

# Chapter 26

## Hormones and the Endocrine System

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PowerPoint Lectures for

***Biology: Concepts and Connections, Fifth Edition***

*– Campbell, Reece, Taylor, and Simon*

# Learning Objectives

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Understand:

- the nature of chemical regulation.
- the vertebrate endocrine system.
- what hormones and homeostasis are.

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## Testosterone and Male Aggression: Is There a Link?

- Among male animals, the primary role of testosterone and other androgens
  - Is to promote the development and maintenance of
    - male reproductive anatomy, and
    - secondary sexual characteristics
- Does testosterone also promote aggressive behavior?

- 
- Research on **cichlid fish**
    - Has shown that **androgen levels** in males increase during displays of territorial behavior



- 
- Establishing links between androgens and human male aggression
    - Has been found to be problematic



VS



Does testosterone play a role in aggressive behavior?



# THE NATURE OF CHEMICAL REGULATION

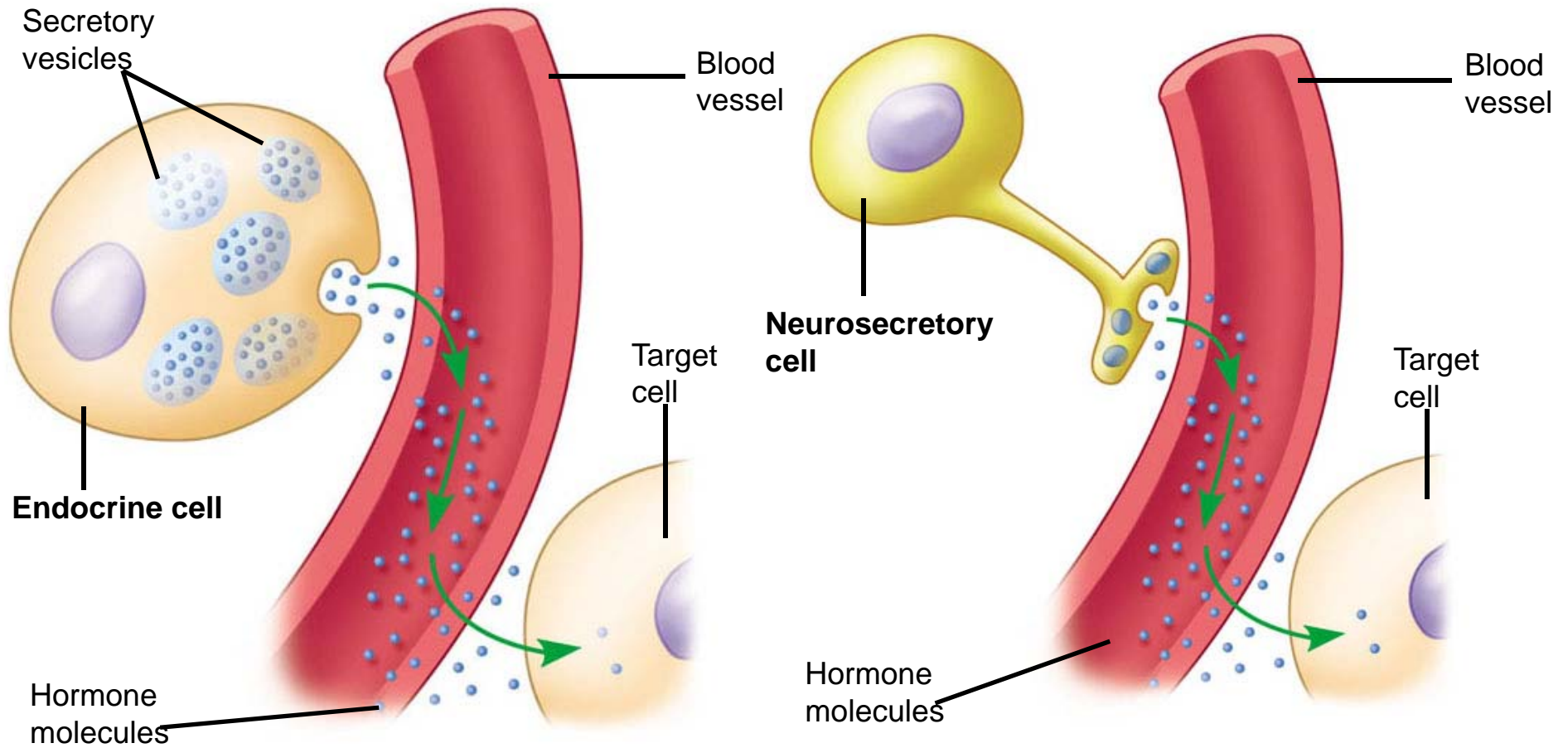
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## 26.1 Chemical signals coordinate body functions

Some hormones are **local regulators** – affect only nearby cells

- **Hormones** are chemical signals, usually carried in the **blood**
  - That cause specific changes in target cells
- All hormone-secreting cells make up **the endocrine system**
  - Which works with the **nervous system** in regulating body activities

- Hormones are secreted by
  - Endocrine glands and neurosecretory cells



**Figure 26.1A, B**

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- A few chemicals serve BOTH
    - as **hormones** in the **endocrine system**, and
    - as **chemical signals** in the **nervous system**

