LECTURE PRESENTATIONS
For CAMPBELL BIOLOGY, NINTH EDITION
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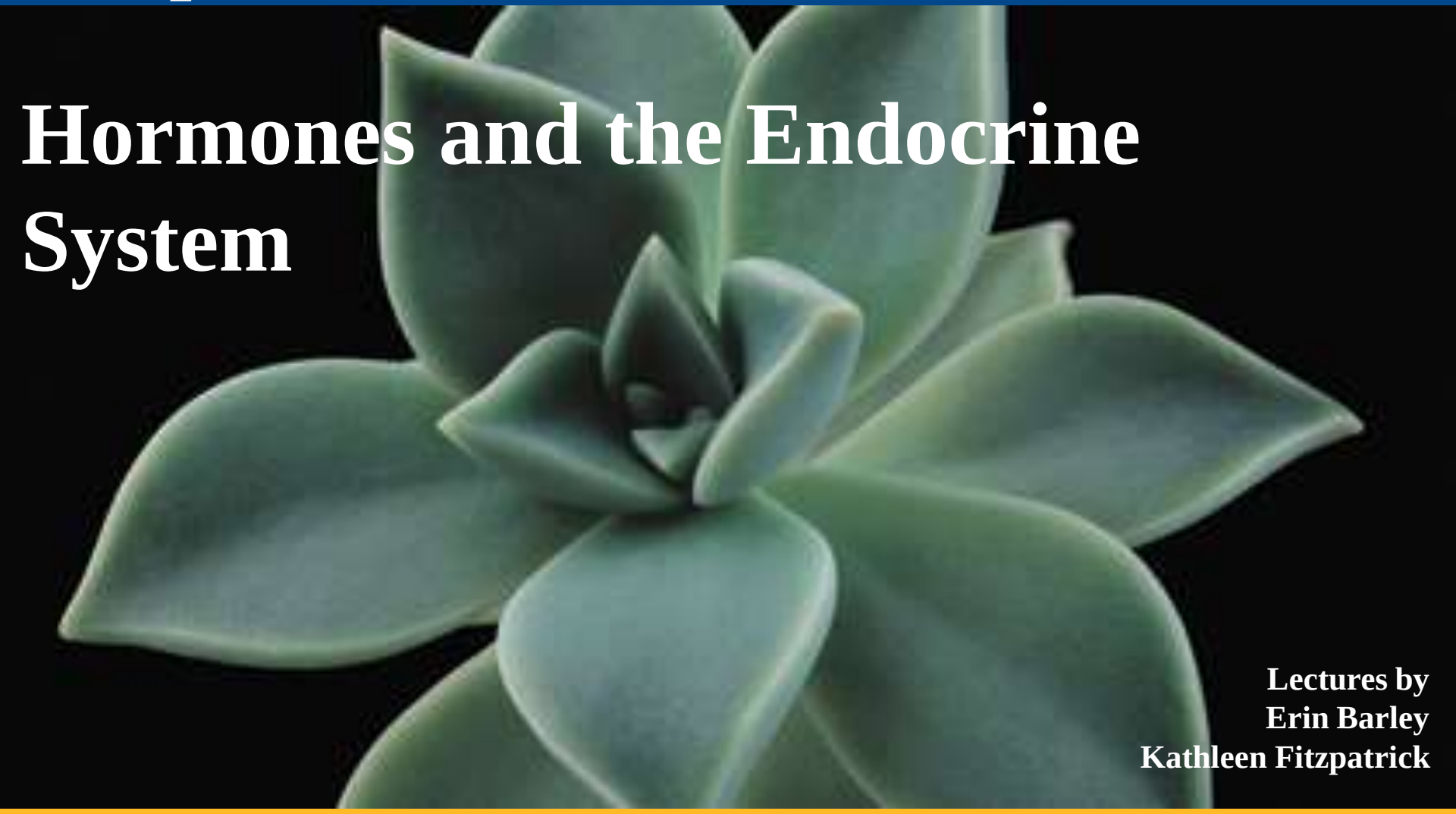
Chapter 45

Hormones and the Endocrine System



Lectures by
Erin Barley
Kathleen Fitzpatrick

Overview: The Body's Long-Distance Regulators

- Animal **hormones** are **chemical signals that are secreted into the circulatory system** and communicate regulatory messages within the body
- Hormones reach all parts of the body, but only target cells have receptors for that hormone
- Insect metamorphosis is regulated by hormones

- Two systems coordinate communication throughout the body: **the endocrine system and the nervous system**
- The **endocrine system** secretes hormones that coordinate slower but longer-acting responses including reproduction, development, energy metabolism, growth, and behavior
- The **nervous system** conveys high-speed electrical signals along specialized cells called neurons; these signals regulate other cells

Concept 45.1: Hormones and other signaling molecules bind to target receptors, triggering specific response pathways

- Endocrine signaling is just one of several ways that information is transmitted between animal cells

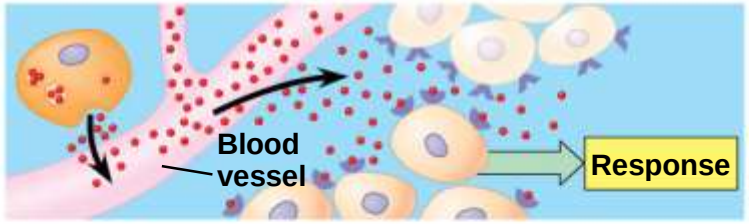
Intercellular Communication

- **The ways that signals are transmitted between animal cells are classified by two criteria**
  - **The type of secreting cell**
  - **The route taken by the signal in reaching its target**

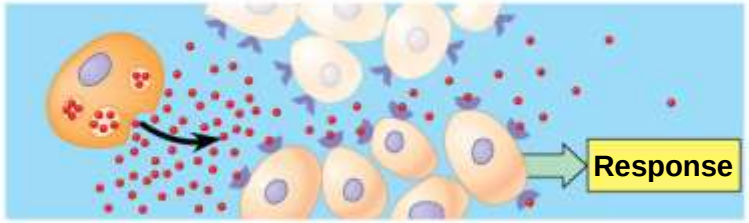
Endocrine Signaling

- Hormones secreted into extracellular fluids by endocrine cells reach their targets via the bloodstream
- Endocrine signaling maintains homeostasis, mediates responses to stimuli, regulates growth and development

