10

The Endocrine System

FOCUS: The endocrine system is one of the major regulatory systems in the body, along with the nervous system. However, the endocrine system responds more slowly, and has a longer-lasting, more general effect on the body than the nervous system. Endocrine tissues internally produce hormones which are released into the blood, where they are carried to target tissue and produce a response. Some hormones bind to receptors on the surface of the cell membrane, producing permeability changes or production of a substance inside the cell. Other hormones diffuse into the cell and cause new proteins to be produced. The secretion of hormones is controlled by negative-feedback mechanisms. The major endocrine glands are the pituitary, thyroid, parathyroids, adrenal glands, pancreas, testes, ovaries, thymus, and pineal body.

CONTENT LEARNING ACTIVITY

Chemical Signals

"*Chemical signals, or ligands, are molecules released from one location that move to another location to produce a response.*"

A. Match these terms with the correct statement or definition:

Intercellular chemical signals
Intracellular chemical signals

_____ 1. Produced in one part of a cell, and travel to another part of the same cell and attach to receptors.

_____ 2. Released from one cell, carried in the intercellular fluid, and bind to their receptors on other cells.

B. Match these terms with the correct statement or definition:

Autocrine
Hormones and neurohormones
Neuromodulators and neurotransmitters
Paracrine
Pheromones

_____ 1. Chemical signals released by cells that have a local effect on the same cell type from which the chemical signals were released.

_____ 2. Chemical signals released by cells that have effects on other cell types near the cells from which they are released.

_____ 3. Intercellular chemical signals secreted into the circulatory system; carried to organs they control, where they bind to receptors and produce a response.

_____ 4. Intercellular chemical signals, secreted by nerve cells; important in the function of the nervous system.

_____ 5. Chemical signals secreted into the environment that modify the behavior and physiology of other individuals.

Receptors

"*Chemical signals bind to proteins or glycoproteins, called receptor molecules, to produce a response.*"

A. Match these terms with the correct statement or definition:

Intracellular receptors
Membrane-bound receptors

_____ 1. Receptors located in either the cytoplasm or nucleus of the cell.

_____ 2. Receptors that extend across the cell membrane and have a receptor site on the outer surface of the membrane.

_____ 3. Relatively small chemical signals that are soluble in lipids bind to these receptors.

_____ 4. Large, water-soluble chemical signals that do not diffuse across the cell membrane bind to these receptors.

_____ 5. When chemical signals bind to these receptors, messenger RNA synthesis is increased, and new proteins are produced.

_____ 6. When chemical signals bind to these receptors, many specific enzymes in the cell may be rapidly activated, producing a cascade effect.

_____ 7. Several hours are required between the time when chemical signals bind to these receptors and the response.

B. Using the terms provided, complete these statements:

cAMP	G protein
cGMP	GTP
Enzymes	Phosphate
Ion channels	

A hormone that binds to membrane-bound receptors may cause (1) to open or close, or may cause the activity of (2) inside the cell to increase or decrease. For example, when some intercellular chemical signals bind to receptor sites, a protein complex called (3) on the inner surface of the cell membrane is activated. GDP is replaced by (4) on the alpha subunit of the G proteins; this complex activates enzymes that produce intracellular chemical signals such as DAG, IP_3, and (5). Some intercellular chemical signals directly alter enzyme activity on the inner surface of the cell membrane, which can increase or decrease synthesis of intracellular chemical signals such as (6). Other intercellular chemical signals alter the activity of an enzyme on the inner surface of the cell membrane, which, in turn, adds a (7) group to proteins inside the cell. The proteins with phosphates attached then produce a response in the cell.

1. _____
2. _____
3. _____
4. _____
5. _____
6. _____
7. _____

Hormones

"*Intercellular chemical signals secreted by endocrine glands are called hormones.*"

A. Match these terms with the correct statement or definition:

Endocrine glands	Exocrine glands	Hormones
Receptors	Target tissues	

_____ 1. Glands that secrete their chemical signals into the blood, e.g., thyroid gland and adrenal glands.

_____ 2. Glands that secrete their products into ducts, e.g., sweat glands and salivary glands.

_____ 3. Intercellular chemical signals produced in minute amounts, secreted into the blood, that act on tissues at another site in the body to influence their activity in a specific way.