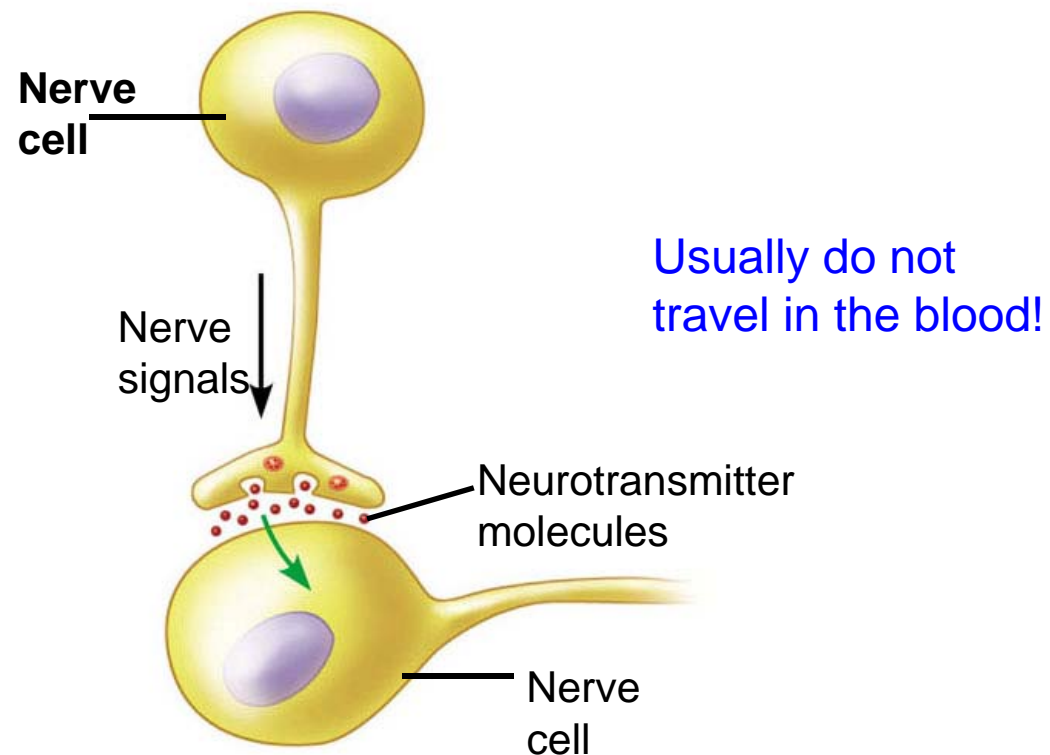


Figure 26.1C



## 26.2 Hormones affect target cells by two main signaling mechanisms

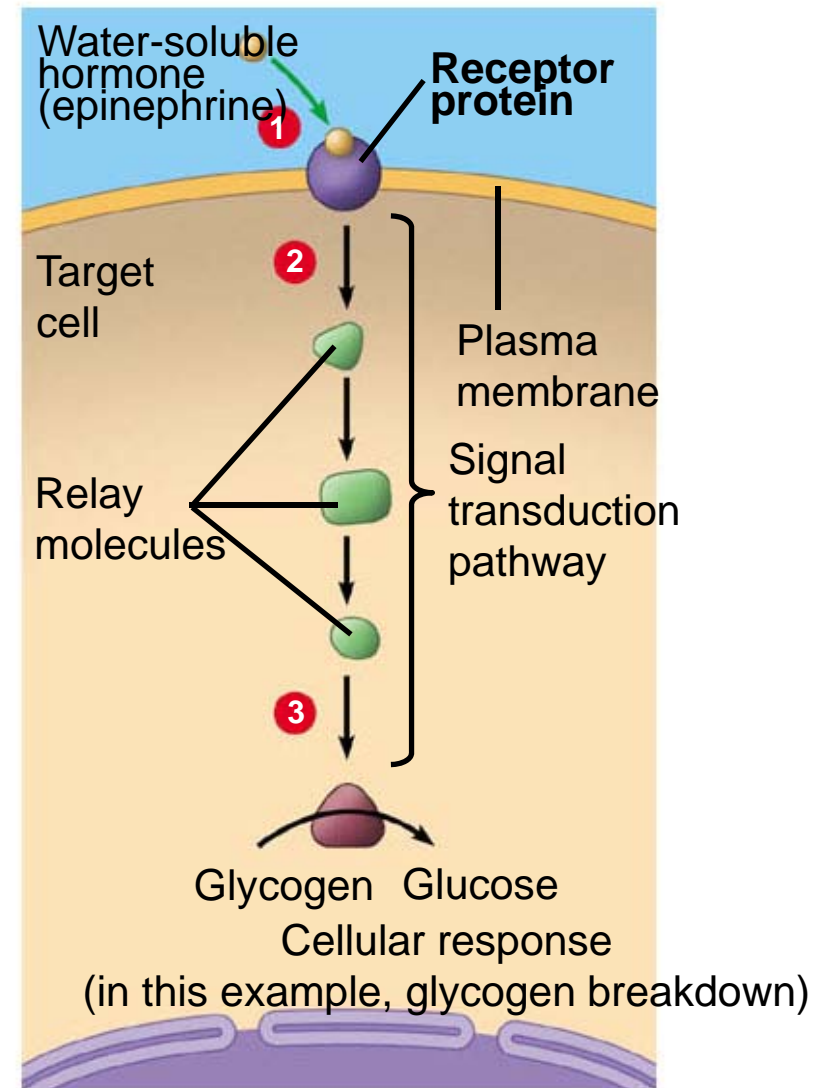
(1) **Water-soluble hormones** such as proteins and amines

- Bind to plasma-membrane **receptors** on **target cells**



Action of  
non-steroid hormones

Figure 26.2A



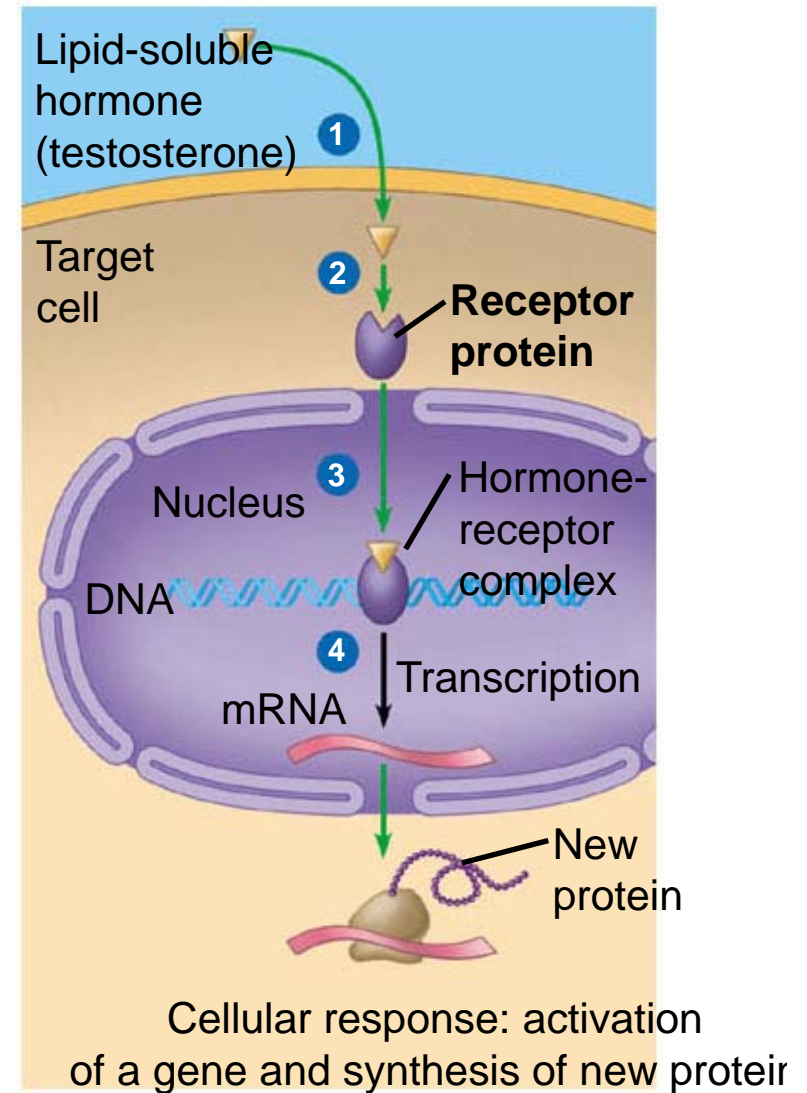
(2) **Lipid-soluble hormones**, such as the steroid hormones (e.g. the sex hormones estrogen and testosterone)

- **Diffuse** through the plasma membrane of target cells and bind to **intracellular receptors**



Action of steroid hormones

Figure 26.2B



# THE VERTEBRATE ENDOCRINE SYSTEM

## 26.3 Overview: The vertebrate endocrine system

- The vertebrate endocrine system
  - Consists of more than a dozen glands secreting more than 50 hormones

