Hormonal Response To Exercise

Dr. Mustafa Qamar

Did you know?…

- One reason that kittens sleep so much is because a growth hormone is released only during sleep.
- The levels of two stress hormones, cortisol and epinephrine which suppress the body's immune system, will actually drop after a dose of laughter.
- Chocolate is associated with the release of serotonin, the hormone that makes you feel relaxed, calm, and happy. So are hugs.
- Digit Ratio

What are endocrine systems for?

Endocrine Functions

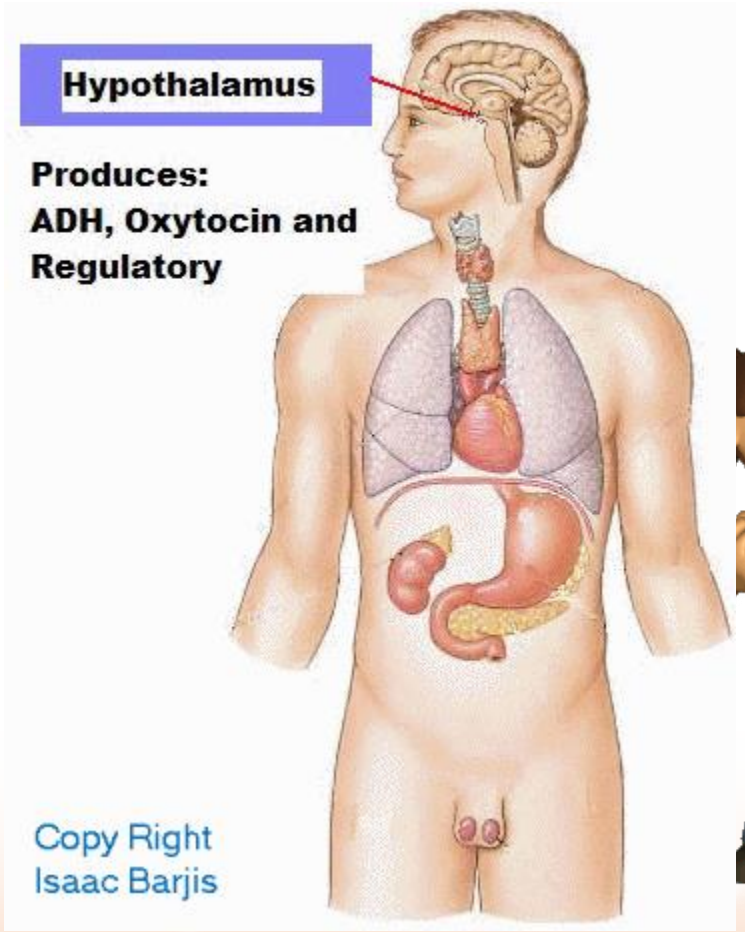
- Maintain Internal Homeostasis
- Support Cell Growth
- Coordinate Development
- Coordinate Reproduction
- Facilitate Responses to External Stimuli

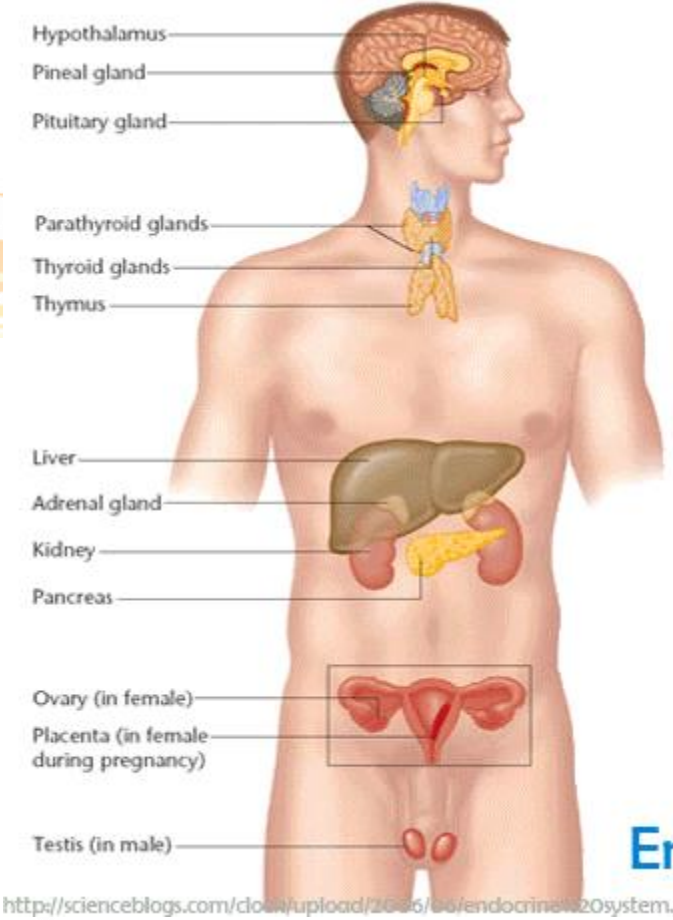
Neuroendocrinology

- Neuroendocrine system
  - Endocrine system releases hormones
  - Nervous system uses neurotransmitters
- Endocrine glands
  - Release hormones directly into the blood
- Hormones
  - Alter the activity of tissues that possess receptors to which the hormone can bind
  - Several classes based on chemical makeup
    - Amino acid derivatives
    - Peptides/protein
    - Steroids

Hormone-Receptor Interactions

- Hormones only affect tissue with specific receptors
- Magnitude of effect dependent on:
  - Concentration of the hormone
  - Number of receptors on the cell
  - Affinity of the receptor for the hormone
- Downregulation
  - Decrease in receptor number in response to high concentration of hormone
- Upregulation
  - Increase in receptor number in response to low concentration of hormone





Endocrine System

http://scienceblogs.com/clock/upload/2006/06/endocrine%20system.jpg

Joseph®
Clinchem3ob

HYPOTHALAMUS

TRH

GnRH

CRH

Factors That Influence the Secretion of Hormones

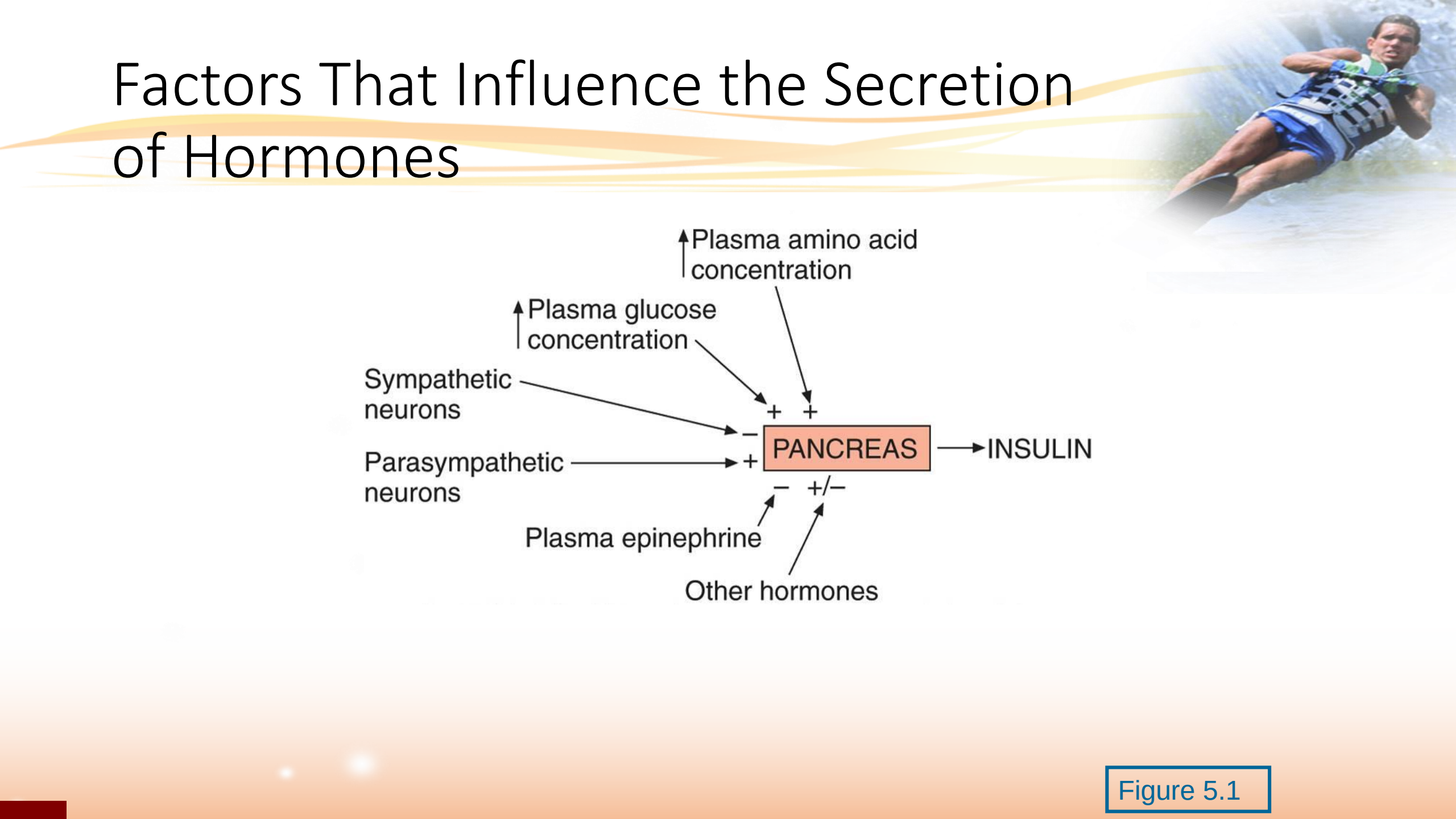
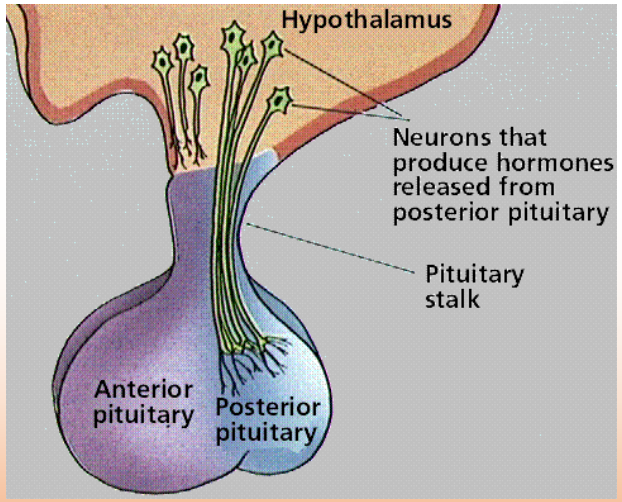


