

# The Endocrine System

# The Endocrine System

- Glands and organs produce hormones
- Second messenger system of the body
- 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 much of homeostasis
  - Regulation of metabolism



# Hormone Overview

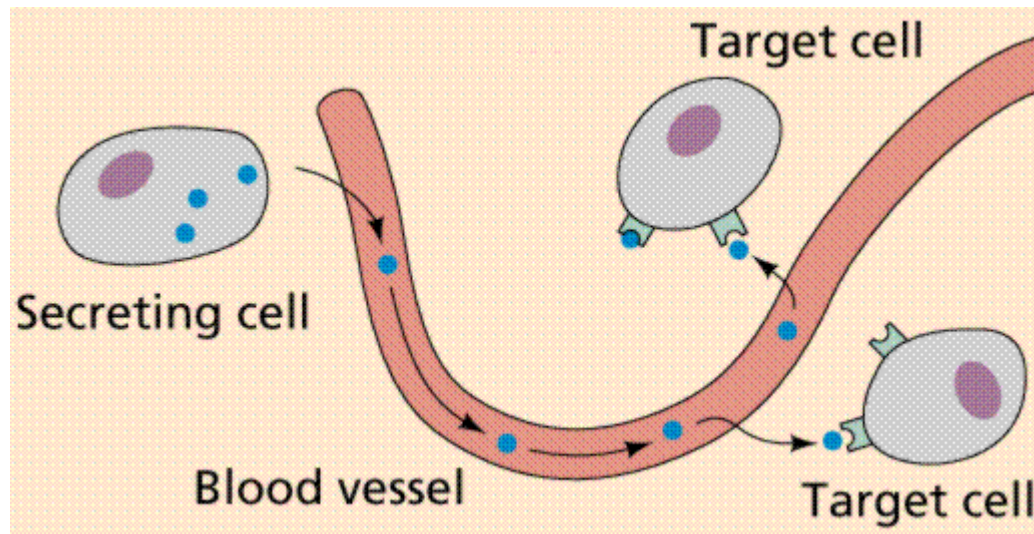
- Hormones are produced by specialized cells
- Cells secrete hormones into extracellular fluids
- Blood transfers hormones to target sites
- These hormones regulate the activity of other cells

# The Chemistry of Hormones

- Amino acid-based hormones
- Steroids – made from cholesterol
- Prostaglandins – made from highly active lipids

# Mechanisms of Hormone Action

- Hormones affect only certain tissues or organs (target cells or organs)
- Target cells must have specific protein receptors
- Hormone binding influences the working of the cells



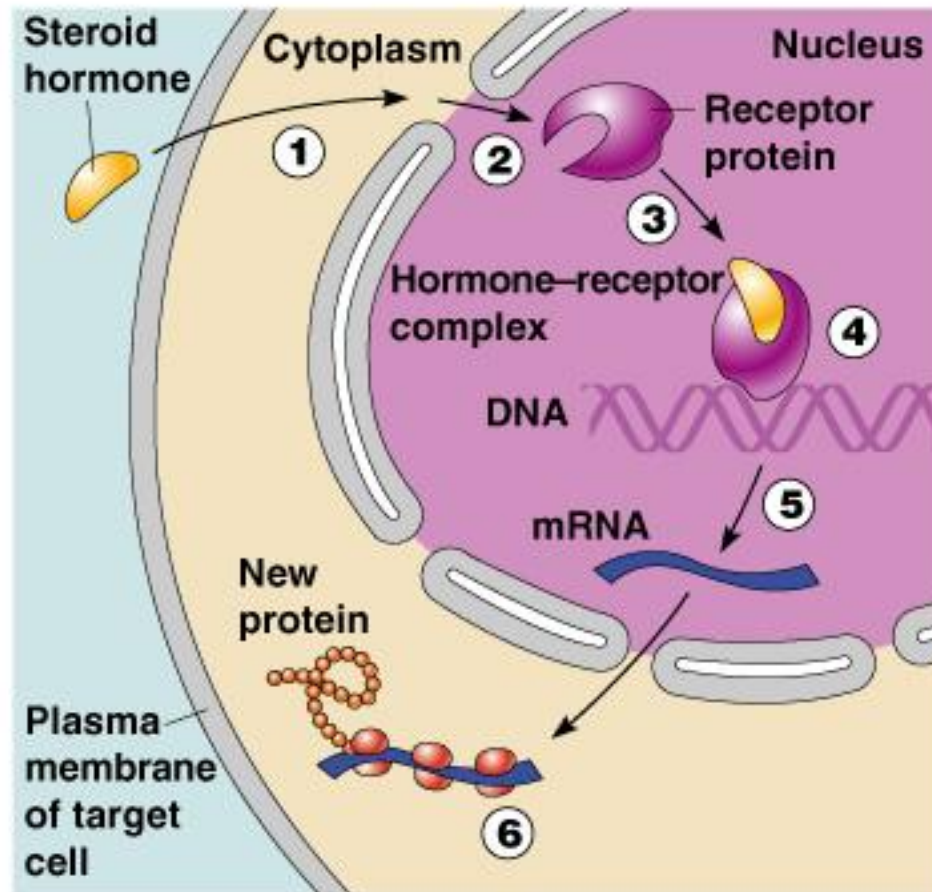
# Effects Caused by Hormones

- 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 synthesis of new proteins

# Steroid Hormone Action



**(a) Steroid hormone action**

**PRESS  
TO PLAY**

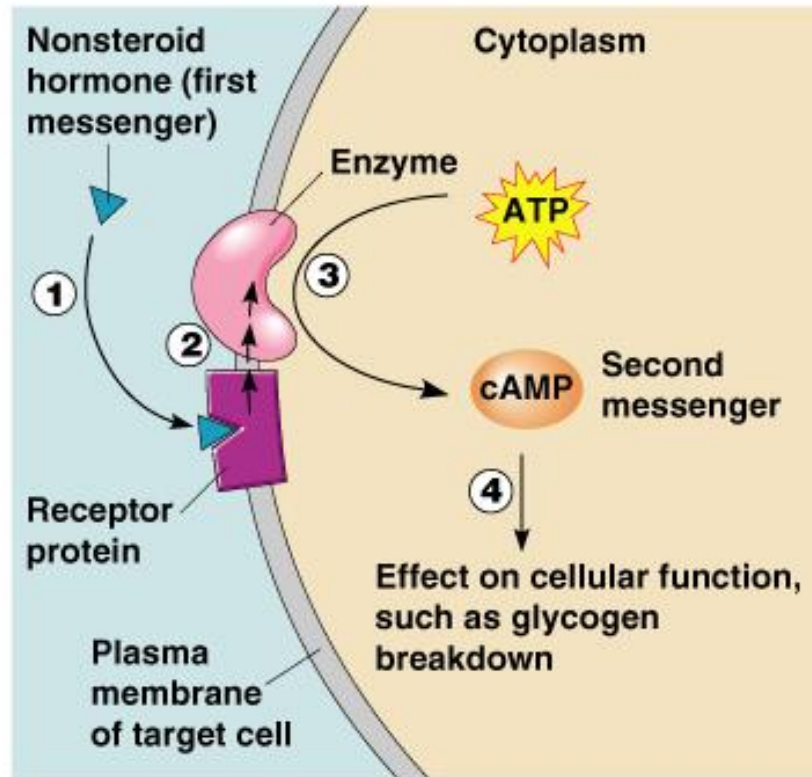
**STEROID HORMONE ANIMATION**



# Nonsteroid Hormone Action

- Hormone binds to a membrane receptor
- Hormone does not enter the cell
- Sets off a series of reactions that activates 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**