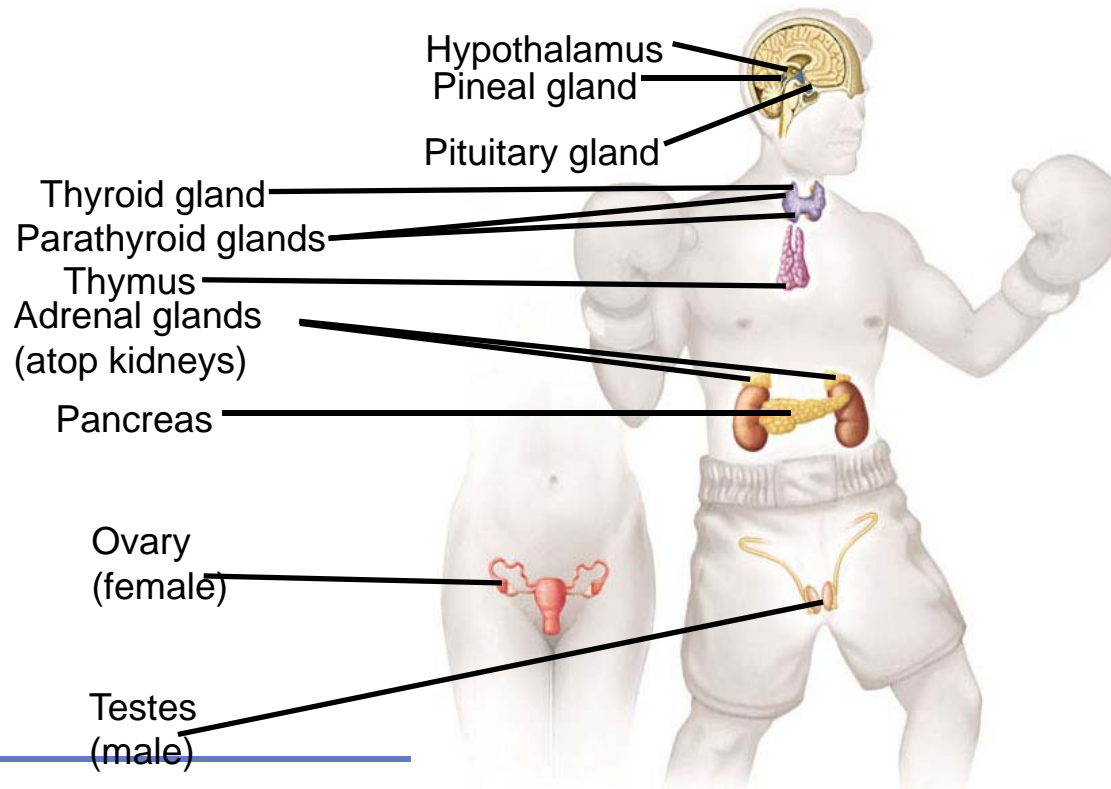


Figure 26.3

- 
- Some glands are specialized for hormone secretion only
    - While others also do other jobs
    - E.g. **pancreas** secretes
      - **Insulin** & various **digestive enzymes**
  - Some hormones have a very narrow range of targets and effects
    - While others have numerous effects on many kinds of target cells

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## 26.4 The **hypothalamus** (下視丘), closely tied to the pituitary, connects the nervous and endocrine systems

- The **hypothalamus** exerts **master control** over the endocrine system
  - By using the pituitary gland to relay directives to other glands

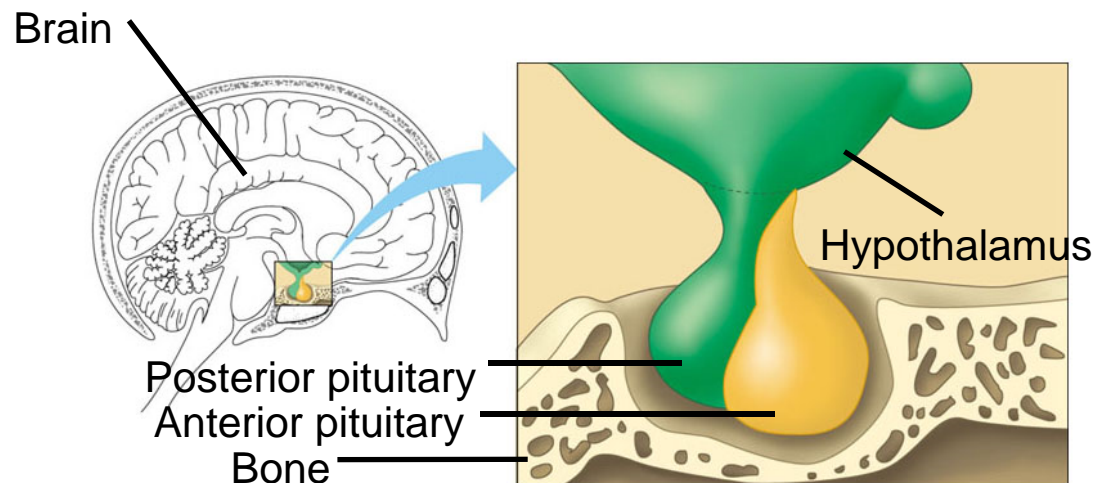


Figure 26.4A

- 
- **Releasing** and **inhibiting** hormones from the hypothalamus

- Control the secretion of several other hormones



- **Releasing** hormones

- Stimulates the release of other hormones



- **Inhibiting** hormones

- Inhibits/Reduces the release of other hormones

- The posterior pituitary

(腦下垂體後葉)

- Secretes (mainly)
  - oxytocin, and
  - antidiuretic hormone (ADH)

TSH-releasing hormone (TRH) is also secreted by hypothalamus

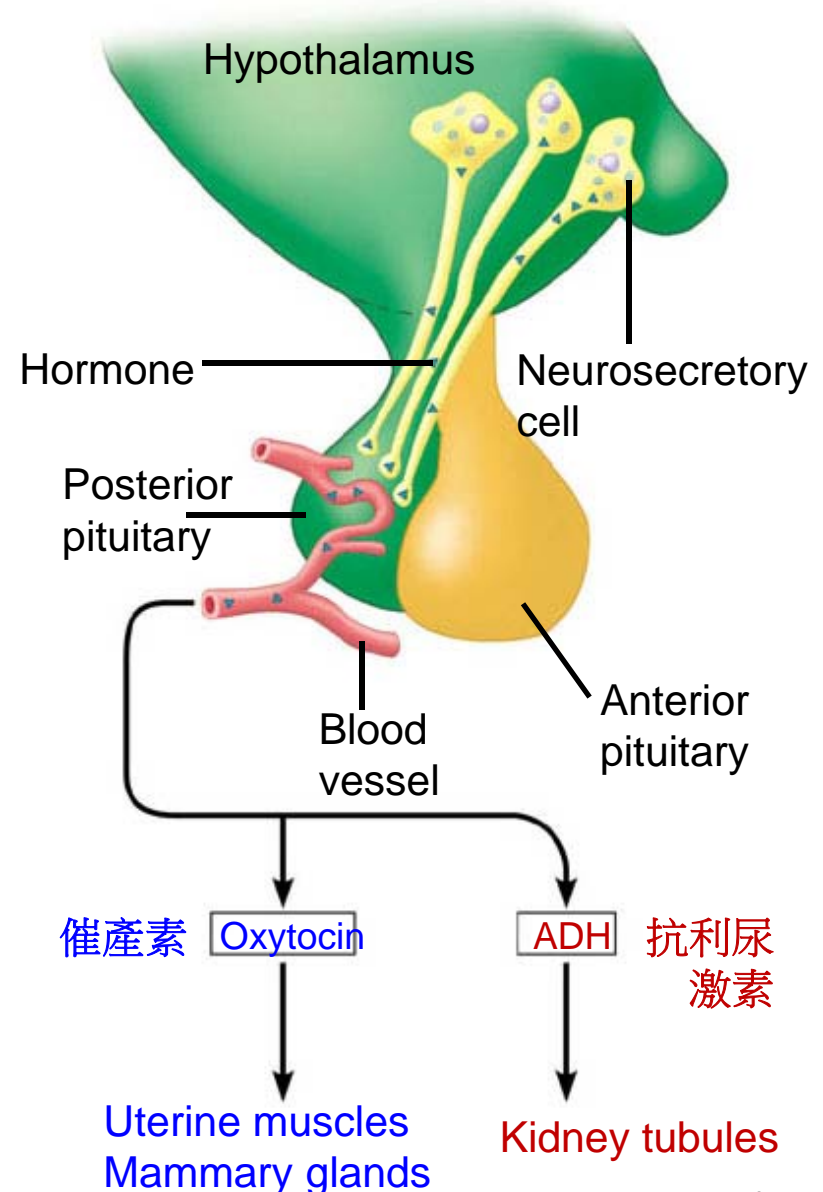


Figure 26.4B

- The anterior pituitary (腦下垂體前葉)

