The Endocrine System

- Uses chemical messages (hormones) that are released into the blood
- Hormones control several major processes:
  - Reproduction
  - Growth and development
  - Mobilization of body defenses
  - Maintenance of homeostasis
  - Regulation of metabolism

The Chemistry of Hormones

- Amino acid-based hormones:
  - Proteins
  - Peptides
  - Amines
- Steroids – made from cholesterol.
- Prostaglandins – made from highly active lipids.

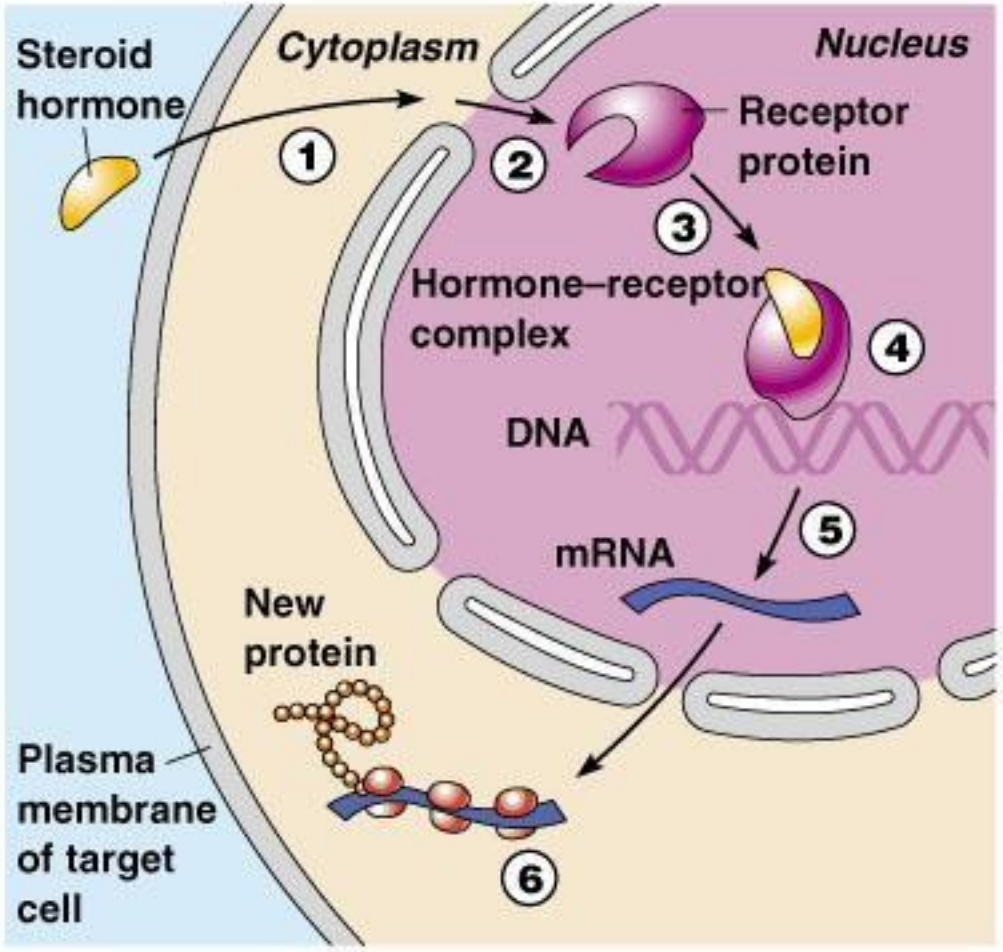
Effects Caused by Hormones:

- Changes in plasma membrane permeability or electrical state.
- Synthesis of proteins, such as enzymes.
- Activation or inactivation of enzymes.
- Stimulation of mitosis.

Steroid Hormone Action:

- Diffuse through the plasma membrane of target cells.
- Enter the nucleus.
- Bind to a specific protein within the nucleus.
- Bind to specific sites on the cell's DNA.
- Activate genes that result in the synthesis of new proteins.

Steroid Hormone Action



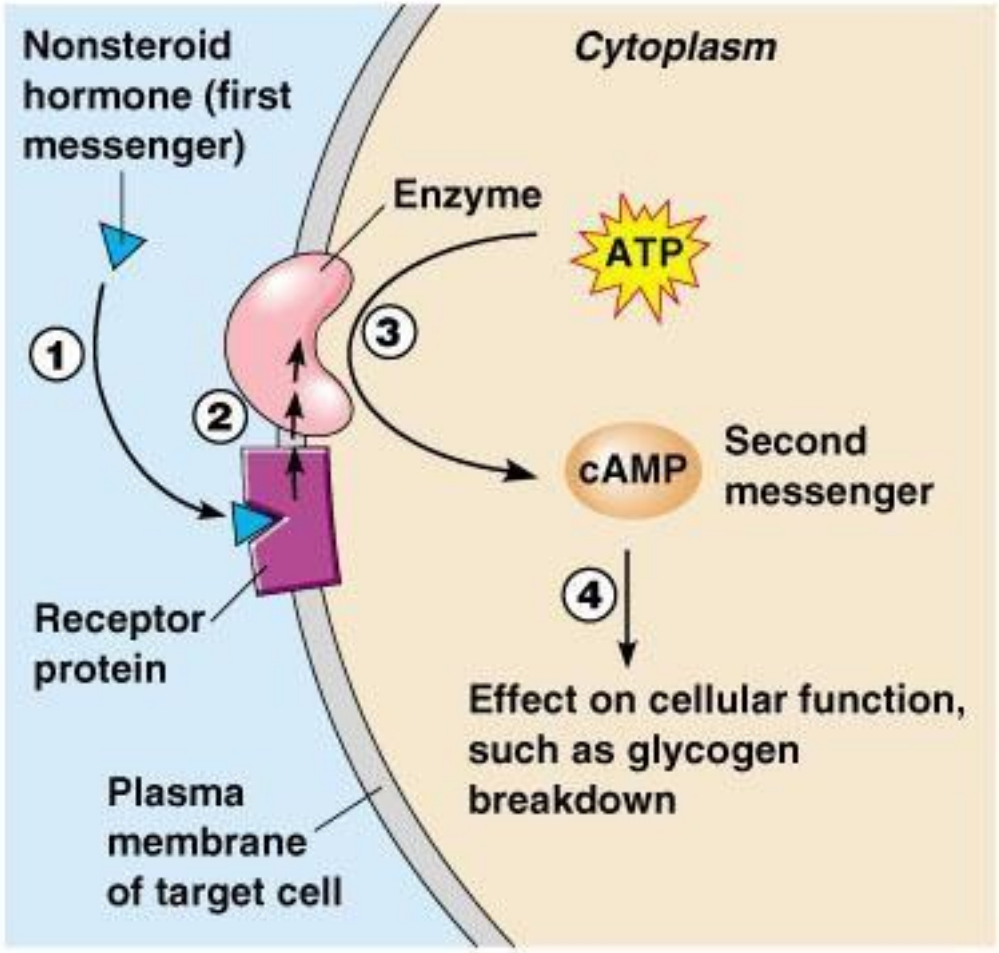
(a) Steroid hormone action

Figure 9.1a

Nonsteroid Hormone Action

- Hormone binds to a membrane receptor.
- Hormone does not enter the cell.
- Sets off a series of reactions that. activate an enzyme.
- Catalyzes a reaction that produces a second messenger molecule.
- Oversees additional intracellular changes to promote a specific response.

Nonsteroid Hormone Action



(b) Nonsteroid hormone action

Figure 9.1b

Control of Hormone Release:

- Hormone levels in the blood are maintained by negative feedback.
- A stimulus or low hormone levels in the blood triggers more hormone release.
- Hormone release stops once an appropriate level in the blood is reached.

