Homeostasis

Internal environment is the environment of the cells, tissues, fluids, and organs

Tissue fluid surrounds cells

Tissue fluid is constantly renewed by exchanges with blood

Blood and tissue fluid are the internal environment of the body

Homeostasis—maintenance of the relatively constant conditions of the internal environment

Even though external conditions vary—internal conditions stay within a narrow range

All body systems contribute to homeostasis.

Organ Systems and Homeostasis

Organ systems of the body interact with the internal and external environment and with one another.

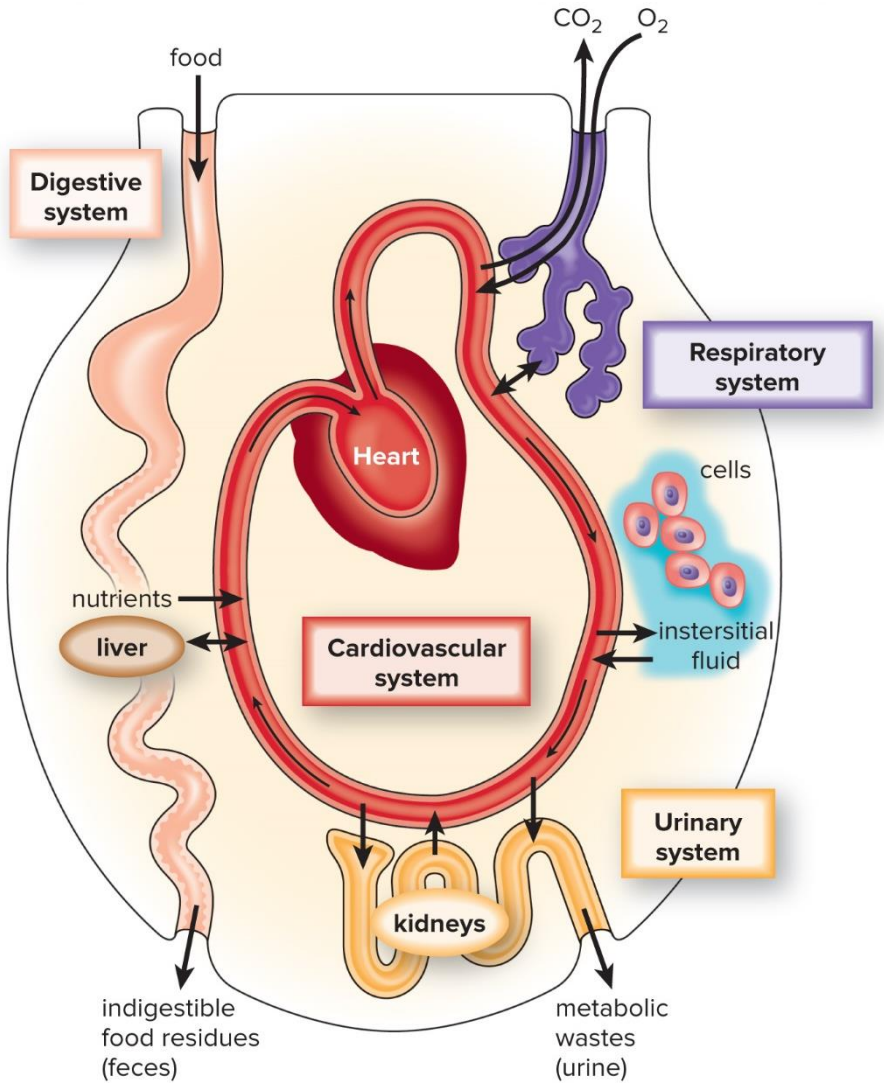
Interactions can alter the composition of the tissue fluids.

Respiratory system exchanges gases with the external environment and with the blood. The blood exchanges nutrients and oxygen for carbon dioxide and other wastes with tissue fluid, thus allowing the composition of the tissue fluid to stay within normal limits.

The digestive system takes in food and adds nutrients to the blood.

The urinary system removes metabolic wastes from the blood and excretes them.