**PRESS  
TO PLAY**

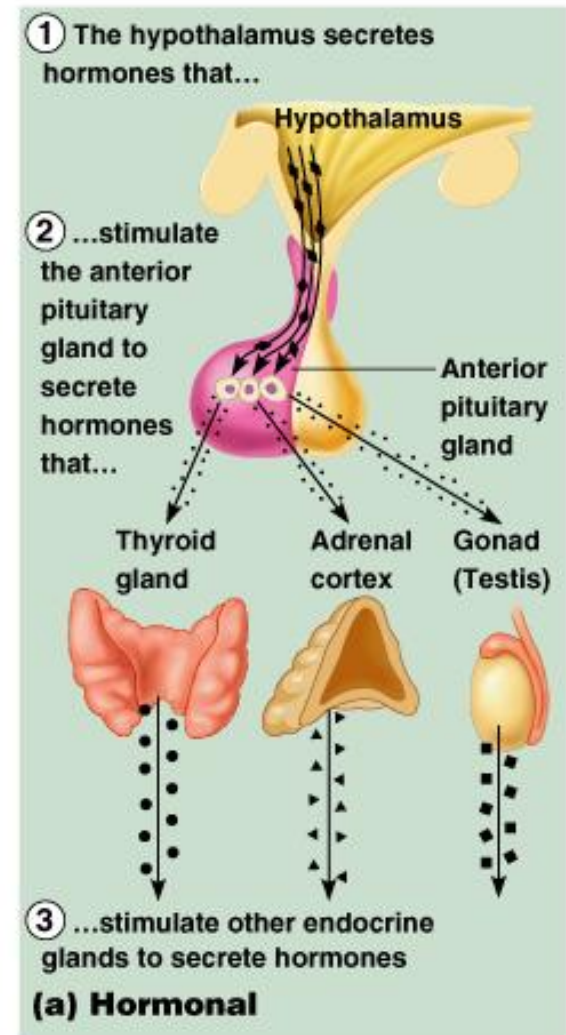
**NONSTEROID HORMONE ANIMATION**

# Control of Hormone Release

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

# Hormonal Stimuli of Endocrine Glands

- Endocrine glands are activated by other hormones
- Hypothalamus in the brain secretes:
- Inhibiting Hormone- turns off pituitary
- Releasing Hormone- turns on pituitary



# Location of Major Endocrine Organs

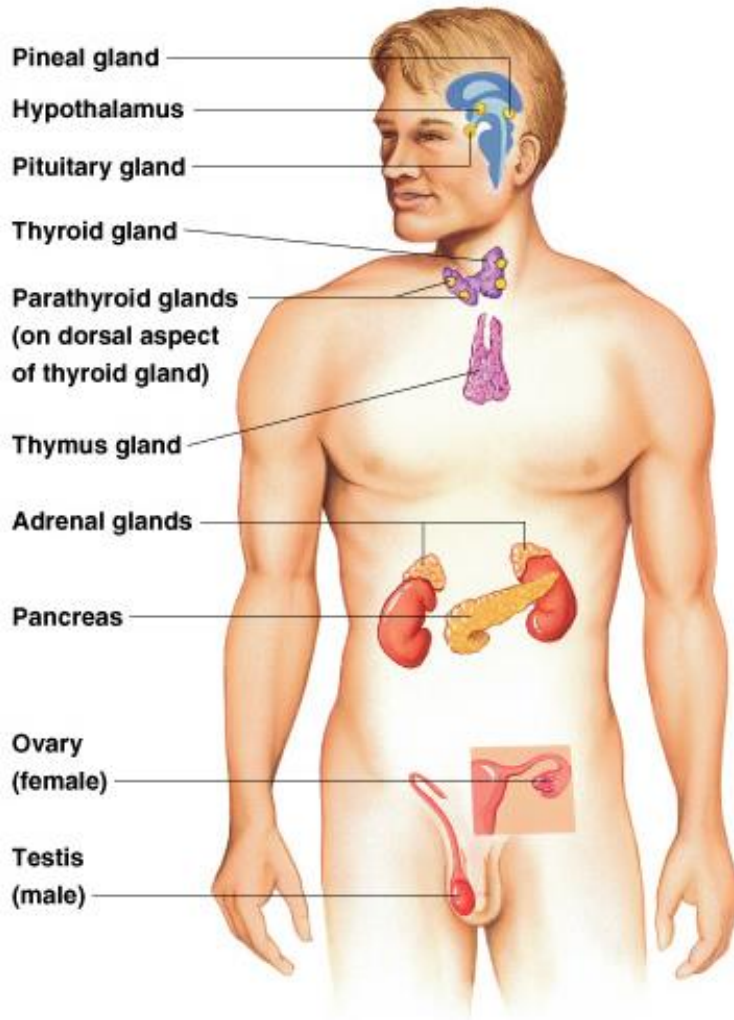
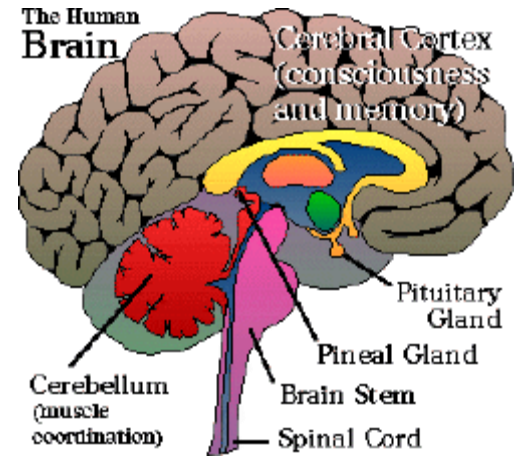


Figure 9.3

# Pituitary Gland

- Size of a grape
- Hangs by a stalk from the hypothalamus
- Protected by the sphenoid bone
- Has two functional lobes
  - Anterior pituitary – glandular tissue
  - Posterior pituitary – nervous tissue