_____ 4. Tissues that respond to each type of hormone.

_____ 5. Location on or in cells where hormones can bind.

Hormones that are proteins, peptides, and amino acid derivatives bind to membrane-bound receptors, except for the thyroid hormones. Steroid hormones bind to intracellular receptors and prostaglandins bind to membrane-bound receptors.

B. Match these terms with the correct statement or definition:

Amino acid derivatives
Peptides
Prostaglandins
Proteins
Steroids

_____ 1. Hormones such as those secreted by the anterior pituitary gland.

_____ 2. Hormones such as those secreted by the posterior pituitary gland.

_____ 3. Hormones such as those secreted by the adrenal medulla.

_____ 4. Lipid hormones derived from cholesterol; secreted mainly by the adrenal cortex and gonads.

_____ 5. Lipid hormones derived from arachidonic acid; produced by many tissues, generally with a local effect.

Secretion of hormones is controlled by negative-feedback mechanisms. The controlling factor may be blood levels of chemicals or secretion of other hormones. In addition, stimulation of some neurons controls the production of neurohormones.

The Pituitary and Hypothalamus

"*The pituitary gland is a pea-sized gland located beneath the hypothalamus.*"

A. Match these terms with the correct statement or definition:

Anterior pituitary
Hypothalamus
Infundibulum
Posterior pituitary

_____ 1. Important autonomic and endocrine control center of the brain located inferior to the thalamus.

_____ 2. Stalk that connects the pituitary gland to the hypothalamus.

_____ 3. Part of the pituitary derived from the embryonic oral cavity.

_____ 4. Part of the pituitary made up of nerve cells.

B. Match these terms with the correct statement or definition:

Hypothalamic-pituitary portal system
Nerve cells in hypothalamus
Releasing hormones

_____ 1. Chemical signals produced by nerve cells of the hypothalamus; influence secretion of hormones from the anterior pituitary.

_____ 2. Capillary beds and veins that transport releasing hormones to the anterior pituitary.

_____ 3. Source of hormones released from the posterior pituitary.

Hormones of the Anterior Pituitary

"*The anterior pituitary secretes several hormones that affect other glands.*"

Match these hormones with the correct function or description:

Adrenocorticotropic hormone (ACTH)
Follicle-stimulating hormone (FSH)
Growth hormone (GH)
Luteinizing hormone (LH)
Melanocyte-stimulating hormone (MSH)
Prolactin
Thyroid-stimulating hormone (TSH)

_____ 1. Stimulates the growth of bones, muscles, and other organs by increasing protein synthesis; favors fat breakdown.

_____ 2. Increases the secretion of cortisol from the adrenal cortex.

_____ 3. A gonadotropin that causes ovulation in females and sex hormone secretion in males and females; sometimes called ICSH in males.

_____ 4. A gonadotropin that stimulates development of eggs in the ovary and sperm cells in the testis.

_____ 5. Promotes breast development during pregnancy and causes milk production.

In a young person, too little growth hormone produces a pituitary dwarf, and too much growth hormone produces giantism. Too much growth hormone after bone growth is complete produces acromegaly.

Hormones of the Posterior Pituitary

"*Posterior pituitary hormones are produced in nerve cell bodies in the hypothalamus, and released from their axon endings in the posterior pituitary.*"

Match these hormones with the correct function or description:

Antidiuretic hormone (ADH)
Oxytocin

_____ 1. Increases water reabsorption by the kidney tubules and constriction of blood vessels; also called vasopressin.

_____ 2. Causes contraction of muscles of the uterus and milk letdown.

The Thyroid Gland

"*The thyroid gland is made up of two lobes connected by a narrow band called the isthmus.*"

A. Match these terms with the correct statement or definition:

Calcitonin
Parafollicular cells
Thyroid follicles
Thyroid hormones

_____ 1. Small spheres of cuboidal epithelium that synthesize and store thyroid hormones.

_____ 2. Hormones produced in the thyroid gland that regulate the rate of metabolism in the body.

_____ 3. Cells located in a network of loose connective tissue between thyroid follicles.

_____ 4. Hormone that decreases calcium ion levels in the body; synthesized by parafollicular cells.

One thyroid hormone, called thyroxine or tetraiodothyronine (T_4), contains four iodine atoms; the other thyroid hormone is called triiodothyronine (T_3) and contains three iodine atoms.