Major Organ Systems and Homeostasis

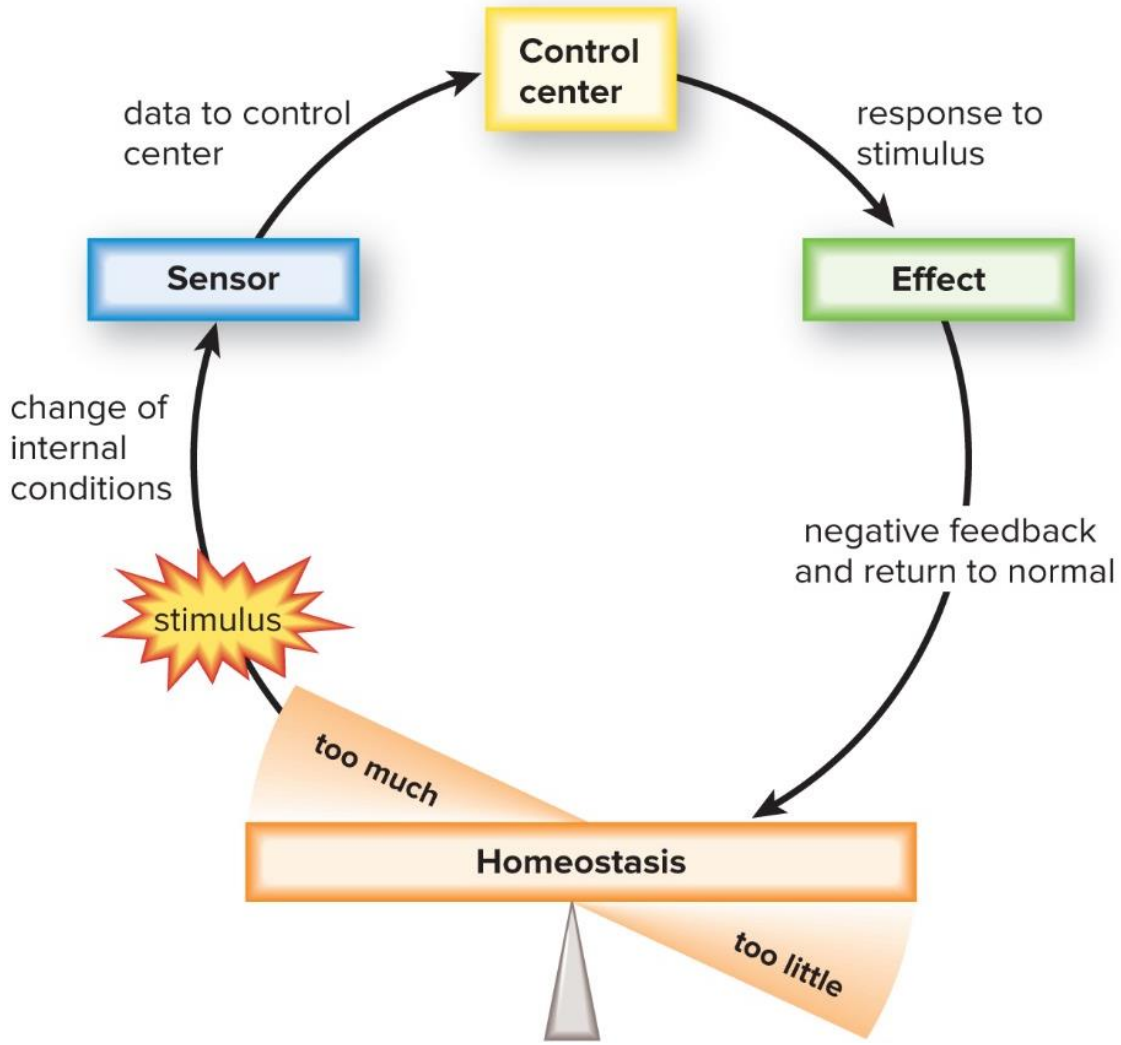


Negative Feedback

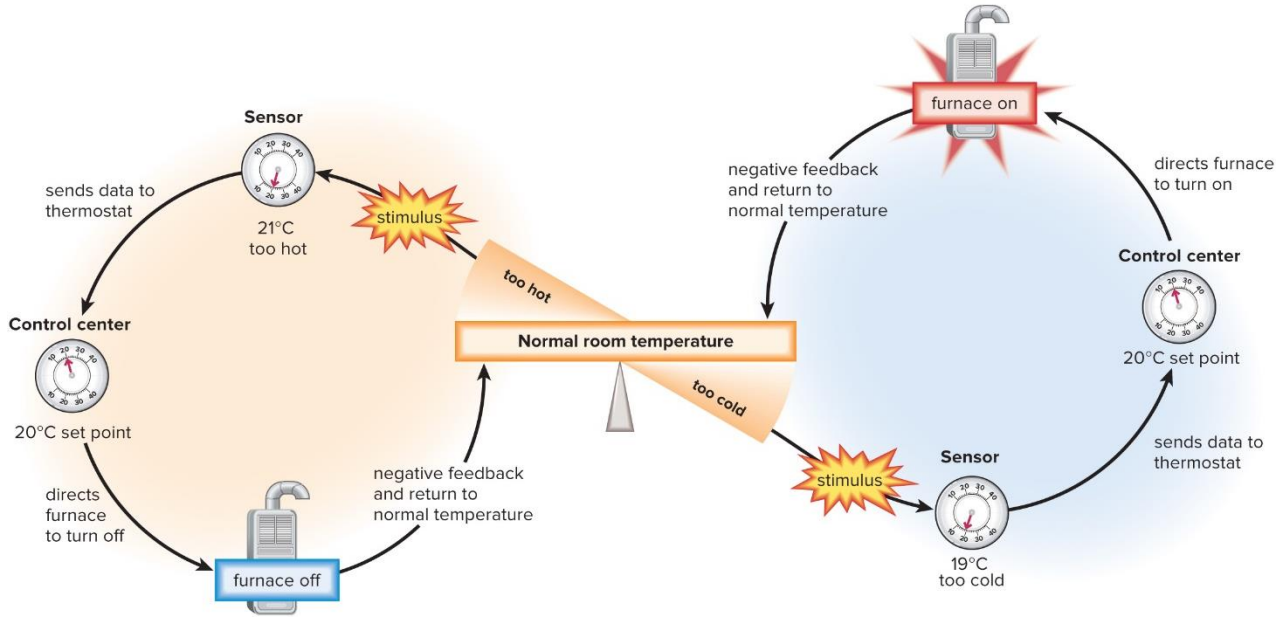
Negative feedback

- Primary homeostatic mechanism
- Two components
  - Sensor—detects changes in the internal environment (stimulus)
  - Control center—initiates an effect that brings conditions back to normal
- Example
  - Pancreas detects blood sugar too high
  - Pancreas secretes hormone insulin that causes cells to take up glucose
  - Blood sugar levels return to normal

