

Endocrine System

Course

Anatomy and Physiology

Unit IX

Endocrine System

Essential Question

What are the tissues and systems of the human body?

TEKS

130.206 (c)
2F,2H
4A,4C
6A,6B
8A,8B,8C
10A,10B,10C,
10D
11A

Prior Student Learning

Basic body terms

Estimated time

4-8 hours

Rationale

The endocrine system is responsible for coordinating and regulating body cells, tissues, organs, and systems to maintain homeostasis by secreting chemicals known as hormones.

Objectives

Upon completion of this lesson, the student will be able to:

- define and decipher terms pertaining to the endocrine system;
- distinguish between the major organs of the endocrine system;
- analyze diseases and disorders of the endocrine system; and
- evaluate case studies related to the endocrine system.

Engage

How does the endocrine system work?

Key Points

Endocrine Power point

- I. Glands
 - A. Endocrine - ductless glands that secrete hormones directly into the bloodstream that flows through the gland
 - B. Exocrine - carried by a duct to a surface of a tissue - glands which are responsible for things like tears, sweat, or digestive juices
 - C. Gland - any organ/structure that produces a secretion
 1. Exocrine - carried by a duct or organ to the tissues
 2. Endocrine - carried by blood or lymph; NO ducts
- II. Hormones are chemical messengers released by one tissue (gland) and transported by the bloodstream to reach the target tissues; the target tissue is where the effect of the hormone actually occurs
 - A. Functions of Hormones
 1. Regulation of metabolism
 2. Regulation of growth and development
 3. Regulation of reproduction
 4. Regulation of stress response
 5. Regulation of cell permeability
 - B. Secretion and Storage of Hormones
 1. All are formed by the endoplasmic reticulum
 2. Transported by the Golgi apparatus that packages the hormones in secretory vesicles which are stored in the cytoplasm of the endocrine cell
 3. Waits for nerve signal or chemical signal to initiate the

secretion

- a. Hormonal stimuli
- b. Humoral stimuli
- c. Neural stimuli

C. Negative Feedback

1. Endocrine glands tend to over-secrete their hormones so the target organ has enough to function properly
2. When too much function occurs, some factor feeds back to the endocrine gland to cause a negative effect on the gland to decrease its secretory rate
3. Hormone is monitored and regulated internally

D. Transport

1. Hormones travel to target cells by carrier blood plasma proteins for specific hormones
2. Target cells have specific receptor proteins for specific hormones
3. Target cells become biologically active to regulate the function of other organs when binding occurs on the target cell

III. Endocrine Glands (See Endocrine Gland Diagram)

A. The pituitary gland or the hypophysis is found in the brain. It is attached to the hypothalamus by a small stalk called the infundibulum and sits in a bony depression of the sphenoid bone called the sella turcica. The pituitary gland is divided into anterior and posterior regions. It is nicknamed the "master gland" since it produces nine hormones.

1. Anterior Lobe: adenohypophysis; connected to hypothalamus by a system of vessels
 - a. ACTH (adrenocorticotrophic hormone): stimulates the adrenal cortex to secrete steroids
 - b. GH, HGH (growth hormone): somatotropin that controls body size by increasing mitosis, increasing cell size, and increasing the rate of protein synthesis
 - c. TSH (thyroid stimulating hormone): stimulates thyroid to secrete thyroxin (T4)
 - d. Gonadotropins = FSH and LH
 - e. LTH (Prolactin): promotes growth of breast tissue and milk secretion after delivery
 - f. MSH (Melanocyte stimulating hormone): stimulates melanin skin pigment formation
2. Posterior Lobe: neurohypophysis, connected to the hypothalamus by a stalk of nerve tissue
 - a. ADH (Antidiuretic hormone/vasopressin): promotes water reabsorption by kidney tubules and increases blood pressure

- (1) Trauma increases ADH, so body retains fluid
- (2) Alcohol decreases ADH, so diuresis occurs
- (3) Diabetes insipidus: decreased ADH secretion; S & S → polyuria, polydipsia, dehydration

b. Oxytocin: sucking stimulates oxytocin release, so milk is let down, contracts uterus, too

- (1) Pitocin: synthetic oxytocin

B. Adrenal Glands - There are two adrenal glands, each superior to a kidney. Each adrenal gland has two parts -- an outer adrenal cortex and an inner adrenal medulla. Each section produces its own hormones. The adrenal cortex appears yellow in color due to the presence of lipids. It produces more than two dozen steroid hormones known as corticosteroids, including the glucocorticoids and the mineral corticoids. The adrenal medulla is reddish brown in color due to the large number of blood vessels. It contains many sympathetic nerve cells and functions with the sympathetic division of the nervous system.