Hormonal Stimuli of Endocrine Glands

- Other hormones activate endocrine glands.

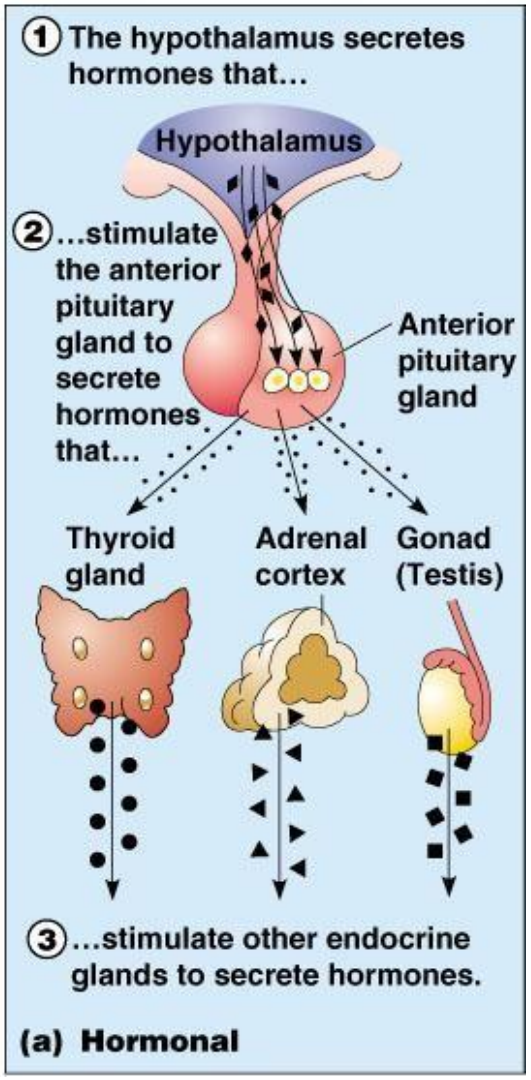


Figure 9.2a

Location of Major Endrocrine Organs

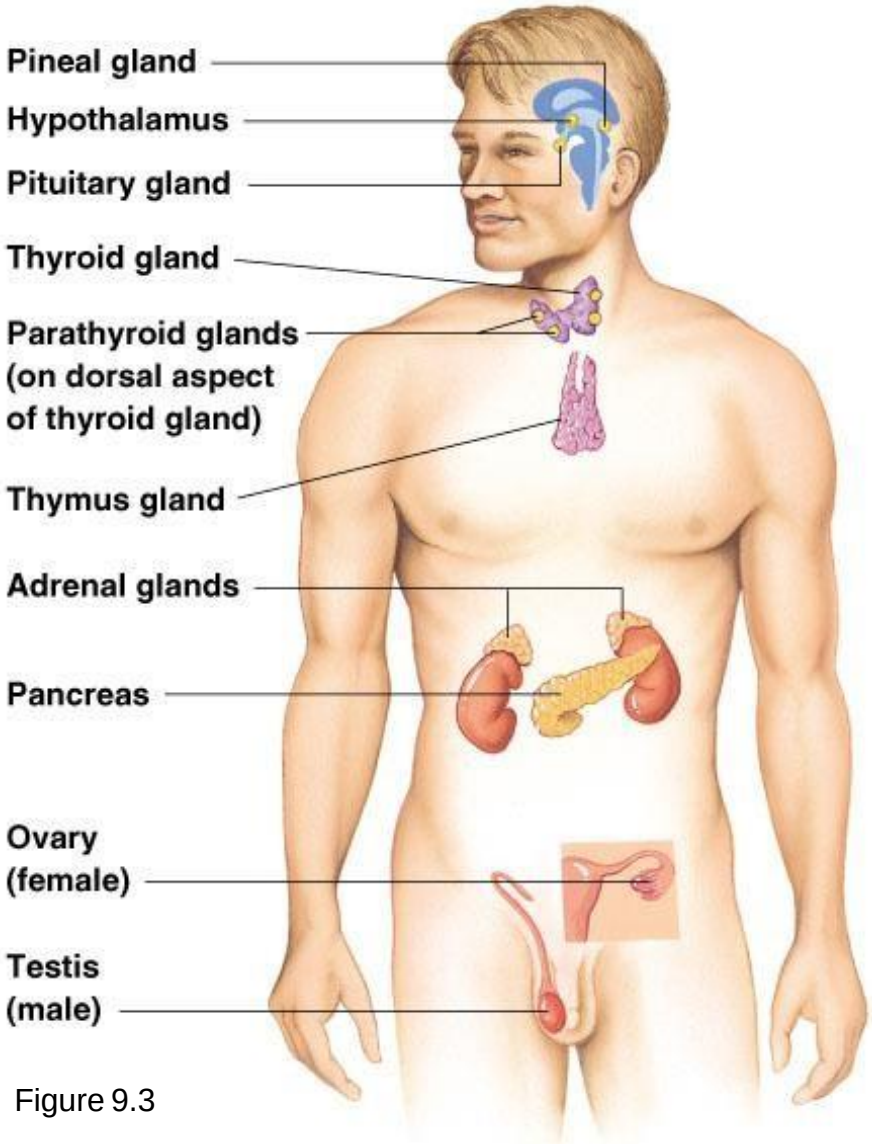


Figure 9.3

Pituitary Gland:

- Hangs by a stalk from the hypothalamus.
- Has two functional lobes:
  - Anterior pituitary – glandular tissue.
  - Posterior pituitary – nervous tissue.

Hormones of the Anterior Pituitary

- Six anterior pituitary hormones.
- Two affect non-endocrine targets.
  - Four stimulate other endocrine glands (tropic hormones).
- Characteristics of all anterior pituitary hormones:
  - Proteins (or peptides).
  - Act through second-messenger systems.
  - Regulated by hormonal stimuli, mostly negative feedback.