Negative Feedback Mechanism



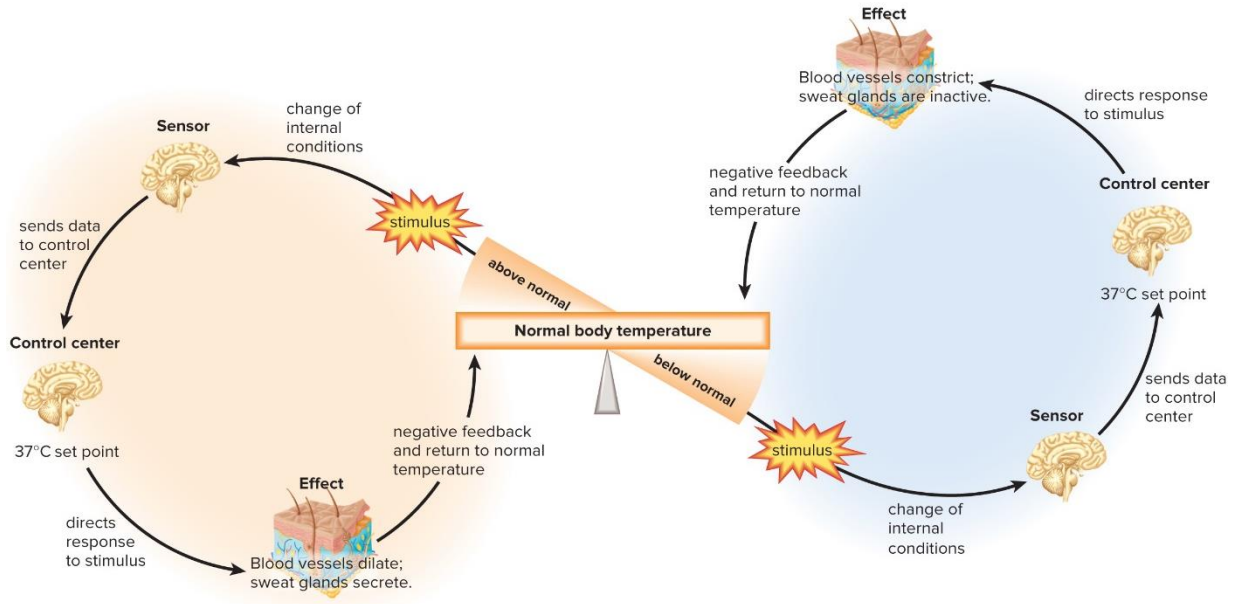
Regulation of Room Temperature



Mechanical negative feedback example

- Home heating system
- Set thermostat at a set point
  - Thermometer is sensor
  - Control center turns furnace on and off
  - Results in fluctuation above and below the set point

Regulation of Body Temperature



Human example: Body temperature

- Hypothalamus in the brain is our thermostat
- When core body temperature falls below normal, control center acts (via nerve impulses) to bring temperature up
- When body temperature is too high, control center acts to bring temperature down

27.2 Endocrine System

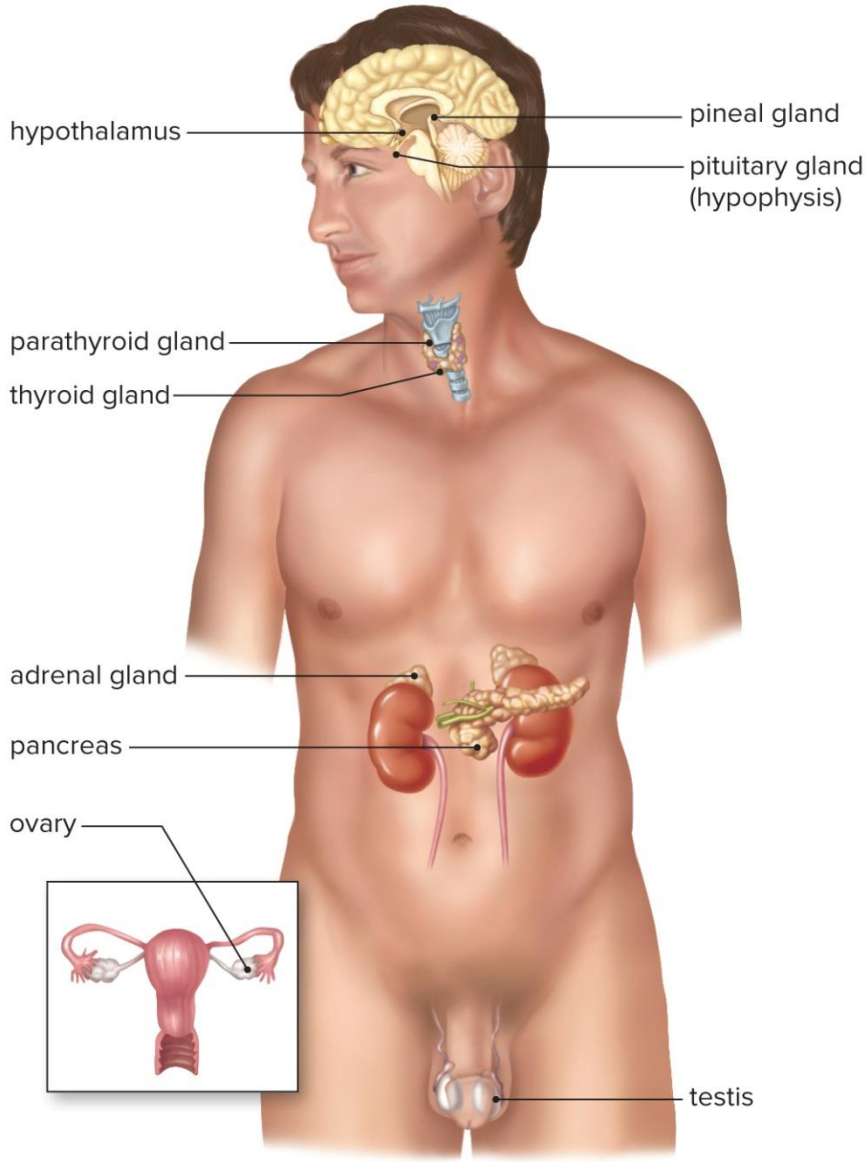
Consists of glands and tissues that secrete hormones

Endocrine glands do not have ducts.