B. Match these conditions with the correct symptom or condition:

Hyperthyroidism
Hypothyroidism

_____ 1. Cretinism in infants.

_____ 2. In adults, a reduced metabolic rate, sluggishness, myxedema, and a reduced ability to perform routine tasks.

_____ 3. Elevated metabolic rate, extreme nervousness, and chronic fatigue; Graves disease and exophthalmia.

_____ 4. Iodine deficiency and goiter.

C. Match these terms with the correct statement :

Decreases
Increases

_____ 1. Increased thyroid hormone production ____ TSH production.

_____ 2. Decreased TSH production _____ thyroid hormone production.

_____ 3. Excess TSH _____ the size of the thyroid gland.

_____ 4. Increased calcium ion levels in blood _____ calcitonin secretion.

_____ 5. Calcitonin _____ calcium ion levels in the blood.

The Parathyroid Glands

"*Four tiny parathyroid glands are embedded in the posterior wall of the thyroid gland.*"

A. Match these terms with the correct statement:

Decreases
Increases

_____ 1. Parathyroid hormone (PTH) _____ active vitamin D formation.

_____ 2. Active vitamin D _____ absorption of calcium ions by the small intestine.

_____ 3. PTH _____ the breakdown of bone tissue to release calcium ions into the blood.

_____ 4. PTH _____ the rate at which calcium ions are lost in the urine.

_____ 5. Decreased calcium ion levels in the blood _____ PTH production.

PTH is more important than calcitonin in regulating blood calcium levels.

B. Match these terms with the correct symptoms:

Hyperparathyroidism
Hypoparathyroidism

_____ 1. Easily fractured bones, fatigue and muscle weakness, or kidney stones.

_____ 2. Muscle cramps or tetanus produced by low blood calcium levels.

The Adrenal Glands

"*The adrenal glands, or suprarenals, are two small glands, each located on top of a kidney.*"

Match these terms with the correct statement or definition:

Adrenal cortex
Adrenal medulla

_____ 1. Inner part of the adrenal gland; releases epinephrine and norepinephrine.

_____ 2. Outer part of the adrenal gland; releases steroid hormones.

The Adrenal Medulla

"*Epinephrine and norepinephrine are released in response to stimulation by the sympathetic nervous system.*"

Match these terms with the correct statement:

Decrease
Increase

_____ 1. Adrenal medulla hormones (epinephrine and norepinephrine) will cause a(n) _____ in blood flow to internal organs and skin.

_____ 2. Adrenal medulla hormones _____ heart rate and blood pressure.

_____ 3. Adrenal medulla hormones _____ the metabolic rate in skeletal muscle, cardiac muscle, and nervous tissue.

_____ 4. Adrenal medulla hormones _____ the diameter of bronchioles.

_____ 5. Adrenal medulla hormones _____ the release of glucose and fatty acids into the blood.

Epinephrine and norepinephrine are referred to as the fight or flight hormones because of their role in preparing the body for vigorous physical activity.

