The Human Body: How It Works
THE ENDOCRINE SYSTEM

Introduction

This program is part of the nine-part series *The Human Body: How It Works*. The series uses physiologic animations and illustrations, microscopic imaging, expert commentary, and footage of the body in motion to provide a thorough overview of the amazing human machine. The series includes:

- Cells, Tissues, and Skin
- The Immune System
- Human Development and the Reproductive System
- The Respiratory System
- The Circulatory System
- The Skeletal and Muscular Systems
- Digestion and Nutrition
- The Endocrine System
- The Nervous System and the Senses

Topics

**Chapter 1: Introduction to the Endocrine System**
The program begins by introducing the endocrine system, and contrasting its functioning — with its use of hormones as “chemical messengers” — to that of the nervous system.

**Chapter 2: Hormones and How They Work**
Two main classifications of hormones are presented in this section: steroid and nonsteroid. Animations illustrate the differences between water-soluble hormones and those that are lipids, and how both types interact with their target cells. Also covered: Receptor proteins; signal transduction.
Chapter 3: The Endocrine Organs
The glands and organs of the endocrine system are now described, and the associated hormones involved in processes ranging from sleep to growth to immunity to levels of glucose and calcium in the blood. Also covered: The fight-or-flight response.

Chapter 4: Blood Glucose Levels
The coordination of insulin and glucagon in maintaining blood glucose levels — and the role of glycogen synthesis in this — is the focus here. Animations of the liver and pancreas help make the process clear. Also covered: The islets of Langerhans, and alpha and beta cells.

Chapter 5: Growth and Metabolism
This section explains how the hypothalamus and pituitary control the release of growth hormone and thyroid hormone, which then work together to promote human development. The feedback loop involving GHRH and somatostatin is included. Also covered: The role of the sex hormones; risks associated with the use of anabolic steroids.

Chapter 6: Reproduction
This section provides a brief overview of estrogens and testosterone.

Chapter 7: Stress
In this section viewers learn how the body responds to stress, as the adrenal glands release hormones and blood glucose levels rise due to the actions of ACTH and cortisol. Also covered: The effect of cortisol on the immune system.

Chapter 8: Mineral Balance
How the parathyroids, thyroid, and kidneys maintain the body’s mineral balance is the subject of the last section, with emphasis on the regulation of calcium levels. The section also addresses the importance of electrolytes, explaining how the pituitary, kidneys, vasopressin, and blood pressure are all involved in maintaining fluid and electrolyte balance. Also covered: Why calcium is important beyond strong teeth and bones; sports drinks.

Learning Objectives
Students will learn…
• The glands and organs of the endocrine system, and which hormones they produce
• The role of various hormones in physiological processes
• The difference between steroid and nonsteroid hormones, including how they interact with target cells
• How blood glucose levels are maintained, and the organs and hormones involved in this
• The organs and hormones involved in growth and metabolism
• The risks associated with the use of anabolic steroids
• The action of the adrenal glands, blood glucose levels, ACTH, and cortisol when the body perceives a threat
• The importance of the endocrine system in maintaining mineral balance (especially calcium levels) for proper physiological functioning
• How the endocrine system maintains water and electrolyte balance, and why this is important

Vocabulary

ACTH: Adrenocorticotropic hormone, a hormone that stimulates the release of cortisol.

active vitamin D: Calcitriol, a form of vitamin D produced in the kidneys. It is one of three hormones that help to regulate calcium levels in the body.

adrenal glands: Organs of the endocrine system located above the kidneys. The adrenal glands secrete cortisol, epinephrine, and norepinephrine.

amine: A type of nonsteroidal hormone, such as that produced by the thyroid gland.

anabolic steroid: A form of testosterone used to enhance muscle development and performance.

androgen: A substance, such as testosterone, that regulates the development of male characteristics.

atrial natriuretic factors: Hormones released by the heart when blood pressure increases. They stimulate the kidneys to produce more urine, which reduces fluid volume in the blood, which reduces blood pressure.

calcitonin: A hormone produced by the thyroid gland that helps lower the level of calcium in the blood.

cortisol: A hormone secreted by the adrenal glands, that raises blood glucose levels and increases blood volume and blood pressure when the body is under stress; cortisol also suppresses the immune system.

electrolytes: Also called salts, they are charged particles dissolved in the body’s water that are crucial to the body’s proper functioning (e.g., nerve impulses, the contraction of muscles, and maintaining fluid balance in the body). Sodium, potassium, magnesium, and chloride are the most important electrolytes.
endorphins: Hormones secreted by the pituitary gland that reduce the perception of pain.

epinephrine: Also known as adrenaline, it is a hormone released by the adrenal glands during periods of stress. Epinephrine increases heart rate and the supply of oxygen and glucose to the brain and muscles while suppressing other functions, thus creating the fight-or-flight response.

erthropoietin: A hormone produced by the kidneys that stimulates red bone marrow to produce more red blood cells.

estrogens: Hormones that produce female characteristics.