- Secrete hormones directly into blood for distribution throughout the body
- Exocrine glands have ducts and secrete product into duct for delivery to a specific organ

Endocrine and nervous systems are intimately involved in homeostasis

Figure 27.14 The Endocrine System

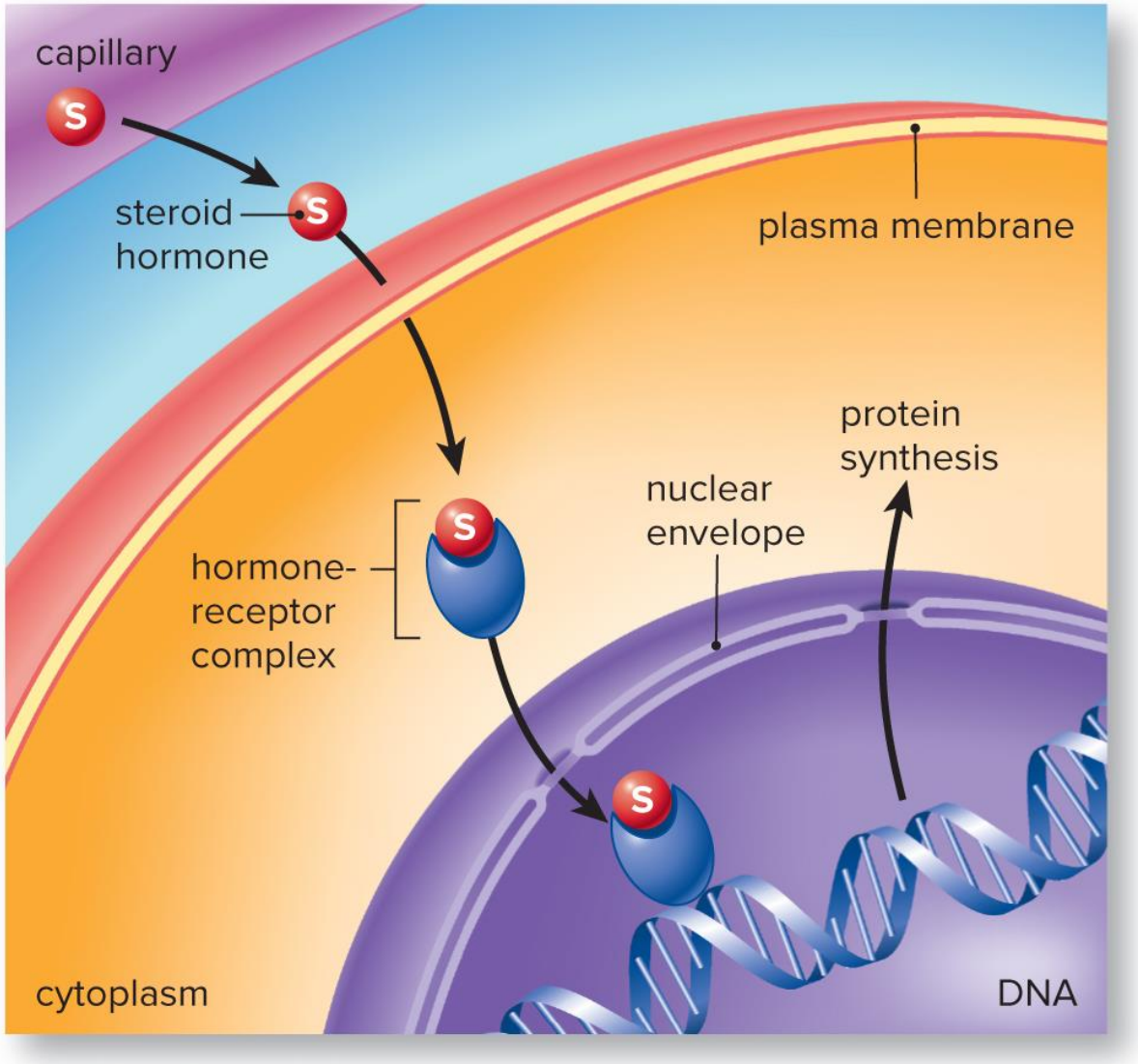


Hormones, 1

Action of hormones

- Only cells with receptors for the hormone respond to that hormone.
- Response is a metabolic change
- Type of change dependent on chemical structure of hormone
- Steroid hormones
  - Lipids that can pass through plasma membrane
  - Hormone-receptor complex binds to DNA
  - Activates gene expression