1. Epinephrine accounts for 80 percent of the secretions from the adrenal medulla. The target tissues of epinephrine include skeletal muscles, adipose tissue, and the liver. The effects of epinephrine include the breakdown of glycogen to form glucose to provide more ATP, increased muscular power and endurance, and increased heart rate and force of contractions. Epinephrine increases blood flow to the vital organs, such as the brain, increased mental alertness, enlarged airways, and increased breathing rate. In other words, it helps the body cope with emergency and stress situations.
2. Norepinephrine accounts for 20 percent of the secretions from the adrenal medulla. The target tissues for norepinephrine include the skeletal muscles, adipose tissue, and the liver. The effects include the breakdown of glycogen to form glucose to provide more ATP, increased muscular power and endurance, and increased heart rate. Norepinephrine increases blood flow to the vital organs, such as the brain, increased mental alertness, enlarged airways, and increased breathing rate. In other words, it helps the body cope with emergency and stress situations.
3. Cortisol is one of the glucocorticoids produced by the adrenal cortex. The primary role of cortisol is to

promote glucose production and glycogen destruction in the liver in a process called gluconeogenesis which provides the body cells with adequate glucose to produce ATP. The adrenal cortex provides back up for the stress responses created by the adrenal medulla. Other effects of cortisol include suppressing inflammation and inhibiting allergens.

- C. Ovaries: hormones stimulated by FSH and LH of anterior pituitary then secreted by the ovarian follicles
 - 1. Estrogen develops and maintains secondary sexual characteristics
 - 2. Progesterone: secreted by corpus luteum during the last half of the menstrual cycle, prepares uterus for pregnancy and the breasts for lactation, also secreted by the placenta during pregnancy
- B. Testes: hormone secretion stimulated by LH of the anterior pituitary and secreted by the Leydig cells of the testes
 - 1. Testosterone: causes the growth and maintenance of secondary sexual characteristics and spermatogenesis under FSH control
- C. Pineal Gland (Body): above the roof of the 3rd ventricle of the brain
Melatonin: suppresses/regulates gonadotropic hormones, controls sexual drive, delays puberty, some research relates it to SAD (seasonal affective disorder)
- D. Thyroid gland - located just below the thyroid cartilage (Adam's apple) of the larynx. It has a bow-tie shape and is reddish-brown in color.
 - 1. Thyroxine (T4)
 - a. Requires the mineral iodine in order to be made
 - b. Thyroxine targets most body cells and acts to increase metabolism by improving energy utilization, oxygen consumption, growth, and development.
 - 2. Calcitonin: regulates calcium metabolism (vitamin D is essential for calcium absorption)
- B. Parathyroid Glands: 4 tiny pea-like structures embedded posterior to the thyroid gland
 - 1. Parathormone: PTH; regulates the amount of calcium and phosphorus in circulating blood and storage of calcium in bones and teeth
 - a. Hypo PTH: hypocalcemia causes tetany with laryngeal spasms
 - b. Hyper PTH: hypercalcemia
- C. Thymus: secretes thymosin which stimulates the production of antibodies in early life by maturing the T-cells; atrophies after

puberty

- D. Pancreas - lies in the fold of the duodenum posterior to the stomach and peritoneal membranes. It is a pink organ with a nodular appearance. It contains both exocrine cells which produce digestive enzymes, and endocrine cells which produce hormones.
 - 1. Glucagon - produced by the alpha cells of the pancreas, glucagon functions to increase blood glucose (sugar) levels by stimulating the liver to convert glycogen to glucose. When the blood glucose level rises, glucagon is inhibited.
 - 2. Insulin - produced by the beta cells of the pancreas, insulin functions to decrease blood sugar levels by stimulating the liver to convert glucose to glycogen and to facilitate the diffusion of glucose into the body cells where it can be used for energy or stored as lipids. When the blood glucose level falls, insulin is inhibited.
 - 3. Effects of pancreatic hormones
 - a. After a meal, blood sugar increases. Insulin secretion increases and glucagon secretion decreases to lower the high plasma glucose concentration.
 - b. With fasting, blood sugar decreases. Insulin secretion decreases and glucagon secretion increases to keep plasma glucose concentrations up to a safe minimum level.

