Chapter 45:
Hormones and the Endocrine System

AP Biology 2013

1

Hormones

- Chemical signal that is secreted into the circulatory system and communicates regulatory messages within the body
- May reach all parts of the body but only certain types of cells (target cells) are equipped to respond
- Works independently and in conjunction with the nervous system to maintain homeostasis, development, and reproduction
  - Nervous system conveys high-speed electrical signals along specialized cells (neurons)
  - Endocrine system is made up of glands that secrete hormones that coordinate slower but longer-acting responses to stimuli

2

Hormones

- Hormones convey information through the bloodstream to target cells throughout the body
  - Proteins (and peptides), amines (from amino acids), and steroids are the three major classes of hormones.
- Signaling involves three events: reception, signal transduction, and response
- Binding of a hormone to its receptor initiates signal transduction leading to responses in the cytoplasm or a change in gene expression
- The same hormone may have different effects on cells that have different receptors for that hormone, different signal transduction pathways, or different proteins for carrying out the response.

3

Types of Signaling

- Autocrine - cells secretes a hormone or chemical messenger that binds to the same cell leading to changes in that cell
- Paracrine - target cells is near the signal-releasing cell
  - Can have various functions: neurotransmitters, growth factors, prostaglandins (regulate aggregation of platelets)
- Intracrine - hormone acts inside a cell (usually on nuclear receptors)
- Endocrine - target cells is necessarily located near the signal-releasing cell and the signal travels through the blood stream

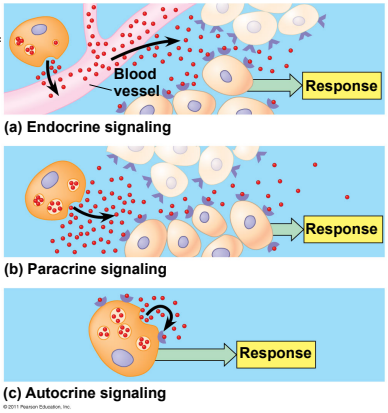


Fig. 45.2

Neuroendocrine Signaling

- Specialized nerve cells called neurosecretory cells release neurohormones into the blood
- Three types of hormonal pathways
- All pathways consist of a feedback loop connecting a response to an initial stimuli
  - Many hormonal responses pathways involved in homeostasis are negative feedback pathways

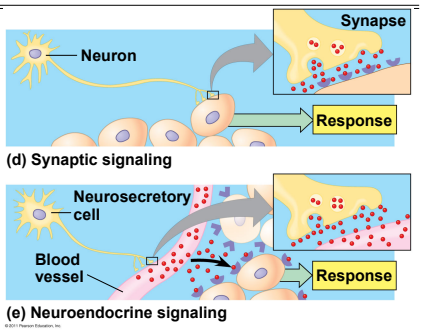


Fig. 45.2

Fig. 45.3

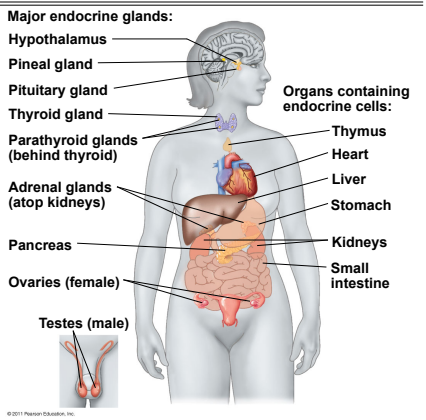
Pheromones

- Members of the same species sometimes communicate with pheromones (chemicals released into the environment)
- Used for marking trails, identifying food sources, defining territories, warning of predators, and attracting mates

Endocrine Tissues and Organs

Fig. 45.4

- In some tissues, endocrine cells are grouped together in ductless organs called endocrine glands
- Endocrine glands secrete hormones directly into surrounding fluid
- Exocrine glands have ducts which secrete substances onto body surfaces or into cavities
- Classes of hormones: polypeptides, amines (derived from amino acids), and steroid hormones



7

Receptors

- Water soluble hormones have receptors embedded in the plasma membrane, projecting from the cell surface
- Steroids, thyroid hormones, and the hormonal form of vitamin D enter target cells and bind to specific protein receptors in the cytoplasm or nucleus (intracellular receptors)
  - The protein-receptor complex acts as a transcription factor in the nucleus, regulating transcription of specific genes