Hormones of the Anterior Pituitary

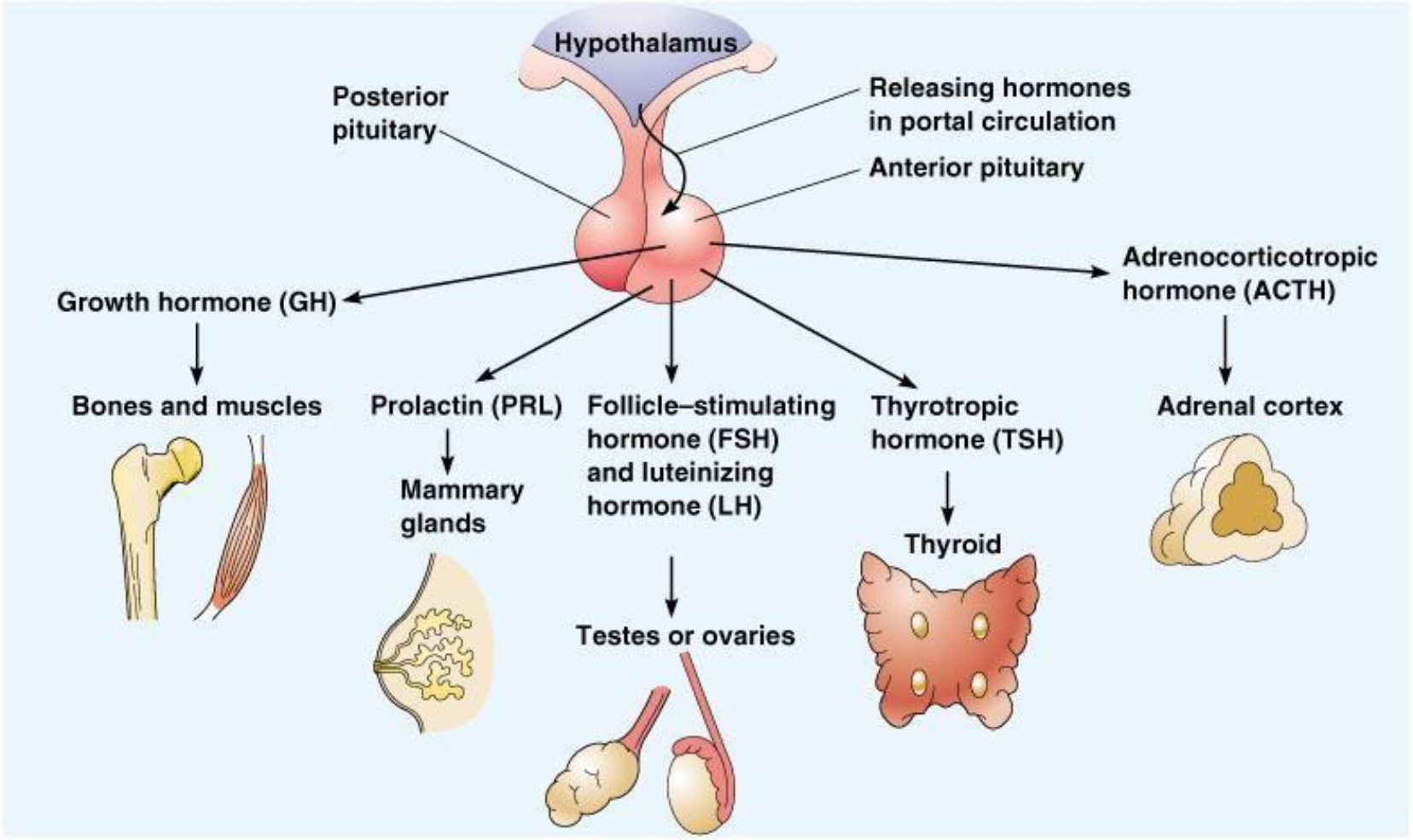


Figure 9.4

Growth Hormone (GH);

- General metabolic hormone.
- Major effects are directed to the growth of skeletal muscles and long bones.
- Causes amino acids to be built into proteins.
- Causes fats to be broken down for a source of energy.

Functions of Other Anterior Pituitary Hormones

- Prolactin (PRL):
  - Stimulates and maintains milk production following childbirth.
- Adrenocorticotropic hormone (ACTH):
  - Regulates endocrine activity of the adrenal cortex.
- Thyroid-stimulating hormone (TSH).
  - Influences growth and activity of the thyroid.

Functions of Other Anterior Pituitary Hormones

- Gonadotropic hormones:
  - Regulate hormonal activity of the gonads.
    - Follicle-stimulating hormone (FSH):
      - Stimulates follicle development. In ovaries.
      - Stimulates sperm development in the testes.

Functions of Other Anterior Pituitary Hormones:

- **Gonadotropic hormones:**
  - Luteinizing hormone (LH):
    - Triggers ovulation.
    - Causes ruptured follicle to become the corpus luteum.
    - Stimulates testosterone production in males.

Pituitary - Hypothalamus Relationship

- Release of hormones is controlled by releasing and inhibiting hormones produced by the hypothalamus.
- The posterior pituitary is not strictly an endocrine gland but does release hormones.

Hormones of the Posterior Pituitary

- Oxytocin:
  - Stimulates contractions of the uterus during labor.
  - Causes milk ejection.
- Antidiuretic hormone (ADH):
  - Can inhibit urine production.
  - In large amounts, causes vasoconstriction leading to increased blood pressure (vasopressin).

Hormones of the Posterior Pituitary

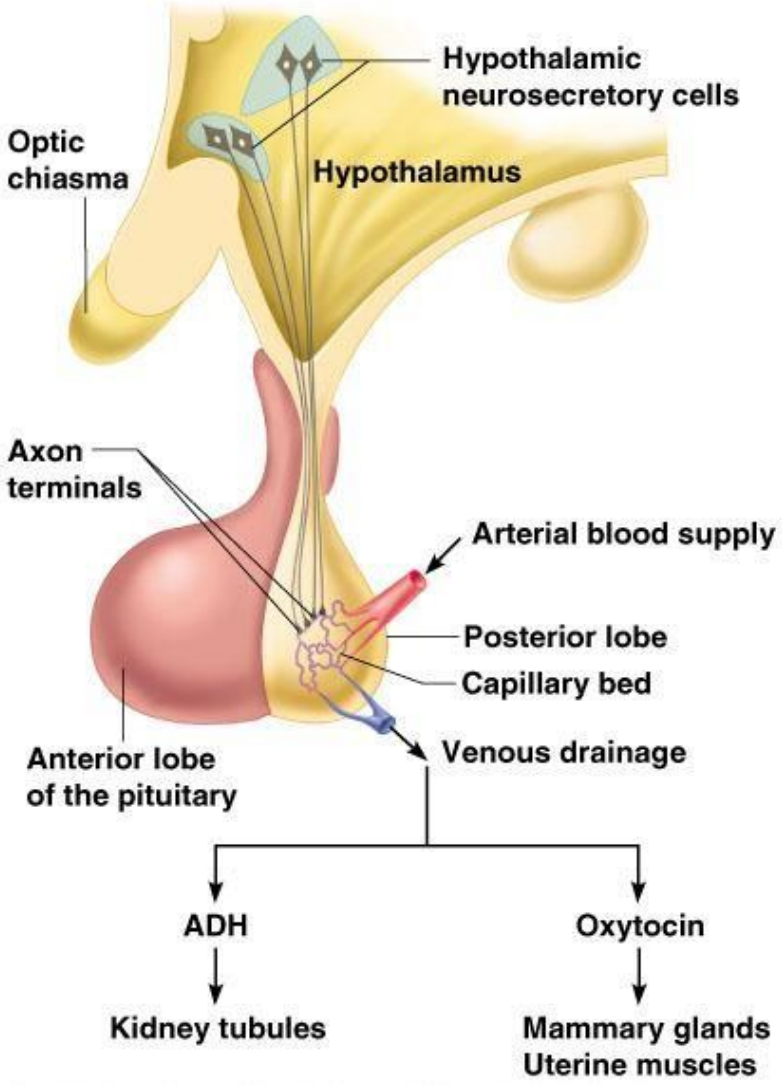


Figure 9.5

Thyroid Gland:

- Found at the base of the throat.
- Consists of two lobes.
- Produces **two hormones**.
  - Thyroid hormones.
  - Calcitonin.