The Adrenal Cortex

"*There are three classes of steroid hormones secreted by the adrenal cortex.*"

A. Match these terms with the correct statement or definition:

Aldosterone
Androgens
Cortisol
Glucocorticoids
Mineralocorticoids

_____ 1. Class of steroid hormones that help to regulate blood nutrient levels in the body.

_____ 2. Major glucocorticoid hormone.

_____ 3. Class of steroid hormones that help regulate blood volume and levels of sodium and potassium ions.

_____ 4. Major mineralocorticoid hormone.

_____ 5. Class of steroid hormones that stimulate the development of male sexual characteristics.

B. Match these terms with the correct statement:

Decreases
Increases

_____ 1. Cortisol _____ glucose, fatty acids, and amino acids in blood.

_____ 2. Stress _____ the secretion of cortisol.

_____ 3. Cortisol _____ the inflammatory response.

_____ 4. If ACTH increases, the secretion of cortisol _____.

C. Match these terms with the correct statement:

Decreases
Increases

_____ 1. Aldosterone _____ sodium ion and water retention in the body.

_____ 2. Aldosterone _____ potassium ion retention in the body.

_____ 3. Aldosterone secretion _____ when blood potassium levels increase.

_____ 4. Aldosterone secretion _____ when blood pressure or sodium levels decrease.

_____ 5. High blood pressure _____ the release of renin from the kidney.

_____ 6. Angiotensin II _____ aldosterone production and constriction of blood vessels.

_____ 7. Blood pressure _____ when angiotensin II increases.

Cortisone, a steroid closely related to cortisol, is often given as a medication to reduce inflammation during certain allergic responses and injuries.

The Pancreas, Insulin, and Diabetes

"*The pancreatic islets secrete two hormones, insulin and glucagon, that help regulate blood nutrient levels, especially glucose.*"

A. Match these terms with the correct statement or definition:

Diabetes mellitus
Glucagon
Insulin
Pancreatic islets

_____ 1. Endocrine cell clusters among exocrine cells in the pancreas.

_____ 2. Secreted by beta cells in response to increased blood glucose levels, parasympathetic stimulation, and increased amino acid levels in blood.

_____ 3. Disorder caused by secretion of too little insulin by pancreas, or insufficient or defective insulin receptors on target cells.

_____ 4. Secreted from alpha cells when blood glucose levels are low.

B. Match these terms with the correct statement:

Decreases
Increases

_____ 1. If blood glucose level decreases below normal, the ability of the nervous system to function _____.

_____ 2. When blood glucose level decreases below normal, the breakdown of fat _____.

_____ 3. Increased breakdown of fat _____ the pH of the body fluids, leading to acidosis.

_____ 4. If blood glucose levels are too high, the volume of urine produced _____, resulting in dehydration.

C. Match these terms with the correct statement:

Decrease(s)
Increase(s)

_____ 1. In people with diabetes mellitus, glucose uptake into tissues _____.

_____ 2. In people with diabetes mellitus, blood glucose level _____.

_____ 3. In people with diabetes mellitus, glucose is not available for metabolism, so breakdown of fats and proteins _____.

_____ 4. In people with diabetes mellitus, appetite and thirst _____.

_____ 5. In people with diabetes mellitus, energy level and amount of body tissue _____.

D. Match these terms with the correct statement:

Decrease(s)
Increase(s)

_____ 1. Insulin causes glucose uptake, glycogen synthesis, and fat synthesis in the body to _____.

_____ 2. Insulin causes blood glucose level to _____.

_____ 3. Glucagon _____ the breakdown of glycogen to glucose.

_____ 4. Glucagon causes blood glucose level to _____.

_____ 5. When blood glucose levels increase, insulin secretion _____.

_____ 6. When blood glucose levels decrease, glucagon secretion _____.

_____ 7. When blood glucose levels increase, secretion of epinephrine, glucocorticoids, and growth hormone _____.

When too much insulin is present, blood glucose levels become so low that the brain malfunctions, a condition known as insulin shock. Symptoms include disorientation, convulsions, and loss of consciousness.

The Testes and Ovaries

"*The testes of the male and the ovaries of the female secrete sex hormones in addition to producing sperm or eggs.*"

A. Using the terms provided, complete these statements:

Anterior pituitary hormones	Menstrual cycle
Decrease	Ovaries
Estrogen and progesterone	Testosterone
Increase	

The main hormone produced by the testes in the male is (1). It is responsible for growth and development of the male reproductive structures, a(n) (2) in muscle size and body hair, voice changes, and sex drive. In the female, (3) contribute to development and function of female reproductive structures and other female sexual characteristics. The female (4) is controlled by cyclic release of estrogens and progesterone from the (5), and the secretion of these hormones, in turn, is controlled by (6).

