Chapter 18
Endocrine Glands
and Hormones

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Introduction

• The human body has two types of glands:
  – Exocrine glands contain cells that produce
    secretions transported through ducts
  – Endocrine glands (ductless glands) secrete
    hormones directly into the bloodstream or to
    neighboring cells

• Some organs possess endocrine qualities:
  – Hypothalamus
  – Thalamus
  – Kidneys
  – Gastric and intestinal mucosa
  – Heart
  – Placenta

• Endocrine system works with the nervous
  system to coordinate the functions of all
  body systems
• Nervous system uses impulses to
  communicate information quickly, whereas
  endocrine system uses hormones to
  communicate information over long
  distances with widespread effects

The Endocrine System

Anatomical Structures

• Adrenals
• Gonads
• Hormones
• Pancreatic inlets
• Parathyroids
• Pineal
• Pituitary
• Thyroid
• Hormones
Physiological Properties of the Endocrine System

- Produce and secrete hormones
- Regulate body activities
- Regulate activities of smooth muscle, cardiac muscle and some glands
- Help body adapt during times of stress
- Regulate chemical composition and volume of body and cell fluids
- Contribute to the reproductive process

Hormones

- Internal secretions that function as chemical messengers
- Act as catalysts in biochemical reactions and regulate physiological activity of cells
- Hormones only affect target cells that have receptor sites for that hormone

Types of Hormones

- Biogenic amines—neurotransmitters
- Eicosanoids—alter smooth muscle contractions
- Peptide hormones—introduce chemical reactions to alter cell metabolism
- Steroid hormones—turn genes on and off to alter cell activity

Hormonal Control Systems

- Hormonal secretions are regulated by three systems:
  - Negative feedback system
  - Hormonal control system
  - Neural control system

Negative Feedback System

- Primary means of hormonal regulation
- When the amount of a hormone (or desired product) is too high, the gland is triggered to secrete less hormone
- When the amount of a hormone (or product) is too low, the gland is triggered to secrete more hormone

Hormonal Control System

- Some hormones stimulate or inhibit the release of other hormones
- Example:
  - Hypothalamus secretes hormones, activating the anterior portion of the pituitary gland
  - Some hypothalamic hormones cause an increase in secretions
  - Other hypothalamic hormones cause a decrease in secretions
Neural Control System

- Hormonal secretion due to direct nerve stimulation
  - Example: adrenal gland release of epinephrine and norepinephrine as a stress response
  - Neural control system has the fastest response time

Individual Endocrine Glands

- The endocrine glands:
  - Pituitary gland
  - Pineal gland
  - Thyroid gland
  - Parathyroid glands
  - Adrenal glands
  - Pancreatic islets
  - Female ovaries and male testes
- Other organs also possess endocrine qualities

Pituitary Gland

- Attached to hypothalamus and sits in the sella turcica of the sphenoid bone

- About the size of a small grape
- Pituitary hormones regulate many other glands; pituitary itself is regulated by the hypothalamus
- Anterior lobe—adenohypophysis
  - Produces 7 of the 9 pituitary hormones
- Posterior lobe—neurohypophysis
  - Stores and releases hormones produced by the hypothalamus
Anterior Pituitary Hormones

- Adrenocorticotropic hormone (ACTH)—regulates adrenal cortex, especially cortisol secretions
- Growth hormone (GH)—stimulates muscle and bone growth
- Thyroid-stimulating hormone (TSH)—stimulates thyroid to produce its hormones such as triiodothyronine (T₃) and thyroxine (T₄)

Anterior Pituitary Hormones

- Follicle-stimulating hormone (FSH)—stimulates estrogen and egg production in ovaries; stimulates sperm production in testes
- Luteinizing hormone (LH)—stimulates ovulation and production of estrogen and progesterone by ovaries, and testosterone production by testes

Anterior Pituitary Hormones

- Prolactin (PRL)—stimulates milk production in the mammary glands
- Melanocyte-stimulating hormone (MSH)—increases skin pigmentation by stimulating distribution of melanin granules

Posterior Pituitary Hormones

- Antidiuretic hormone (ADH)—stimulates kidneys to retain water to prevent dehydration
- Oxytocin—stimulates uterine contractions; involved in milk expression from mammary glands