# Hormones of the Anterior Pituitary

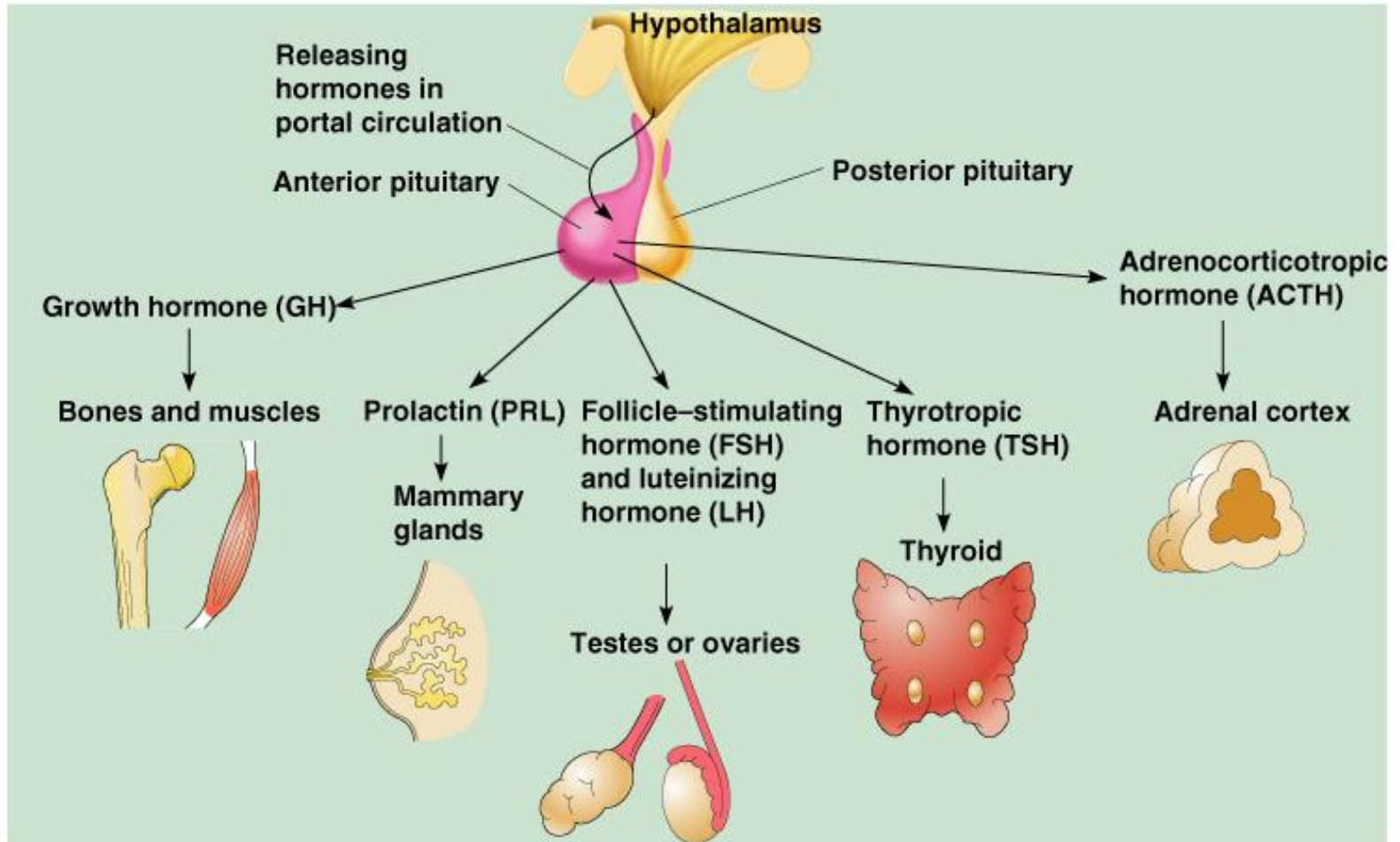


Figure 9.4

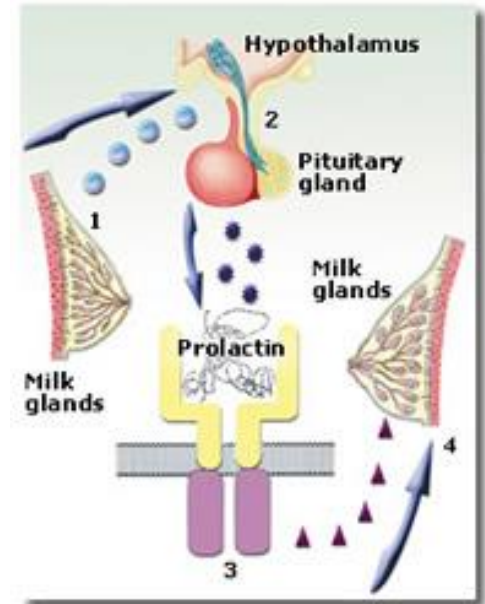
# Growth Hormone (GH)

- General metabolic hormone
- Major effects are directed to 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



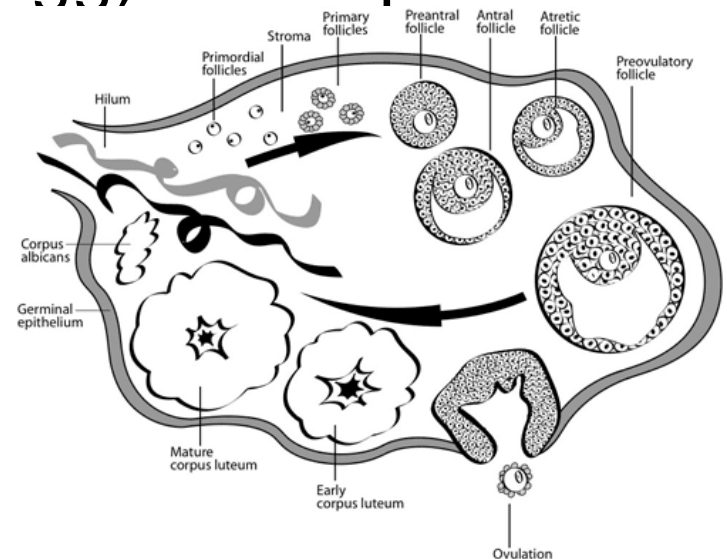
# Anterior Pituitary Hormones

- Prolactin (PRL)
  - Stimulates and maintains milk production in mammary tissue following childbirth
  - Function in males is unknown
- Adrenocorticotrophic hormone (ACTH)
  - Stimulates the activity of the adrenal cortex (gland)
- Thyroid-stimulating hormone (TSH)
  - Influences growth and activity of the thyroid gland



# Anterior Pituitary Hormones

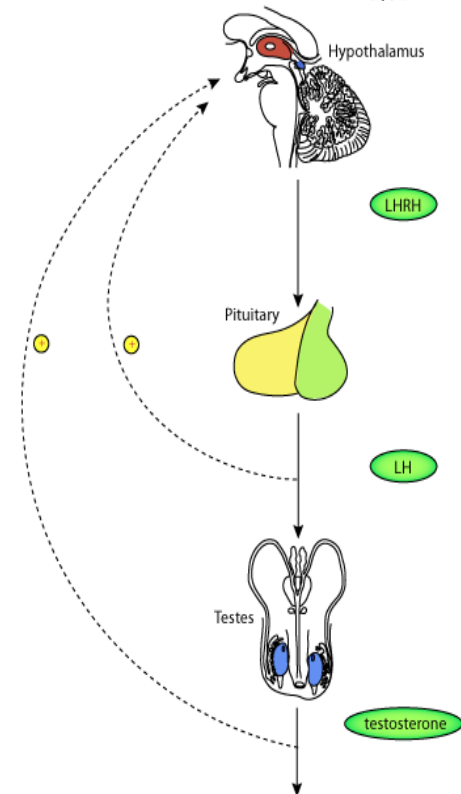
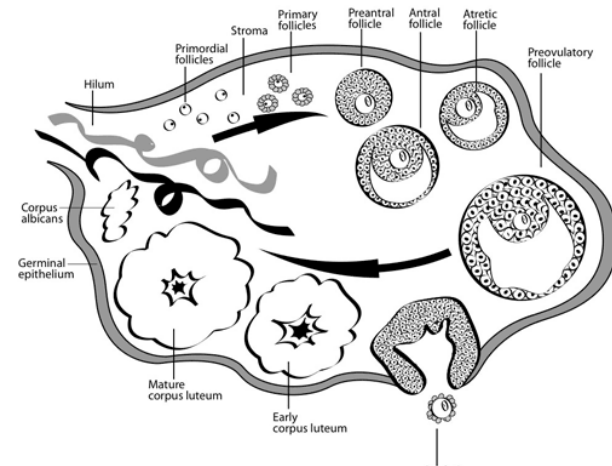
- Follicle-stimulating hormone (FSH)
  - Stimulates follicle (egg) development in ovaries (female)



- Stimulates sperm development in testes (male)

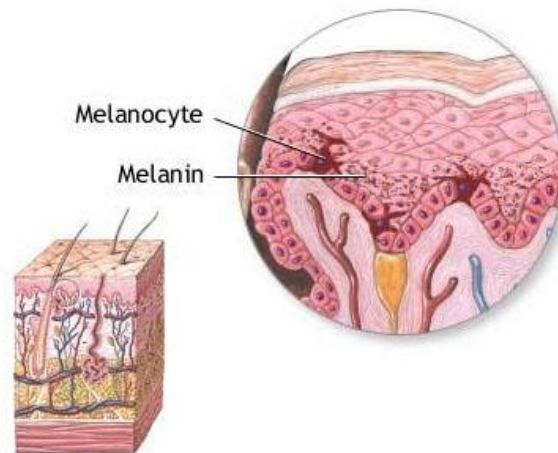
# Functions of Other Anterior Pituitary Hormones

- Luteinizing hormone (LH)
  - Triggers ovulation in ovary in females
  - Causes ruptured follicle to become the corpus luteum which will trigger the production of other hormones
  - Stimulates testosterone production in testes in males



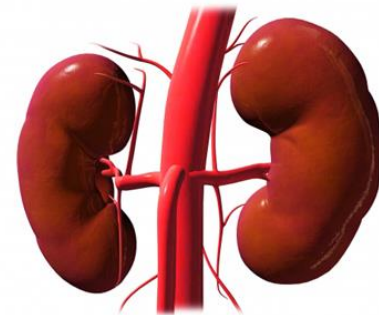
# Anterior Pituitary Hormones

- Melanocyte Stimulating Hormone (MSH)
  - Increases melanin synthesis in the skin
    - *Important in control of skin pigmentation in many non-primate mammals, reptiles, fish and amphibians.*
    - *In Adult humans it is virtually non-existent but is produced in fetal development, very young children, pregnant women and some diseased states.*



# Hormones of the Posterior Pituitary

- Oxytocin
  - Stimulates contractions of the uterus during labor
  - Causes milk ejection in mammary tissue (females)
  - Contractions of sperm duct and prostate in males
- Antidiuretic hormone (ADH)
  - Causes reabsorption of water in the kidneys
  - Can inhibit urine production
  - In large amounts, causes vasoconstriction leading to increased blood pressure and blood volume (vasopressin)