Thyroid Gland

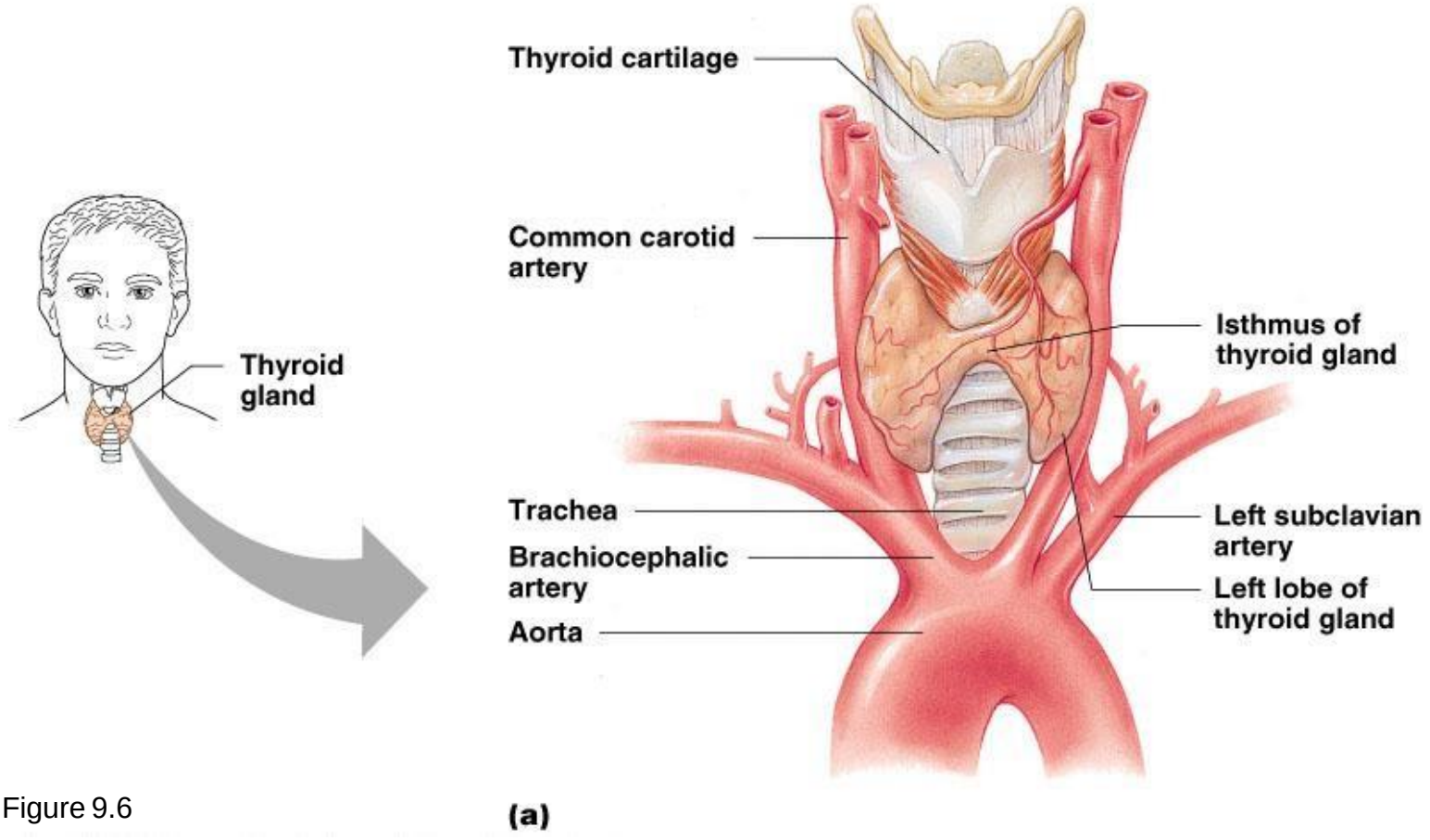


Figure 9.6

Thyroid Hormones:

- Major metabolic hormones.
- Composed of two active iodine-containing hormones.
  - Thyroxine (T_4) – secreted by thyroid follicles.
  - Triiodothyronine (T_3) – convert to T_4 at target tissues.

Calcitonin

- Decreases blood calcium levels by causing its deposition on bone
- Antagonistic to parathyroid hormone
- Produced by C (parafollicular) cells

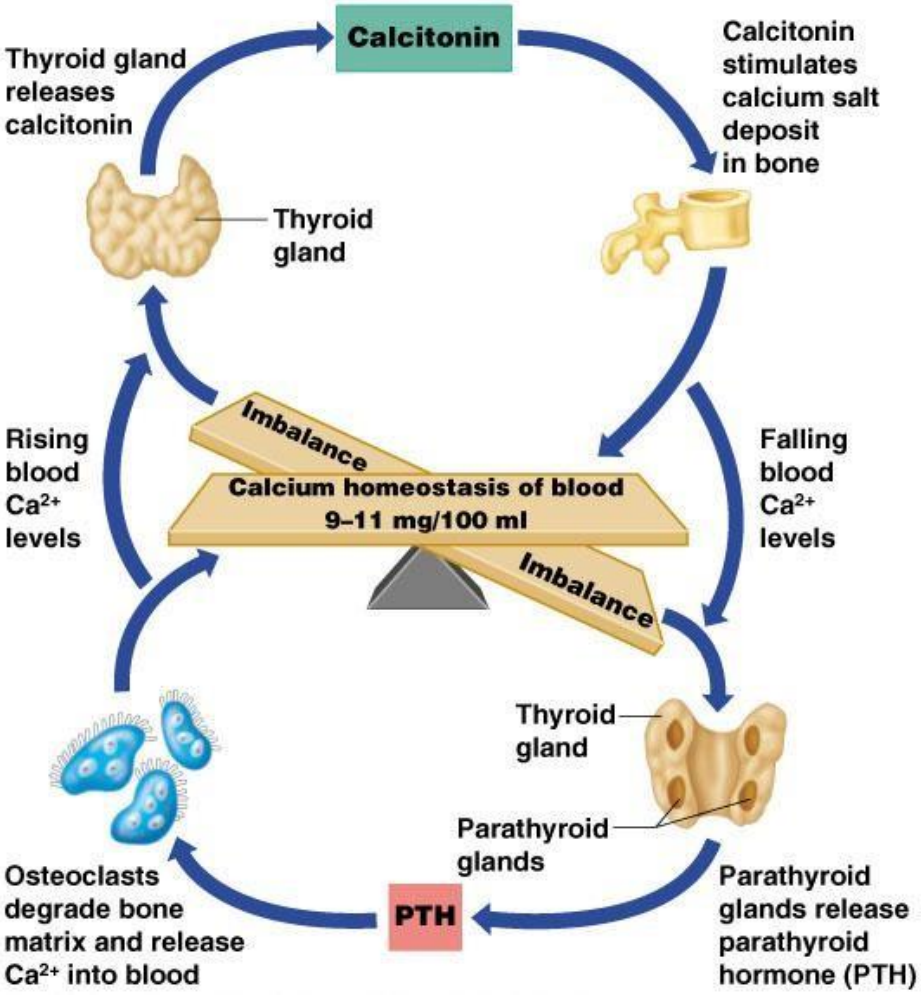


Figure 9.9

Parathyroid Glands:

- Tiny masses on the posterior of the thyroid.
- Secrete parathyroid hormone
  - Stimulate osteoclasts to remove calcium from bone.
  - Stimulate the kidneys and intestine to absorb more calcium.
  - Raise calcium levels in the blood.

Adrenal Glands:

- **Two glands:**
  - Cortex – the outer glandular region in three layers.
  - Medulla – inner neural tissue region.
- Sits on top of the kidneys.

Hormones of the Adrenal Cortex

- Mineralocorticoids (mainly aldosterone).
  - Produced in the outer adrenal cortex.
  - Regulate mineral content in blood, water, and electrolyte balance.
  - The target organ is the kidney.
  - Production stimulated by renin and aldosterone.
  - Production inhibited by atrial natriuretic peptide.