- Secretes TSH, ACTH, FSH and LH, growth hormone, prolactin, and endorphins

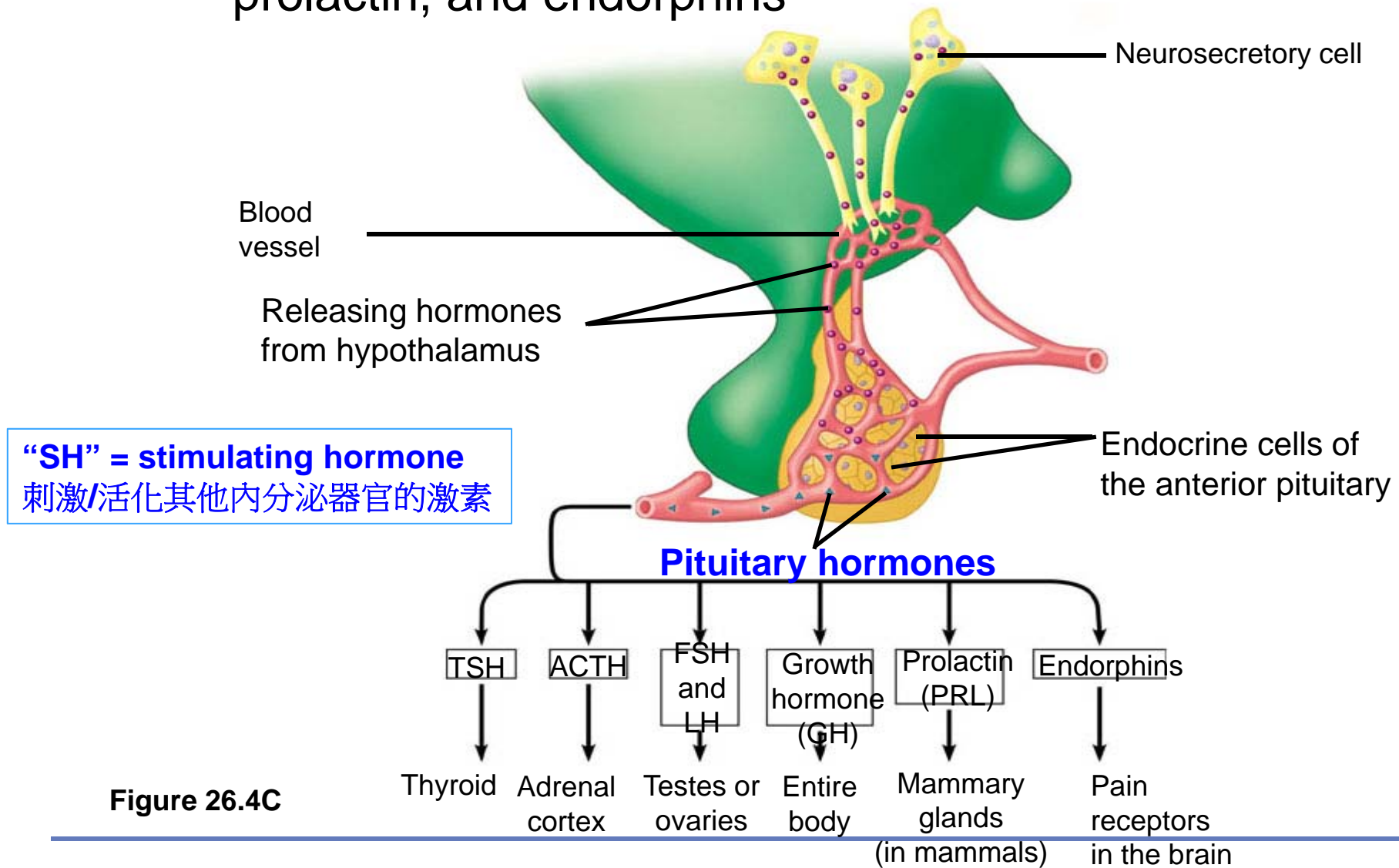


Figure 26.4C



- The thyroid gland (甲狀腺)
- Secretion of **thyroxine (T4)** by the thyroid gland
  - Is controlled by a **negative-feedback mechanism**

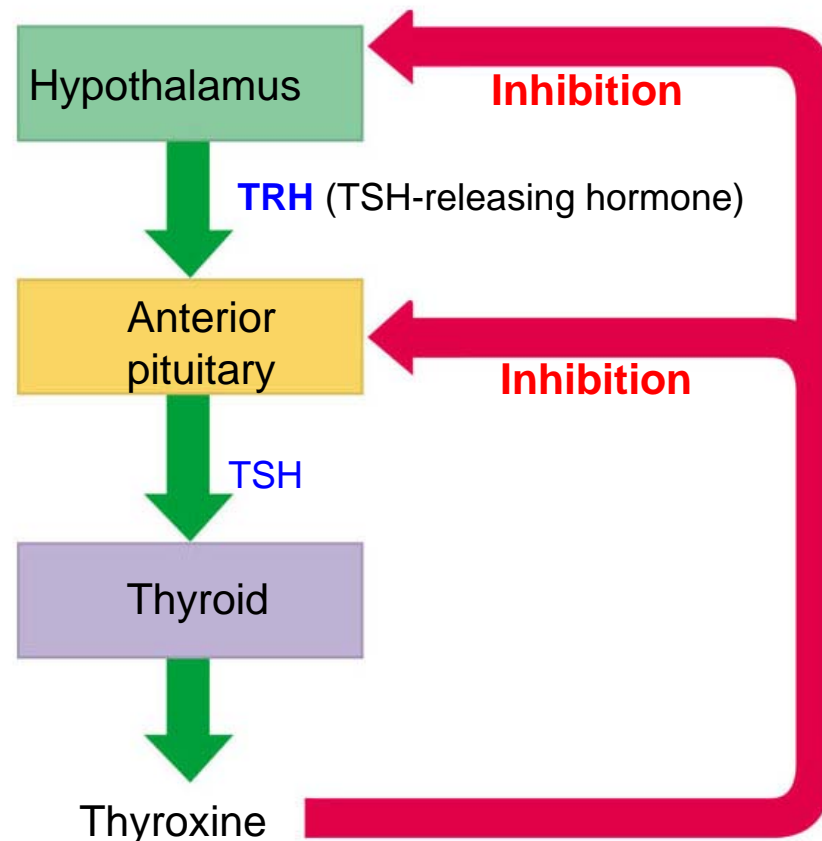


Figure 26.4D

# HORMONES AND HOMEOSTASIS

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## 26.5 The thyroid regulates development and metabolism

- Two hormones from the thyroid gland,  $T_4$  and  $T_3$ 
  - $T_4$  = thyroxine;  $T_3$  = triiodothyronine
  - In target cells,  $T_4$  is finally converted to  $T_3$ .
    - Both exert same effects on cells
  - Regulate an animal's development and metabolism
  - Maintain normal blood pressure, heart rate, muscle tone, digestion & reproduction functions



Next slide (Graves disease)!!!