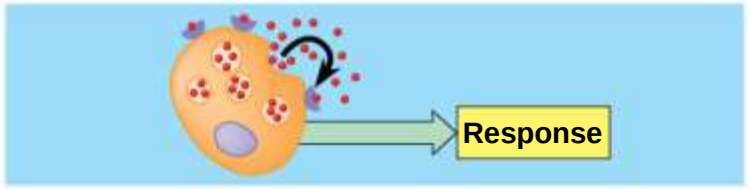
Figure 45.2



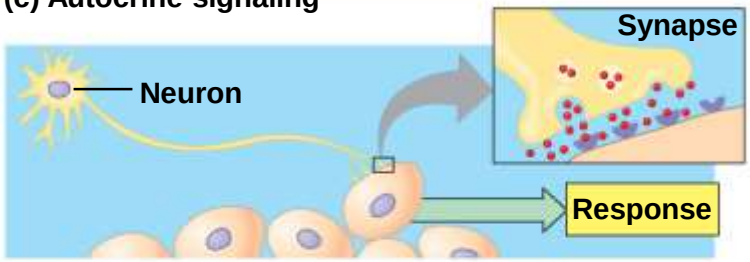
(a) Endocrine signaling



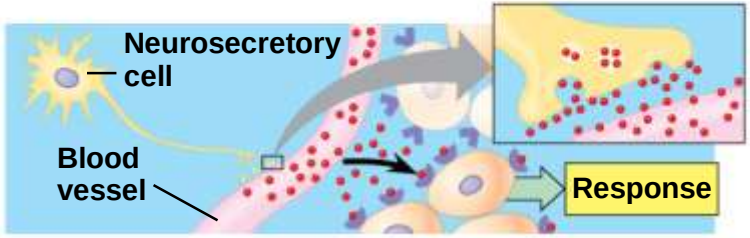
(b) Paracrine signaling



(c) Autocrine signaling



(d) Synaptic signaling



(e) Neuroendocrine signaling

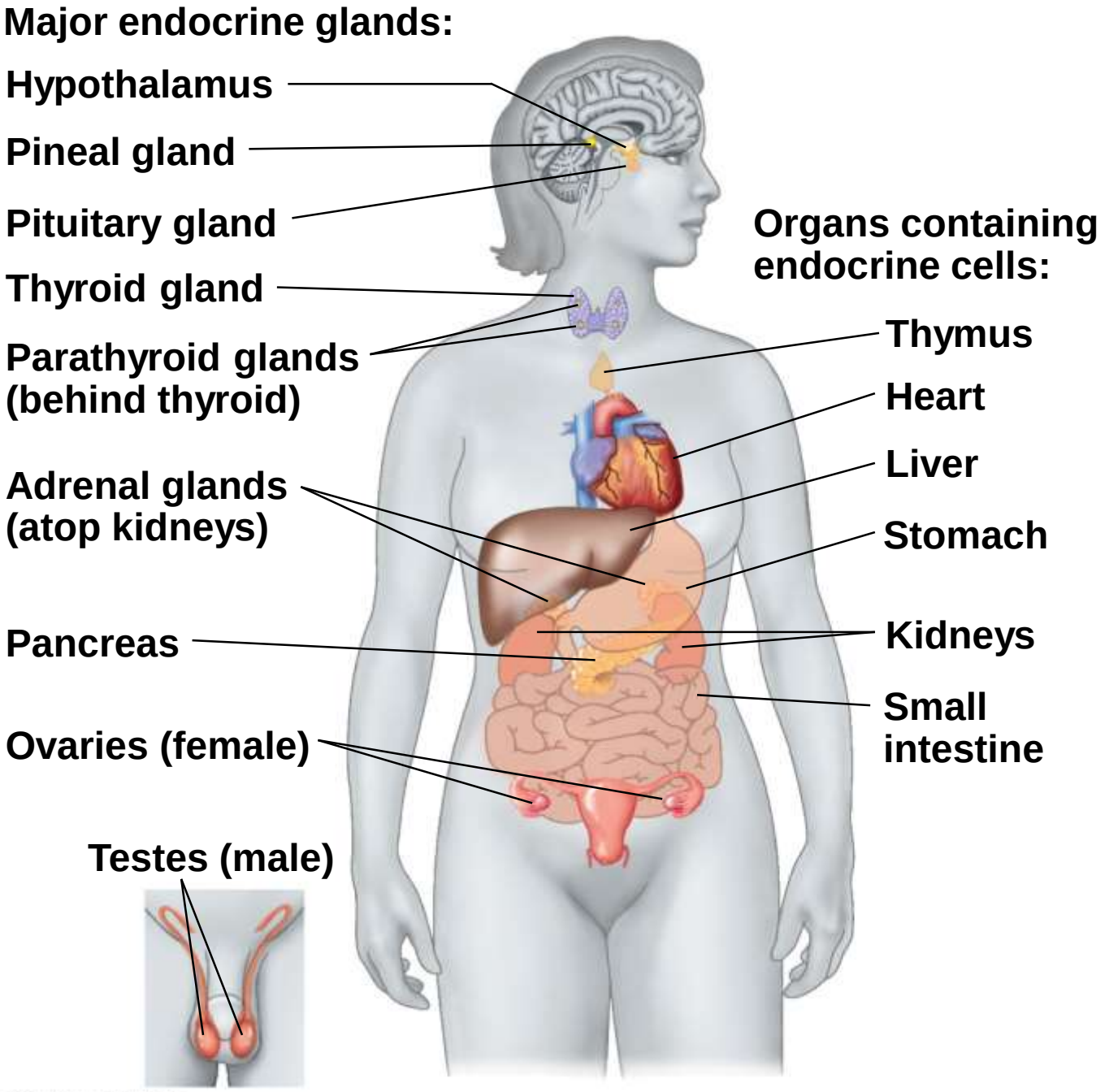
Signaling by Pheromones

- Members of the same animal species sometimes communicate with **pheromones**, chemicals that are released into the environment
- Pheromones serve many functions, including marking trails leading to food, defining territories, warning of predators, and attracting potential mates

Endocrine Tissues and Organs

- In some tissues, endocrine cells are grouped together in ductless organs called **endocrine glands**
- **Endocrine glands secrete hormones directly into surrounding fluid**
- These contrast with exocrine glands, which have ducts and which secrete substances onto body surfaces or into cavities

Figure 45.4



Chemical Classes of Hormones

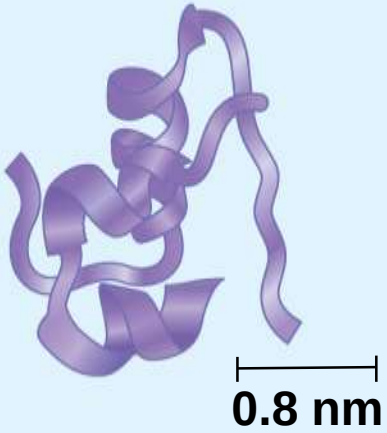
- Three major classes of molecules function as hormones in vertebrates
  - Polypeptides (proteins and peptides)
  - Amines derived from amino acids
  - Steroid hormones

- **Lipid-soluble** hormones (steroid hormones) pass easily through cell membranes, while water-soluble hormones (polypeptides and amines) do not
- **The solubility of a hormone correlates with the location of receptors inside or on the surface of target cells**

Figure 45.5

Water-soluble (hydrophilic)

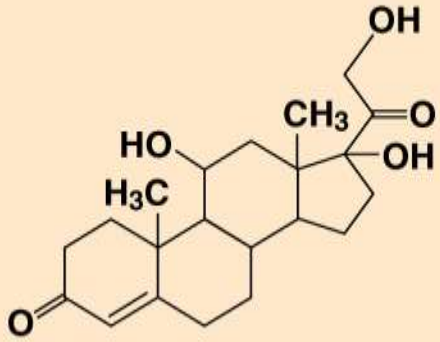
Polypeptides



Insulin

Lipid-soluble (hydrophobic)

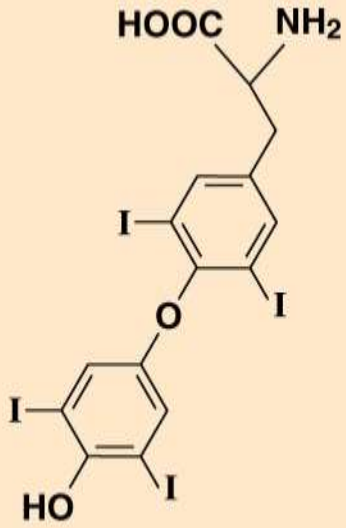
Steroids



Cortisol

Amines

Epinephrine



Thyroxine

Cellular Response Pathways

- Water- and lipid-soluble hormones differ in their paths through a body
- **Water-soluble** hormones **are secreted by exocytosis, travel freely in the bloodstream, and bind to cell-surface receptors**
- Lipid-soluble hormones diffuse across cell membranes, travel in the bloodstream bound to transport proteins, and diffuse through the membrane of target cells