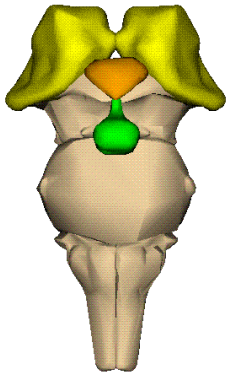
Figure 5.1

Hormones: Regulation and Action

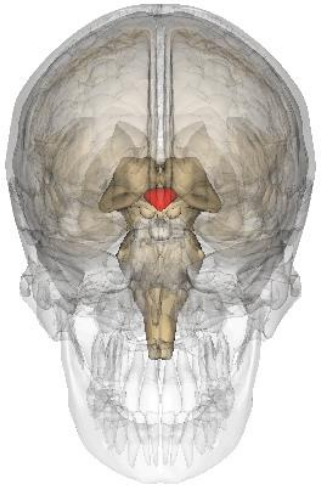
- Hormones are secreted from endocrine glands
  - Hypothalamus and pituitary glands
  - Thyroid and parathyroid glands
  - Adrenal glands
  - Pancreas
  - Testes and ovaries



Hypothalamus and Pituitary Gland



- Hypothalamus
  - Controls secretions from pituitary gland
- Anterior Pituitary Gland
  - Follicle-stimulating hormone (FSH)
  - Luteinizing hormone (LH)
  - Adrenocorticotropic hormone (ACTH)
  - Growth hormone (GH)
  - Melanocyte-stimulating hormone (MSH
  - Thyroid-stimulating hormone (TSH)
  - Prolactin
- Posterior Pituitary Gland
  - Oxytocin
  - Antidiuretic hormone (ADH)



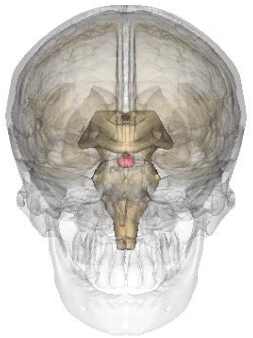
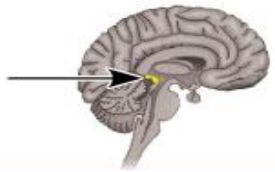


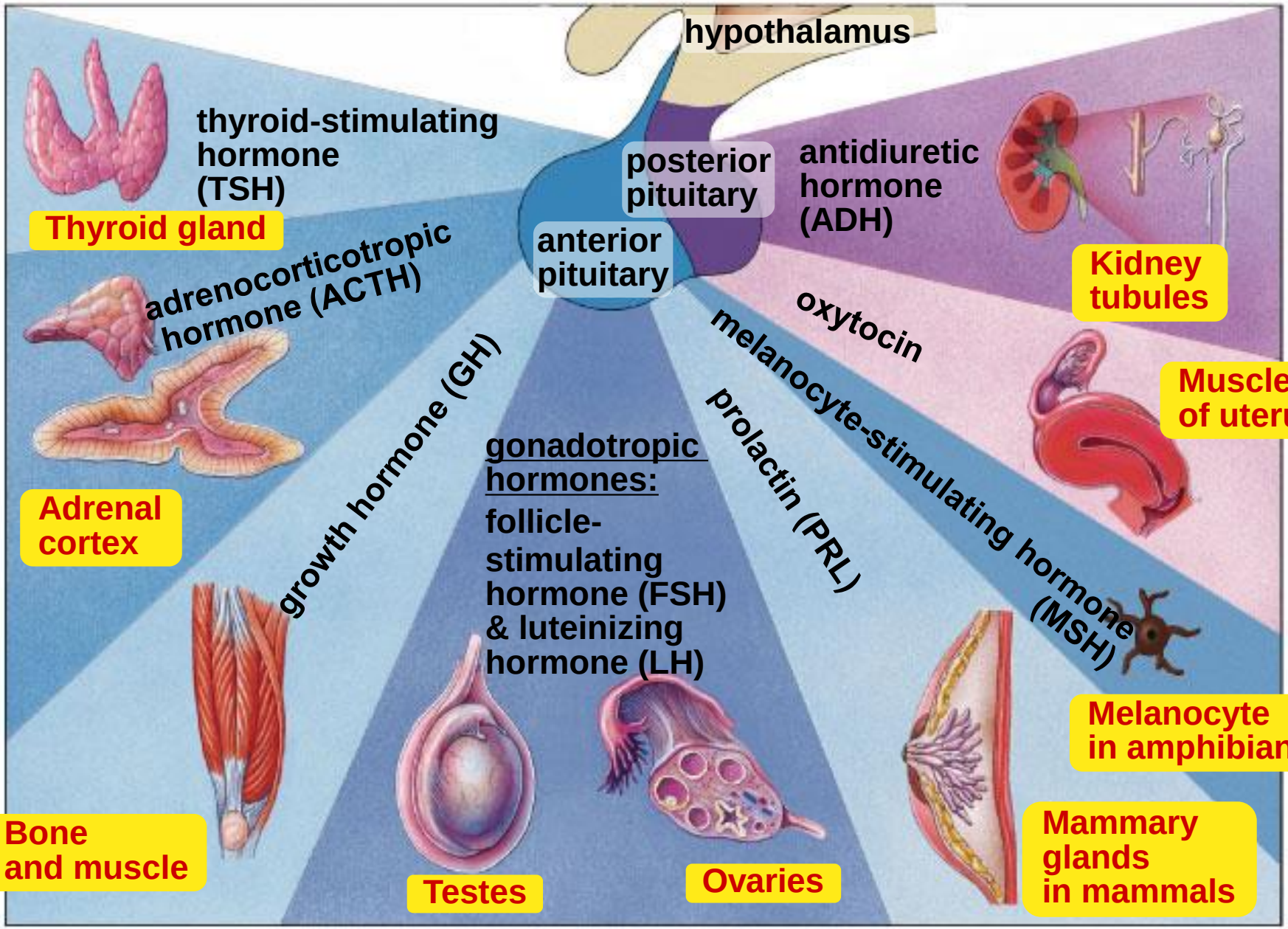
Table 45.1 Major Human Endocrine Glands and Some of Their Hormones

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 45.1 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

Tropic Hormones = Target Endocrine Glands



Growth Hormone

- Secreted from Ant pituitary gland.
- Profound effect on growth of all tissues
- Essential for normal growth.
- GH increases during exercise to

mobilize fatty acids from adipose tissue

- Inadequate secretion lead to Dwarfism
- Administration of GH along with other growth promoting hormone during the growing years.
- Source of GH

Initially Cadavers

✓ Genetic Engineering

Acromegaly

- Excess of GH during Adulthood?

- Does not effect growth in height
- Reason
- Permanent deformities seen thickening of bone e.g in face ,hand,feet
- Athletes taking GH in benefit of Ms growth stimulating effects>>>acromegaly cause besides tumor of Ant pituitary

- Evidence exists showing that GH increases protein synthesis in muscle; however, it is

connective tissue protein (collagen)

that is increased more than contractile protein.

Chronic use of GH may lead to

- ✓Diabetes,
- ✓ Hyperlipidemia,
- ✓Arthritis,
- ✓Cardiomegaly.
- ✓Carpal tunnel compression.
- ✓Muscle disease. And
- ✓Shortened life span

- A recent systematic review of the research on the safety and efficacy of GH on healthy older adults (mean age 69 years) found many more adverse effects than benefits and recommended that GH not be used as an anti-aging therapy

In Summary

- The hypothalamus controls the activity of both the anterior pituitary and posterior pituitary glands.
- GH is released from the anterior pituitary gland and is essential for normal growth.
- GH increases during exercise to mobilize free fatty acids from adipose tissue and to aid in the maintenance of blood glucose.