- Thyroid imbalance

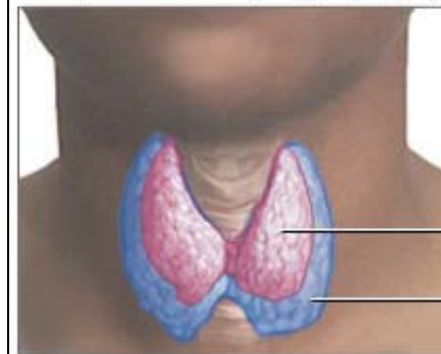
- Can cause disease

### Hyperthyroidism (甲狀腺亢進症) (Graves disease)



Exophthalmos (bulging eyes)

Graves' disease is a common cause of hyperthyroidism, an over-production of thyroid hormone, which causes enlargement of the thyroid and other symptoms such as exophthalmos, heat intolerance and anxiety



Normal thyroid

Enlarged thyroid

Diffuse goiter

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#### Clinical signs:

1. Exophthalmos (眼球突出)
2. Goiter enlargement (甲狀腺腫)
3. Pretibial myxedema (脛骨前黏液水腫)

## Hypothyroidism

(甲狀腺功能低下症)  
由於飲食缺碘所造成

- Negative feedback
  - Maintains homeostatic levels of  $T_4$  and  $T_3$  in the blood

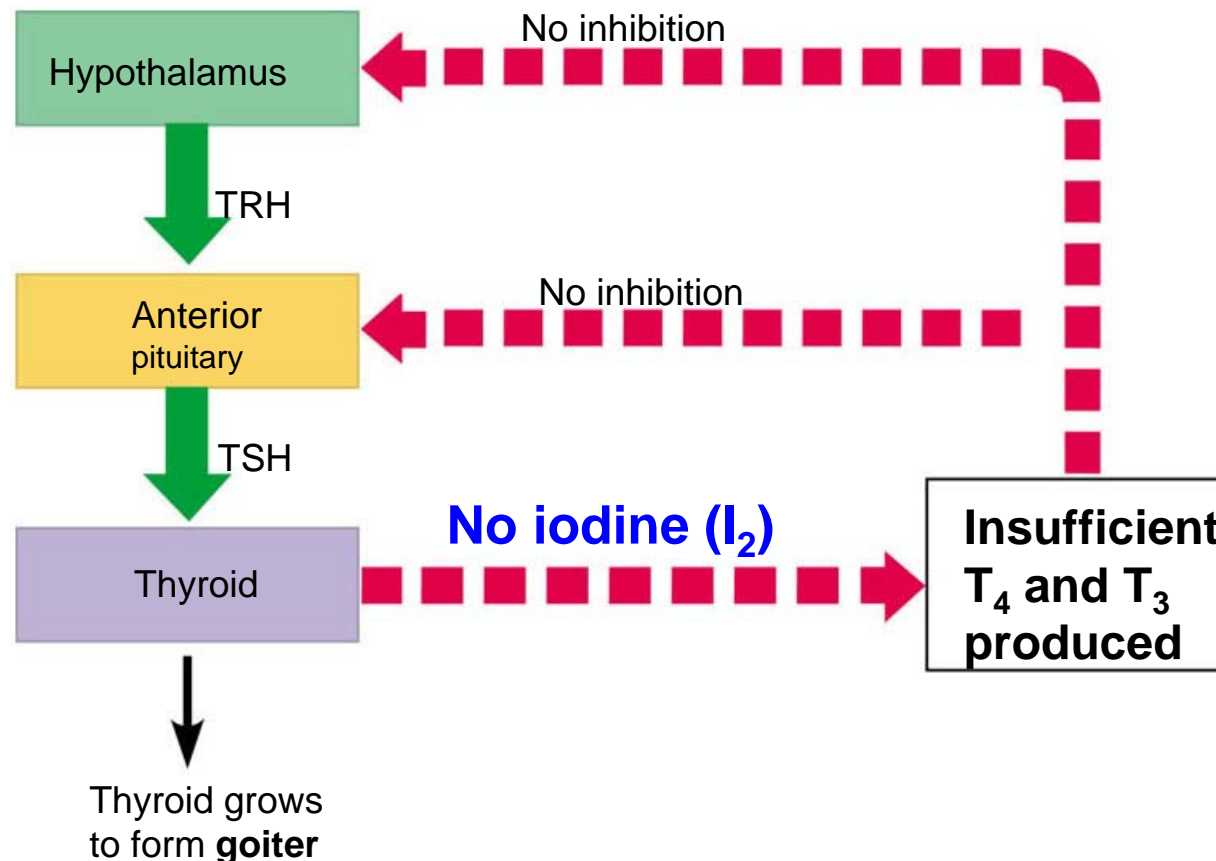


Figure 26.5B

Thyroid grows  
to form **goiter**

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## 26.6 Hormones from the **thyroid** and **parathyroids** maintain calcium homeostasis

- Blood calcium level is regulated by a tightly balanced antagonism
  - Between **降鈣激素**  $\longleftrightarrow$  **副甲狀腺激素**
    - calcitonin from the thyroid, and
      - to decrease blood  $[Ca^{++}]$
    - parathyroid hormone (PTH) from the parathyroid glands
      - to increase blood  $[Ca^{++}]$