Figure 45.6-2

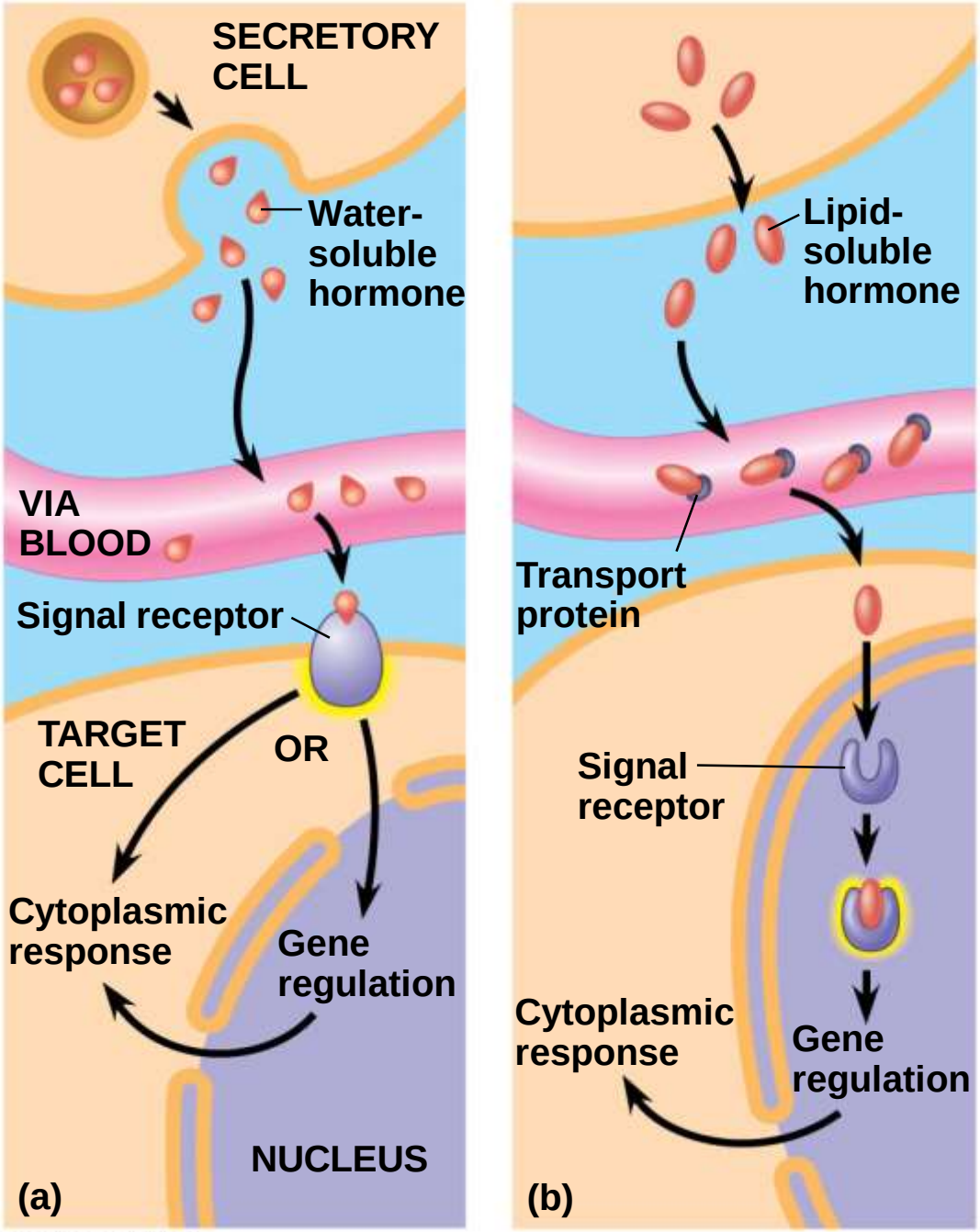


Figure 45.7-2

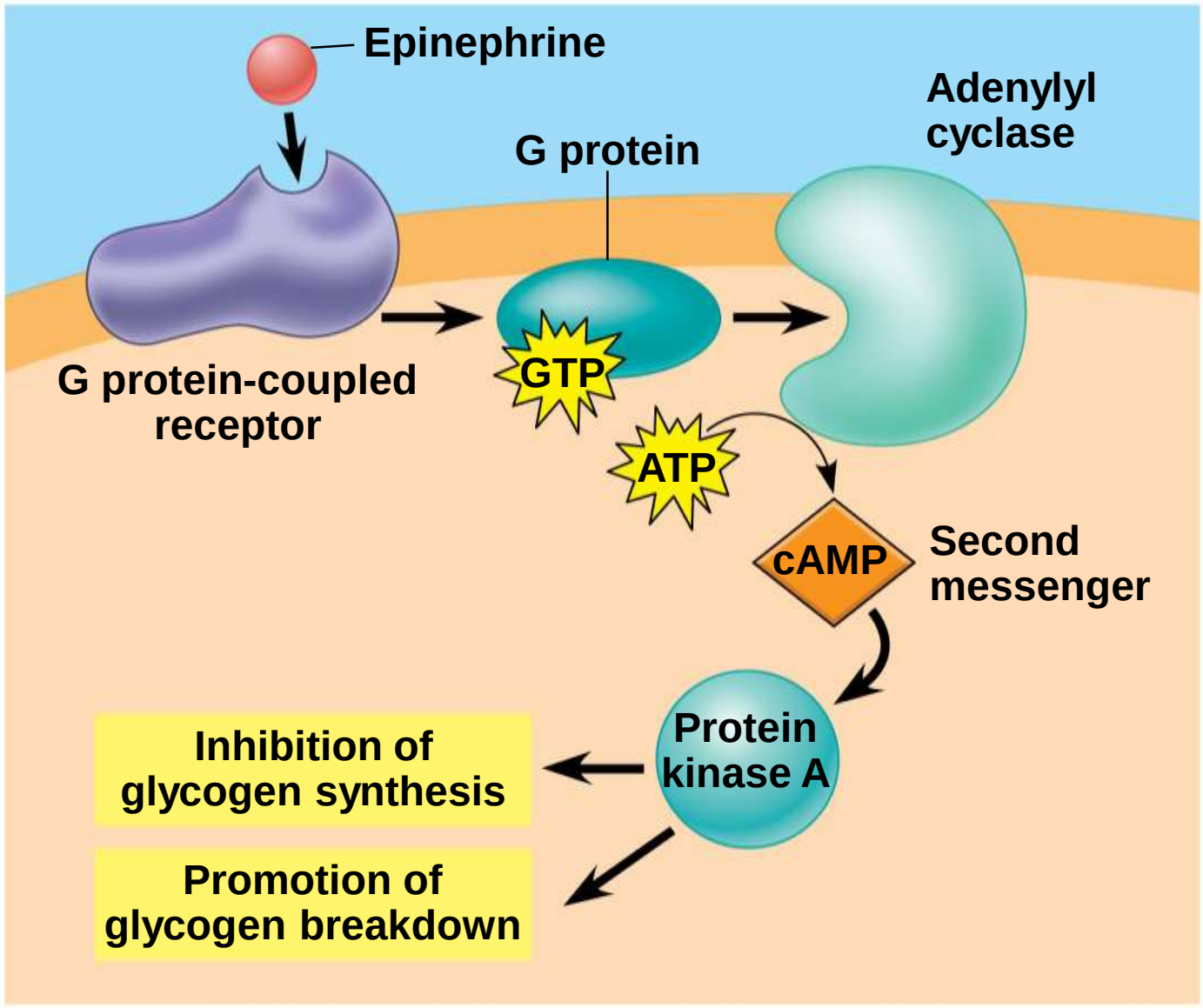
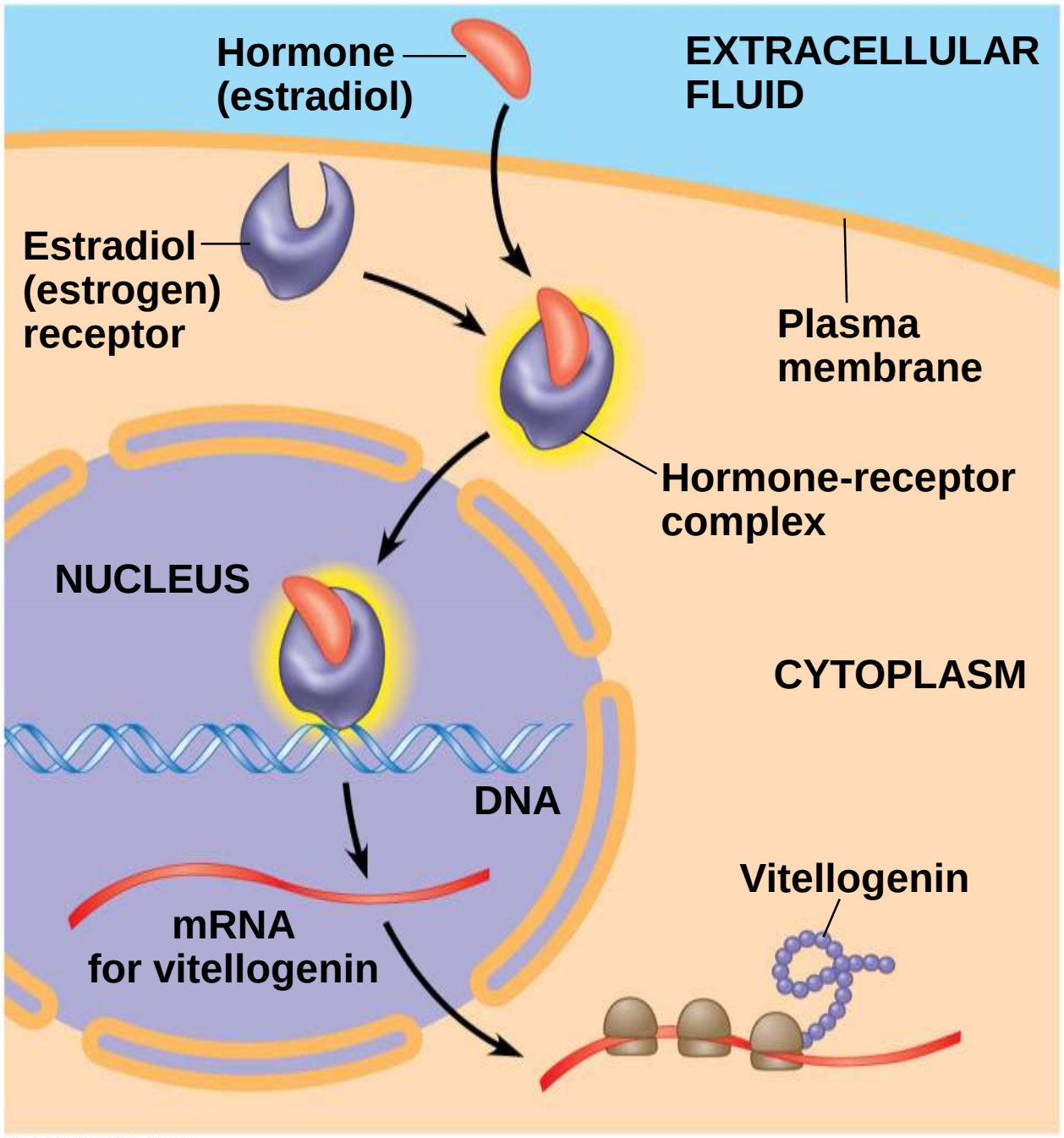


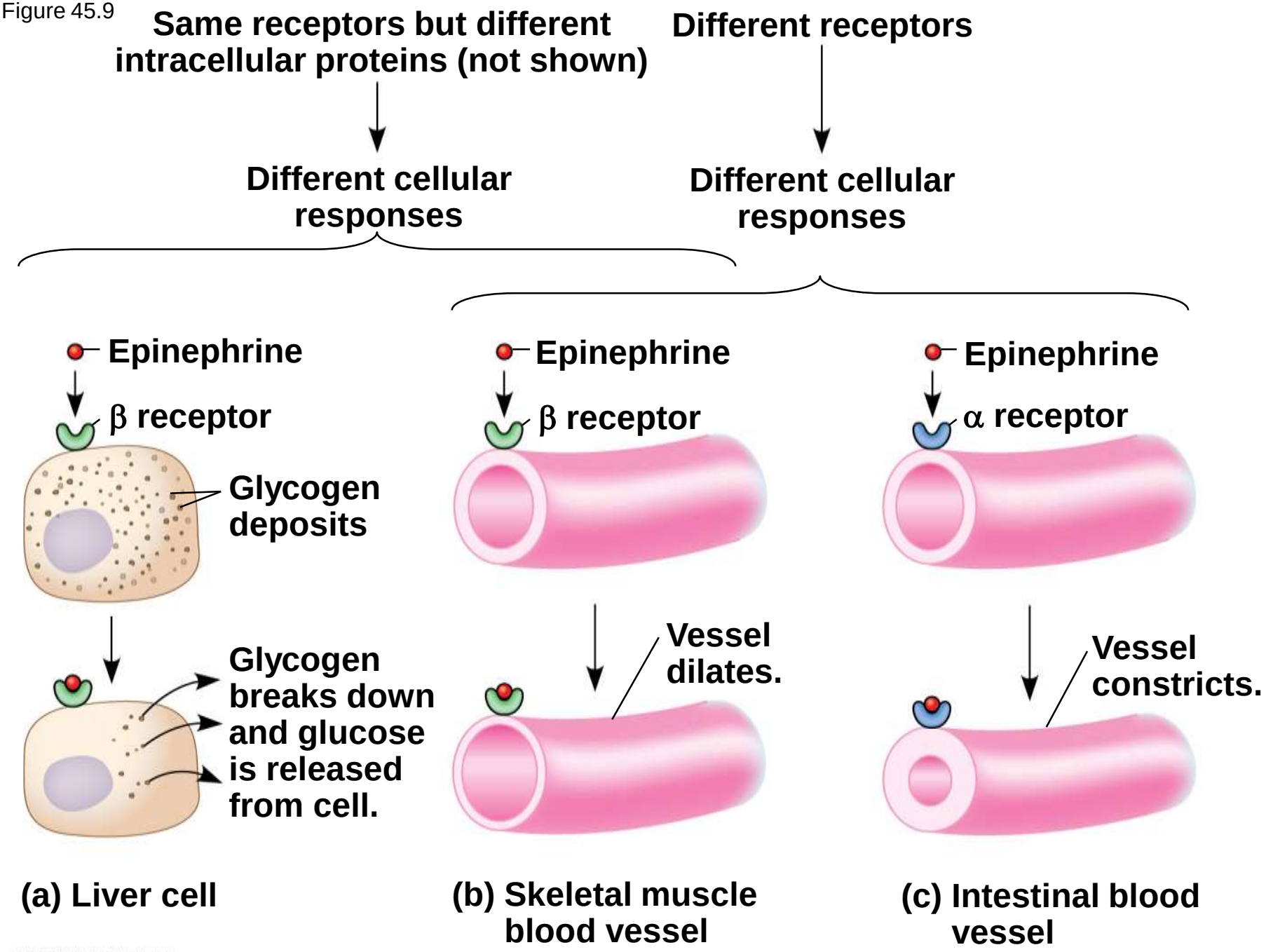
Figure 45.8-2



Multiple Effects of Hormones

- The same hormone may have different effects on target cells that have
  - Different receptors for the hormone
  - Different signal transduction pathways