Hormones of the Adrenal Cortex

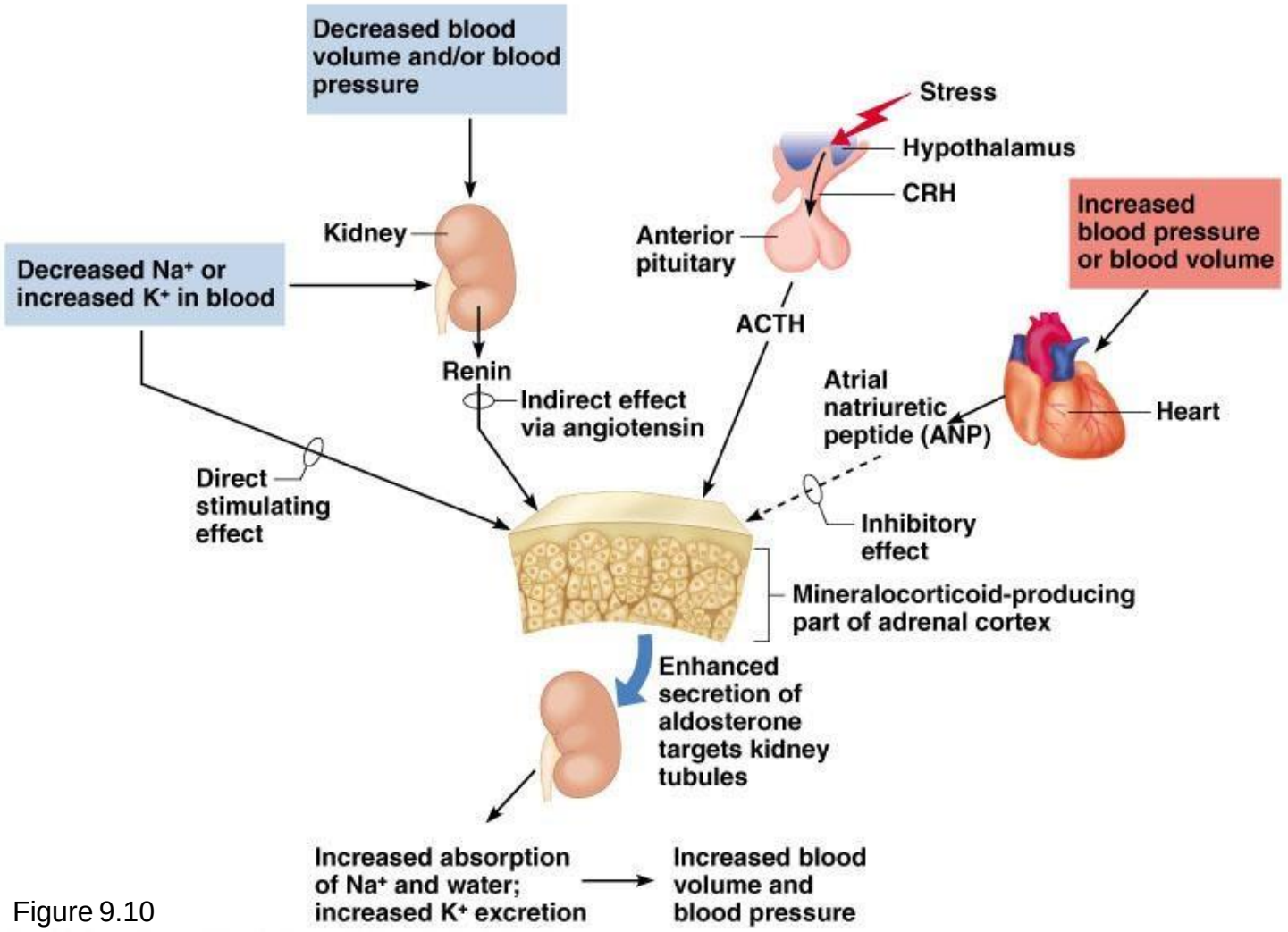


Figure 9.10

Hormones of the Adrenal Cortex

- Glucocorticoids (including cortisone and cortisol)
  - Produced in the middle layer of the adrenal cortex
  - Promote normal cell metabolism
  - Released in response to increased Adrenocorticotropic hormone (ACTH) blood levels.

Hormones of the Adrenal Cortex:

- **Sex hormones**:
  - Produced in the inner layer of the adrenal cortex.
  - Androgens (male) and estrogen (female)

Hormones of the Adrenal Medulla

- Produces two similar hormones (catecholamines):
  - Epinephrine
  - Norepinephrine
- These hormones prepare the body to deal with short-term stress.

Roles of the Hypothalamus and Adrenal Glands in the Stress Response

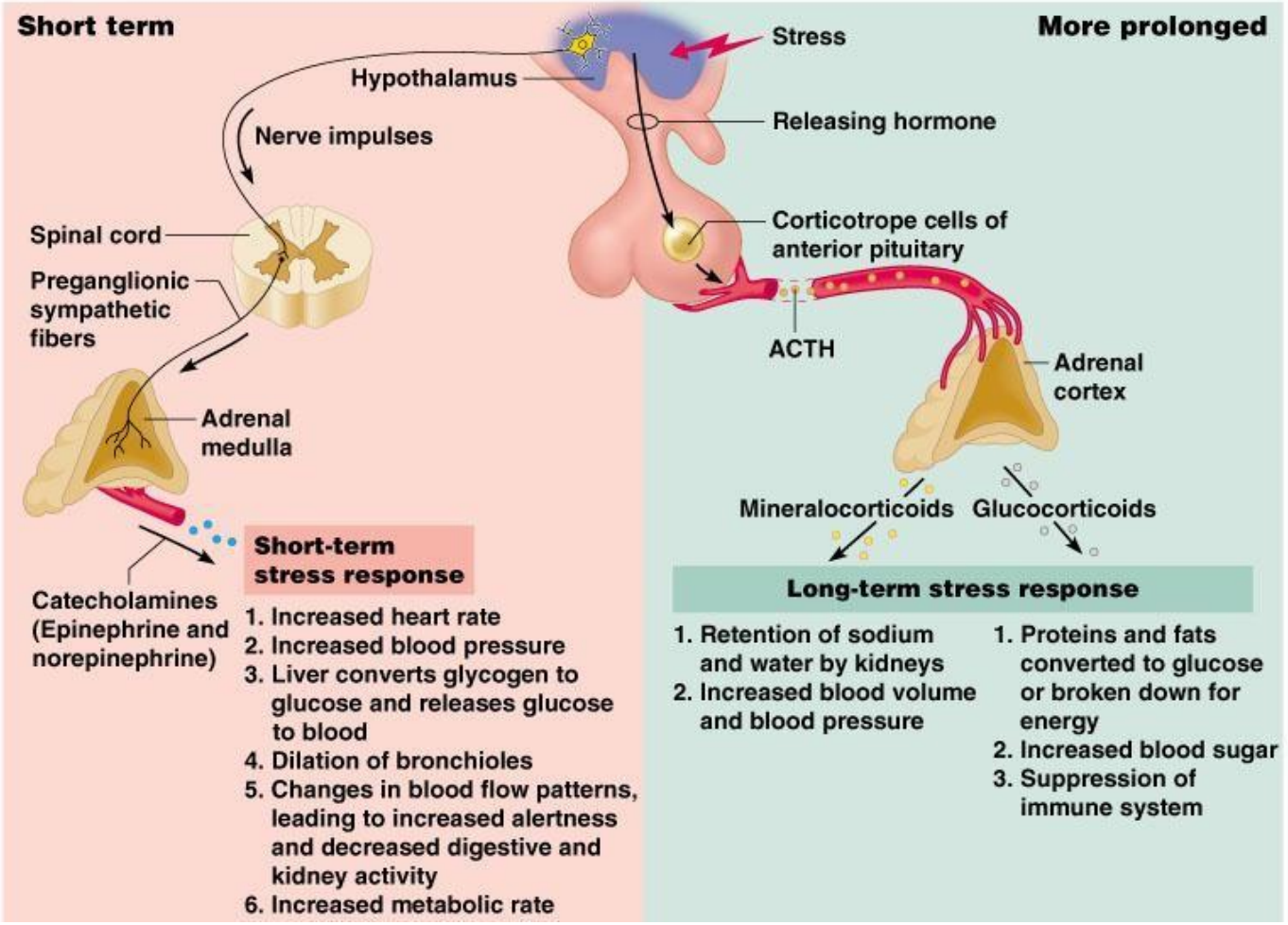


Figure 9.12

Pancreatic Islets:

- The islets of the pancreas produce hormones:
  - Insulin – allows glucose to cross plasma membranes into cells from beta cells.
  - Glucagon – allows glucose to enter the blood from alpha cells.
  - These hormones are antagonists that maintain blood sugar homeostasis.