1. _____
2. _____
3. _____
4. _____
5. _____
6. _____

B. Match these terms with the correct statement:

Decrease(s)
Increase(s)

_____ 1. Releasing hormone from the hypothalamus _____ FSH and LH secretion from the anterior pituitary.

_____ 2. LH and FSH _____ the secretion of hormones of the ovary and testis.

_____ 3. Increases in testosterone, or estrogen and progesterone, _____ secretion of releasing hormone from the anterior pituitary.

Thymus Gland, Pineal Body, and Other Hormones

"*Several other glands and tissues produce hormones that have widespread effects in the body.*"

Match these hormones with the correct description:

Digestive hormones
Erythropoietin
Human chorionic gonadotropin
Melatonin
Prostaglandins
Thymosin

1. _____ Assists in the development of white blood cells called T cells; produced by the thymus.
2. _____ Pineal body hormone that decreases releasing hormone for FSH and LH; linked to the onset of puberty.
3. _____ Hormones produced in the lining of the stomach and small intestine that increase production of digestive juices and movement of food through the digestive tract.
4. _____ Hormone produced in widespread tissues throughout the body that causes relaxation or contraction of smooth muscle, blood vessel dilation, swelling, and pain; function mainly as autocrine or paracrine chemical signals.
5. _____ Hormone produced in the kidney that acts on bone marrow to increase red blood cell production.
6. _____ Placental hormone similar in structure and function to LH.

QUICK RECALL

1. Name nine functions of the endocrine system.

2. List seven kinds of intercellular chemical signals.

3. List four chemical categories of hormones.

4. List three ways of regulation of hormone secretion.

5. Name seven hormones secreted by the anterior pituitary.

Match these endocrine glands with the correct hormone each secretes:

Adrenal cortex
Adrenal medulla
Anterior pituitary
Ovaries
Pancreas
Parathyroid glands
Pineal body
Posterior pituitary
Thymus gland
Thyroid gland (follicle cells)
Thyroid gland (parafollicular cells)
Testes

_____ 6. ACTH

_____ 7. ADH

_____ 8. Adrenal androgens

_____ 9. Aldosterone

_____ 10. Calcitonin

_____ 11. Cortisol

_____ 12. Epinephrine

_____ 13. Estrogen

_____ 14. FSH and LH

_____ 15. GH

_____ 16. Insulin

_____ 17. Melatonin

_____ 18. PTH

_____ 19. Oxytocin

_____ 20. Progesterone

_____ 21. Thymosin

_____ 22. Thyroxine

_____ 23. Testosterone

_____ 24. Prolactin

_____ 25. Glucagon

WORD PARTS

Give an example of a new vocabulary word that contains each word part.

WORD PART	MEANING	EXAMPLE
hormon-	to set in motion	1. _____
anti-	against	2. _____
diure-	urinate	3. _____
trop-	turn; change	4. _____
pro-	before	5. _____
-lact-	milk	6. _____

MASTERY LEARNING ACTIVITY

Place the letter corresponding to the correct answer in the space provided.

_____ 1. An endocrine gland
   a. lacks a duct.
   b. secretes its chemical signal to an internal or external surface of the body.
   c. produces sweat or saliva.
   d. all of the above.

_____ 2. The secretion of a hormone from an endocrine tissue is regulated by
   a. other hormones.
   b. other chemicals in the blood.
   c. the nervous system.
   d. all of the above

_____ 3. Lipid-soluble hormones influence a target cell by
   a. activating G proteins.
   b. increasing protein synthesis in the cell.
   c. increasing membrane permeability.
   d. all of the above

_____ 4. The pituitary gland
   a. is derived from the brain.
   b. is derived from the mouth.
   c. has two parts.
   d. all of the above

_____ 5. Secretion of hormones from the anterior pituitary is controlled by
   a. releasing hormones produced in the hypothalamus.
   b. releasing hormones produced in the posterior pituitary.
   c. the thalamus.
   d. the thymus gland.