Pineal Gland

- Pinecone-shaped structure in the brain
- Pineal gland hormone:
  - melatonin—involved in control of circadian rhythms (sleeping and eating) and in growth and development of sexual organs

Thyroid Gland
Thyroid Gland Hormones

- Triiodothyronine (T3) and thyroxine (T4), which increase metabolic rate
  - Cannot be made without iodine
- Calcitonin (CT) increases calcium storage in bones and lowers blood calcium levels

Parathyroid Glands

- Four tiny glands on the posterolateral surface of the thyroid lobes
- Parathyroid gland hormone
  - Parathyroid hormone (PTH)—Raises blood calcium levels by breaking down bone tissue, and by increasing reabsorption from blood

Adrenal Glands

- Located superior to each kidney
- Highly vascular
- Divided into two regions:
  - Adrenal cortex—outer region, comprises most of the gland; produces steroid hormones:
  - Adrenal medulla—inner region, produces neurohormones in response to sympathetic nervous system and prolongs its effects

Adrenal Cortex Hormones

- Aldosterone—stimulates water and sodium retention by kidneys; maintains mineral balance
- Cortisol—affects metabolism; produces anti-inflammatory response
- Adrenal androgens and estrogens—support sexual functions

Adrenal Medulla Hormones

- Epinephrine (adrenaline)—increases blood pressure by stimulating vasoconstriction
- Norepinephrine (noradrenaline)—increases heart rate, blood pressure, and blood glucose levels; dilates bronchii
Pancreatic Islets

- Pancreatic gland located inferior to the stomach and has both endocrine and exocrine functions
- Hormones secreted by specialized cells called pancreatic islets or islets of Langerhans
  - Consists of alpha and beta cells
  - Pancreatic hormones are involved in carbohydrate metabolism

Pancreatic Hormones

- Insulin
  - Secreted by beta cells
  - Decreases blood glucose levels by stimulating body cells to take up glucose in blood
- Glucagon
  - Secreted by alpha cells
  - Increases blood glucose levels by stimulating breakdown of glycogen from liver and skeletal muscles

Gonads

- Female—ovaries
  - Located in pelvic cavity
  - LH and FSH from anterior pituitary work with ovarian hormones to regulate reproductive cycle
  - Contains the corpus luteum
- Male—testes
  - Located in scrotum
  - Androgens, primarily testosterone, produced by interstitial cells of Leydig

Ovarian Hormones

- Estrogen—secreted by follicle cells; responsible for female secondary sex characteristics and regulating menstrual cycle
- Progesterone—secreted by corpus luteum; prepares endometrium for pregnancy
- Relaxin—softens connective tissue of pregnant women to facilitate fetal delivery

Testicular Hormones

- Androgens—maintain male sex characteristics
  - Testosterone—principal testicular androgen; promotes secondary male sex characteristics, libido (sex drive), and sperm production

Placenta

- Temporary reproductive organ with endocrine tissues
- Produces and secretes human chorionic gonadotropin (hCG)
  - hGC stimulates secretion of estrogen and progesterone and decreases lymphocyte activation
- Also produces estrogens
Thymus Gland
• Bilobed gland posterior to sternum
• Considered to be primarily a lymphatic organ
• Thymic Hormones
  – Thymosin and thymopoietin
    • Both assist in growth and development of the immune system and the growth and maturation of T cells

Gastric and Intestinal Mucosa
• The mucus lining of the stomach and intestines secrete hormones to regulate and coordinate the digestive process
• Gastric Hormones:
  – Gastrin: Stimulate bile, pancreatic enzymes, and gastric juices
• Intestinal Hormones:
  – Cholecystokinin: Stimulate gallbladder and pancreas
  – Secretin: Stimulates pancreas

Heart
• Hormone-producing cells are located in atrial walls
• Produces atrial natriuretic hormone
  – Decrease sodium by triggering urine production
  – Acts as an antagonist to antidiuretic hormone and aldosterone

Pathological Conditions of the Endocrine System
• Acromegaly—caused by overproduction of growth hormone during the adult years
  – Characterized by elongation and enlargement of bones of extremities, face, and jaw
  – Gentle massage permissible with clearance from client’s physician