Figure 27.15a How Hormones Work



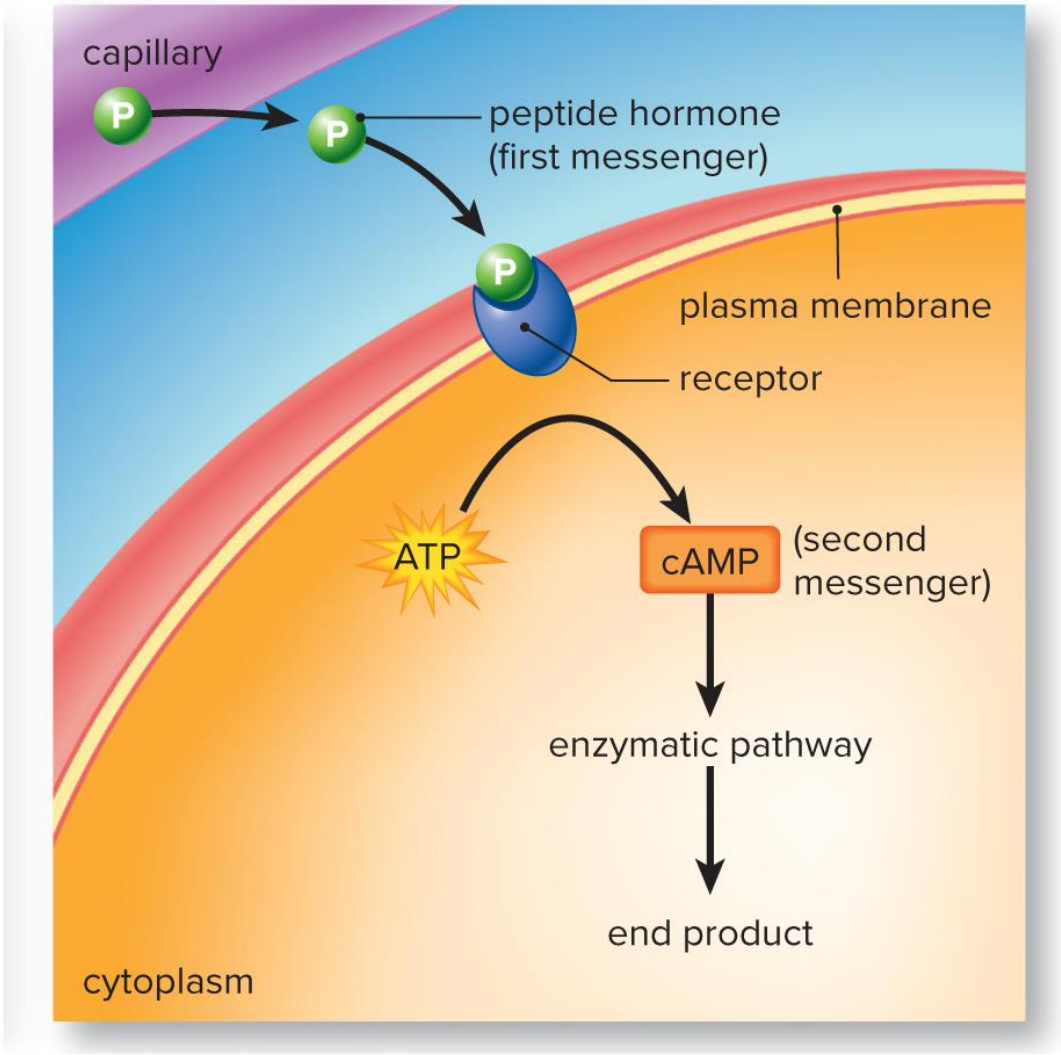
a. Action of steroid hormone

Hormones, 2

Peptide hormones

- Comprise peptides, proteins, glycoproteins, and modified amino acids
- Bind to receptor on plasma membrane
- Peptide hormone is “first messenger” that activates signal transduction pathway
- “Second messenger” sets in motion an enzyme pathway
- May be a cascade so single hormone molecule results in thousandfold response

Figure 27.15b How Hormones Work



b. Action of peptide hormone

Hypothalamus and Pituitary Gland

Hypothalamus and pituitary gland

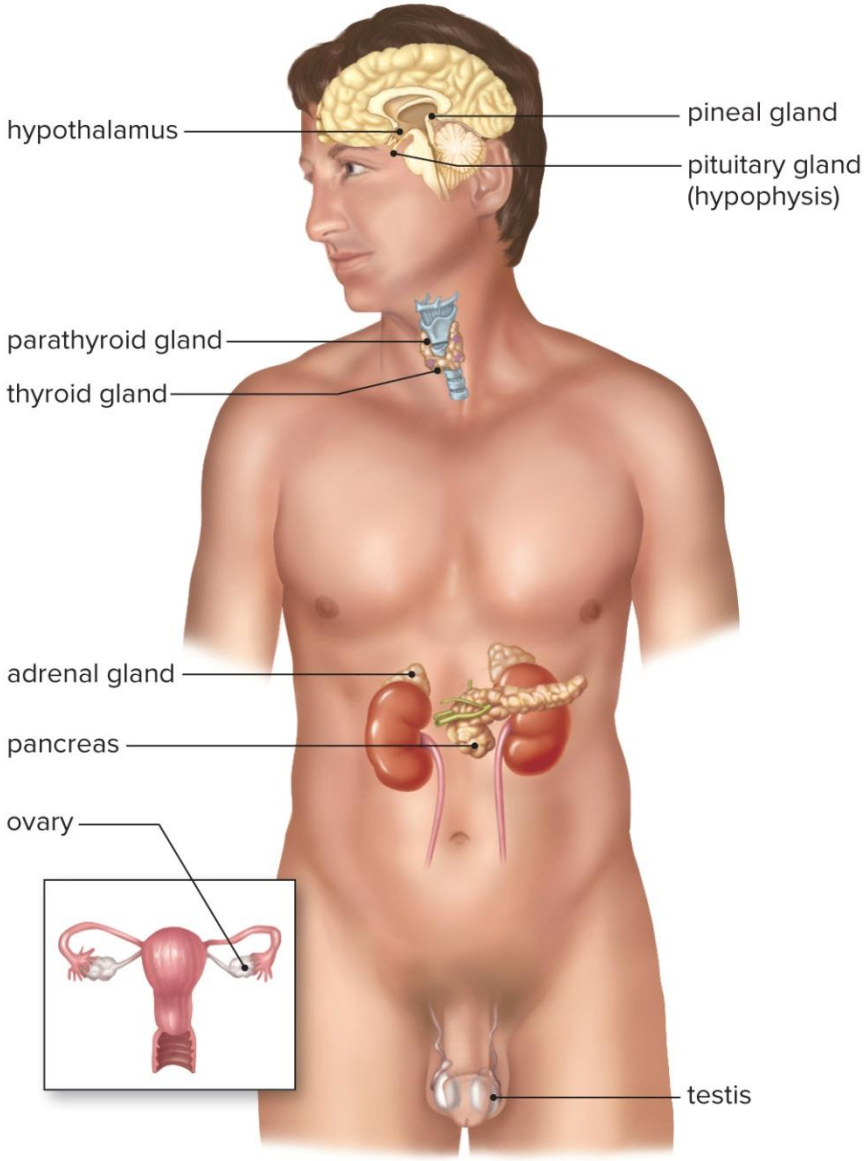
- Hypothalamus—part of brain
  - Part of nervous system and endocrine system
  - Contains specialized hormone-secreting neurons
  - Controls secretion of pituitary gland
- Pituitary gland—connected to brain by stalk
  - Anterior pituitary
  - Posterior pituitary