- Calcium homeostasis

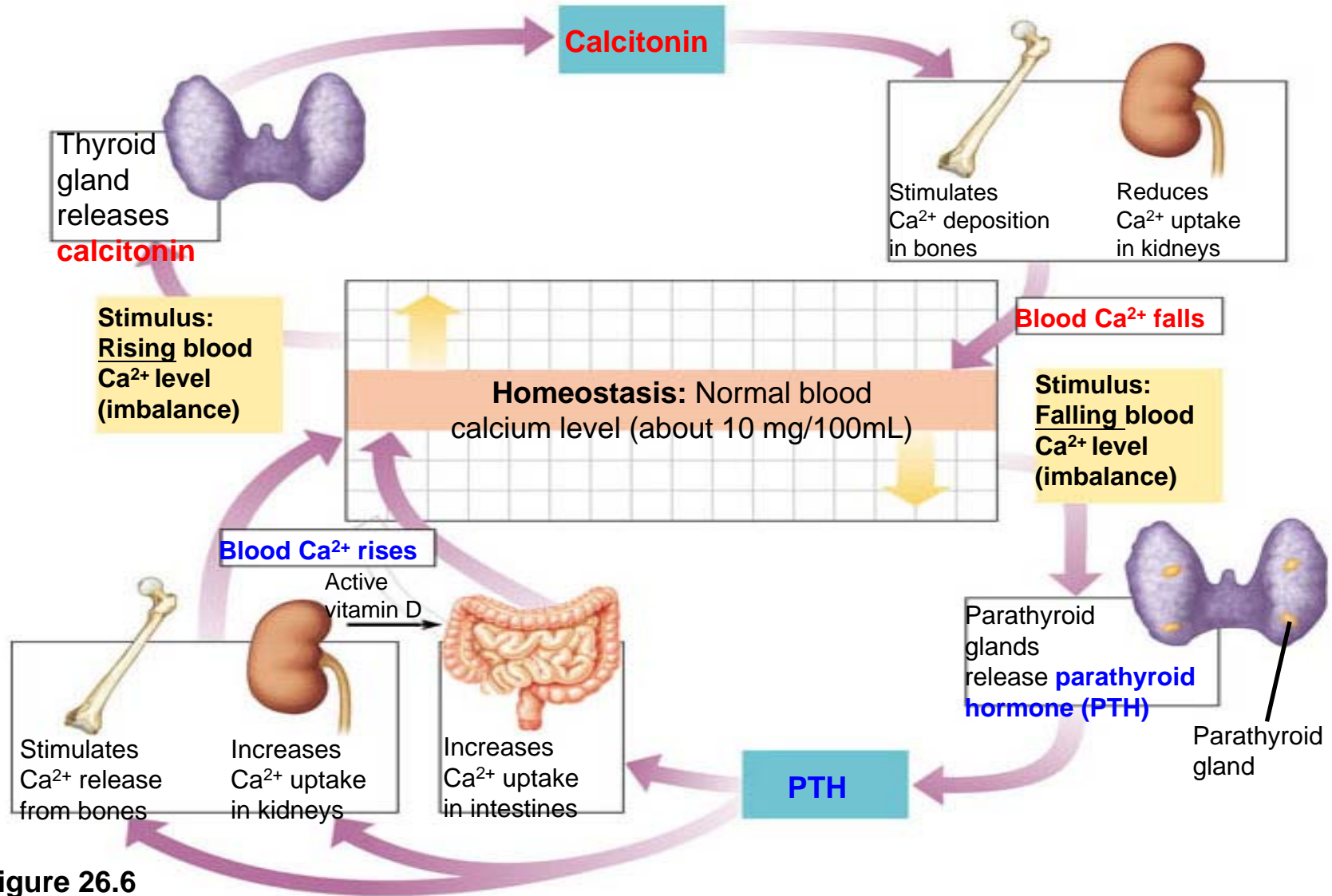


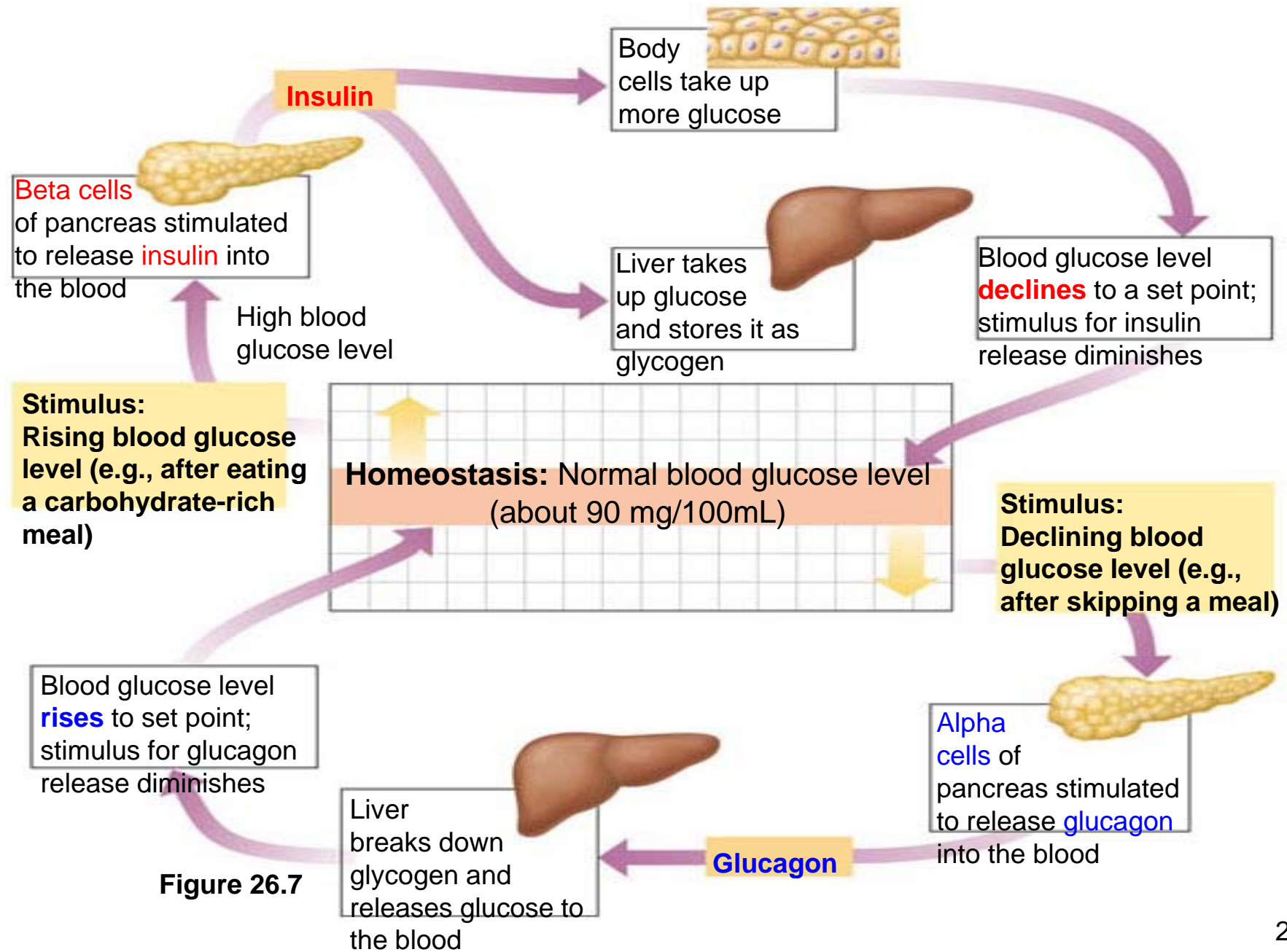
Figure 26.6

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## 26.7 Pancreatic hormones regulate blood glucose levels

- The pancreas secretes two hormones that control blood glucose levels
  - **Insulin (胰島素)**
    - Signals cells to use and store glucose
    - Decreases blood [Glucose]
  - **Glucagon (升糖素)**
    - Causes cells to release stored glucose into the blood
    - Increases blood [Glucose]

- Glucose homeostasis





# CONNECTION

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## 26.8 Diabetes is a common endocrine disorder

- Diabetes mellitus
  - Results from a **lack of insulin** or a **failure of cells to respond to it**

# Types of diabetes

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## **Type I** diabetes mellitus (insulin-dependent diabetes)

“IDDM”

- Is an autoimmune disorder
- the immune system destroys the beta cells of the pancreas (no insulin secreted!!)

## **Type II** diabetes mellitus (non-insulin-dependent diabetes) → the most common type of diabetes

- either by a deficiency of insulin or by reduced responsiveness of target cells due to some change in insulin receptors

- Diabetes can be detected

(口服葡萄糖耐受試驗)