Pathological Conditions of the Endocrine System
• Addison’s disease (hypoadrenalism)—caused by failure of adrenal functions due to autoimmune disease, infection, or hemorrhage
  – Characterized by general weakness, reduced endurance, and increased skin pigmentation (bronzing)
  – Accompanied by loss of appetite, anxiety, depression, and other emotional disturbances

Pathological Conditions of the Endocrine System
• Cretinism—congenital defect in the secretion of thyroid hormones
  – Characterized by a lack of mental and physical development
  – Typical in countries where iodine deficiency and goiters are common
Pathological Conditions of the Endocrine System

• Cushing's disease (hyperadrenalism)—caused by overproduction of adrenocortical steroids
  – Characterized by accumulation of fluids and fat on face, neck, and upper back
  – May also develop muscle weakness, osteoporosis, or diabetes mellitus
  – Marked by an increased tendency to bruise easily and poor wound healing

Pathological Conditions of the Endocrine System

• Diabetes insipidus—caused by posterior pituitary gland dysfunction resulting in deficient production of antidiuretic hormone (ADH)
  – Not related to pancreas or insulin
  – Increases urine production and thirst
  – Same massage considerations as for diabetes mellitus

Pathological Conditions of the Endocrine System

• Diabetes mellitus—group of disorders leading to elevated blood glucose levels (hyperglycemia)
  – Type I diabetes—deficiency of insulin; usually diagnosed in children and young adults
  – Type II diabetes—90% of cases; usually occurs in adults
  – Complications include peripheral vascular disease and neuropathy in hands and feet

Pathological Conditions of the Endocrine System

• Goiter—caused by enlarged thyroid gland
  – May be associated with hypothyroidism, hyperthyroidism, inflammation, infection, or lack of dietary iodine
  – Prevalent in countries where dietary iodine is inadequate

Pathological Conditions of the Endocrine System

• Graves’ disease—characterized by hyperthyroidism, increased metabolic rate, and associated symptoms (e.g., anxiety, tremors)
  – Symptoms include enlarged thyroid and lymph nodes, and protrusion of eyeballs
  – Thought to be an autoimmune disorder

Pathological Conditions of the Endocrine System

• Hyperparathyroidism—caused by an overproduction of parathyroid hormone
  – Characterized by increased reabsorption of calcium from the bones and increased absorption of calcium from kidneys and gastrointestinal tract
  – Often accompanied by pain, spontaneous fractures, and gastrointestinal symptoms
Hyperpituitarism—over-production of growth hormone
- During childhood and puberty, leads to gigantism
- During adulthood, leads to acromegaly
- Can also lead to Cushing’s disease

Hyperthyroidism—hyperactivity of the thyroid gland
- Marked by overproduction of T4
- Characterized by enlarged thyroid, nervousness and tremor, heat intolerance, increased appetite with weight loss, rapid forceful pulse, or increased respiration rate

Hypoglycemia—excess loss of blood glucose levels
- Caused by overdose of prescribed insulin, excessive pancreatic insulin production, or extreme dietary deficiencies
- Signs include weakness, light-headedness, hunger, visual disturbances, anxiety, or sudden changes in personality
- If left untreated, can result in delirium, coma, or death

Hypoparathyroidism—diminished function of the parathyroid gland
- Caused by surgical removal, autoimmune disease, or genetic factors
- Decrease in calcium levels can result in muscle pain, tingling in hands and feet, dry skin, and rapid heartbeat

Hypopituitarism—reduced secretion of pituitary gland hormones
- During childhood, results in dwarfism
- During adulthood, results in infertility, lethargy, dry skin, hypoglycemia, loss of appetite, hypotension, abdominal pain, or intolerance to cold

Hypothyroidism—deficiency of thyroid activity
- Marked by fatigue, slow metabolism, dry skin, weight gain, or slowed mental processes
- More common in women than in men
- Can lead to cretinism
Summary

• Endocrine system—the endocrine glands and the hormones they secrete
• Ductless glands empty directly into the bloodstream
• Functions—regulate growth, development, metabolism, fluid balance; maintain homeostasis; contribute to reproduction

Summary

• Hormones—chemical messengers that act as catalytic agents
• Types include steroids, peptides, biogenic amines, and eicosanoids
• Levels are regulated by negative feedback, other hormones, and the nervous system
• Related diseases include diabetes, hypoglycemia, and obesity