# Hormones of the Posterior

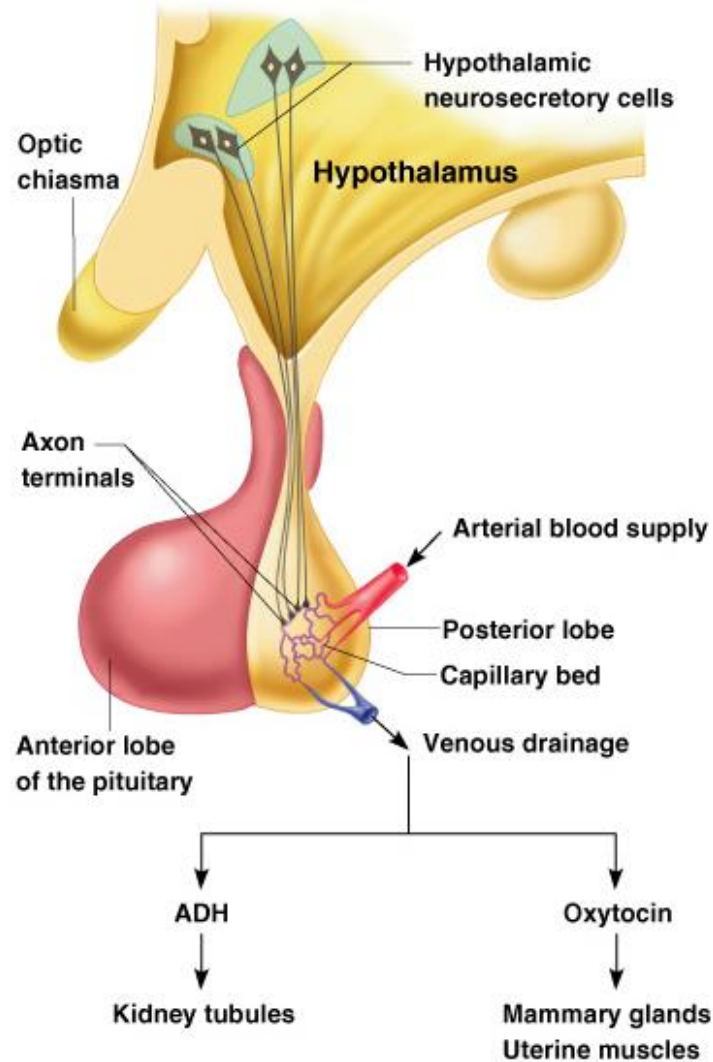
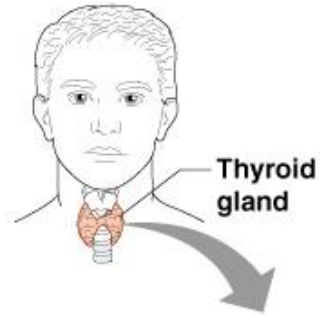


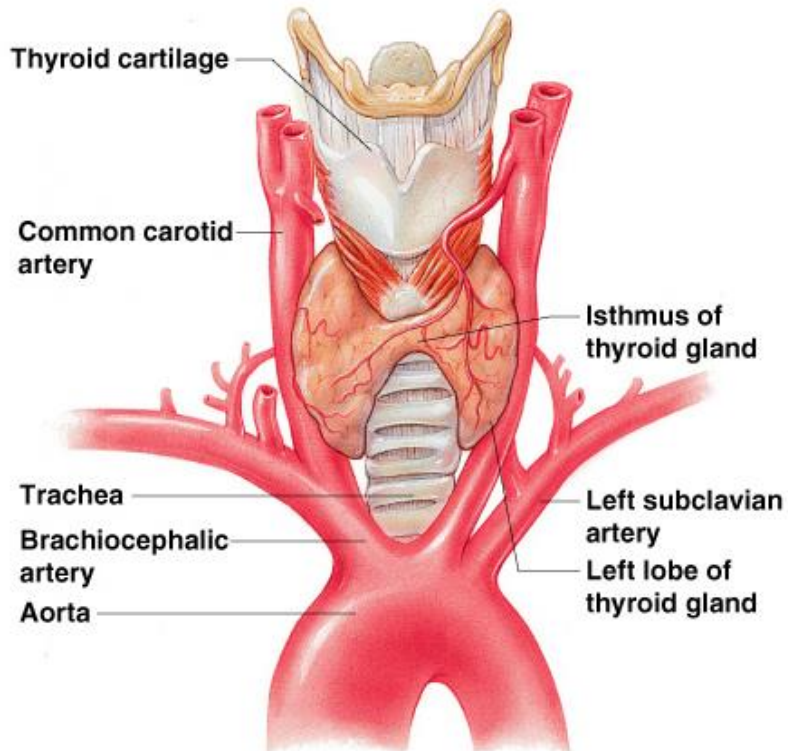
Figure 9.5

# Thyroid Gland

- Found at the base of the throat
- Consists of two lobes and a connecting isthmus
- Produces two hormones
  - Thyroid hormone
  - Calcitonin



# Thyroid Gland



(a)

Figure 9.6



# Thyroid Hormone

- Major metabolic hormone- regulates cell energy usage, oxygen use, growth, development
- Composed of two active iodine-containing hormones
  - Thyroxine ( $T_4$ ) – secreted by thyroid follicles
  - Triiodothyronine ( $T_3$ ) – conversion of  $T_4$  at target tissues
  - Easily cross cell membranes and effect most cells in the body

# Calcitonin (CT)

- Decreases blood calcium levels by causing its deposition on bone through osteoblast activity
- Antagonistic to parathyroid hormone

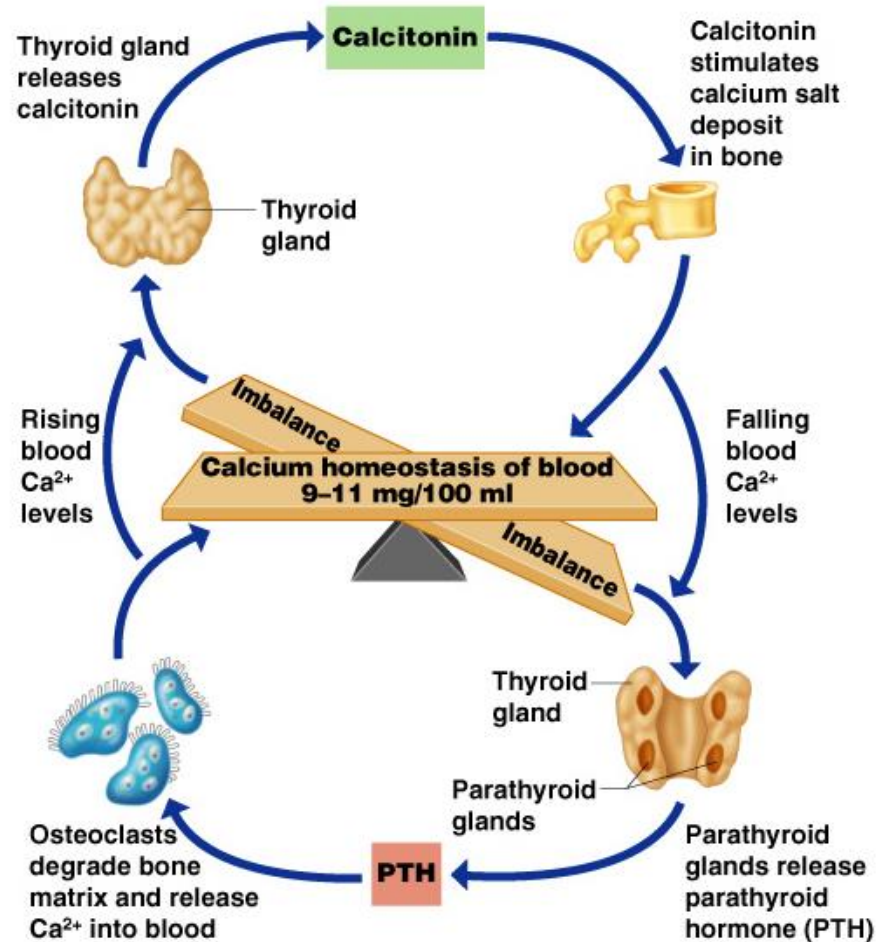
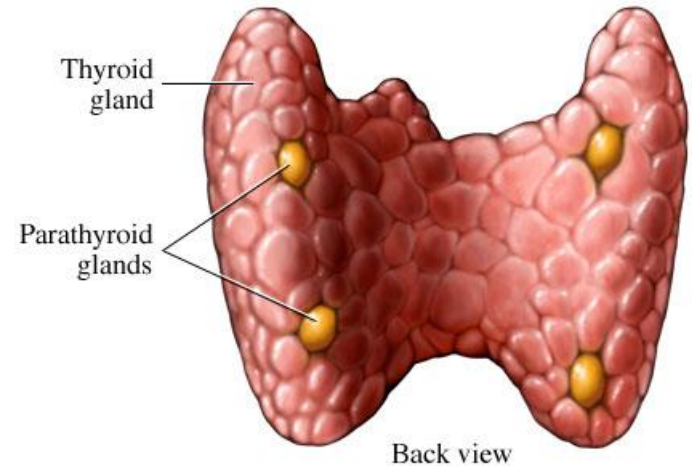