Posterior Pituitary Gland

- Oxytocin
- Antidiuretic hormone (ADH)
  - Reduces water loss from the body to maintain plasma volume
    - Favors reabsorption of water from kidney tubules to capillaries
  - Release stimulated by high plasma osmolality and low plasma volume
    - Due to sweat loss without water replacement
  - Increases during exercise >60% VO_2 max
    - To maintain plasma volume

Change in Plasma ADH Concentration During Exercise

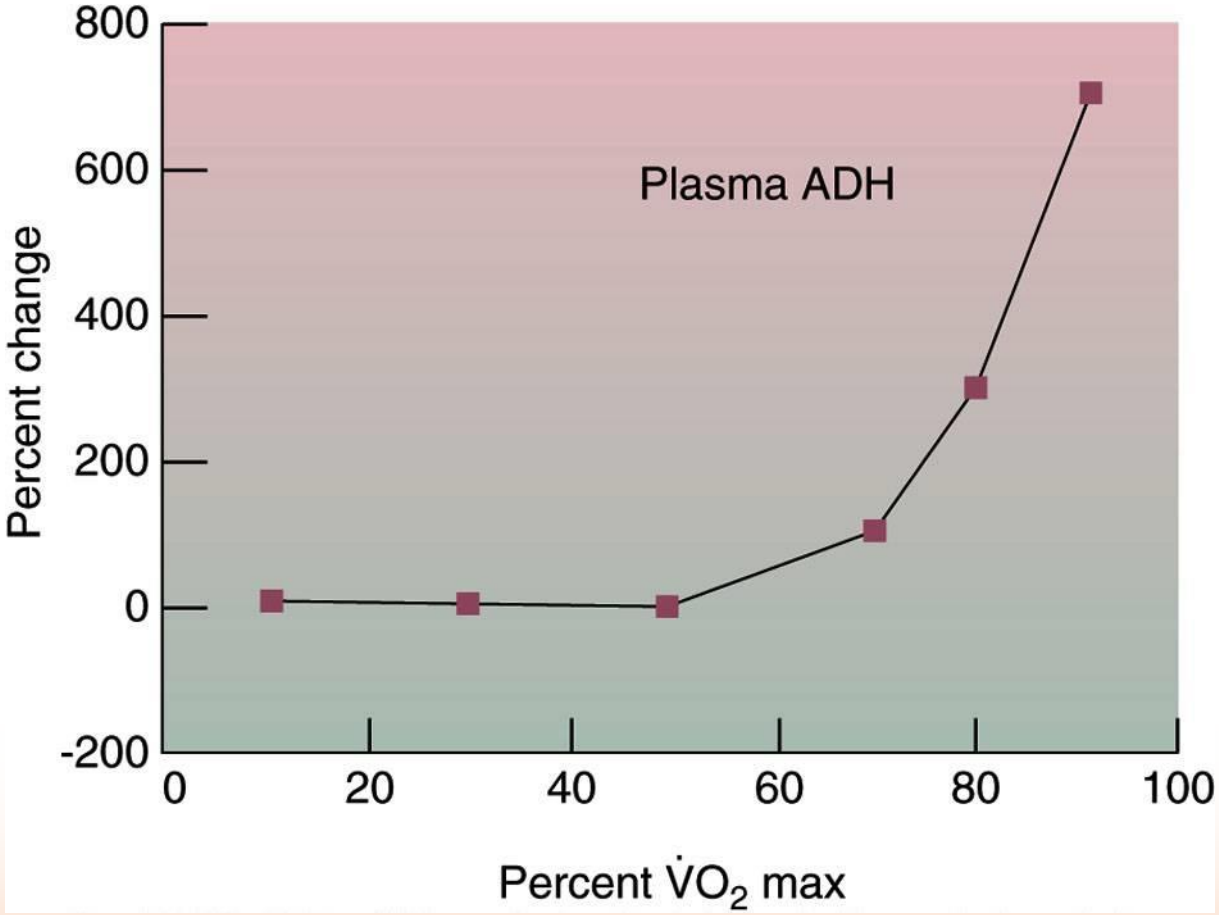


Figure 5.7

Thyroid Gland

- Stimulated by TSH
- Triiodothyronine (T_3) and thyroxine (T_4)
  - Establishment of metabolic rate
  - Permissive hormones
    - Permit full effect of other hormones
- Calcitonin
  - Regulation of plasma Ca^{+2}
    - Blocks release from bone, stimulates excretion by kidneys

In Summary

- Thyroid hormones T_3 and T_4 are important for maintaining the metabolic rate and allowing other hormones to bring about their full effect.

Parathyroid Gland

- Parathyroid hormone
  - Primary hormone in plasma Ca^{+2} regulation
  - Stimulates Ca^{+2} release from bone
  - Stimulates reabsorption of Ca^{+2} by kidneys
  - Converts vitamin D_3 into a hormone that increase Ca^{+2} absorption from GI tract

The roles of parathyroid hormone (PTH) in regulating blood calcium levels in mammals.

