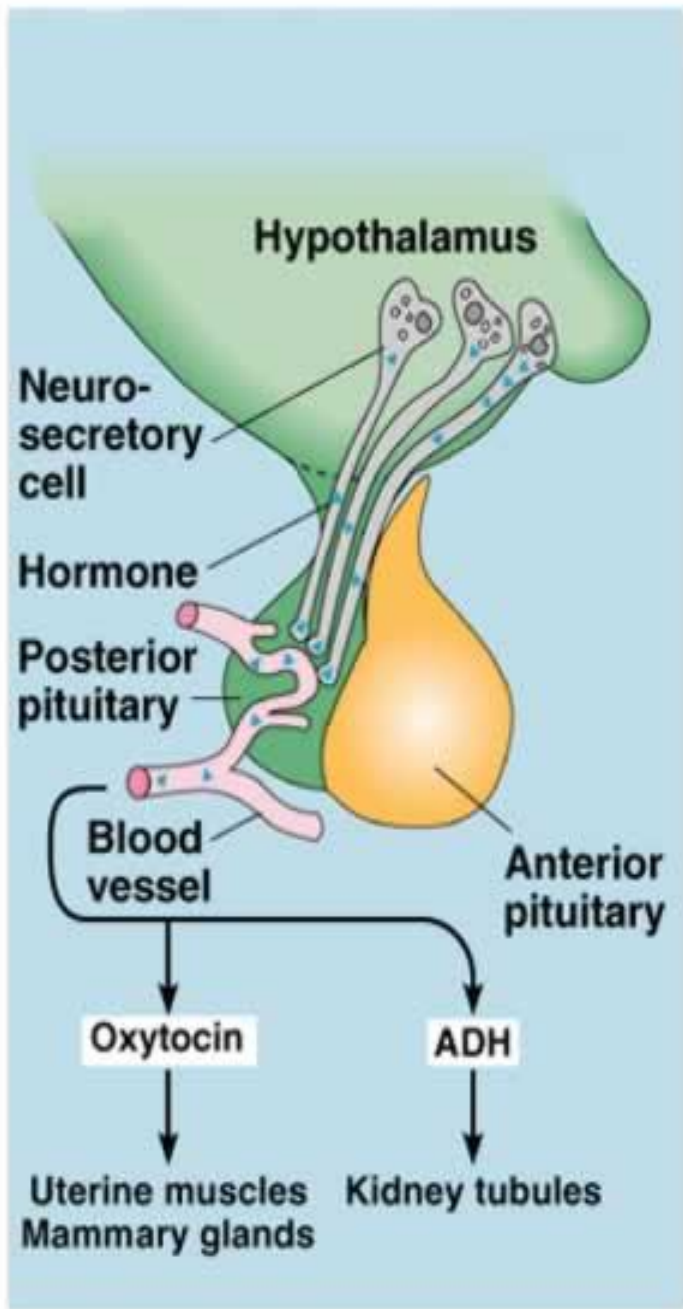


Figure 14:4 Diagram of the negative feedback regulation of the secretions of hormones by the anterior lobe of the pituitary gland.



Thank you