Figure 9.9

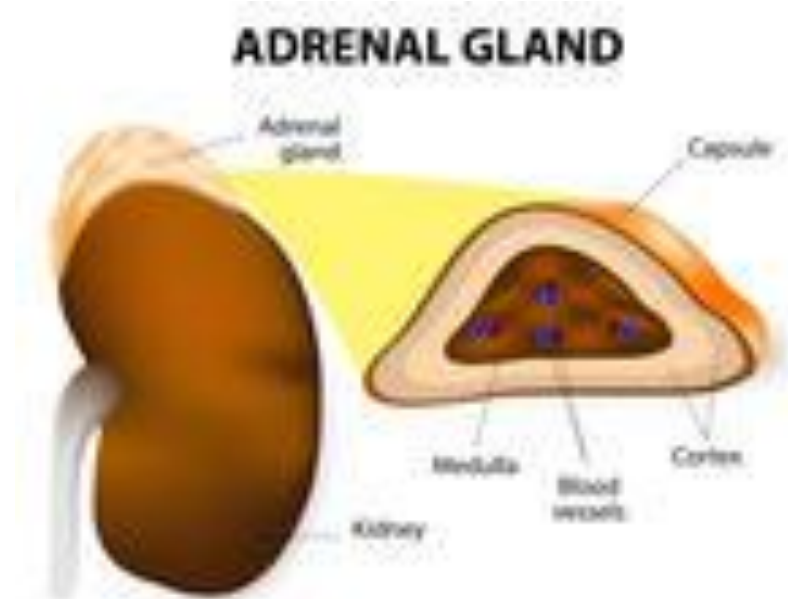
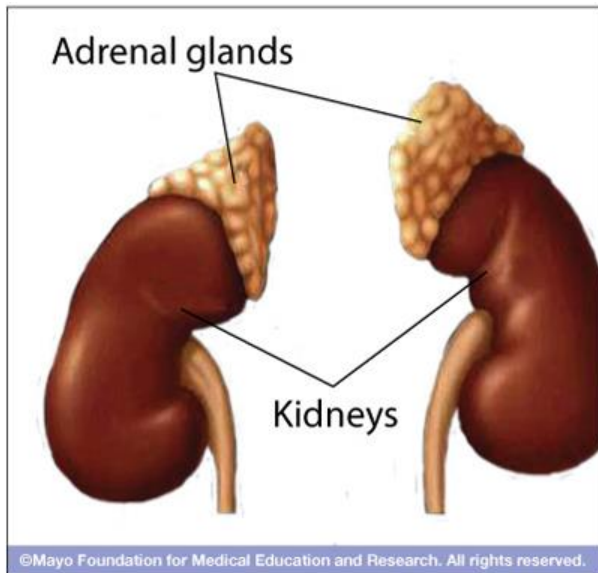
# Parathyroid Glands

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



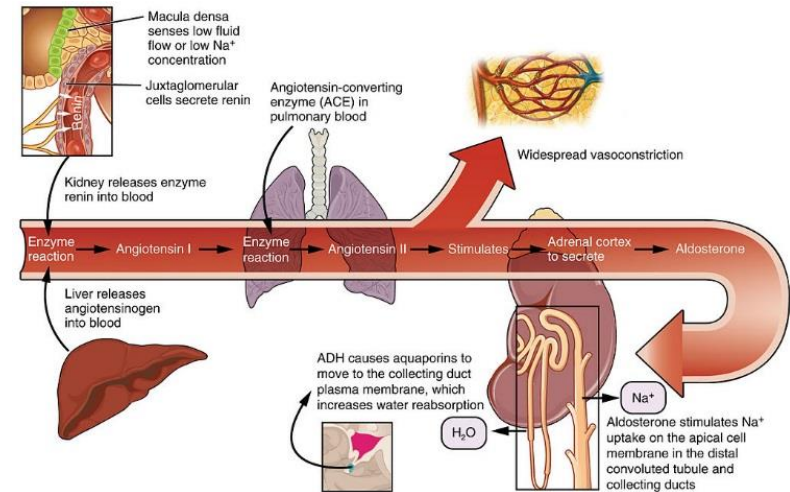
# Adrenal Glands

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



# Hormones of the Adrenal Cortex

- Aldosterone
  - Produced in outer adrenal cortex
  - Regulate mineral content in blood, water, and electrolyte balance
  - Raises sodium levels in blood, decreases potassium levels in blood
  - Target organ is the kidney



# Hormones of the Adrenal Cortex

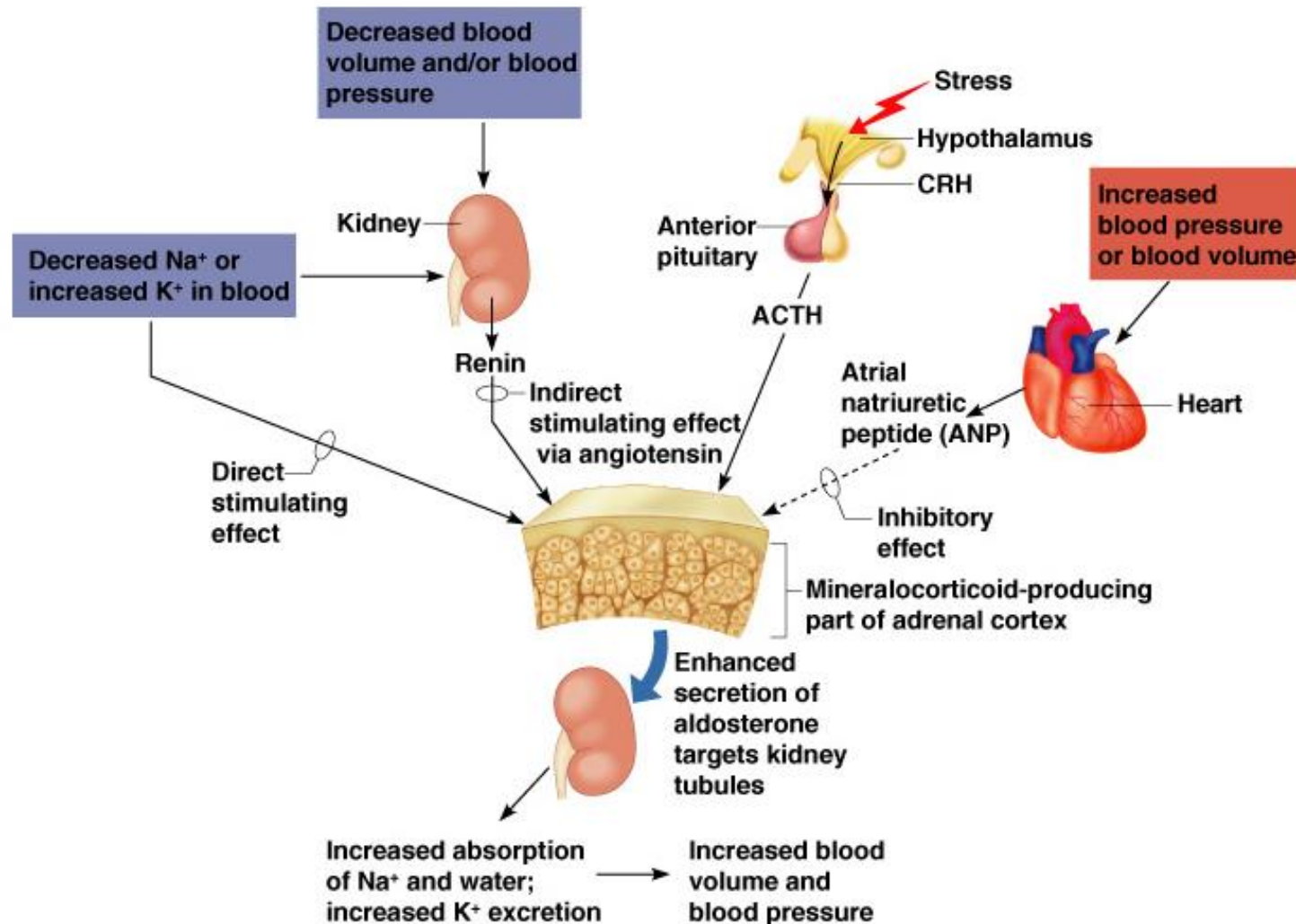


Figure 9.10

# Hormones of the Adrenal Cortex

- Cortisol/ Cortisone
  - Produced in the middle layer of the adrenal cortex
  - Promote normal cell glucose metabolism
  - Help resist long-term stressors
  - Anti-inflammatory effects
  - Released in response to increased blood levels of ACTH
  - Target most cells in the body