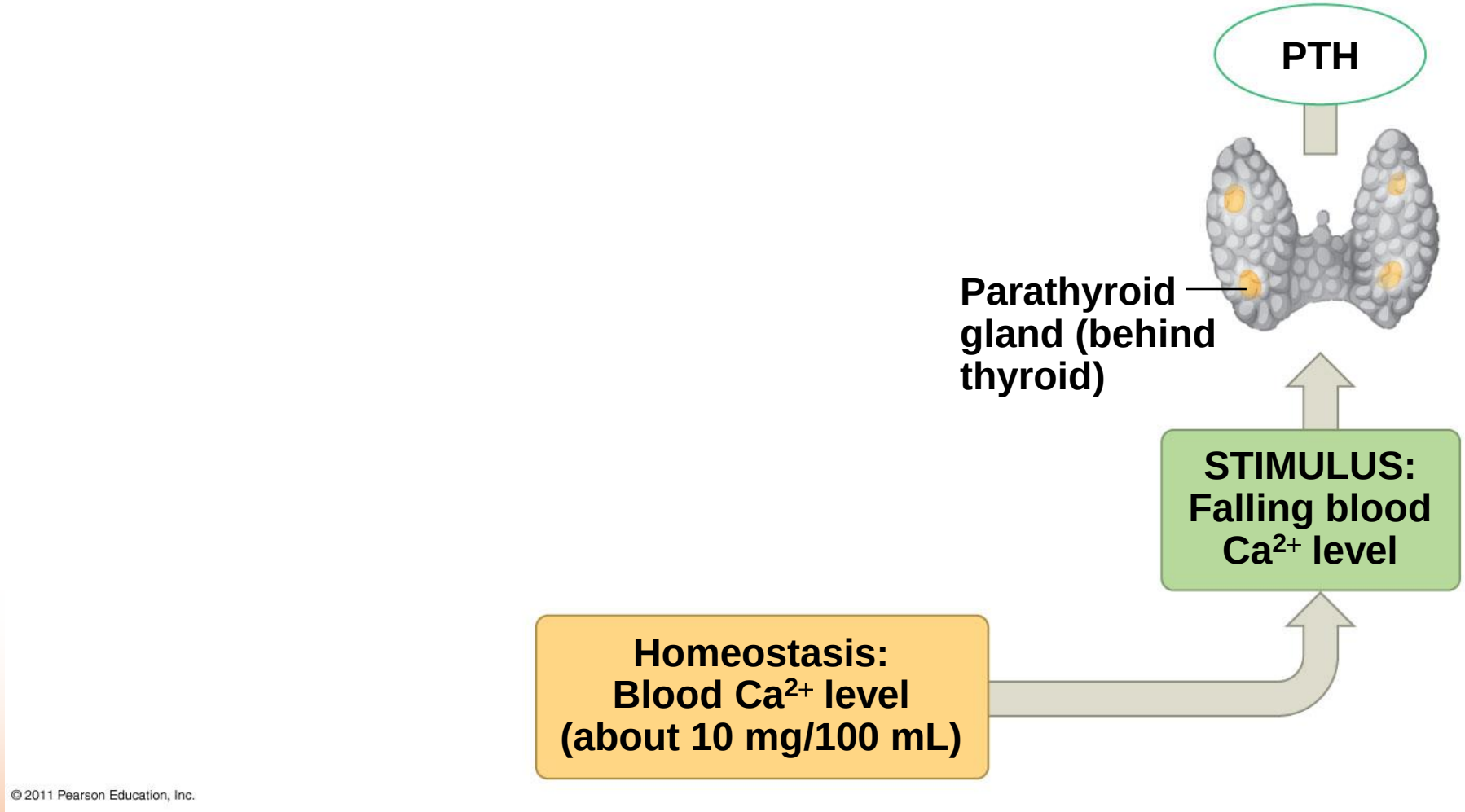
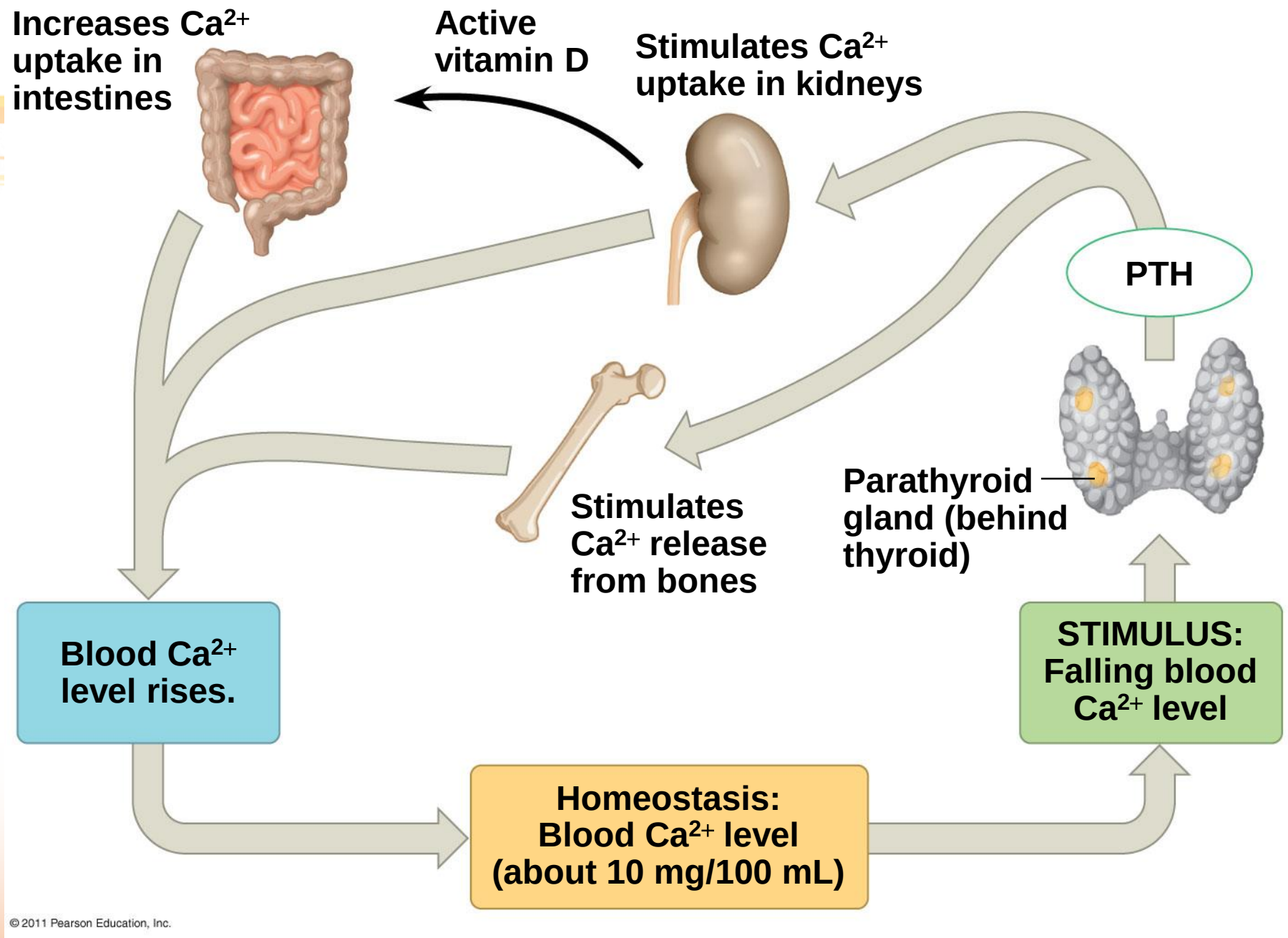
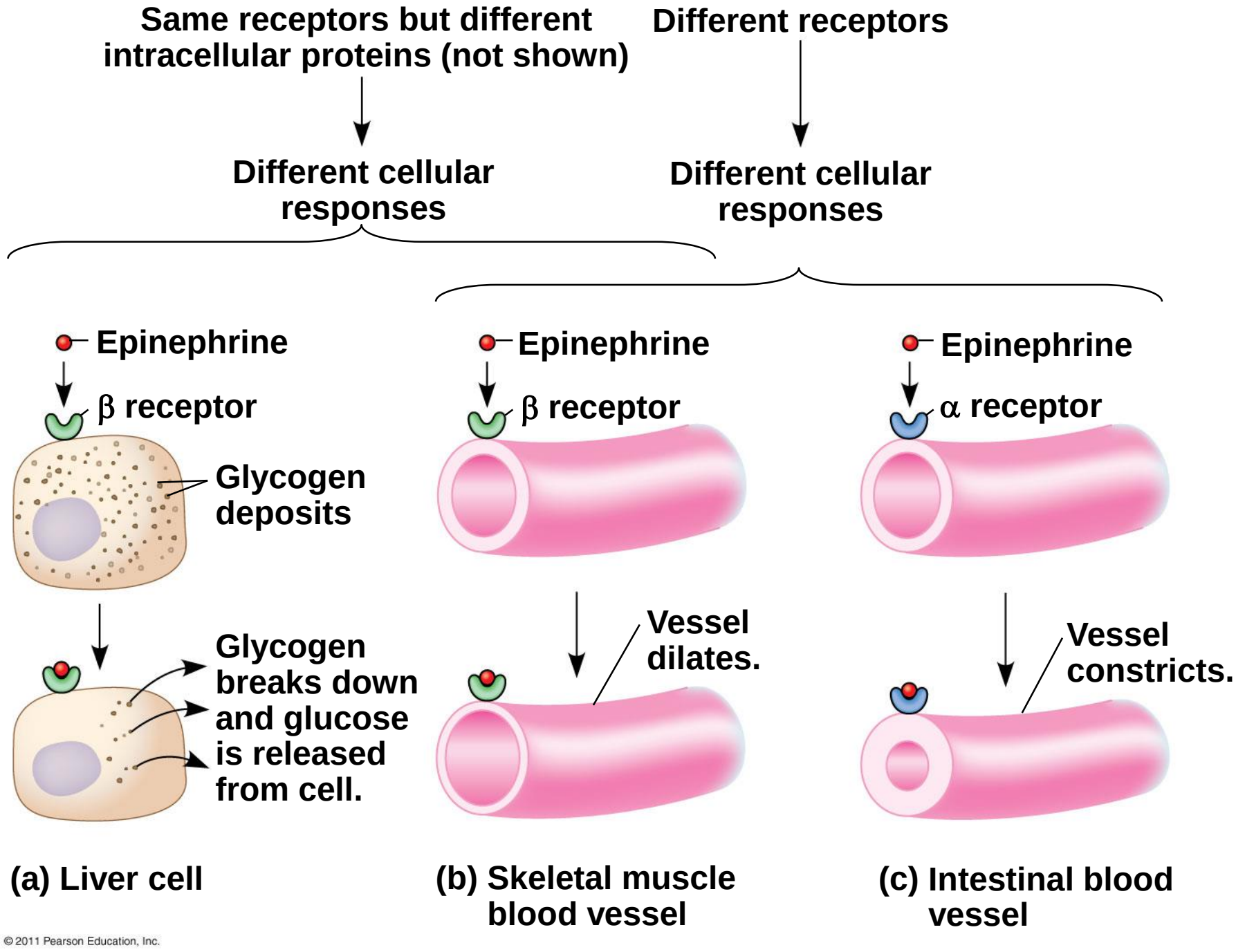


Figure 45.20-2



Adrenal Medulla

- Secretes the catecholamines
  - Epinephrine (E) and norepinephrine (NE)
    - Fast-acting hormones
    - Part of “fight or flight” response
  - Bind to adrenergic receptors
    - Alpha (α)
    - Beta (β)
  - Effects depend on hormone used and receptor type



Adrenal Cortex

- Secretes steroid hormones
  - Derived from cholesterol
- Mineralcorticoids
  - Aldosterone
  - Maintenance of plasma Na^+ and K^+
- Glucocorticoids
  - Cortisol
  - Regulation of plasma glucose
- Sex steroids
  - Androgens and estrogens
  - Support prepubescent growth

Aldosterone

- Control of Na^+ reabsorption and K^+ secretion
  - Na^+/H_2O balance
- Regulation of blood volume and blood pressure
  - Part of renin-angiotensin-aldosterone system
  - All three hormones increase during exercise
- Stimulated by:
  - Increased K^+ concentration
  - Decreased plasma volume