IV. Diseases and Disorders of the Endocrine System

- A. Acromegaly is a hypersecretion of the growth hormone during adulthood. Characteristics of this disease include enlargement of the bones of the hands, feet, jaws, and cheeks. A prominent forehead and large nose are also typical features of this disease.
- B. Cretinism is the hyposecretion of the thyroid hormones during infancy and childhood which results in low metabolism, retarded growth, and often mental retardation. It is treated with synthetic hormones which prevent the onset of symptoms.
- C. Diabetes mellitus is the inability of the body to regulate one's blood glucose level. Type 1 diabetes mellitus occurs when the body fails to produce sufficient insulin. Type 2 diabetes mellitus occurs when the body cells become resistant to the effects of insulin. The most common reasons diabetes mellitus occurs in the United States are poor nutrition, inadequate exercise, and increasing obesity rates. The major symptoms include polydipsia, polyphagia, and polyuria. Type 1 diabetes mellitus is controlled with insulin injections and diet. Type 2 diabetes mellitus is controlled with diet, weight loss, pills to

- improve the effect of insulin, and sometimes insulin injections.
- D. Dwarfism is due to a hyposecretion of the growth hormone during childhood resulting in a small person who has a body frame of normal proportions.
 - E. Gigantism is due to a hypersecretion of the growth hormone during childhood resulting in a person who grows to a very large size.
 - F. Hyperthyroidism is due to the hypersecretion of the thyroid hormones. There is a dramatic increase in the metabolic rate which results in weight loss, increased appetite, irritability, restlessness, and over activity. Many patients have characteristic protruding eyeballs or exophthalmos. It is treated with medications to reduce the production of the thyroid hormone or sometimes radiation to destroy part of the thyroid gland reducing its secretions.
 - G. Hypothyroidism is due to the hyposecretion of the thyroid hormones. It may be the result of inadequate iodine intake or unknown causes. The adult form of hypothyroidism is called myxedema which leads to reduced mental and physical energy, loss of hair, swelling, and weight gain. It is treated with a synthetic thyroid hormone.

Activity

- I. Complete Hormone Chart. (*This can be completed by the student as notes are given.*)
- II. Complete the Endocrine System Worksheet
- III. Complete the Endocrine System Case Study
- IV. Identify anatomical structures of endocrine system on dissected cat (*This can be accomplished as a virtual tour on the internet or, if your budget allows, the students can dissect cats.*)
- V. Research and report on disorders of the Endocrine system

Assessment

Successful completion of Endocrine System Worksheet
Successful completion of Endocrine System Case Studies

Materials

Hormone Chart
Endocrine System Worksheet
Endocrine Case Studies
Dissection Cat: 1 for every 2-4 students, and dissection tools AND/OR computers with internet access
Computers

Utah State Office of Education, (2005). *Medical Anatomy and Physiology Teacher Resource CD*. Utah.

Accommodations for Learning Differences

For reinforcement, students will create flashcards for the terminology associated with the endocrine system.

For enrichment, the students will identify and report on pharmaceutical agents used to treat diseases of the endocrine system. Present using multimedia technology.

National and State Education Standards

National Health Science Cluster Standards

HLC01.01 Academic Foundations

Health care workers will know the academic subject matter required (in addition to state high school graduation requirements) for proficiency within their area. They will use this knowledge as needed in their role.

HLC10.01 Technical Skills

Health Care Workers will apply technical skills required for all career specialties. They will demonstrate skills and knowledge as appropriate.