# Hormones of the Adrenal Medulla

- Epinephrine/ Norepinephrine
- These hormones prepare the body to deal with short-term stress (adrenaline)
  - Increase cardiac activity, blood pressure, sugar breakdown, release of lipids by adipose tissue
  - Most cells effected





# Hypothalamus and Adrenal Glands in Stress Response

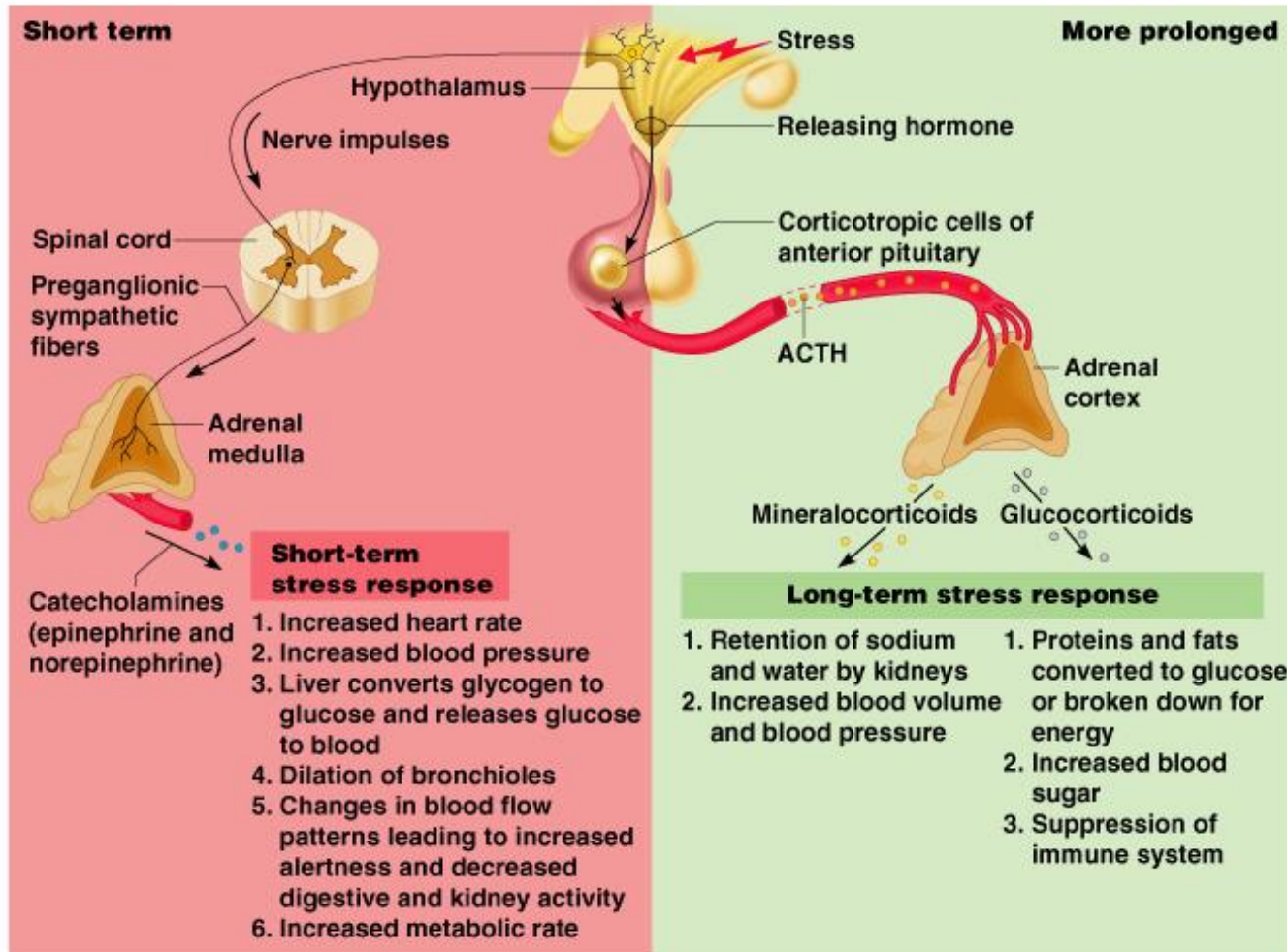
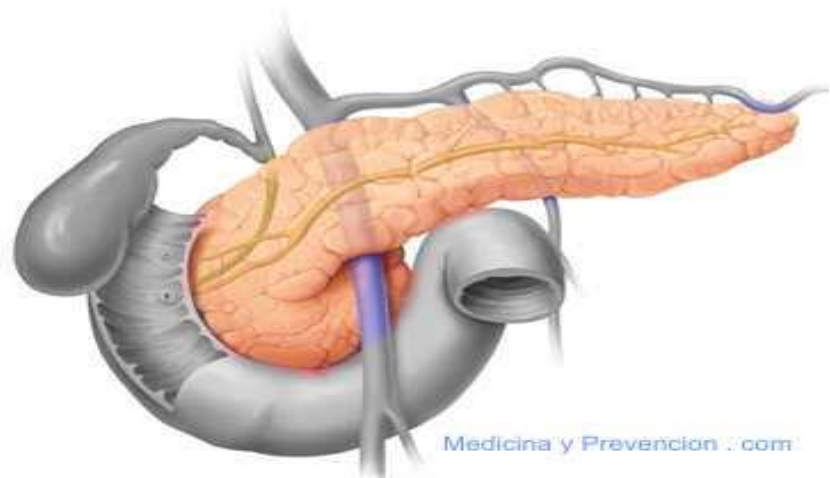


Figure 9.12

# Pancreas

- The pancreas is a mixed gland inferior to the stomach
- The islets of the pancreas produce hormones
- Some digestive functions too



- These hormones are antagonists that maintain blood sugar homeostasis

# Pancreatic Islets

Insulin – allows glucose to cross plasma membranes into most cells in the body (nerve and red blood cells do not have insulin receptors)

Glucagon – allows glucose to enter the blood targeting liver, muscle and adipose tissue

