Chapter 11

The Endocrine System
What you absolutely need to know

• Distinguish between endocrine and exocrine glands
• Identify and locate the primary endocrine glands and list the major hormones produced by each gland
• Describe the mechanisms of steroid and non-steroid hormone action
Objectives

- Explain how negative and positive feedback mechanisms regulate secretion of endocrine hormones
- Mechanisms of endocrine disorders
- Identify the principal functions of each major endocrine hormone and describe the conditions that may result from hypossecretion or hypersecretion
Mechanisms of Hormone Action

- Endocrine glands secrete chemicals (hormones) into the blood
- Hormones perform general functions of communication and control, but a slower, longer-lasting type of control than that provided by nerve impulses
- Cells acted on by hormones are called target organ cells
Name and Location
Mechanisms of Hormone Action

- Nonsteroid hormones (first messengers) bind to receptors on the target cell membrane, triggering second messengers to affect the cell’s activities.
- Steroid hormones bind to receptors within the target cell nucleus and influence cell activity by acting on DNA.
Regulation of Hormone Secretion

• Hormone secretion is controlled by homeostatic feedback

• Negative feedback—mechanisms that reverse the direction of a change in a physiological system

• Positive feedback—(uncommon) mechanisms that amplify physiological changes
**Negative feedback** In this example, an increase in blood glucose triggers secretion of insulin. Because insulin promotes glucose uptake by cells, the blood glucose level is restored to its lower, normal level.
Mechanisms of Endocrine Disease

- **Hypersecretion**—secretion of excess hormone
- **Hyposecretion**—insufficient hormone secretion
- Polyendocrine disorders—many—hyper- or hyposecretion of more than one hormone
- Target cell insensitivity produces results similar to hyposecretion
- Endocrinologists have developed many different strategies for treatment (e.g., surgery and hormone therapy)
Prostaglandins

- Prostaglandins (PGs) are powerful substances found in a wide variety of body tissues.
- PGs are often produced in a tissue and diffuse only a short distance to act on cells in that tissue.
- PGs influence many body functions, including respiration, blood pressure, gastrointestinal secretions, and reproduction.
Name and Location
Pituitary Gland

- Anterior pituitary gland
- Cranial cavity
  - Names of major hormones
    - Thyroid-stimulating hormone (TSH)
    - Adrenocorticotropin hormone (ACTH)
    - Follicle-stimulating hormone (FSH)
    - Luteinizing hormone (LH)
    - Growth hormone (GH)
    - Prolactin (lactogenic hormone)
Pituitary Gland

– Functions of major hormones
  • TSH—stimulates growth of the thyroid gland; also stimulates it to secrete thyroid hormone
  • ACTH—stimulates growth of the adrenal cortex and stimulates it to secrete glucocorticoids (mainly cortisol)
  • FSH—initiates growth of ovarian follicles each month in the ovary and stimulates one or more follicles to develop to the stage of maturity and ovulation; FSH also stimulates estrogen secretion by developing follicles; stimulates sperm production in the male
Pituitary Gland

Functions of major hormones

- LH—acts with FSH to stimulate estrogen secretion and follicle growth to maturity;
- causes ovulation;
- causes luteinization of the ruptured follicle and stimulates progesterone secretion by corpus luteum;
- causes interstitial cells in the testes to secrete testosterone in the male
Pituitary Gland

- GH—growth hormone, growth in all organs, mobilizes food molecules increasing blood sugar concentration by slowing glucose catabolism, tends to increase blood glucose to higher than normal level (hyperglycemia)
  - Hypersecretion during childhood results in gigantism and during adulthood results in acromegaly
  - Hyposecretion during childhood results in pituitary dwarfism

- Prolactin or lactogenic hormone—stimulates breast development during pregnancy and secretion of milk (milk letdown) after the delivery of the baby
Pituitary Gland

• Posterior pituitary gland
  • ADH—accelerates water reabsorption from urine in the kidney tubules into the blood, thereby decreasing urine secretion
  • Oxytocin—stimulates the pregnant uterus to contract; may initiate labor; causes glandular cells of the breast to release milk into ducts
Posterior and Anterior Pituitary
Hypothalamus

• Actual production of ADH and oxytocin occurs in the hypothalamus
• After production in the hypothalamus, hormones pass along axons into the pituitary gland
• The secretion and release of posterior pituitary hormones is controlled by nervous stimulation
• The hypothalamus controls many body functions related to homeostasis (temperature, appetite, and thirst)
Thyroid Gland

• Names of hormones
  – Thyroid hormone—thyroxine (T₄) and triiodothyronine (T₃)
  – Calcitonin (CT)

• Functions of hormones
  – Thyroid hormones—accelerate catabolism (increase the body’s metabolic rate)
  – Calcitonin—decreases the blood calcium concentration by inhibiting breakdown of bone, which would release calcium into the blood
Thyroid Gland

• Hyperthyroidism (hypersecretion of thyroid hormones) increases metabolic rate
  – Characterized by restlessness and exophthalmos (protruding eyes)
  – Graves disease is an inherited form of hyperthyroidism
Thyroid Gland

• Hypothyroidism (hypossecretion of thyroid hormones)
  – May result from different conditions
  – Simple goiter—painless enlargement of thyroid caused by dietary deficiency of iodine
  – Hypossecretion during early development may result in cretinism (retardation) and during adulthood in myxedema (characterized by edema and sluggishness)
Parathyroid Glands