TEKS

130.206(c)(2)(F) collect and organize qualitative and quantitative data and make measurements with accuracy and precision using tools such as calculators, spreadsheet software, data-collecting probes, computers, standard laboratory glassware, microscopes, various prepared slides, stereoscopes, metric rulers, electronic balances, hand lenses, Celsius thermometers, hot plates, lab notebooks or journals, timing devices, petri dishes, lab incubators, dissection equipment, meter sticks, and models, diagrams, or samples of biological specimens or structures;

130.206(c)(2)(H) communicate valid conclusions supported by the data through methods such as lab reports, labeled drawings, graphic organizers, journals, summaries, oral reports, and technology-based reports;

130.206(c)(4)(A) analyze the chemical reactions that provide energy for the body;

130.206(c)(4)(C) analyze the effects of energy deficiencies in malabsorption disorders such as diabetes, hypothyroidism, and Crohn's disease;

130.206(c)(6)(A) investigate and describe the integration of the chemical and physical processes, including equilibrium, temperature, pH balance, chemical reactions, passive transport, active transport, and biofeedback, that contribute to homeostasis;

130.206(c)(6)(B) determine the consequences of the failure to maintain homeostasis;

130.206(c)(8)(A) analyze the physical, chemical, and biological properties of transport systems, including circulatory, respiratory, and excretory;

130.206(c)(8)(B) determine the factors that alter the normal functions of transport systems;

130.206(c)(8)(C) contrast the interactions among the transport systems;

130.206(c)(10) (A) analyze the relationships between the anatomical structures and physiological functions of systems, including the integumentary, nervous, skeletal, musculoskeletal, cardiovascular, respiratory, gastrointestinal, endocrine, and reproductive;
130.206(c)(10)(B) evaluate the cause and effect of disease, trauma, and congenital defects on the structure and function of cells, tissues, organs, and systems;
130.206(c)(10)(C) research technological advances and limitations in the treatment of system disorders;
130.206(c)(10)(D) examine characteristics of the aging process on body systems; and
130.206(c)(11)(A) explain embryological development of tissues, organs, and systems.

Texas College and Career Readiness Standards

English Language Arts

II. B. Understand new vocabulary and concepts and use them accurately in reading, writing, and speaking.

III. B. Develop effective speaking styles for both group and one-on-one situations.

IV. A. Apply listening skills as an individual, and as a member of a group in a variety of settings.

IV. B. 2. Listen actively and effectively in one-on-one communication situations.

Science

1.A.1. Utilize skepticism, logic, and professional ethics in science.

1.A.2. Use creativity and insight to recognize and describe patterns in natural phenomena.

1.A.3. Formulate appropriate questions to test understanding of a natural phenomenon.

1.A.4. Rely on reproducible observations of empirical evidence when constructing, analyzing, and evaluating explanations of natural events and processes.

1.E.2. Use essential vocabulary of the discipline being studied.

3.A.1. Use correct applications of writing practices in scientific communication.

Hypothalamus and Anterior Pituitary Gland

Hypothalamus			Ant. Pituitary		
Type of Stimulus	Hormone	Result	Hormone (All Hormonal Stimuli)	Organ Stimulated	Action

Posterior Pituitary, Thyroid, Adrenal Glands

Gland	Hormone	Stimulus	Result	Action
Posterior Pituitary				
Thyroid Gland				
Parathyroid Gland				
Adrenal Cortex				
Adrenal Medulla				

Pancreas

Gland	Hormone	Stimulus	Result	Action
Pancreas				

Gonads, Pineal, and Thymus Gland

Gland	Hormone	Stimulus	Result	Action
Ovaries				
Testes				
Pineal				
Thymus				

Hypothalamus and Anterior Pituitary Gland

Hypothalamus			Ant. Pituitary		
Type of Stimulus	Hormone	Result	Hormone (All Hormonal Stimuli)	Organ Stimulated	Action
Humoral	GHRH (GHIH or decreased GH)	AP	GH	Bone, Muscle	Growth
Humoral (decreased TH)	TRH	AP	TSH	Thyroid	T3, T4
Neural (stress), Humoral (decreased glucose)	CRH	AP	ACTH	Adrenal cortex	Corticosteroids
Humoral (levels of sex hormones)	GnRH	AP	FSH	Gonads (testes, ovaries)	Gamete Production (sperm, egg)
Humoral (sex hormones)	GnRH	AP	LH	Gonads	Sex hormones
Humoral (sex hormones, Neural (breast feeding))	PRH	AP	PRL	Breasts	Milk Production