Figure 45.9



Concept 45.2: Feedback regulation and antagonistic hormone pairs are common in endocrine systems

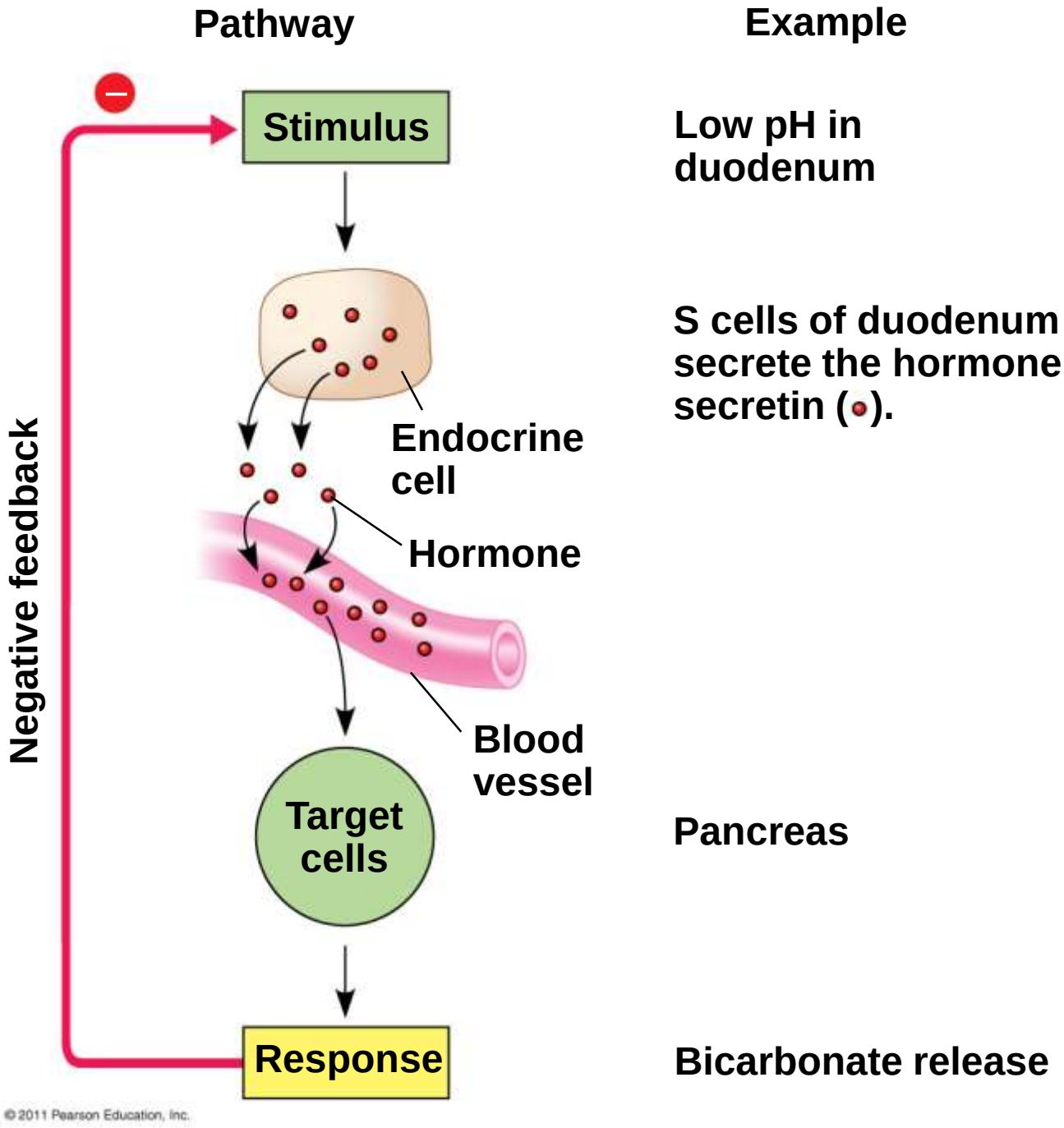
- Hormones are assembled into regulatory pathways

Simple Hormone Pathways

- Hormones are released from an endocrine cell, travel through the bloodstream, and interact with specific receptors within a target cell to cause a physiological response

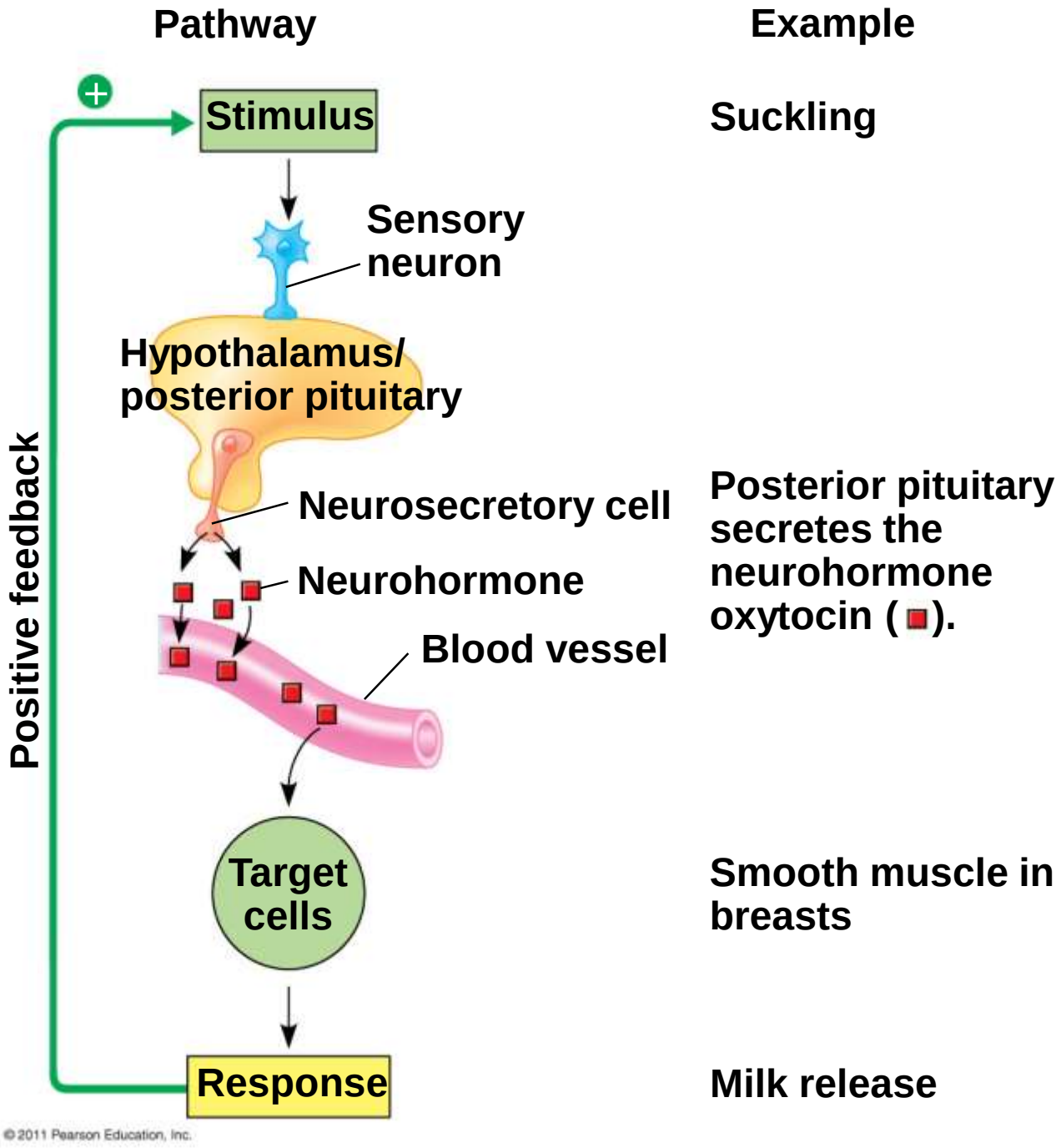
- For example, the release of acidic contents of the stomach into the duodenum stimulates endocrine cells there to secrete secretin
- This causes target cells in the **pancreas**, a gland behind the stomach, to raise the pH in the duodenum