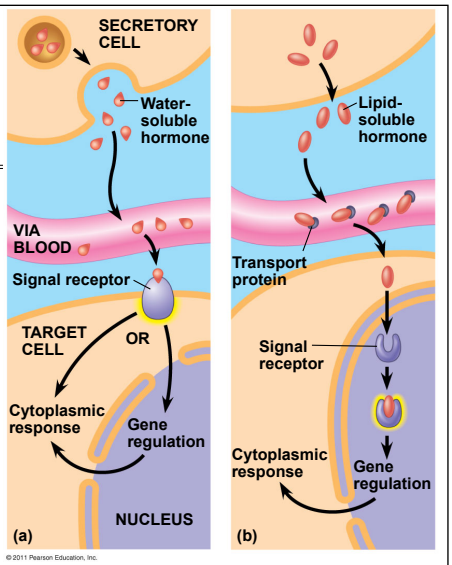


Fig. 45.6

8

Epinephrine

- Has multiple effects on mediating the body's response to short term stress

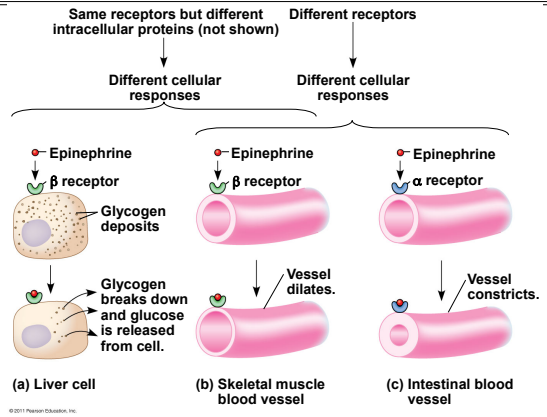


Fig. 45.4

9

Generalized Endocrine and Neuroendocrine Pathways

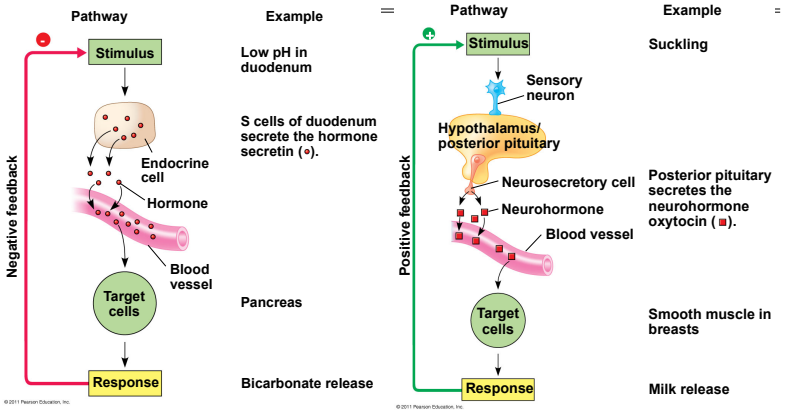


Fig. 45.11 Fig. 45.12

10

Insulin and Glucagon

- Two types of cells that secrete insulin and glucagon (antagonistic hormones) that help maintain glucose homeostasis
- Cells found in clusters in the islets of Langerhans
  - Glucagon (produced by alpha cells) increases blood glucose levels
    - Stimulates glycogen breakdown to glucose in the liver, stimulates breakdown of fat and protein into glucose
  - Insulin (produced by beta cells) reduces blood glucose levels
    - Promotes cellular uptake of glucose, slows glycogen breakdown, promotes fat storage

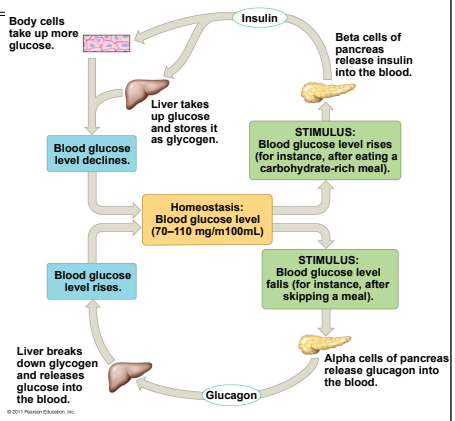


Fig. 45.12

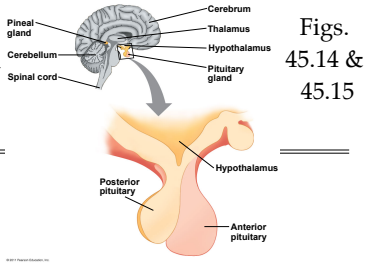
11

Diabetes Mellitus

- Probably best-known endocrine disorder
- Caused by a deficiency of insulin or a decreased response to insulin in a target tissue
- Marked by elevated blood glucose levels
- *Type 1 diabetes mellitus* (insulin-dependent) is an autoimmune disorder in which immune system cells destroy pancreatic beta cells
- *Type 2 diabetes mellitus* (non-insulin-dependent) involves insulin deficiency or reduced response of target cells to change in insulin receptors