- By a test called a **oral glucose tolerance (OGTT)**

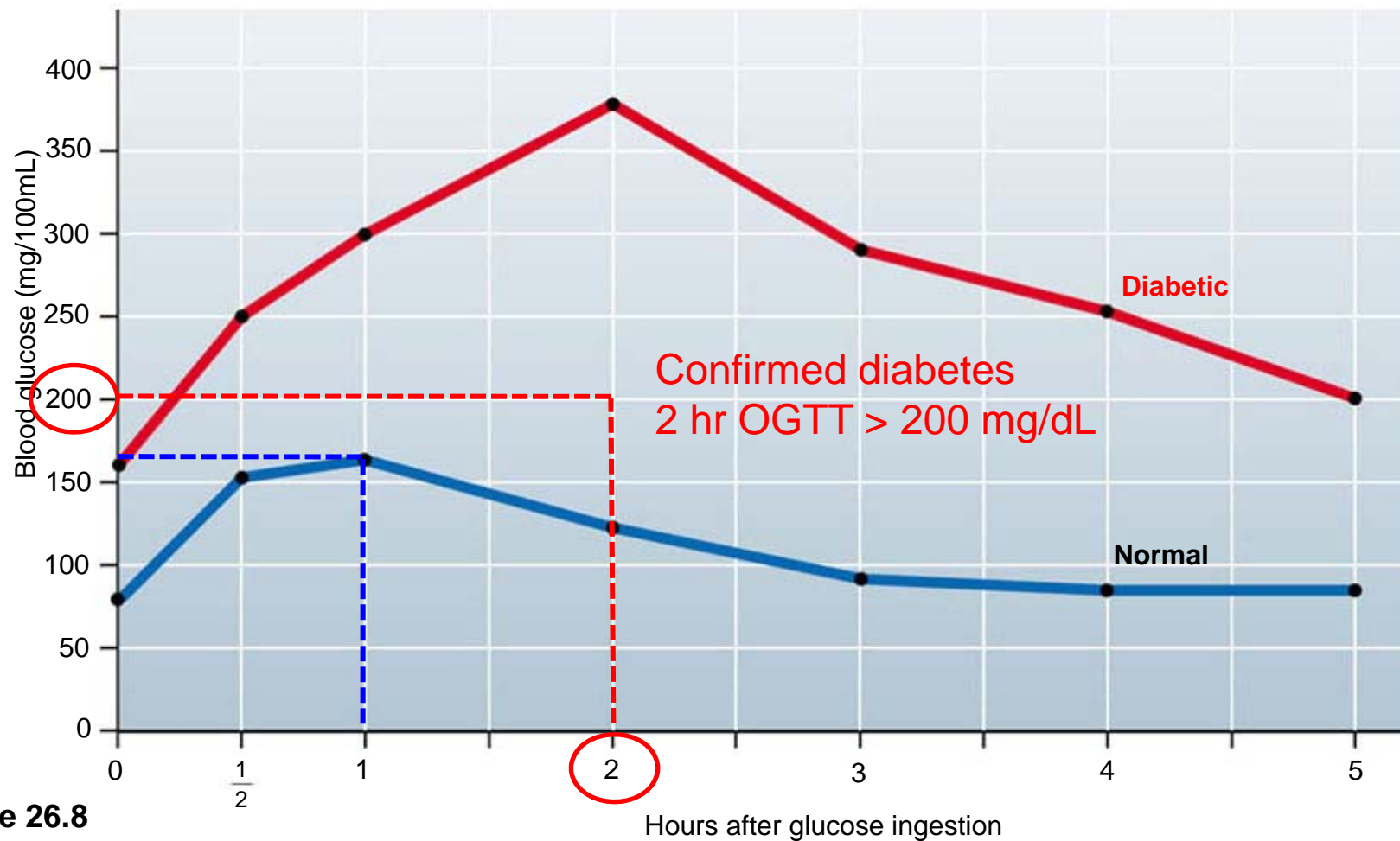


Figure 26.8

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## 26.9 The **adrenal glands** mobilize responses to **stress**

- Hormones from the adrenal glands
  - Help maintain homeostasis when the body is **stressed**
- Adrenal glands can be stimulated via
  - (1) **Nerve signals**
    - from hypothalamus
  - (2) **ACTH** (adrenocorticotropic hormone)
    - from pituitary gland      促腎上腺皮質激素

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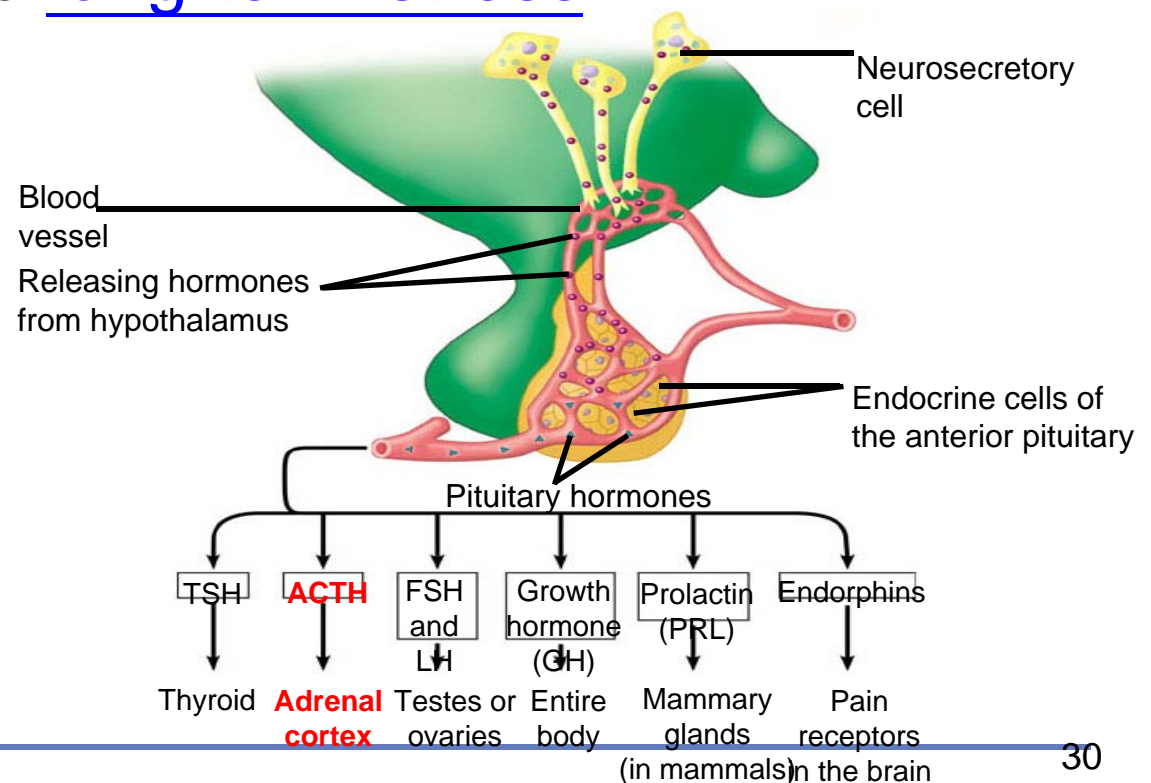
## (1) Nerve signals from the **hypothalamus**

- Stimulate the **adrenal medulla** to secrete
  - **epinephrine** and **norepinephrine**,
- which quickly trigger the **fight-or-flight responses**



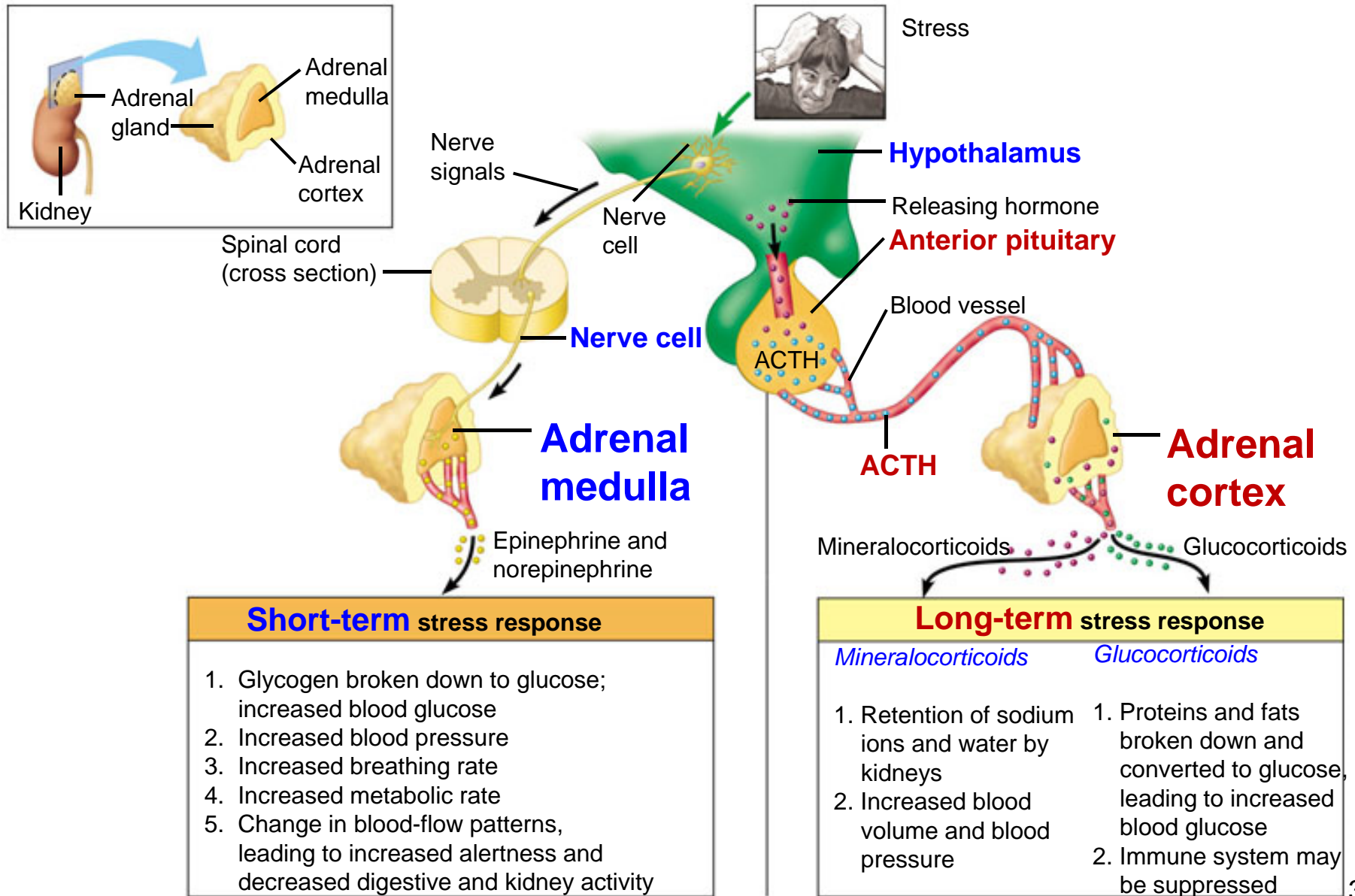
(2) ACTH from the **pituitary** causes the **adrenal cortex** to secrete **glucocorticoids** and **mineralocorticoids**