_____ 6. Hormones secreted in the posterior pituitary
   a. are produced in the hypothalamus.
   b. are transported to the posterior pituitary within axons.
   c. include ADH and oxytocin.
   d. all of the above

_____ 7. Growth hormone
a. increases the breakdown of fat.
b. decreases protein synthesis.
c. increases protein breakdown.
d. all of the above

_____ 8. Hypersecretion of growth hormone
a. results in giantism if it occurs in children.
b. causes acromegaly in adults.
c. causes dwarfism.
d. both a and b

_____ 9. LH and FSH
a. are produced in the hypothalamus.
b. production is increased by TSH.
c. regulate growth and function of the gonads.
d. inhibit the production of prolactin.

_____ 10. Which of these would result from a thyroidectomy (removal of the thyroid gland)?
a. increased calcitonin secretion
b. increased TSH secretion
c. increased thyroid hormone secretion
d. increased GH secretion

_____ 11. If parathyroid hormone levels increase, which of these would be expected?
a. Breakdown of bone is increased.
b. Calcium absorption from the small intestine is decreased.
c. Calcium reabsorption from urine is decreased.
d. Less active vitamin D would be formed in the kidneys.

_____ 12. If a condition produced hypersecretion of the adrenal medulla, which of these symptoms would you expect?
a. low blood pressure
b. decreased heart rate
c. increased blood flow to internal organs
d. increased glucose and fatty acids in the blood
e. all of the above

_____ 13. The hormone secreted from the adrenal cortex is
a. aldosterone.
b. cortisol.
c. androgen.
d. a and b
e. all of the above

_____ 14. Cortisol
a. increases the breakdown of fats.
b. increases the breakdown of proteins.
c. increases blood sugar levels.
d. decreases inflammation.
e. all of the above

_____ 15. Aldosterone
a. causes increased sodium retention in the body.
b. causes increased water retention in the body.
c. causes increased potassium retention in the body.
d. a and b
e. all of the above

_____ 16. Given these events which occurred after blood pressure decreased:

1. angiotensin II produced
2. blood pressure increases
3. increased aldosterone production
4. renin produced in kidneys

Which represents the correct sequence for these events?
a. 1,2,3,4
b. 4,1,3,2
c. 3,1,4,2
d. 4,3,2,1

_____ 17. Insulin
a. increases the uptake of glucose by target cells.
b. increase uptake of amino acids by target cells.
c. increases glycogen synthesis in liver and skeletal muscle cells.
d. all of the above

_____ 18. If a person who has diabetes mellitus forgets to take an insulin injection, symptoms that may soon appear include
a. acidosis.
b. hyperglycemia.
c. increased urine production.
d. increased thirst.
e. all of the above

_____ 19. When blood glucose levels decrease, the secretion of _____ increases.
a. glucagon
b. epinephrine
c. cortisol
d. growth hormone
e. all of the above

_____ 20. Which of these hormones helps in the development of T cells?
a. erythropoietin
b. human chorionic gonadotropin
c. melatonin
d. prostaglandins
e. thymosin

FINAL CHALLENGES

Use a separate sheet of paper to complete this section.

1. A young boy (6 years old) exhibited marked and rapid development of sexual characteristics. On examination his testicles were not found to be larger than normal, but his plasma testosterone levels were elevated. As a mental exercise, a student nurse decided that she would propose a cure. She considered the symptoms and decided on surgery to remove an adrenal tumor. Explain why you agree or disagree with her diagnosis.

2. If there is insufficient dietary intake of iodine, goiter can develop. Would the levels of TSH and thyroid hormones be higher or lower than normal? Explain.

3. A patient has pheochromocytoma, a condition in which a benign tumor causes hypersecretion of the adrenal medulla. Would you expect the pupils of the patient to be dilated or constricted?

4. Addison's disease is caused by hyposecretion of aldosterone and cortisol. One of the symptoms of Addison's disease is increased skin pigmentation because of high levels of ACTH. Explain why ACTH levels are high.