Pancreatic Islets

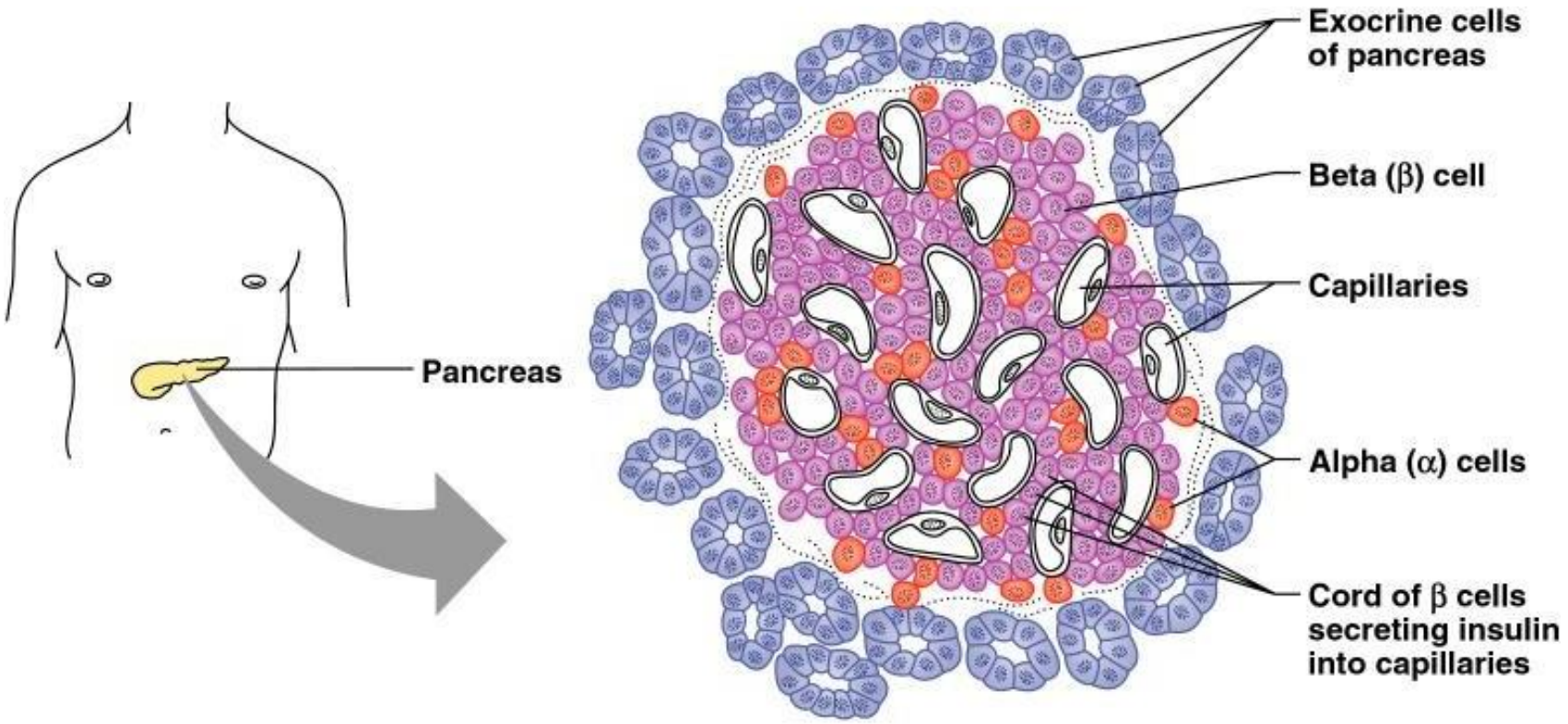


Figure 9.13

Pancreatic Hormones and Blood Sugar

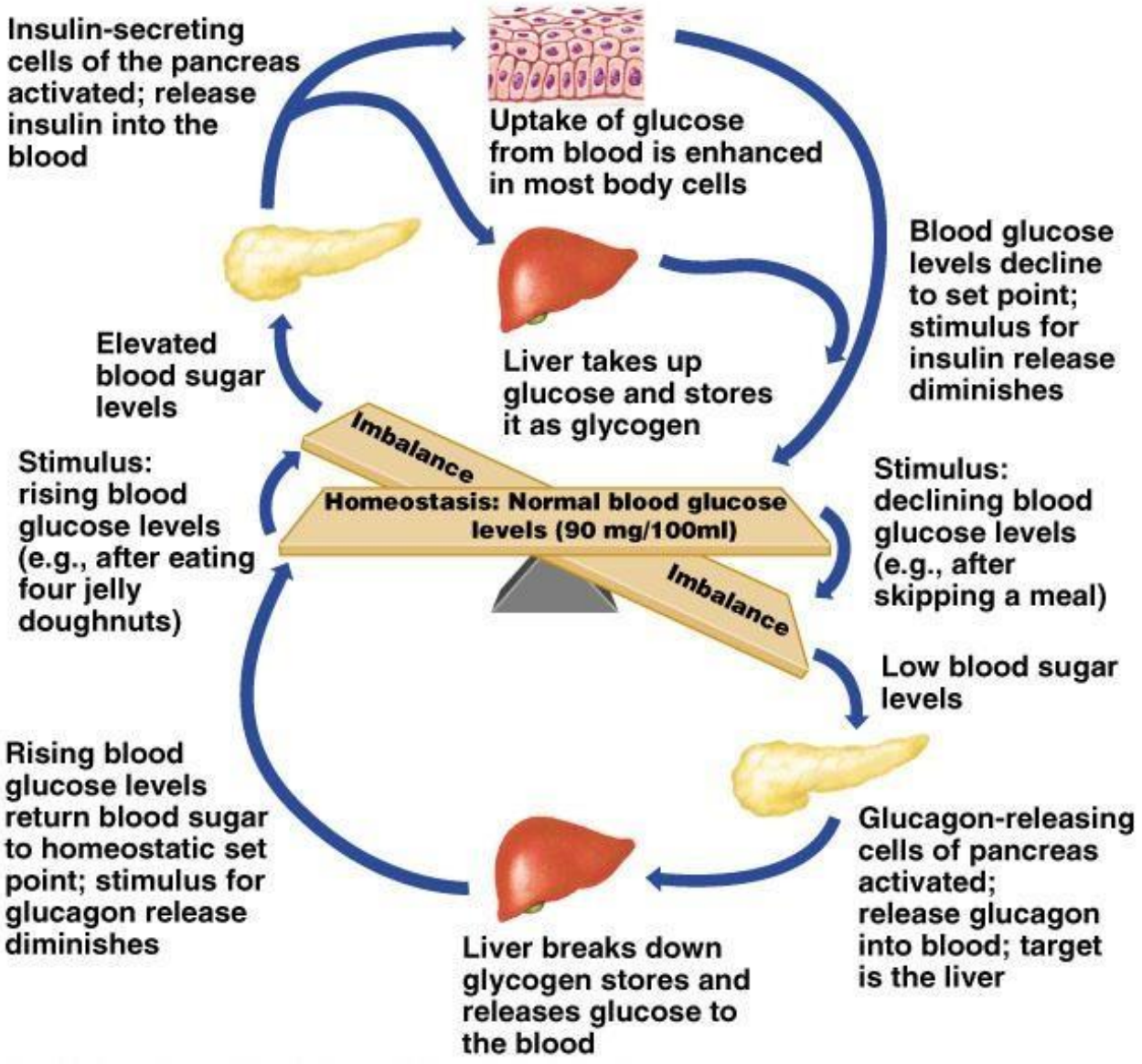


Figure 9.14

Pineal Gland:

- Found on the third ventricle of the brain.
- Secretes melatonin.
  - Helps establish the body's wake and sleep cycles.