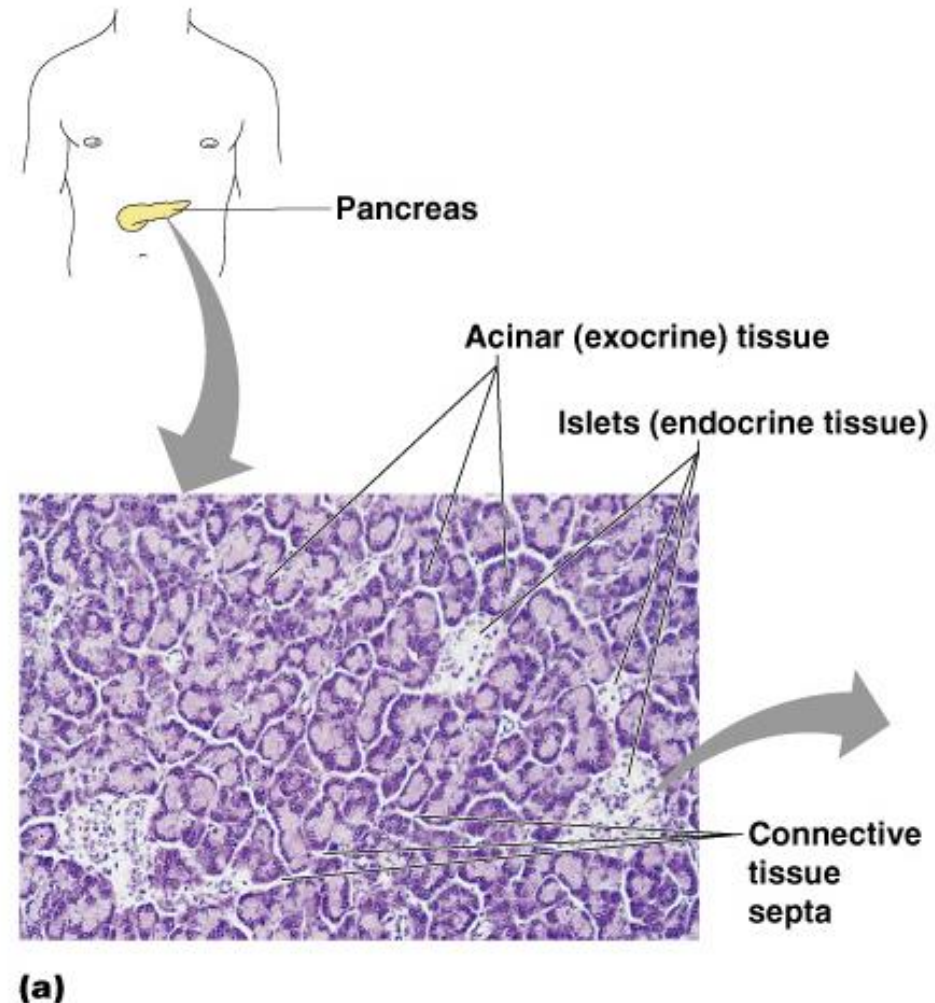


Figure 9.13

# Pancreatic Hormones and Blood Sugar

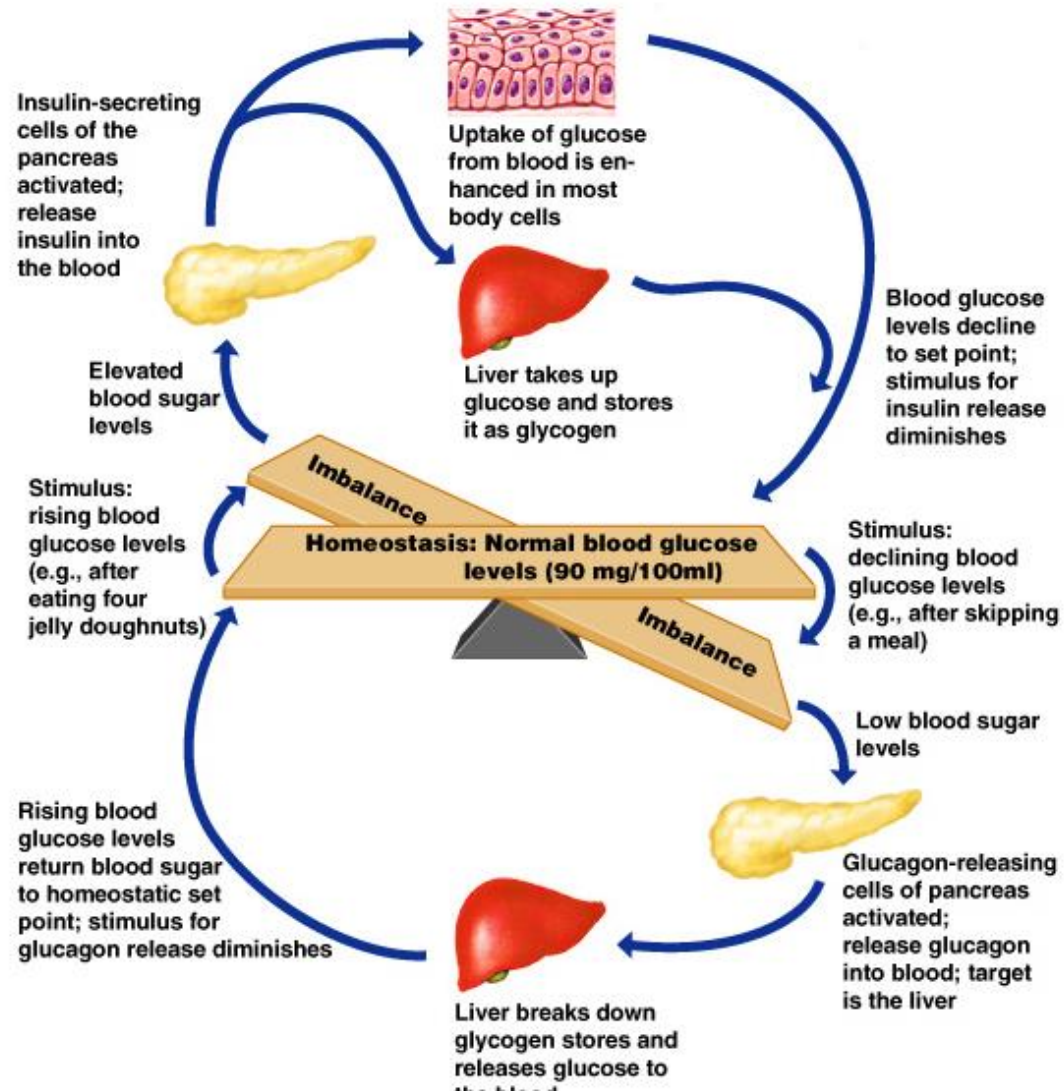


Figure 9.14

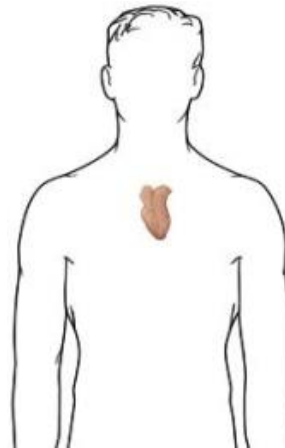
# Pineal Gland

- Found on the third ventricle of the brain
- Secretes melatonin
  - Helps establish the body's wake and sleep cycles in the brain
  - Stimulated by light (external stimulus)



# Thymus

- Located posterior to the sternum
- Largest in infants and children
- Produces thymosin
  - Matures some types of white blood cells
  - Important in developing the immune system

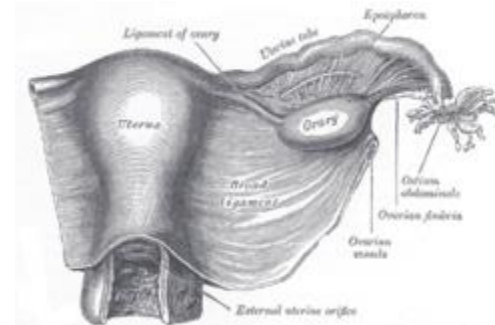


Thymus gland



# Hormones of the Ovaries

- Estrogen
  - Stimulates the development of secondary female characteristics
  - Matures female reproductive organs
  - Helps prepare the uterus to receive a fertilized egg
  - Helps maintain pregnancy
  - Prepares the breasts to produce milk
  - Target most cells



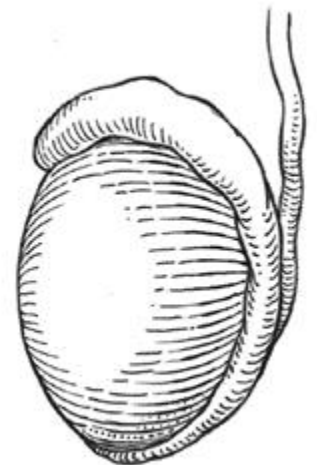
# Hormones of the Ovaries

- 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
- Inhibin: Stops secretion of FSH by the pituitary (males too produced in testes)



# Hormones of the Testes

- Testosterone
- Responsible for adult male secondary sex characteristics
  - Promotes growth and maturation of male reproductive system
  - Required for sperm cell production
  - Skeletal muscle production
  - Targets most cells



Pineal gland

Hypothalamus

Pituitary gland

Thyroid gland

Parathyroid glands  
(on dorsal aspect  
of thyroid gland)