• Name of hormone—parathyroid hormone (PTH)
• Function of hormone—increases blood calcium concentration by increasing the breakdown of bone with the release of calcium into the blood
Adrenal Glands

• Adrenal cortex
  – Names of hormones (corticoids)
    • Glucocorticoids (GCs)—chiefly cortisol (hydrocortisone)
    • Mineralocorticoids (MCs)—chiefly aldosterone
    • Sex hormones—small amounts of male hormones (androgens) secreted by adrenal cortex of both sexes
Adrenal Glands

- Three cell layers (zones)
  - Outer layer—secretes mineralocorticoids
  - Middle layer—secretes glucocorticoids
  - Inner layer—secretes sex hormones

- Mineralocorticoids—increase blood sodium and decrease body potassium concentrations by accelerating kidney tubule reabsorption of sodium and excretion of potassium
Adrenal Glands

- Functions of glucocorticoids
  - Help maintain normal blood glucose concentration by increasing gluconeogenesis—the formation of “new” glucose from amino acids produced by the breakdown of proteins, mainly those in muscle tissue cells; also the conversion to glucose of fatty acids produced by the breakdown of fats stored in adipose tissue cells
  - Play an essential part in maintaining normal blood pressure—make it possible for epinephrine and norepinephrine to maintain a normal degree of vasoconstriction, a condition necessary for maintaining normal blood pressure
Adrenal Glands

- Act with epinephrine and norepinephrine to produce an antiinflammatory effect, to bring about normal recovery from inflammations of various kinds
- Produce anti-immunity, antiallergy effect; bring about a decrease in the number of lymphocytes and plasma cells and therefore a decrease in the amount of antibodies formed
- Secretion of glucocorticoid quickly increases when the body is thrown into a condition of stress; high blood concentration of glucocorticoids, in turn, brings about many other stress responses
High blood glucocorticoid concentration

- Increased mobilization of fats and tissue proteins
  - Increased liver gluconeogenesis from mobilized fats and proteins; also decreased glucose catabolism but increased fat catabolism
    - (tend to produce)
      - Hyperglycemia
  - Atrophy of thymus
    - Decreased number of lymphocytes
      - Decreased immunity
    - Decreased number of eosinophils
      - Decreased allergic responses
  - Inhibited inflammatory response
    - Accelerated recovery from inflammation
Adrenal Glands

• Adrenal medulla
  – Names of hormones—epinephrine (Epi), or adrenaline, and norepinephrine (NR)
  – increased epinephrine secretion is the first endocrine response to stress
Adrenal Glands

• Adrenal abnormalities
  – Hypersecretion of glucocorticoids causes Cushing syndrome: moon face, hump on back, elevated blood sugar levels, frequent infections
  – Hypersecretion of adrenal androgens may result from a virilizing tumor and cause masculinization of affected women
Adrenal Glands

- Hyposecretion of cortical hormones may result in Addison disease: muscle weakness, reduced blood sugar, nausea, loss of appetite, and weight loss
Pancreatic Islets

• Names of hormones
  – Glucagon—secreted by alpha cells
  – Insulin—secreted by beta cells

• Functions of hormones
  – Glucagon increases the blood glucose level by accelerating liver glycogenolysis (conversion of glycogen to glucose)
Pancreatic Islets

• Functions of hormones
  – Insulin decreases the blood glucose by accelerating the movement of glucose out of the blood into cells, which increases glucose metabolism by cells
Pancreatic Islets

- Diabetes mellitus
  - Type 1 results from hyposcretion of insulin
  - Type 2 results from target cell insensitivity to insulin
  - Glucose cannot enter cells and thus blood glucose levels rise, producing glycosuria (glucose in the urine)
Female Sex Glands

• The ovaries contain two structures that secrete hormones—the ovarian follicles and the corpus luteum; see Chapter 22

• Effects of estrogen (feminizing hormone)
  – Development and maturation of breasts and external genitals
  – Development of adult female body contours
  – Initiation of menstrual cycle
Male Sex Glands

- The interstitial cells of testes secrete the male hormone testosterone; see Chapter 22
- Effects of testosterone (masculinizing hormone)
  - Maturation of external genitals
  - Beard growth
Male Sex Glands

- Effects of testosterone
  - Voice changes at puberty
  - Development of musculature and body contours typical of the male
Thymus

- Name of hormone—thymosin
- Function of hormone—plays an important role in the development and function of the body’s immune system
Placenta

- Name of hormones—chorionic gonadotropins, estrogens, and progesterone
- Functions of hormones—maintain the corpus luteum during pregnancy
Pineal Gland

• A small gland near the roof of the third ventricle of the brain
  – Glandular tissue predominates in children and young adults
  – Becomes fibrous and calcified with age
• Called *third eye* because its influence on secretory activity is related to the amount of light entering the eyes
Pineal Gland

• Secretes melatonin, which:
  – Inhibits ovarian activity
  – Regulates the body’s internal clock

• Abnormal secretion of (or sensitivity to) melatonin may produce seasonal affective disorder (SAD) or winter depression, a form of depression that occurs when exposure to sunlight is low and melatonin levels are high
Other Endocrine Structures

- Many organs (e.g., the stomach, intestines, and kidney) produce endocrine hormones
- The atrial wall of the heart secretes atrial natriuretic hormone (ANH), which stimulates sodium loss from the kidneys
- Fat-storing cells secrete leptin, which controls how full or hungry we feel