Anterior Pituitary, 1

Anterior pituitary

- Secretions controlled by hypothalamic-releasing hormones
- FLAT PeG
- Secretions stimulate other glands
  - FSH (Follicle-Stimulating Hormone) → Gonads
  - LH (Luteinizing Hormone) → Gonads
  - ACTH (Adrenocorticotropic Hormone) → Adrenal Cortex
  - TSH (Thyroid-Stimulating Hormone) → Thyroid Gland
  - PRL (Prolactin) → Mammary glands
  - GH (Growth Hormone) → Musculoskeletal System

- Gonadotropic hormones (FSH and LH) stimulate gonads (testes or ovaries) to produce gametes and sex hormones
- Adrenocorticotropic hormone (ACTH) stimulates adrenal cortex to produce glucocorticoids
- Thyroid-stimulating hormone (TSH) stimulates thyroid to produce triiodothyronine (T_3) and thyroxine (T_4)
- Prolactin (PRL)
  - Causes mammary glands to develop and produce milk
- Growth hormone (GH)
  - Promotes skeletal and muscular growth
  - Underproduction leads to pituitary dwarfism, overproduction leads to gigantism

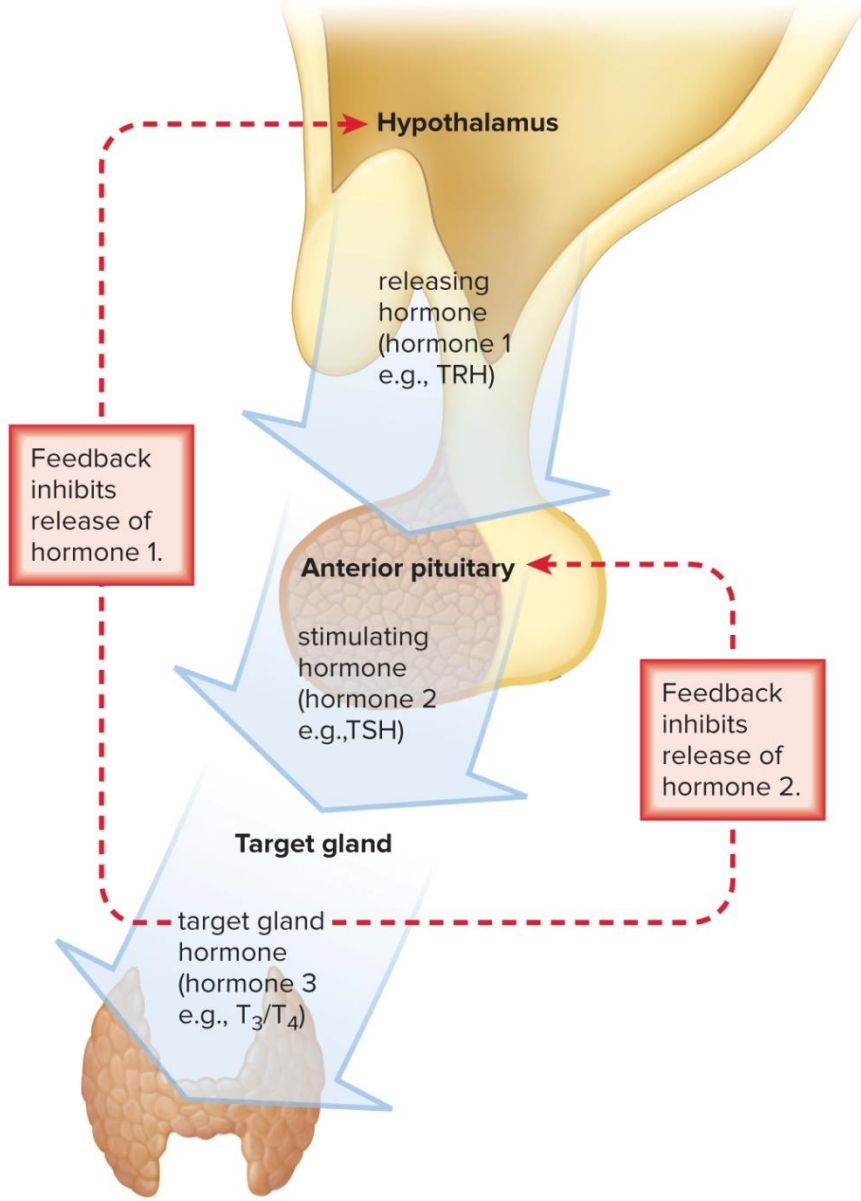


Anterior Pituitary, 2

Three-tiered negative feedback control system

- Secretion of thyroid-releasing hormone (TRH) by hypothalamus
- TRH stimulates anterior pituitary to secrete thyroid-stimulating hormone (TSH)
- TSH stimulates thyroid to produce triiodothyronine (T_3) and thyroxine (T_4)
- T_3 and T_4 feedback to inhibit release of TRH and TSH