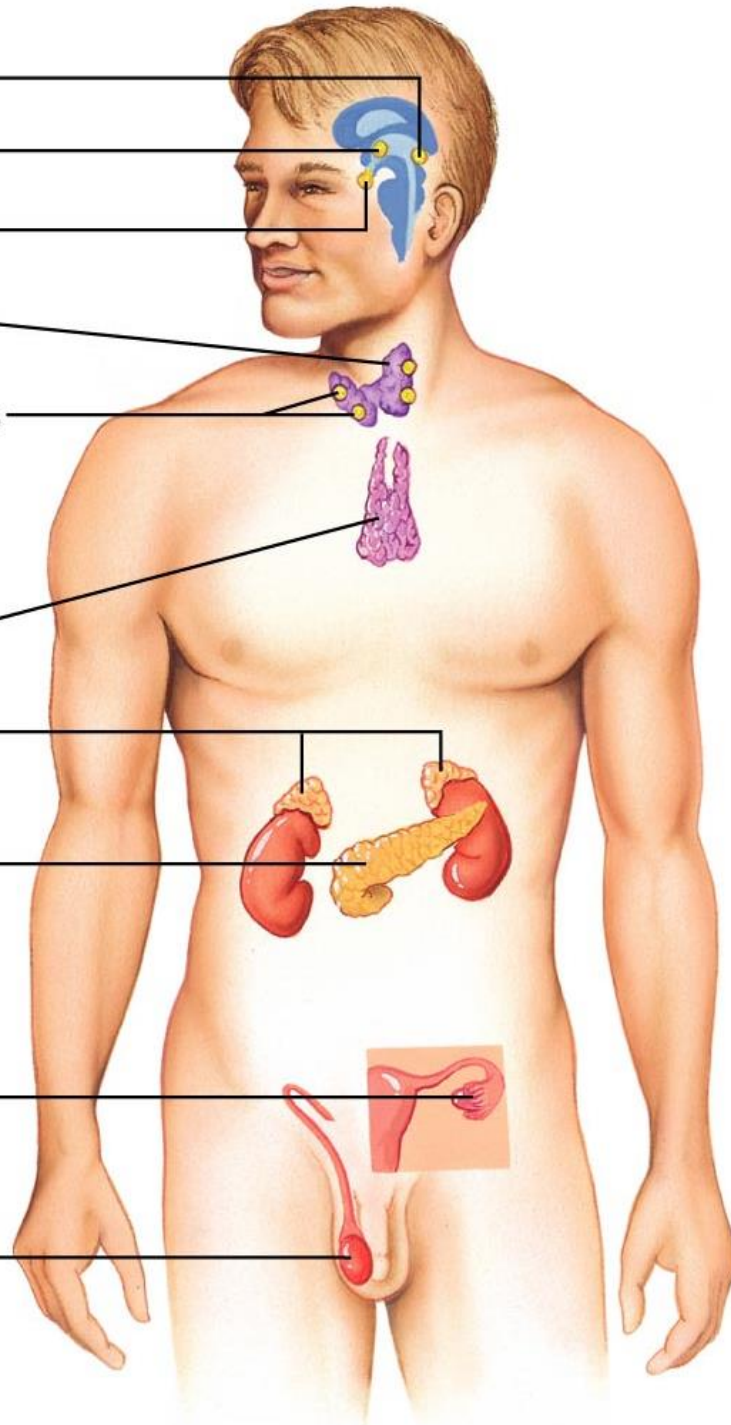
Thymus gland

Adrenal glands

Pancreas

Ovary  
(female)

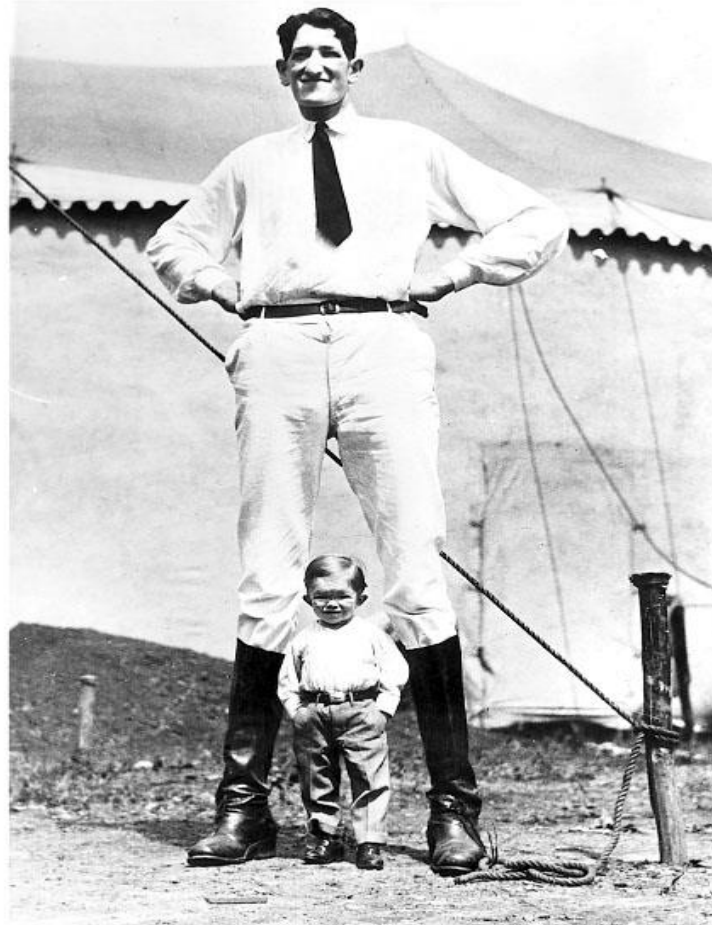
Testis  
(male)



# Endocrine organs (review)

# Effect of growth hormone

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a.

Greatest production occurs during childhood

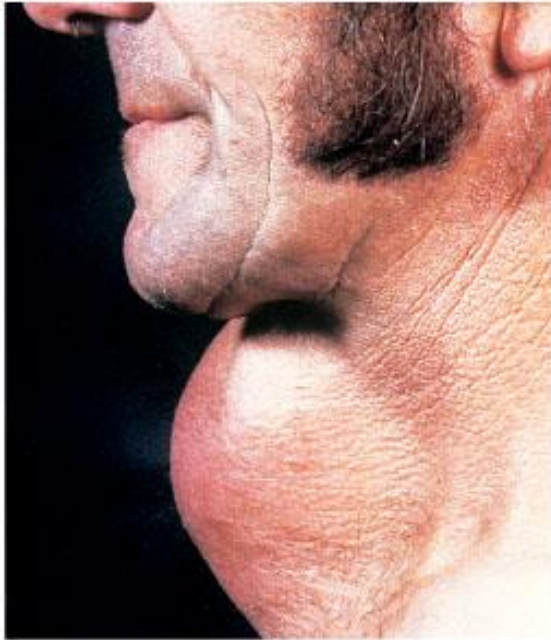
Lack of GH- **pituitary dwarfism**

Excess - **giantism**



# Abnormalities of the thyroid

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a. Simple goiter



b. Cretinism



c. Exophthalmic goiter

**Cretinism**- abnormal thyroid development; short, stocky body type. Severe hypothyroidism causes mental retardation

**Myxedema** - Hypothyroidism in adults-lethargy, weight gain, loss of hair. **Grave's disease**- hyperthyroidism; causes exophthalmic goiter-edema behind eyes causes bulging; hyperactivity, arrhythmias.

# Acromegaly

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Age 9



Age 16



Age 33



Age 56

Excess production of GH; the growth plates of bone have closed so no increased growth in height. Feet, hands, and face become “heavy” in appearance

# Addison's disease

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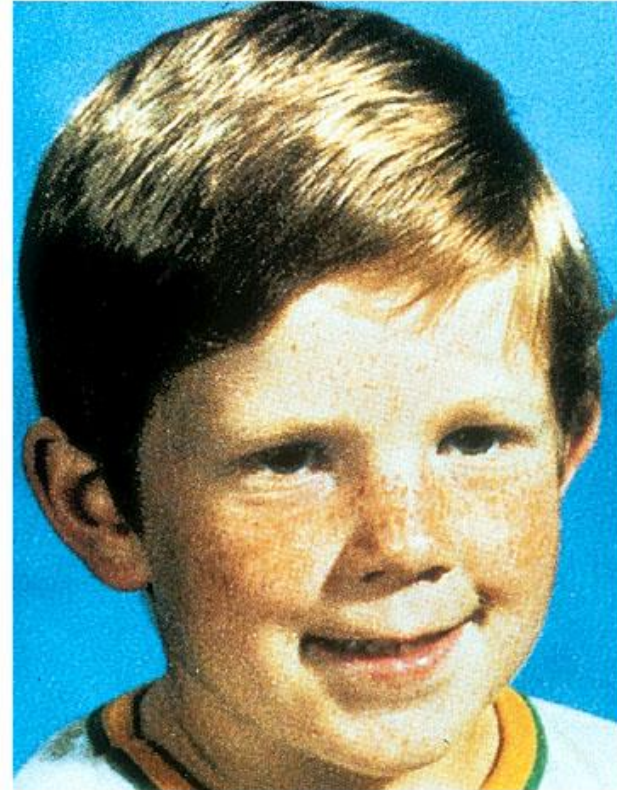


ACTH accumulates causing stimulation of melanocytes (bronze skin color). Without cortisol, there is no mobilization of glucose under stress; can be life-threatening. Hyposecretion of aldosterone-most serious, causes **hyperkalemia** (low blood potassium) leading to cardiac arrest



# Cushing's syndrome

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Hypersecretion of the adrenal cortex hormone, cortisol is primary problem. Results in **Diabetes mellitus** from increased blood glucose; Subcutaneous fat deposited in midsection; High blood pressure