- Which boost blood pressure and energy in response to **long-term stress**



# • How the adrenal glands control our responses to stress?

Figure 26.9



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**Adrenal  
medulla**

**Short-term stress response**

by *Epinephrine* and *Norepinephrine*

1. Glycogen broken down to glucose; increased blood glucose
2. Increased blood pressure
3. Increased breathing rate
4. Increased metabolic rate
5. Change in blood-flow patterns, leading to increased alertness and decreased digestive and kidney activity

**Adrenal  
cortex**

**Long-term stress response**

***Mineralocorticoids***

1. Retention of sodium ions and water by kidneys
2. Increased blood volume and blood pressure

***Glucocorticoids***

1. Proteins and fats broken down and converted to glucose, leading to increased blood glucose
2. Immune system may be suppressed



# CONNECTION

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26.10 **Glucocorticoids** offer relief from pain, but not without serious risks

- Glucocorticoids relieve **inflammation** and **pain**
  - But they can mask injury and suppress immunity



Figure 26.10

**Bill Walton,**  
Boston Celtics  
Hall-of-Famers (1992-93)

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## 26.11 The gonads secrete sex hormones

- Estrogens, progestins, and androgens are steroid sex hormones
  - Produced by the gonads in response to signals from the hypothalamus and pituitary

Gonads (性腺) = Testes + Ovaries






Progestin (黃體脂酮), 可分為天然與合成兩大類。其中，由卵巢分泌的為Progesterone (黃體激素)。

- 
- Estrogens and progestins
    - Stimulate the development of female characteristics and maintain the female reproductive system
  - Androgens, such as testosterone
    - Trigger the development of male characteristics

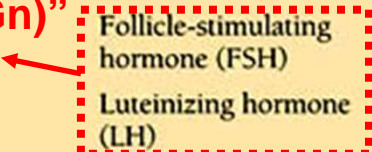


# Table 26.3 Major Human Endocrine Glands & Hormones

**Table 45.1 Major Human Endocrine Glands and Some of Their Hormones**

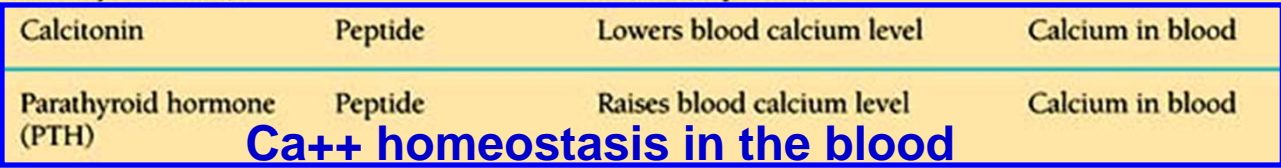
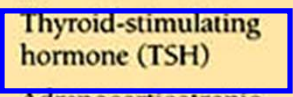
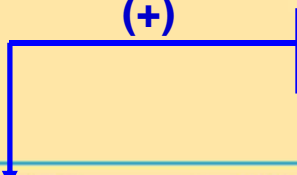
Gland	Hormone	Chemical Class	Representative Actions	Regulated By	
Hypothalamus		Hormones released from the posterior pituitary and hormones that regulate the anterior pituitary (see below)			
Pituitary gland Posterior pituitary (releases neuro-hormones made in hypothalamus)  Anterior pituitary		Oxytocin	Peptide	Stimulates contraction of uterus and mammary gland cells	Nervous system
		Antidiuretic hormone (ADH)	Peptide	Promotes retention of water by kidneys	Water/salt balance
		Growth hormone (GH)	Protein	Stimulates growth (especially bones) and metabolic functions	Hypothalamic hormones
		Prolactin (PRL)	Protein	Stimulates milk production and secretion	Hypothalamic hormones
		Follicle-stimulating hormone (FSH)	Glycoprotein	Stimulates production of ova and sperm	Hypothalamic hormones
		Luteinizing hormone (LH)	Glycoprotein	Stimulates ovaries and testes	Hypothalamic hormones
	Thyroid-stimulating hormone (TSH)	Glycoprotein	Stimulates thyroid gland	Thyroxine in blood; hypothalamic hormones	
	Adrenocorticotropic hormone (ACTH)	Peptide	Stimulates adrenal cortex to secrete glucocorticoids	Glucocorticoids; hypothalamic hormones	
Thyroid gland		Triiodothyronine (T <sub>3</sub> ) and thyroxine (T <sub>4</sub> )	Amine	Stimulate and maintain metabolic processes	TSH
		Calcitonin	Peptide	Lowers blood calcium level	Calcium in blood
Parathyroid glands		Parathyroid hormone (PTH)	Peptide	Raises blood calcium level	Calcium in blood






“Gonadotropins (Gn)”



GnRH

(+)



Gland	Hormone	Chemical Class	Representative Actions	Regulated By
Pancreas 	Insulin	Protein	Lowers blood glucose level	Glucose in blood
	Glucagon	Protein	Raises blood glucose level	Glucose in blood
Adrenal glands				
Adrenal medulla 	Epinephrine and norepinephrine	Amine	Raise blood glucose level; increase metabolic activities; constrict certain blood vessels	Nervous system
Adrenal cortex	Glucocorticoids	Steroid	Raise blood glucose level	ACTH
	Mineralocorticoids	Steroid	Promote reabsorption of Na and excretion of K in kidneys	K in blood
<b>(Steroids)</b>				
Gonads				
Testes 	Androgens	Steroid	Support sperm formation; promote development and maintenance of male secondary sex characteristics	FSH and LH
Ovaries 	Estrogens	Steroid	Stimulate uterine lining growth; promote development and maintenance of female secondary sex characteristics	FSH and LH
	Progesterone	Steroid	Promotes uterine lining growth	FSH and LH
Pineal gland 	Melatonin	Amine	Involved in biological rhythms	Light/dark cycles

# Summary

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- The thyroid regulates development and metabolism.
- Hormones from the thyroid and parathyroids maintain calcium homeostasis.
- The mammalian responses to stress is mainly regulated by the adrenal glands.
- Glucocorticoids can help offer relief from pain.
- The mammalian sex hormones are mainly secreted by the gonads of both males and females.

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# End of Chapter

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