Figure 45.11



- In a simple neuroendocrine pathway, the stimulus is received by a sensory neuron, which stimulates a neurosecretory cell
- The neurosecretory cell secretes a neurohormone, which enters the bloodstream and travels to target cells

Figure 45.12



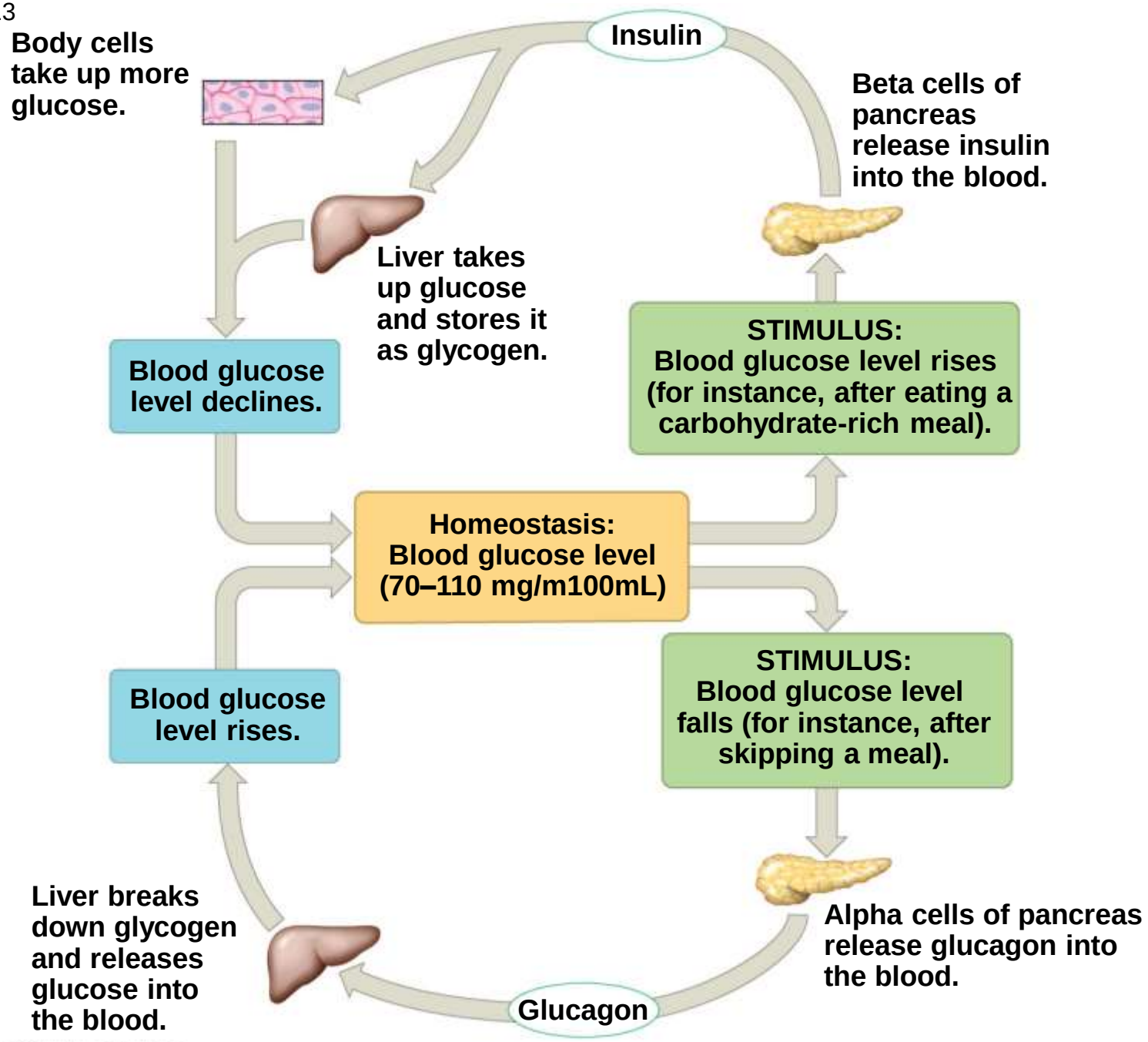
Feedback Regulation

- A **negative feedback** loop inhibits a response by reducing the initial stimulus, thus preventing excessive pathway activity
- **Positive feedback** reinforces a stimulus to produce an even greater response
- For example, in mammals oxytocin causes the release of milk, causing greater suckling by offspring, which stimulates the release of more oxytocin

Insulin and Glucagon: Control of Blood Glucose

- **Insulin** (decreases blood glucose) and **glucagon** (increases blood glucose) are antagonistic hormones that help maintain glucose homeostasis
- The pancreas has clusters of endocrine cells called pancreatic islets with alpha cells that produce glucagon and beta cells that produce insulin

Figure 45.13



Target Tissues for Insulin and Glucagon

- Insulin reduces blood glucose levels by
  - Promoting the cellular uptake of glucose
  - Slowing glycogen breakdown in the liver
  - Promoting fat storage, not breakdown

- Glucagon increases blood glucose levels by
  - Stimulating conversion of glycogen to glucose in the liver
  - Stimulating breakdown of fat and protein into glucose

Diabetes Mellitus

- **Diabetes mellitus** is perhaps the best-known endocrine disorder
- It is caused by a deficiency of insulin or a decreased response to insulin in target tissues
- It is marked by elevated blood glucose levels

- *Type 1 diabetes mellitus* (insulin-dependent) is an autoimmune disorder in which the immune system destroys pancreatic beta cells
- *Type 2 diabetes mellitus* (non-insulin-dependent) involves insulin deficiency or reduced response of target cells due to change in insulin receptors