Posterior Pituitary, Thyroid, Adrenal Glands

Gland	Hormone	Stimulus	Result	Action
Posterior Pituitary	Oxytocin	Neural (Uterine stretch, baby suckling)	Mammary Glands	Milk Release
	ADH	Neural (decreased BP)	Kidneys	Conserve Fluid
Thyroid Gland	TH	Hormonal, TSH	All cells of body, needed for normal tissue growth	Increases BMR
	Calcitonin	Humoral (increased Ca ⁺⁺)	Bones	Decreases Ca ⁺⁺ Levels
Parathyroid Gland	PTH	Humoral (decreased Ca ⁺⁺)	Bones	Increases Ca ⁺⁺ Levels

Adrenal Cortex	Aldosterone	Humoral (decreased fluid, decreased Na ⁺)	Kidneys	Conserves Na ⁺
Adrenal Medulla	Epinephrine	Neural (Sympathetic Nervous System)	Heart, Lungs, Etc.	Increase VS

Pancreas

Gland	Hormone	Stimulus	Result	Action
Pancreas	Insulin	Humoral (increased glucose)	All cells of body	Decreases blood glucose
	Glucagon	Humoral (decreased glucose)	Liver	Increases blood glucose

Gonads, Pineal, and Thymus Gland

Gland	Hormone	Stimulus	Result	Action
Ovaries	Estrogen	Hormonal	Reproductive Development	Puberty Changes
	Progesterone	Hormonal	Breast Development	Menstruation
Testes	Testosterone	Hormonal	Reproductive Development	Sperm/Puberty Changes
Pineal	Melatonin	Neural, Light	Hypothalamus	Sleep/Wake Cycle
Thymus	Thymosin	Humoral	Immune	Lymphocytes

Endocrine System

1. Describe a hormone.
2. Identify 5 functions of hormones.
3. Describe the reaction of thyroxine hormone has on the body.
4. What hormone from the pituitary gland stimulates the release of thyroxine from the thyroid gland?
5. How do epinephrine and norepinephrine help the body cope with stress?
6. What gland is called the "Master Gland" of the body?
7. What gland produces "growth hormone"?
8. What hormone dilates systemic arteries, increases cardiac output, and increases blood flow to the kidneys causing urinary output?

("Medical anatomy and," 2005)

Endocrine System Key

1. Describe a hormone-

Hormone: biologically active chemical (steroid, amino acid, polypeptide, glycoprotein) that combines with specific receptor proteins and regulates the function of other organs. There are over 50 different hormones.

2. Identify 5 functions of hormones.

1. Regulation of metabolism
2. Regulation of growth and development
3. Regulation of reproduction
4. Regulation of stress response
5. Regulation of cell permeability

3. Describe the effect of the thyroxin hormone on the body.

Regulates metabolism by increasing metabolic rate; increases the glucose, fat, carbohydrates, and vitamin metabolism

4. What hormone from the pituitary gland stimulates the release of thyroxin from the thyroid gland?

TSH (thyroid stimulating hormone): stimulates thyroid to secrete thyroxin (T4)

5. How do epinephrine and norepinephrine help the body cope with stress?

Medulla: central portion, has same effect as a direct sympathetic nerve response; called the stress hormones; 'fight or flight' response

Epinephrine: adrenalin

- (1) Accelerates heart rate, increases blood pressure, increases heart output
- (2) Weak vasoconstriction in skin
- (3) Vasodilation of skeletal and cardiac muscles
- (4) Relaxes bronchioles; treats severe respiratory distress
- (5) Increases respirations
- (6) Increases metabolic rate of every cell
- (7) Increases blood glucose levels by increasing glycogen breakdown in liver
- (8) Increases muscle strength and mental activity
- (9) Decreases GI function

Norepinephrine: noradrenaline

- (1) Neurotransmitter, strong vasoconstrictor
- (2) Increases BP, but slows heart, dilates pupils