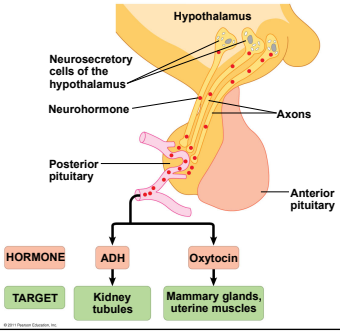
12

Hypothalamus and Pituitary Glands



Figs. 45.14 & 45.15

- Control much of the endocrine system
- Hypothalamus - region of the lower brain that contains different sets of neurosecretory cells
  - Some of these cells produce direct-acting hormones that are stored and released from the posterior pituitary
  - Other hypothalamic cells produce tropic hormones that are secreted into the blood and transported to the anterior pituitary gland

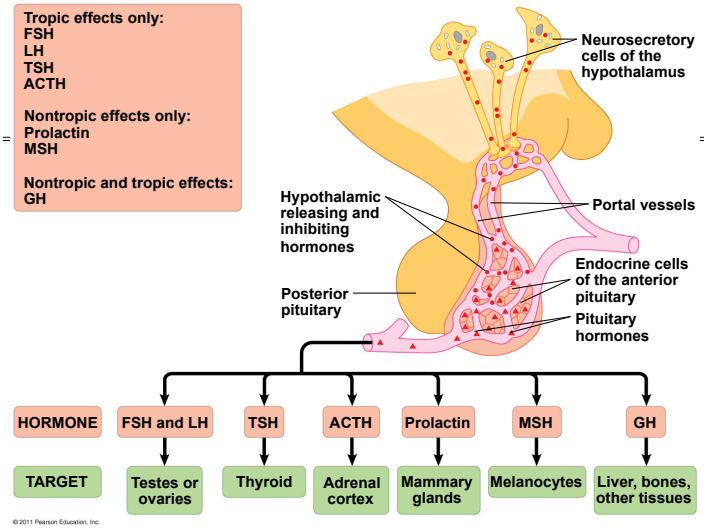


13

Tropic effects only:
FSH
LH
TSH
ACTH

Nontropic effects only:
Prolactin
MSH

Nontropic and tropic effects:
GH



Anterior Pituitary Hormones Fig. 45.16

14

Posterior Pituitary Gland

- The two hormones released from the posterior pituitary gland act directly on nonendocrine tissues
  - Oxytocin - induces uterine contractions and milk ejection
  - Antidiuretic hormone (ADH) - enhances water reabsorption in the kidneys

15

Anterior Pituitary Gland

- Tropic hormones of the hypothalamus control the release of hormones from the anterior pituitary
  - Anterior pituitary gland produces both tropic (target other endocrine glands) and nontropic (target non-endocrine cells) hormones
- Tropic hormones act on target endocrone tissue to stimulate the release of hormones with direct effects
- Four tropic hormones:
  - Follicle-stimulating Hormone (FSH) - development, growth, maturation
  - Lutenizing hormone (LH) - ovulation (females), production of testosterone (males)
  - Thyroid-stimulating hormone (TSH)
  - Adrenocorticotropic hormone (ACTH)

16

Anterior Pituitary Gland

- Nontropic hormones
  - Prolactin - stimulates lactation in mammals; water and salt balance in other animals (fish)
  - Melanocyte-stimulating hormone (MSH) - skin pigmentation in some vertebrates; fat metabolism in mammals
  - Endorphins (β-endorphin) - inhibit sensation of pain
  - Growth hormone (GH) - promotes growth directly and stimulates the production of growth factors by other tissues

17

Thyroid Gland

- Consists of two lobes and is located on the ventral surface of the trachea
- Produces two iodine-containing hormones: thiiodothyronine (T_3) and thyroxine (T_4)
  - Play a crucial role in stimulating metabolism and influence development and maturation
- Secretion of thyroid is controlled by the hypothalamus and anterior pituitary through two negative feedback loops
- Hypothyroidism - excess secretion of thyroid hormones causes Graves' disease