Change in Renin, Angiotensin II, and Aldosterone During Exercise

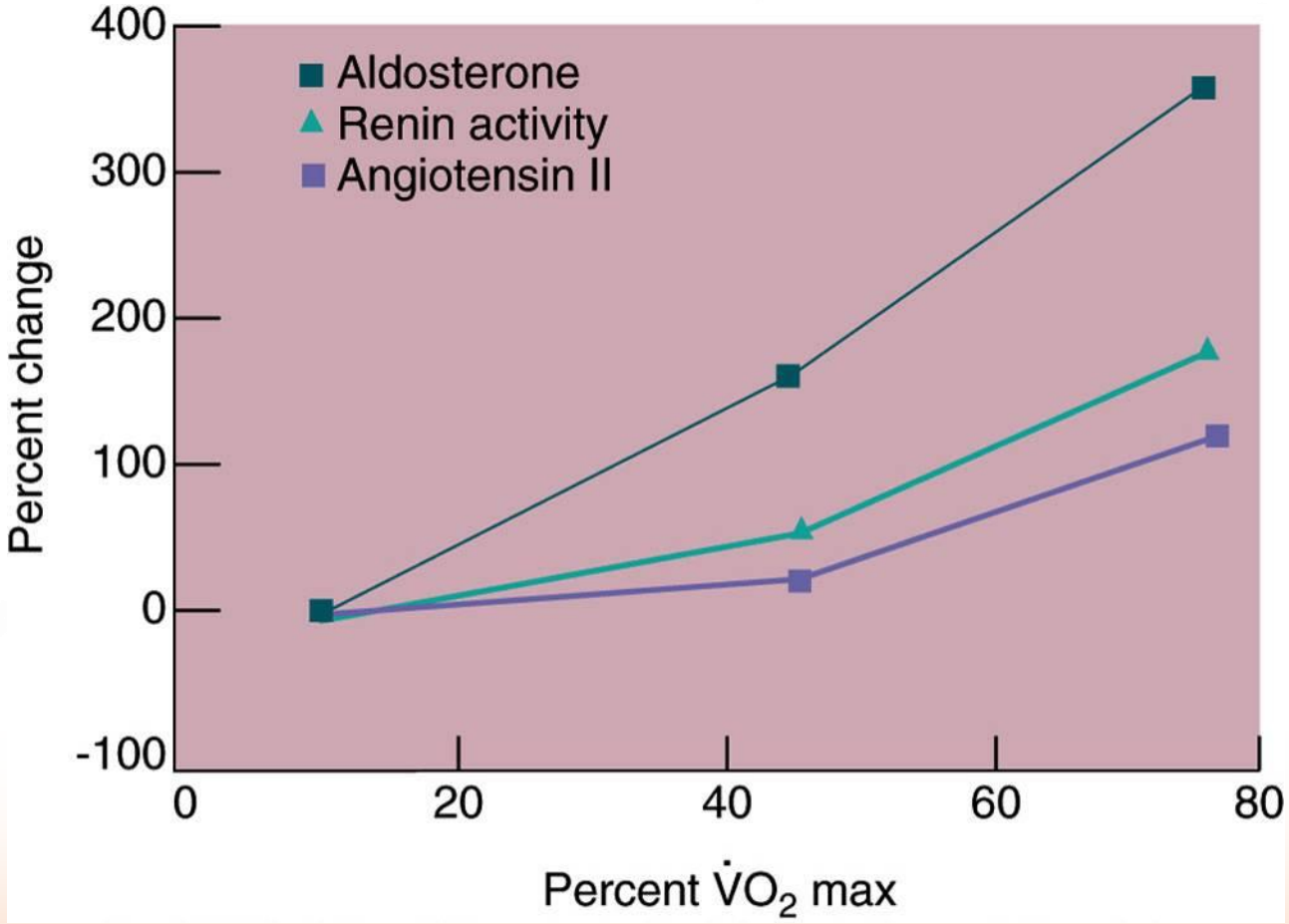


Figure 5.8

Cortisol

- Maintenance of plasma glucose
  - Promotes protein breakdown for gluconeogenesis
  - Stimulates FFA mobilization
  - Stimulates glucose synthesis
  - Blocks uptake of glucose into cells
    - Promotes the use of free fatty acids as fuel
- Stimulated by:
  - Stress, via ACTH
    - Part of General Adaptation Syndrome
  - Exercise

In Summary

- The adrenal cortex secretes aldosterone (mineralcorticoid), cortisol (glucocorticoid), and estrogens and androgens (sex steroids).
- Aldosterone regulates Na^+ and K^+ balance. Aldosterone secretion increases with strenuous exercise, driven by the renin-angiotensin system.
- Cortisol responds to a variety of stressors, including exercise, to ensure that fuel (glucose and free fatty acids) is available, and to make amino acids available for tissue repair.

A Closer Look 5.2

Adipose Tissue Is an Endocrine Organ

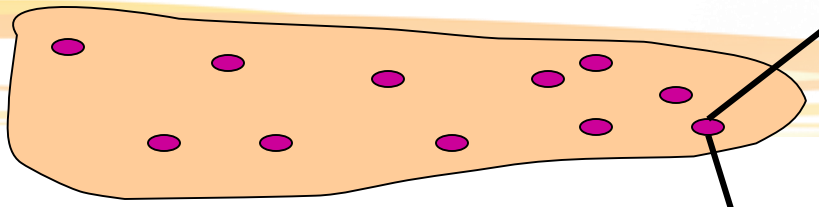
- In addition to storing triglycerides, adipose tissue also secretes hormones
  - Leptin
    - Influences appetite through the hypothalamus
  - Adiponectin
    - Increases insulin sensitivity and fatty acid oxidation
- With increased fat mass (obesity)
  - Higher leptin levels and lower adiponectin
  - Leads to type 2 diabetes and low-grade inflammation

Pancreas

- Both exocrine and endocrine functions
- Secretes:
  - Insulin (from β cells)
    - Promotes the storage of glucose, amino acids, and fats
    - Lack of insulin is called diabetes mellitus
  - Glucagon (from α cells)
    - Promotes the mobilization of fatty acids and glucose
  - Somatostatin (from δ cells)
    - Controls rate of entry of nutrients into the circulation
  - Digestive enzymes and bicarbonate
    - Into the small intestine

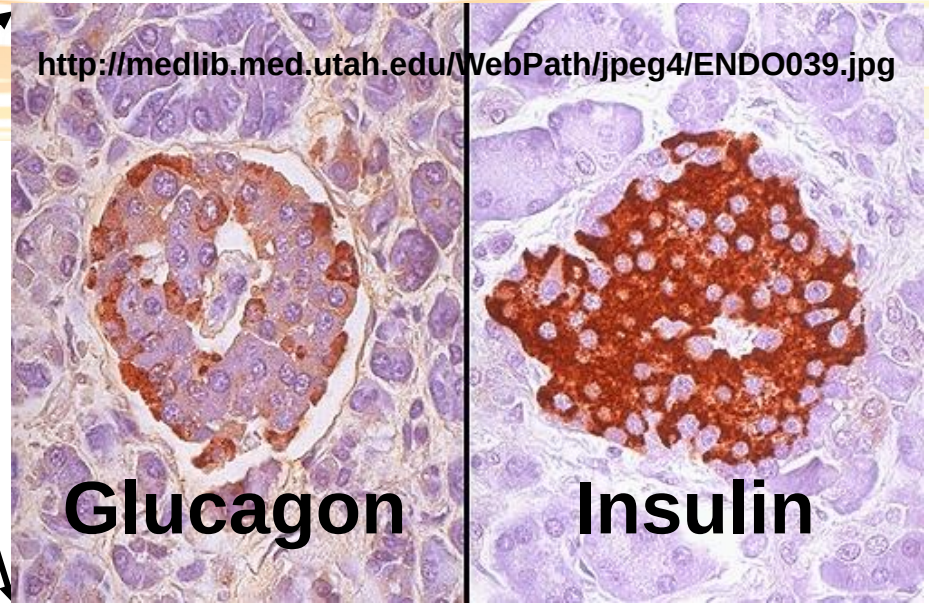

115
9:54 AM
9-18
mg/dL

Hormones Control the Glucose Balance



Pancreas

Islets of Langerhans



Insulin acts on body cells to allow them to take in circulating glucose. Insulin levels rise when glucose rises.

Glucagon acts on liver to stimulate glucose production & release, & on fat to cause fat breakdown. Glucagon rises when glucose falls.

Adrenaline, cortisol, & growth hormone also make blood glucose rise. But insulin-like-growth factor I acts like insulin.