6. What gland is called the "Master Gland" of the body? Pituitary gland

7. What gland produces "growth hormone"? Pituitary gland

8. What hormone dilates systemic arteries, increases cardiac output, and increases blood flow to the kidneys causing urinary output? Dopamine

("Medical anatomy and," 2005)

Endocrine System Case Studies

1. Kelly is exhibiting neuromuscular irritability, tetany (tingling noted around the mouth and in her feet), dry skin and fingernails, more prone to cavities (you suspect weak tooth enamel). Her blood work is normal, except that hypocalcemia is noted. She is treated with supplemental calcium and Vitamin D.

The disorder is: _____

The hormone of hyposecretion is: _____

2. Luke, age 47, is complaining of his shoes and rings not fitting anymore. He says he has developed large gaps between his teeth. He mentions that he has difficulty chewing and has gained 20 pounds in the last 6 months. He is a diaphoretic (sweating), and he has oily skin. A CT scan reveals a tumor in the pituitary gland, which will be surgically removed.

The disorder is: _____

The hormone of hypersecretion is: _____

3. Autumn, age 30, has had noticeable weight gain resulting in purple striae (stretch marks) along the abdomen. She has increased deposits of adipose tissue in the face (moon face), the shoulders (buffalo hump), neck and trunk. She states that when she cuts herself, it takes "forever" to heal. She complains of an irregular heartbeat as well. A physical examination indicates hypertension (high blood pressure). Her blood work reveals hypernatremia, hypokalemia, and hyperglycemia. A urine test reveals glucosuria. Surgery is recommended to remove the involved glands.

The disorder is: _____

The hormone of hyposecretion is: _____

4. Timothy, 6 months old, is brought into the doctor. The parents, who were thrilled with their "good baby," are now concerned that something is wrong. The child's tongue protrudes from the mouth and jaundice is present. Because of the tongue, respirations seem noisy and difficult. The forehead is short and puffy. The child is generally inactive and sleeps excessively. The child has a dull expression. The skin is cold to touch and mottled in appearance. Blood work reveals that the child should have supplemental thyroid medication.

The disorder is: _____

The hormone of hyposecretion is: _____

5. Duane, age 28, is hospitalized for this eighth kidney stone this year. He is also complaining of having to urinate large amounts frequently, bone tenderness and muscle weakness. His blood work is unremarkable, except for hypercalcemia. It is recommended that he have surgery to remove his parathyroid glands.

The disorder is: _____

The hormone of hypersecretion is: _____

6. Rebecca, age 33, states she has lost a lot of weight in the past 6 months. She claims this is surprising due to her voracious appetite. She complains of her heart racing in her chest, difficulty concentrating, and nervousness. She claims that she can no longer tolerate heat, even though she grew up in New Zealand. Her eyes are protruding, a condition called exophthalmos. Examination reveals an enlarged thyroid gland. Treatment would include anti-thyroid drugs and possibly surgery to remove part of the thyroid gland.

The disorder is: _____

The hormone of hypersecretion is: _____

7. Brittany, age 8, complains of arm and leg pains. She is 12 inches taller than most children her age. Treatment involves the discovery of the underlying cause, such as a tumor in the pituitary gland.

The disorder is: _____

The hormone of hypersecretion is: _____

8. Jerome, age 17, is complaining of frequent urination, fatigue, dry mouth, dizziness, polydipsia (extreme thirst), and a craving for cold water. He is hospitalized to record his intake and output to obtain lab values. In a 24-hour period, he voided 7 liters of dilute urine and drank 8.5 liters of fluid. His blood pressure was an average of 72/36. Treatment involves discovering the cause, possibly a tumor in the pituitary gland.

The disorder is: _____

The hormone of hyposecretion is: _____

Key - Endocrine Case Studies

1. Hypoparathyroidism; parathyroid hormone
2. Acromegaly; growth hormone
3. Cushing's Disease; adrenal cortex hormones
4. Cretinism; thyroxine
5. Hyperparathyroidism (osteomalacia); parathyroid hormone
6. Hyperthyroidism (Graves); thyroxine
7. Gigantism; growth hormone
8. Diabetes insipidus; ADH