Concept 45.3: The hypothalamus and pituitary are central to endocrine regulation

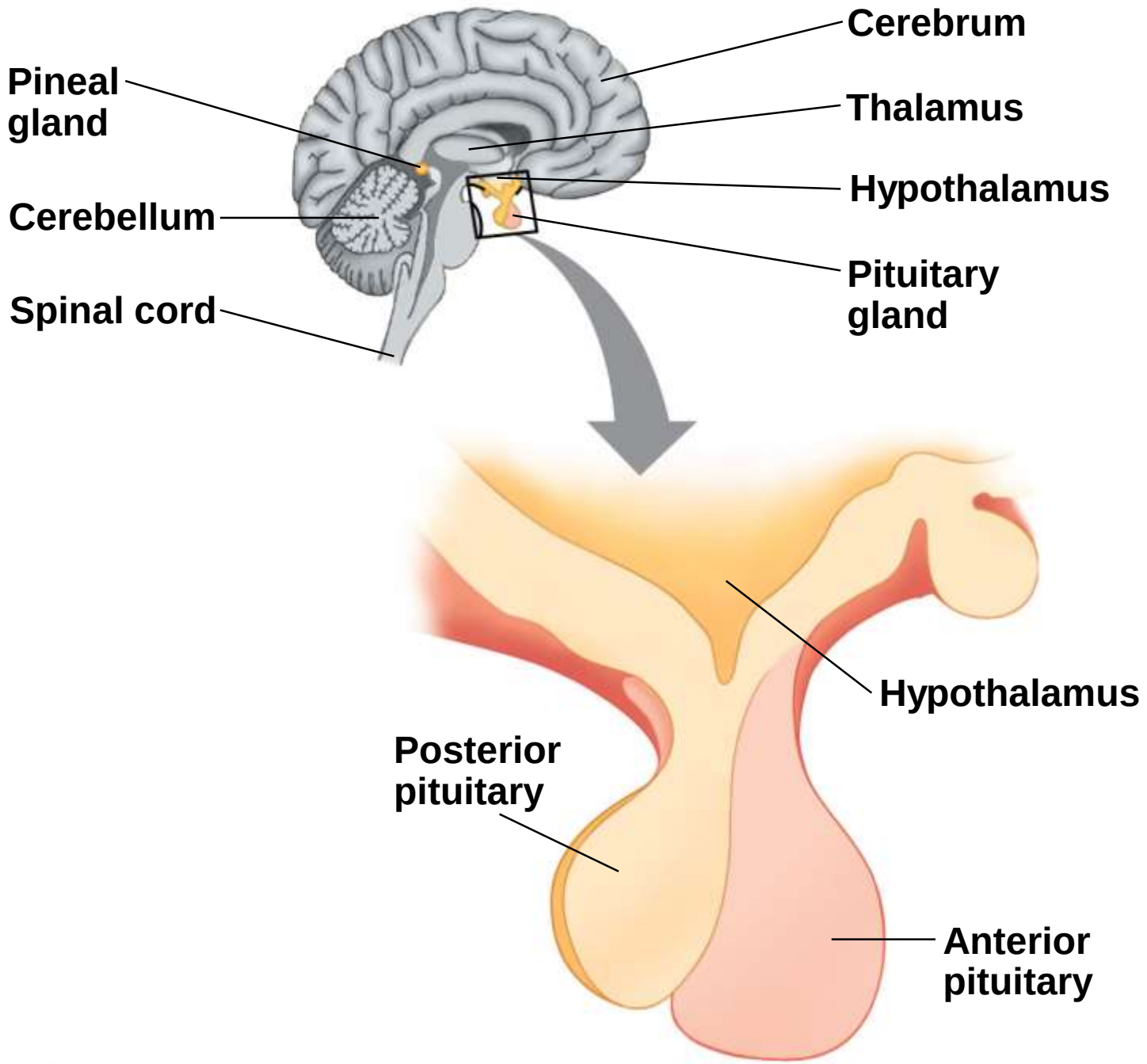
- Endocrine pathways are subject to regulation by the nervous system, including the brain

Coordination of Endocrine and Nervous Systems in Vertebrates

- The **hypothalamus** receives information from the nervous system and initiates responses through the endocrine system
- Attached to the hypothalamus is the **pituitary gland,** composed of the posterior pituitary and anterior pituitary

- The **posterior pituitary** stores and secretes hormones that are made in the hypothalamus
- The **anterior pituitary** makes and releases hormones under regulation of the hypothalamus

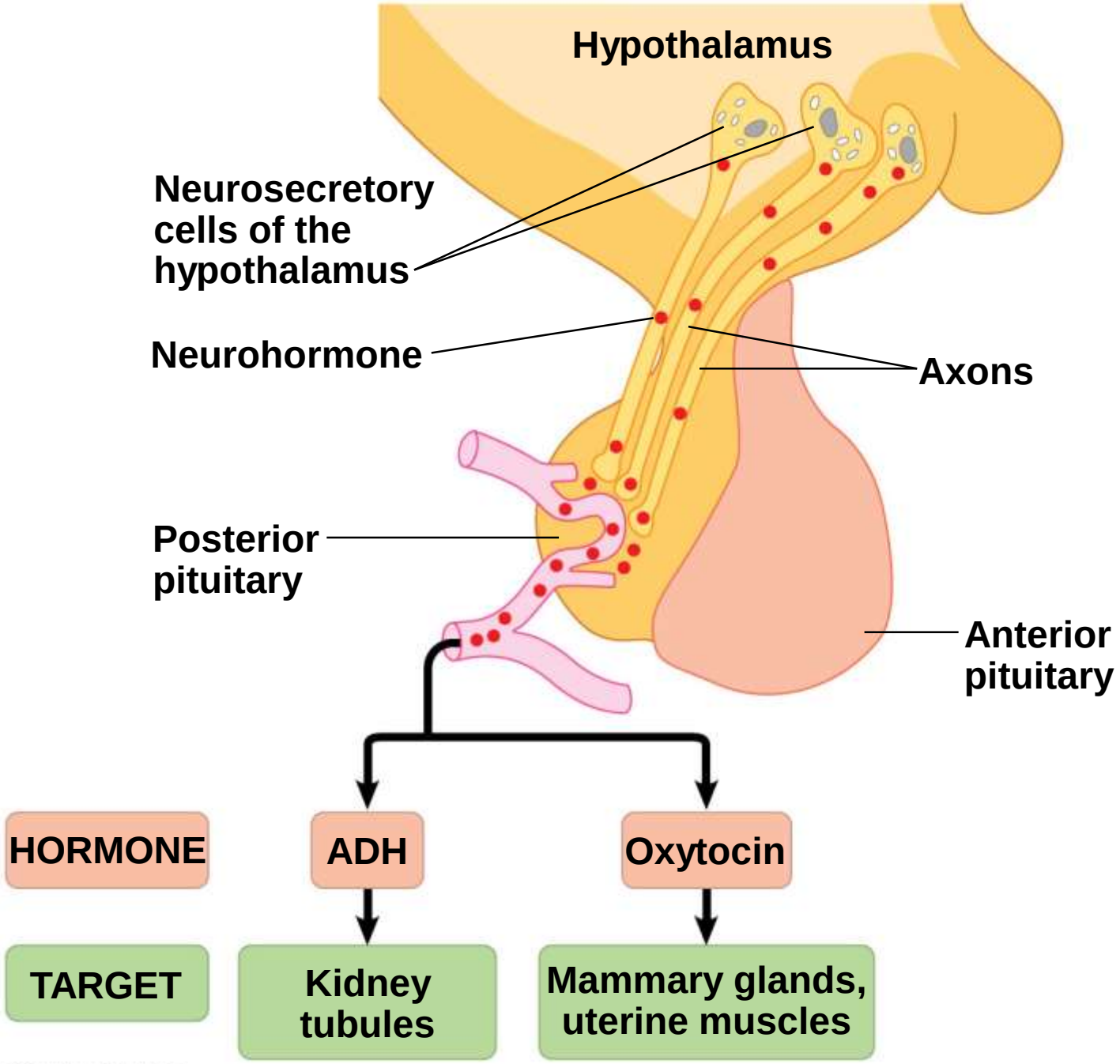
Figure 45.14



Posterior Pituitary Hormones

- The two hormones released from the posterior pituitary act directly on nonendocrine tissues
  - Oxytocin regulates milk secretion by the mammary glands
  - **Antidiuretic hormone (ADH)** regulates physiology and behavior