Hormones of the Ovaries

- **Estrogens:**
  - Produced by Graafian follicles or the placenta
  - Stimulates the development of secondary female characteristics.
  - Mature of female reproductive organs.
  - Helps prepare the uterus to receive a fertilized egg.
  - Helps maintain pregnancy.
  - Prepares the breasts to produce milk.

Hormones of the Ovaries

- Progesterone:
  - Produced by the corpus luteum.
  - Acts with estrogen to bring about the menstrual cycle.
  - Helps in the implantation of an embryo in the uterus.

Endocrine Function of the Placenta

- Produces hormones that maintain the pregnancy.
- Some hormones play a part in the delivery of the baby.
- Produces Human chorionic gonadotropin (HCG) in addition to estrogen, progesterone, and other hormones.

Developmental Aspects of the Endocrine System

- Most endocrine organs operate smoothly until old age.
  - Menopause is brought about by the lack of efficiency of the ovaries.
  - Problems associated with reduced. Estrogen is common.
  - Growth hormone production declines with age.
  - Many endocrine glands decrease output with age.

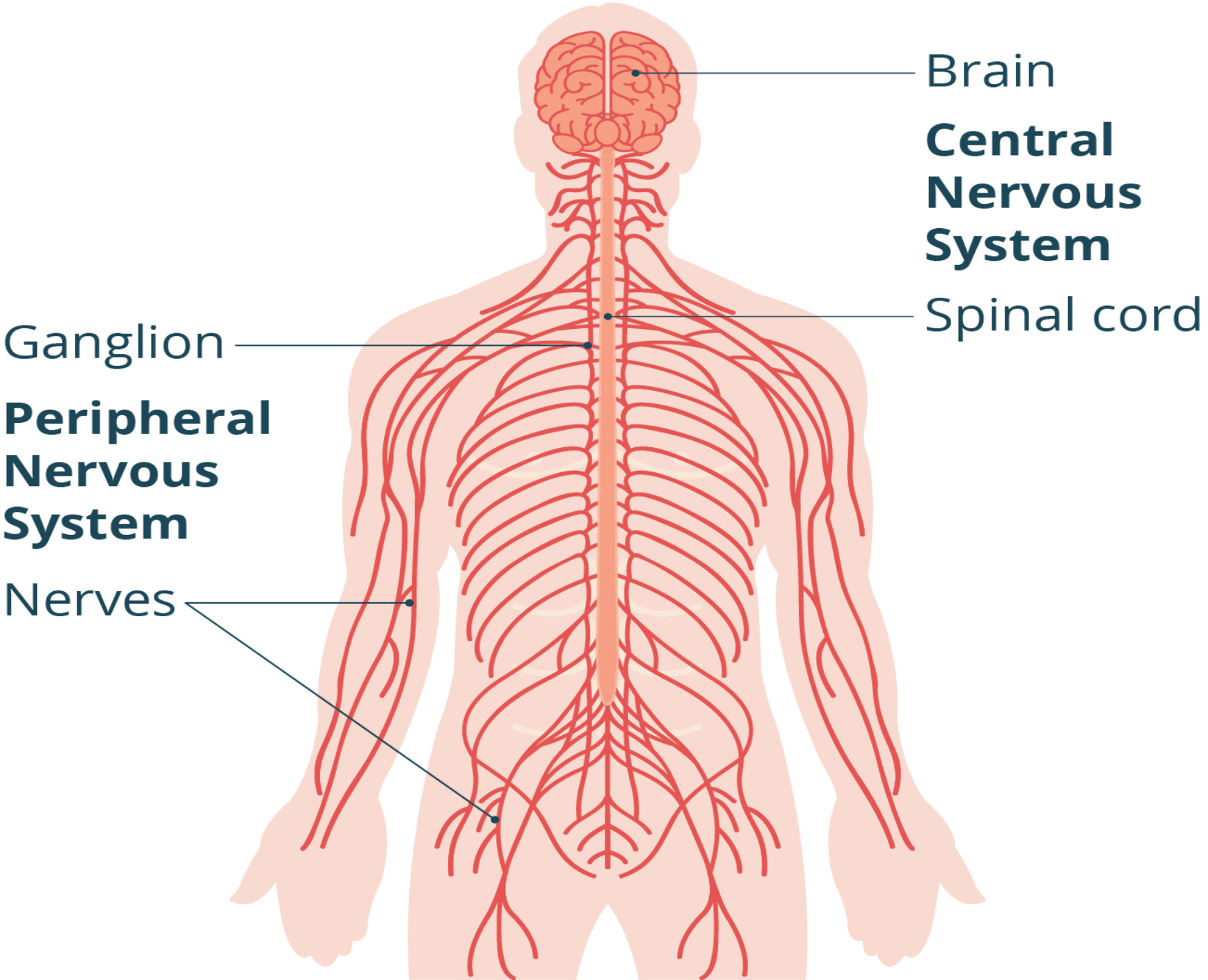
Introduction to the Central Nervous System (CNS):

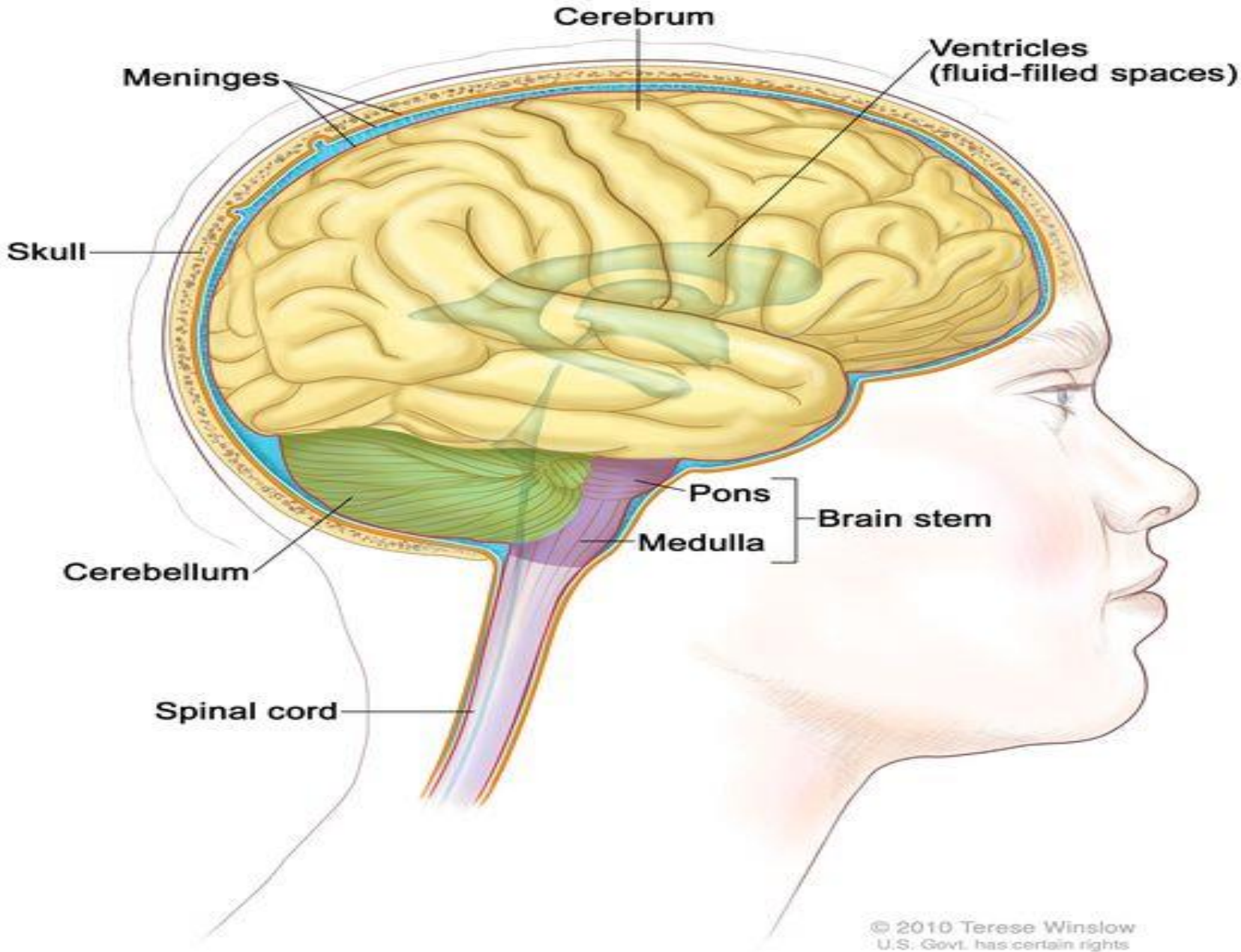
- What is the CNS? (Brain and spinal cord)
- Its primary function: Control and coordination of bodily functions.
- Relevance to Pharmacy: Understanding CNS function is crucial for comprehending the mechanism of action of numerous drugs, particularly psychotropics and neurotherapeutics. Many drugs interact with CNS receptors or enzymes.