Figure 27.17 Negative Feedback Inhibition

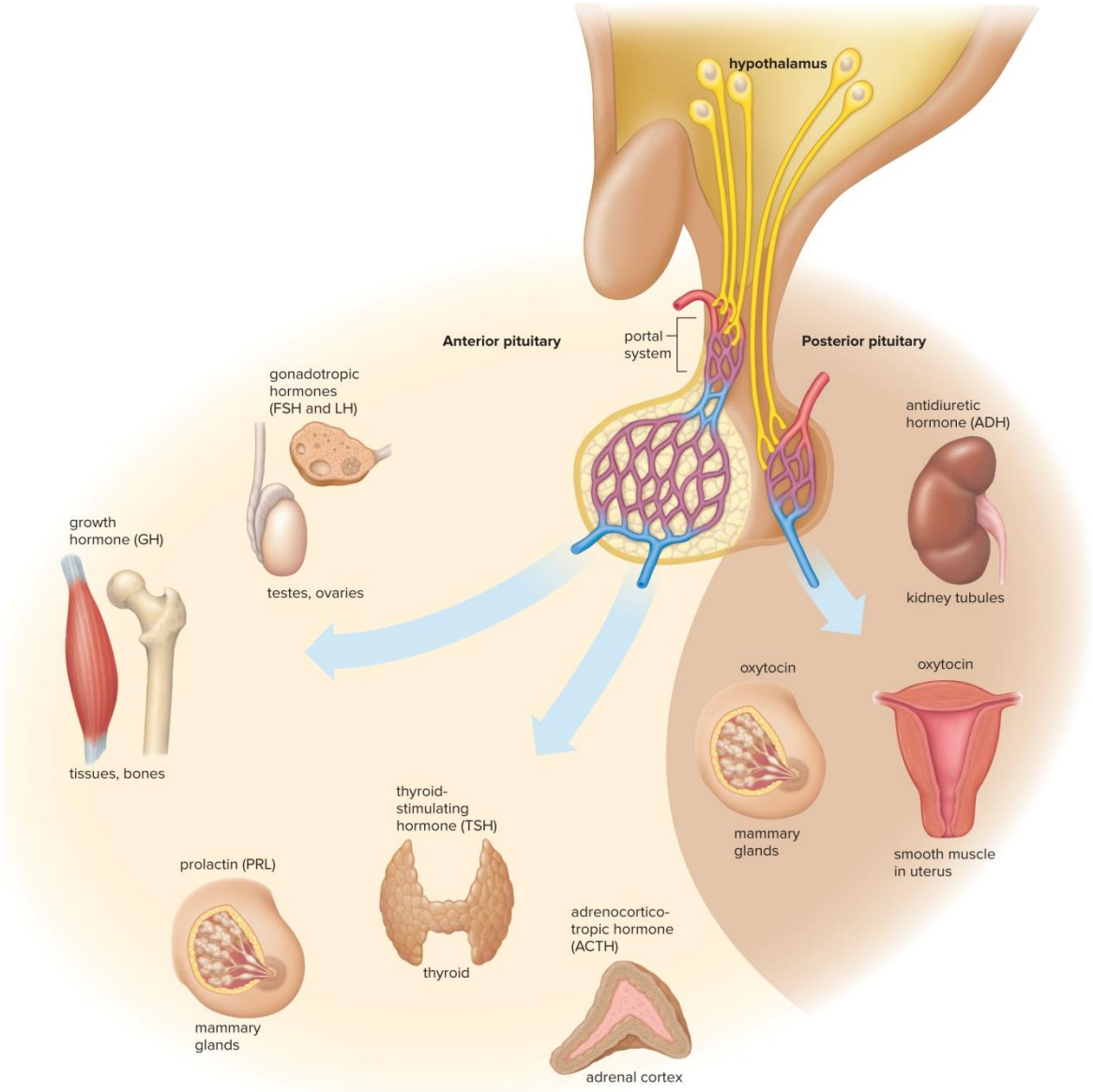


Posterior Pituitary

Posterior pituitary

- Hypothalamus produces two hormones
  - Antidiuretic hormone (ADH)
    - Causes water to be reabsorbed in kidneys
    - Also controlled by negative feedback
  - Oxytocin
    - Causes uterine contractions during childbirth and milk letdown when a baby is nursing
- Axons of hypothalamic secretory neurons extend into posterior pituitary

Figure 27.16 The Hypothalamus and Pituitary



Thyroid

Calcium regulation

- Calcium plays significant role in nervous conduction, muscle contraction, and blood clotting
- Thyroid also produces calcitonin
  - Helps lower blood calcium level
  - Reduces number and activity of osteoclasts—cells that break down bone
- Parathyroid glands produce parathyroid hormone (PTH)
  - Increases blood calcium level
  - Promotes the action of osteoclasts and the release of calcium
  - Also promotes reabsorption of calcium from kidneys
  - Activates vitamin D to stimulate absorption of calcium from intestine
  - Without enough PTH tetany can result—body shakes from continual muscle contraction