Maintenance of glucose homeostasis is done by paired hormones, insulin and glucagon

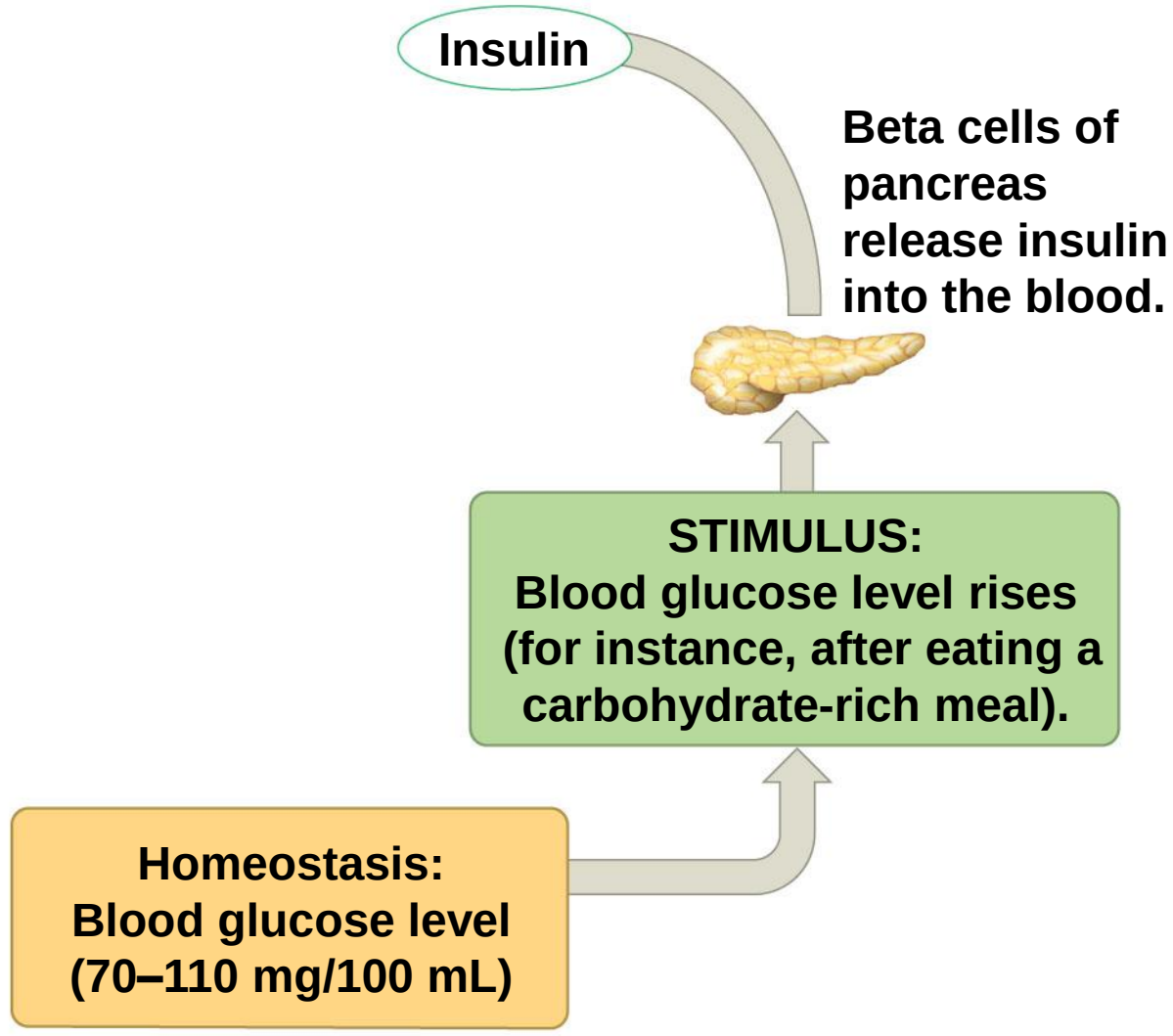


Figure 45.13a-2

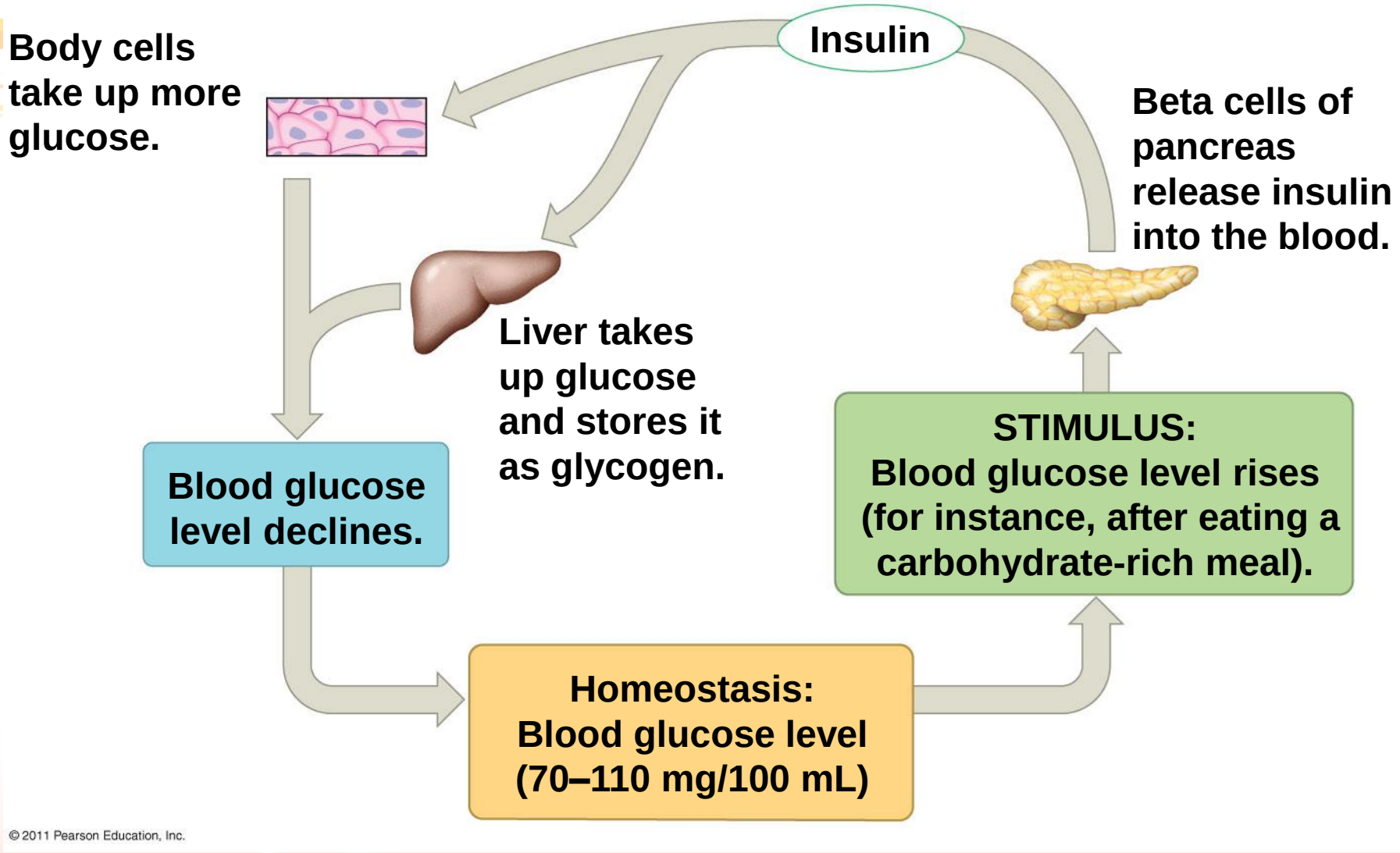


Figure 45.13b-1

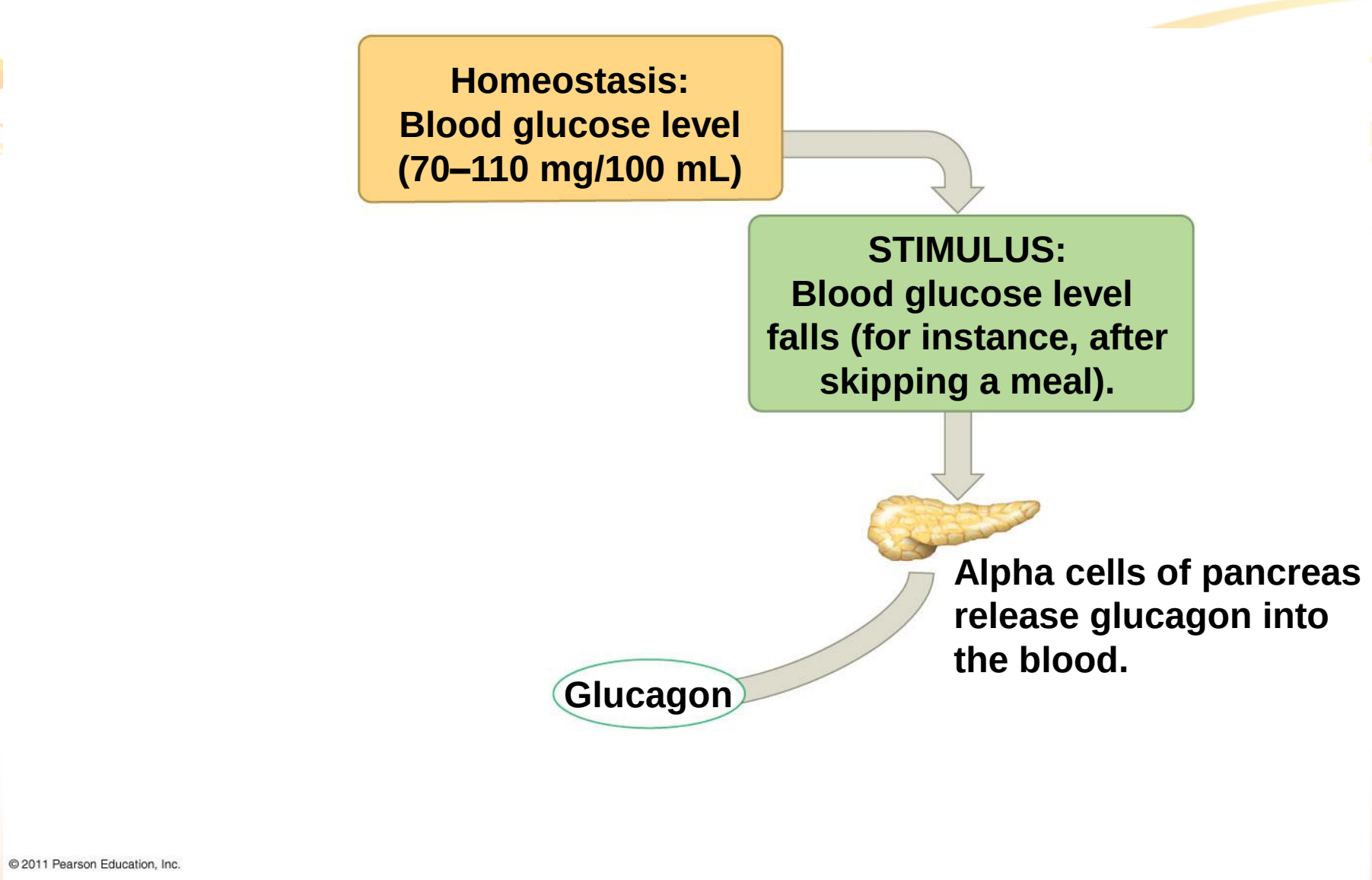
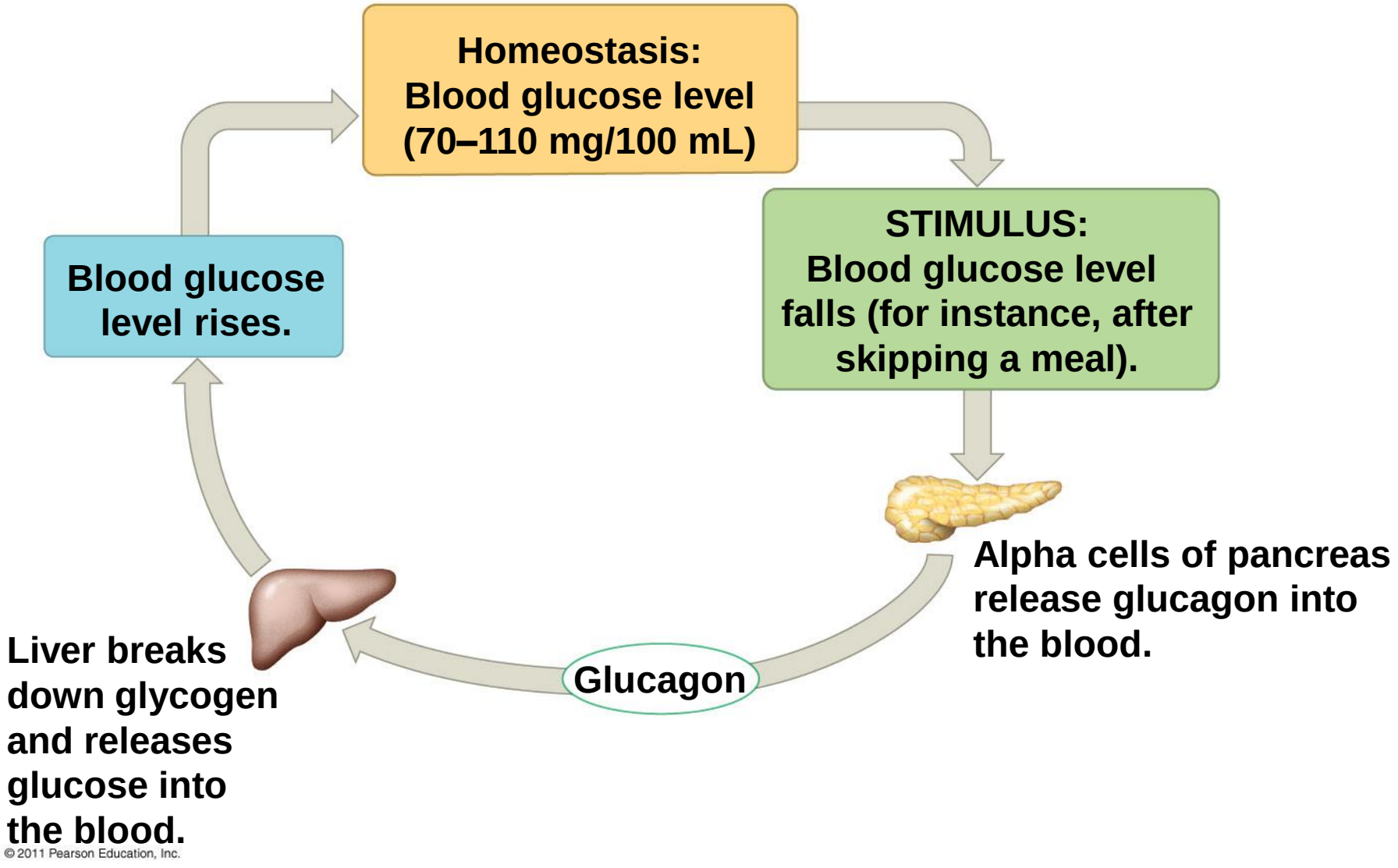


Figure 45.13b-2



In Summary

- Insulin is secreted by the β cells of the islets of Langerhans in the pancreas and promotes the storage of glucose, amino acids, and fats.
- Glucagon is secreted by the α cells of the islets of Langerhans in the pancreas and promotes the mobilization of glucose and fats.

In Summary

- The adrenal medulla secretes the catecholamines epinephrine (E) and norepinephrine (NE). E is the adrenal medulla's primary secretion (80%), while NE is primarily secreted from the adrenergic neurons of the sympathetic nervous system.
- Epinephrine and norepinephrine bind to α- and β-adrenergic receptors and bring about changes in cellular activity (e.g., increased heart rate, mobilization of fatty acids from adipose tissue) via second messengers.

Testes and Ovaries

- Testosterone
  - Released from testes
  - Anabolic steroid
    - Promotes tissue (muscle) building
    - Performance enhancement
  - Androgenic steroid
    - Promotes masculine characteristics
- Estrogen and Progesterone
  - Released from ovaries
  - Establish and maintain reproductive function
  - Levels vary throughout the menstrual cycle