Figure 45.15



Anterior Pituitary Hormones

- Hormone production in the anterior pituitary is controlled by releasing and inhibiting hormones from the hypothalamus
- For example, prolactin-releasing hormone from the hypothalamus stimulates the anterior pituitary to secrete **prolactin** (**PRL**), which has a role in milk production

Figure 45.16

Tropic effects only:
FSH
LH
TSH
ACTH

Nontropic effects only:
Prolactin
MSH

Nontropic and tropic effects:
GH

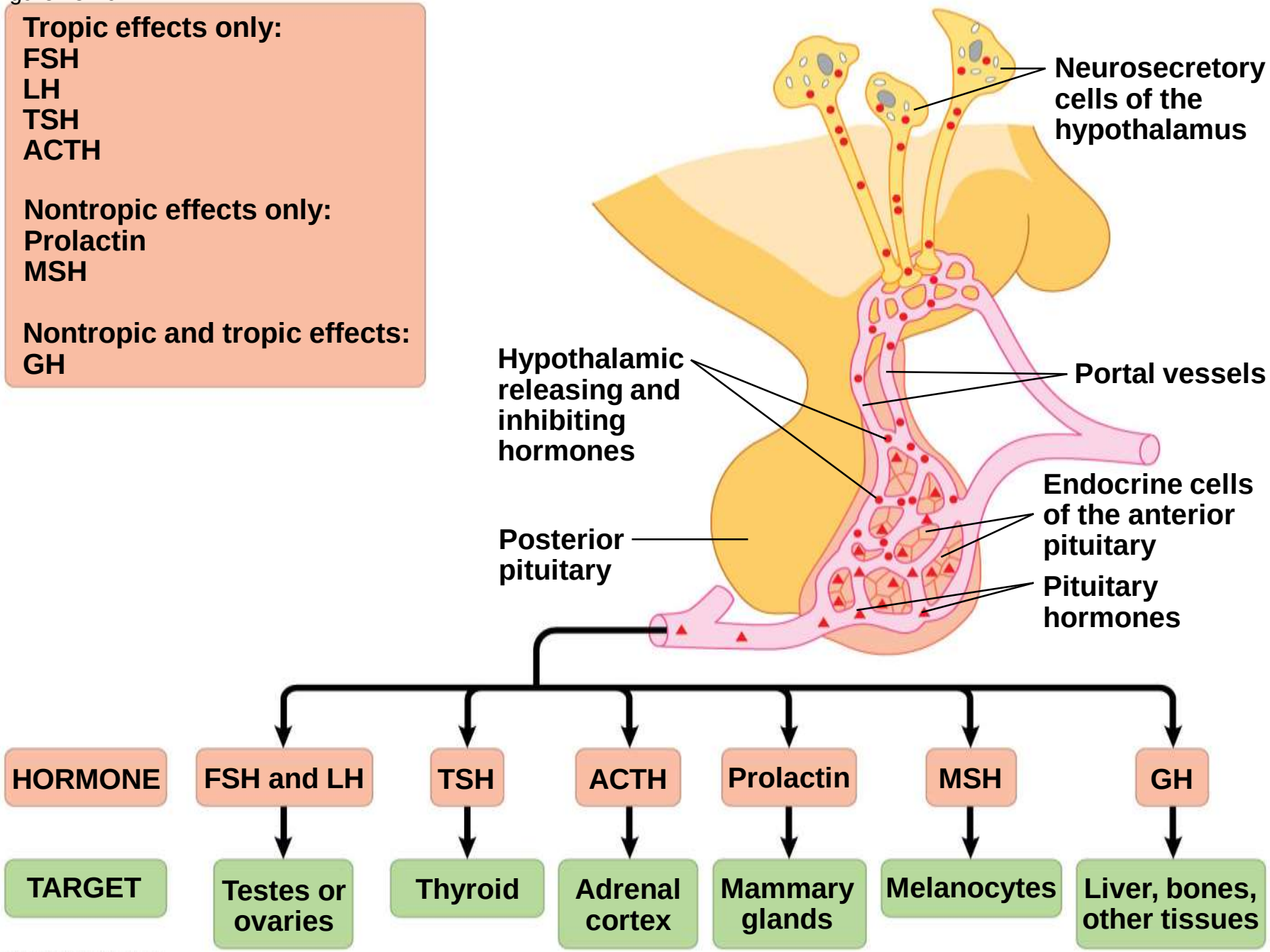


Table 45.1

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)			
Posterior pituitary gland (releases neurohormones made in hypothalamus) 	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
Anterior pituitary gland 	Growth hormone (GH)	Protein	Stimulates growth (especially bones) and metabolic functions	Hypothalamic hormones
	Prolactin	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	Hypothalamic hormones
	Adrenocorticotropic hormone (ACTH)	Peptide	Stimulates adrenal cortex to secrete glucocorticoids	Hypothalamic hormones
Thyroid gland 	Triiodothyronine (T_3) and thyroxine (T_4)	Amines	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
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	Amines	Raise blood glucose level; increase metabolic activities; constrict certain blood vessels	Nervous system
Adrenal cortex	Glucocorticoids	Steroids	Raise blood glucose level	ACTH
	Mineralocorticoids	Steroids	Promote reabsorption of Na^+ and excretion of K^+ in kidneys	K^+ in blood; angiotensin II
Gonads				
Testes 	Androgens	Steroids	Support sperm formation; promote development and maintenance of male secondary sex characteristics	FSH and LH
Ovaries 	Estrogens	Steroids	Stimulate uterine lining growth; promote development and maintenance of female secondary sex characteristics	FSH and LH
	Progestins	Steroids	Promote uterine lining growth	FSH and LH
Pineal gland 	Melatonin	Amine	Involved in biological rhythms	Light/dark cycles

Table 45.1a

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)			
Posterior pituitary gland (releases neurohormones made in hypothalamus) 	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
Anterior pituitary gland 	Growth hormone (GH)	Protein	Stimulates growth (especially bones) and metabolic functions	Hypothalamic hormones
	Prolactin	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	Hypothalamic hormones
	Adrenocorticotropic hormone (ACTH)	Peptide	Stimulates adrenal cortex to secrete glucocorticoids	Hypothalamic hormones
Thyroid gland 	Triiodothyronine (T_3) and thyroxine (T_4)	Amines	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

Table 45.1b

Table 45.1 Major Human Endocrine Glands and Some of Their Hormones (continued)

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	Amines	Raise blood glucose level; increase metabolic activities; constrict certain blood vessels	Nervous system
Adrenal cortex		Glucocorticoids	Steroids	Raise blood glucose level	ACTH
		Mineralocorticoids	Steroids	Promote reabsorption of Na^+ and excretion of K^+ in kidneys	K^+ in blood; angiotensin II
Gonads					
Testes		Androgens	Steroids	Support sperm formation; promote development and maintenance of male secondary sex characteristics	FSH and LH
Ovaries		Estrogens	Steroids	Stimulate uterine lining growth; promote development and maintenance of female secondary sex characteristics	FSH and LH
		Progestins	Steroids	Promote uterine lining growth	FSH and LH
Pineal gland		Melatonin	Amine	Involved in biological rhythms	Light/dark cycles