Adrenal Glands, 1

Adrenal glands

- Sit atop the kidneys
- Each gland has an inner adrenal medulla and outer adrenal cortex.
- Hypothalamus exerts control over both areas
  - Adrenal medulla controlled by nerve impulses from sympathetic nervous system
  - ACTH-releasing hormone (hypothalamus) and ACTH (anterior pituitary) control adrenal cortex
- Stress (emotional or physical) prompts hypothalamus to stimulate both regions

Adrenal Glands, 2

Adrenal medulla

- Epinephrine (adrenaline) and norepinephrine (noradrenaline) rapidly bring about all the body changes when an individual reacts to an emergency.
- Complement action of sympathetic autonomic system
- Effects are short-term

Adrenal Cortex

Adrenal cortex

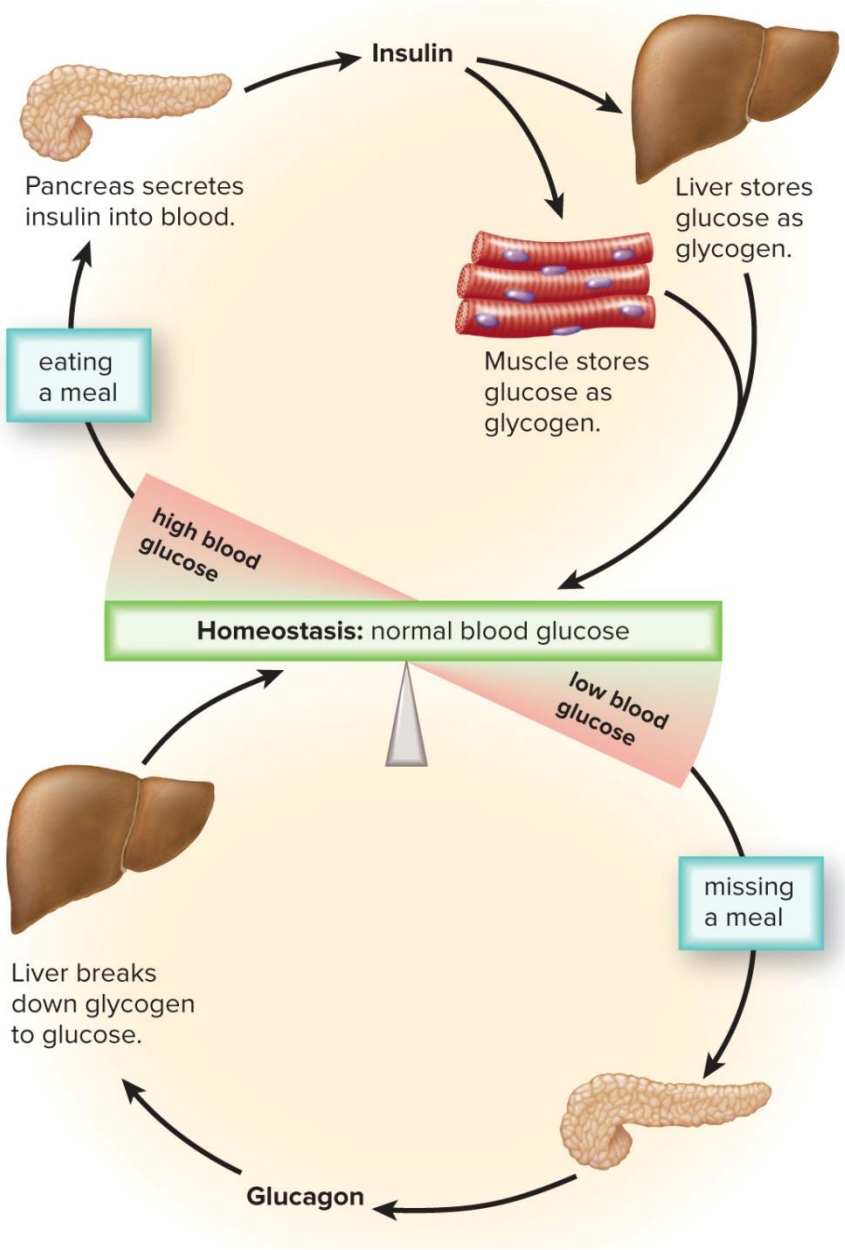
- Mineralcorticoids—like aldosterone
  - Aldosterone acts on kidneys to regulate salt and water balance.
  - Leads to increased blood volume and blood pressure
- Glucocorticoids—like cortisol
  - Cortisol regulates carbohydrate, protein, and fat metabolism.
  - Leads to an increased blood glucose level
  - Also anti-inflammatory
- Small amounts of both male and female sex hormones secreted in both sexes

Pancreas

Pancreas

- Composed of two types of tissue
  - Exocrine tissue produces digestive juices that pass through ducts to the small intestine.
  - Endocrine tissue (pancreatic islets) produces and secretes insulin and glucagon directly into the blood.
- Insulin
  - Lowers blood glucose
  - Stimulates uptake of glucose by cells—especially liver, muscle, and adipose tissue cells
- Glucagon
  - Raises blood glucose
  - Stimulates liver to break down glycogen to glucose and to use fat and protein instead of glucose as an energy source

Figure 27.20 Regulation of Blood Glucose Level



Diabetes Mellitus

Diabetes mellitus

- All body cells do not take up and/or metabolize glucose.
- Cells are in need of glucose even though blood sugar levels are high.
- Type 1 diabetes
  - Insulin-dependent diabetes
  - Pancreas not producing insulin
  - May be an autoimmune disease where cytotoxic T cells destroy pancreatic islets
- Type 2 diabetes
  - Non-insulin-dependent
  - Obesity associated
  - Liver and muscle cells do not respond to insulin—insulin resistant
  - Controlled through diet and exercise