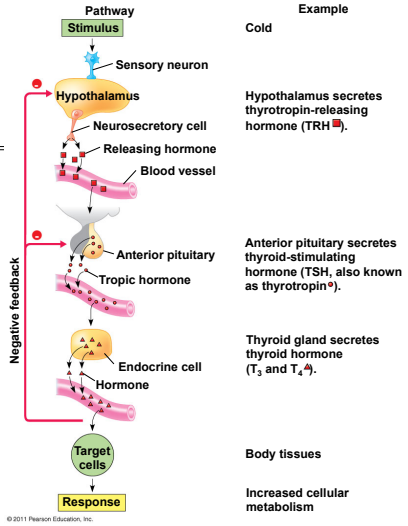


Fig. 45.17

18

Parathyroid Hormone and Calcitonin

- Parathyroid hormone (PTH) and calcitonin are antagonistic
- Calcitonin - secreted by the thyroid gland
  - Stimulates Ca^{2+} deposition in the bones and secretion by the kidneys (lowers blood Ca^{2+} levels)
- PTH - secreted by the parathyroid glands
  - Has opposite effect on bones and kidneys (increases blood Ca^{2+} levels)
  - Also stimulates the kidneys to activate vitamin D which promotes intestinal uptake of Ca^{2+} from food

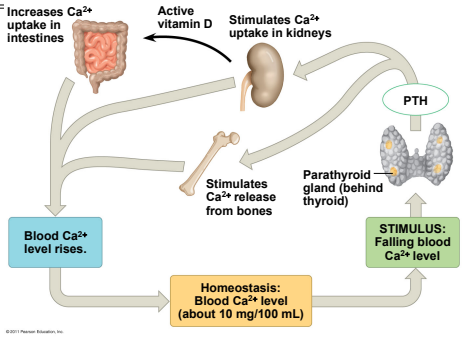


Fig. 45.20

19

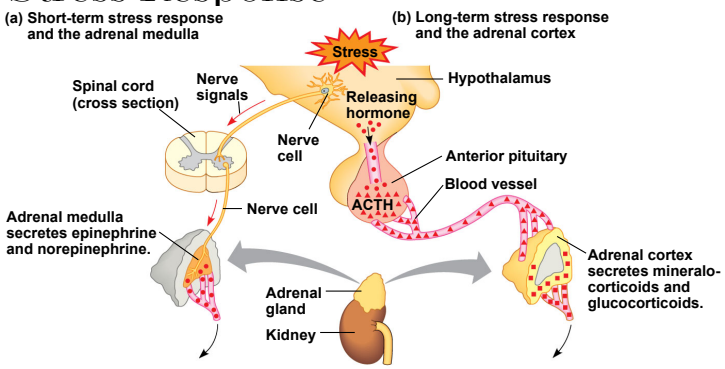
Adrenal Glands

- Adjacent to kidneys and made up of two glands: adrenal medulla and adrenal cortex
- Adrenal Medulla - secretes epinephrine and norepinephrine (class of hormones called catecholamines)
  - Secreted in response to stress-activated impulses from the nervous system (fight-or-flight response)
- Adrenal Cortex - also function in the response to stress (steroid hormones)
  - Glucocorticoids - influence glucose metabolism and the immune system (ex. cortisol)
  - Mineralocorticoids - affect salt and water balance (ex. aldosterone)
  - Sex hormones

20

Stress Response

Fig. 45.13



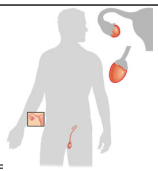
21

Gonads

Fig. 45.22

RESULTS

Chromosome Set	Appearance of Genitalia	
	No surgery	Embryonic gonad removed
XY (male)	Male	Female
XX (female)	Female	Female



- Testes and ovaries produce most of the body's sex hormones (androgens, estrogens, and progestins)
- Testes - primarily synthesize androgens like testosterone
  - Testosterone - stimulates development and maintenance of male reproductive system
    - Can cause an increase in muscle and bone mass
- Ovaries - secrete estrogens (most importantly estradiol) and progesterone
  - Estradiol - responsible for maintenance of female reproductive system and development of secondary sex characteristics
  - Progesterone - preparing and maintaining the uterus

22

Pineal Gland

- Located in the brain and secretes melatonin (biological rhythms associated with reproduction)
- Melatonin release is controlled by light/dark cycles

23

Endocrine Disrupters

- Between 1938 and 1971 some pregnant women at risk for complications were prescribed a synthetic estrogen called diethylstilbestrol (DES)
- Daughters of women treated with DES are at higher risk for reproductive abnormalities including miscarriage, structural changes, and cervical and vaginal cancers
- DES is an endocrine disruptor, a molecule that interrupts normal function of the hormone pathway

24