Control of Testosterone Secretion

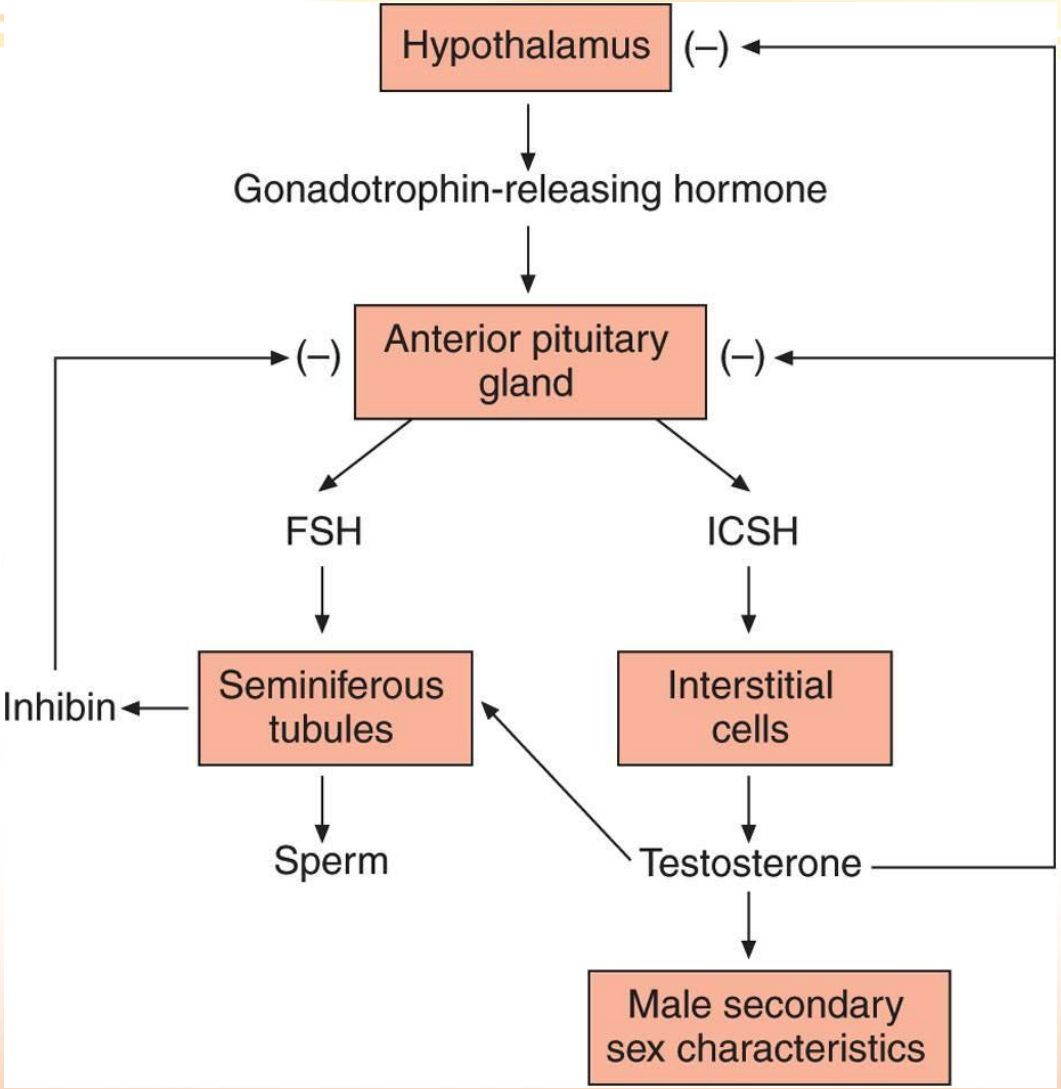


Figure 5.10

Control of Estrogen Secretion

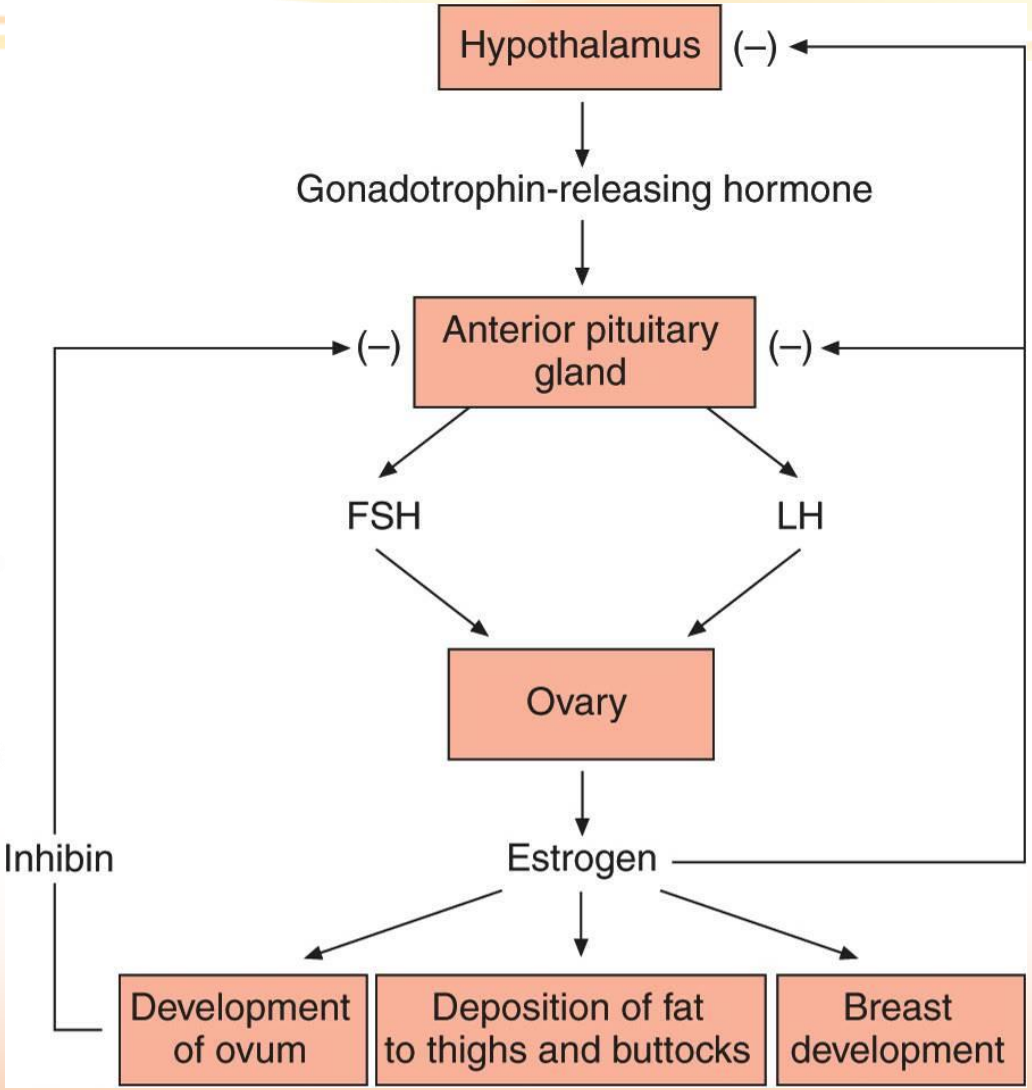


Figure 5.11

Change in FSH, LH, Progesterone, and Estradiol During Exercise

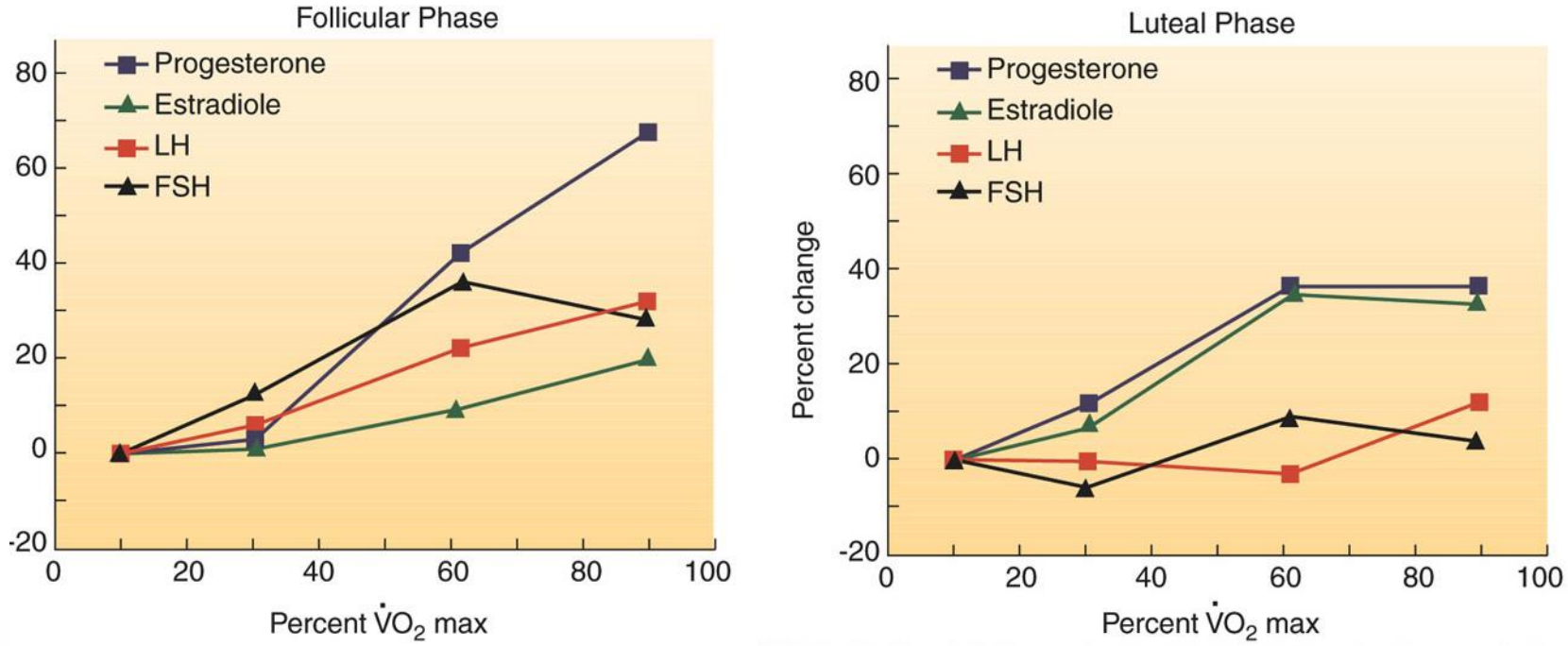


Figure 5.12

A Closer Look 5.3

Anabolic Steroids and Performance

- Initial studies showed no benefit for developing muscle mass
  - In contrast to real-world reports
    - "Subjects" used 10 to 100 times the recommended dosage
- Also associated with negative side effects
  - Revert to normal after discontinuation
- Widespread use has led to testing of competitive athletes
- Most users are not competitive athletes
  - Take more than one steroid in megadoses

In Summary

- Testosterone and estrogen establish and maintain reproductive function and determine secondary sex characteristics.
- Chronic exercise (training) can decrease testosterone levels in males and estrogen levels in females. The latter adaptation has potentially negative consequences related to osteoporosis.

Fuel Sources During Exercise

- Body fuel sources during exercise
- carbohydrates are used as the major fuel source during high-intensity exercise

  (Blood glucose in low I & Ms Glycogen in High I Ex)
- During prolonged exercise, there is a gradual shift from carbohydrate metabolism toward fat Metabolism
- Proteins contribute less than 2% of the fuel used during exercise of less than one hour's duration

- During prolonged exercise (i.e .. three to five hours' duration), the total contribution of protein to the fuel supply may reach 5% to 10% during the final minutes of prolonged work

- Most fat is stored in the form of triglycerides in adipocytes (fat cells),

To be metabolized, triglycerides must be degraded to FFA (three molecules) and glycerol (one molecule).

When triglycerides are split, FFA can be converted into acetyl-CoA and enter the Krebs cycle

Thank You!

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