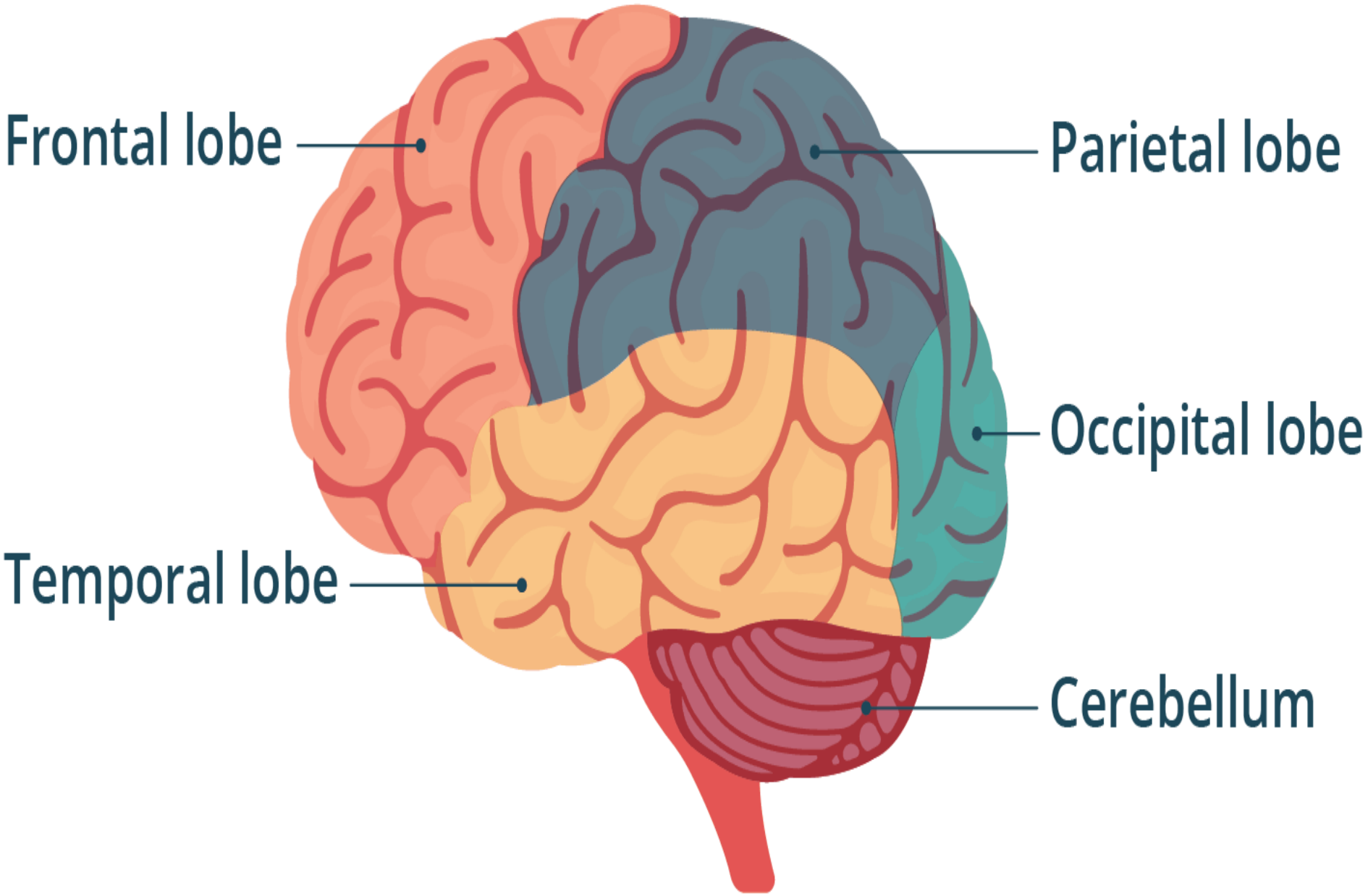
Anatomy of the CNS:

The Brain:

1. **Cerebrum:** The largest part is responsible for higher cognitive functions (thinking, learning, memory, language). lobes: (frontal, parietal, temporal, occipital).
2. **Cerebellum:** Coordination of movement, balance, posture.
3. **Brainstem:** (midbrain, pons, medulla oblongata) Controls vital functions (breathing, heart rate, blood pressure).
4. **Thalamus:** Relays sensory information to the cerebral cortex.
5. **Hypothalamus:** Regulates homeostasis (temperature, hunger, thirst, hormone release).


Brain
Central Nervous System
Spinal cord
Ganglion
Peripheral Nervous System
Nerves


Cerebrum
Ventricles
(fluid-filled spaces)
Meninges
Skull
Pons
Brain stem
Medulla
Cerebellum
Spinal cord
© 2010 Terese Winslow
U.S. Govt. has certain rights


Frontal lobe
Parietal lobe
Occipital lobe
Temporal lobe
Cerebellum

The Spinal Cord:

- Structure: Gray matter (cell bodies) and white matter (axons).
- Function: Transmits nerve impulses between the brain and the rest of the body.

Cells of the Nervous System:

- **Neurons:** Structure (cell body, axon, dendrites). Types (sensory, motor, interneurons). Their function: signal transmission (action potentials).
- **Glial Cells:** Support and protection of neurons.
- **main types:** (astrocytes, oligodendrocytes, microglia).

Blood-Brain Barrier (BBB):

- Definition and function: Protects the brain from harmful substances.
- Implications for drug delivery: Many drugs struggle to cross the BBB, impacting their effectiveness in treating CNS disorders.

Functions of the CNS:

- **Sensory Functions:** Reception and processing of sensory information (sight, hearing, smell, taste, touch).
- **Motor Functions:** Control of voluntary and involuntary movements.
- **Higher-order functions:** Cognition, memory, learning, language, and emotion.