GHRH: Growth Hormone Releasing Hormone, a hormone secreted by the hypothalamus that triggers growth hormone secretion.

glucagon: A hormone secreted by the islets of Langerhans in the pancreas that raises blood glucose levels.

glucose: A sugar molecule that provides cells with energy.

glycogen: A form of glucose that is stored in the liver and muscle cells. When blood glucose levels drop, glucagon will stimulate the liver and muscles to convert the glycogen to glucose.

gonads: Glands, such as the ovaries and testes, that produce sex hormones.

growth hormone: Also called somatotrophin, it is a hormone produced by the pituitary gland that stimulates protein synthesis in bone and muscle, as well as the use of fat as a fuel.

hormones: Chemical messengers secreted by glands of the endocrine system. Hormones circulate through the bloodstream to other organs and tissues to effect the processes of growth, metabolism, sexual function, and mood. Hormones are chemically classified as being either steroids, or nonsteroids (which includes protein hormones and peptide hormones).

hypothalamus: An almond-sized organ of the endocrine system located near the center of the brain. The hypothalamus links the nervous and endocrine systems. It regulates functions such as body temperature, sleep cycles, appetites, and sexual behavior; it also controls the pituitary gland.

insulin: A hormone produced in the pancreas that regulates the amount of sugar in the blood by triggering the conversion of glucose to glycogen, which lowers the blood glucose level.
islets of Langerhans: Clusters of cells in the pancreas that produce glucagon (secreted by alpha cells) and insulin (secreted by beta cells).

kidneys: Two organs of the endocrine system, located at the back of the abdominal cavity, that produce renin, a hormone that ultimately helps regulate blood pressure, and erythropoietin, a hormone that stimulates red bone marrow to produce more red blood cells.

lipid: A type of organic compound that is fat-soluble, meaning it can pass through cell walls. Lipids must combine with protein molecules (forming “lipoproteins”) in order to travel through the blood.

melatonin: A hormone secreted by the pineal gland which is involved in rhythmic behavior such as sleep cycles.

nonsteroid hormone: A chemical classification of hormones which is usually broken up into two types: amines and peptides. The peptides are sometimes also called “polypeptides” or “protein hormones,” and include insulin and growth hormones. Nonsteroid hormones are water-soluble.

norephinephrine: Also known as noradrenaline, it is a hormone that is released by the adrenal glands during periods of stress. Norephinephrine causes the response known as “fight-or-flight.”

pancreas: An organ of the endocrine system located beneath the stomach, it secretes the hormones insulin and glucagon.

parathyroid glands: Four small tissue masses attached to the back of the thyroid, they secrete parathyroid hormone, which raises blood calcium levels.

parathyroid hormone: One of three hormones that help to regulate calcium levels in the body.

pineal gland: A pea-sized organ of the endocrine system located slightly above and behind the hypothalamus near the center of the brain. The pineal gland receives information about light and dark cycles, and secretes melatonin, which is involved in rhythmic behavior such as sleep cycles.

pituitary gland: A pea-sized organ of the endocrine system located on the underside of the brain, it secretes hormones that regulate homeostasis, as well as hormones that stimulate other endocrine glands. The anterior pituitary releases growth hormone and endorphins, and the posterior pituitary secretes oxytocin and vasopressin.

renin: A hormone produced by the kidneys that ultimately helps regulate blood pressure.
**signal transduction:** A process in which a hormone attaches to a receptor protein on a cell, whereupon the receptor causes a specific change inside the cell.

**steroid hormone:** A type of steroid that acts as a hormone. Steroid hormones are formed from cholesterol, and are lipids. Estrogen, progesterone, testosterone, and cortisol are all steroid hormones; certain forms of vitamin D are also grouped with steroid hormones.

**target cell:** In endocrinology, a cell that has a specific receptor protein to which specific, “matching” hormones can bind.

**testosterone:** A hormone that produces male characteristics.

**thymosin:** A chemical produced by the thymus gland that activates lymphocytes, cells that are involved in battling infection.

**thymus gland:** A gland of the endocrine system located in the chest region that produces thymosin.

**thyroid gland:** A gland of the endocrine system located in front of the trachea, it releases thyroid hormone, which plays a critical role in development and growth. The thyroid gland also increases the body’s metabolic rate and the release of calcitonin, a hormone that lowers blood calcium.

**thyroid hormone:** A hormone produced by the thyroid and controlled by the hypothalamus and the pituitary gland that affects growth and development; it also stimulates the metabolism of nearly every tissue in the body.

**vasopressin:** Also called antidiuretic hormone, it is a hormone released by the pituitary when the brain detects an increase in sodium concentration in the blood. Vasopressin acts on the kidneys to reduce urine output.

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**Student Projects**

- Design a visual representation of the parts and functions of the endocrine system. This can be in the form of a labeled poster, but might also be rendered as a children’s picture book, with large, detailed, colorful drawings of each organ or gland and simple descriptions of what each does and why.

- Choose an important physiological process such as signal transduction, the rise and fall of blood glucose levels, the fight-or-flight response, or mineral balance, and explain it in detail to your classmates. Use visual aids (posters, PowerPoint, etc.) to help make complex information clear.
• Create a mini graphic novel illustrating what happens in the brain, pituitary, and kidneys when an athlete or dancer works up a sweat and throws their electrolytes off balance; include the process of rehydration.

• You may already be familiar with some of the terms discussed in this program. Choose one of these and write an in-depth report about it, including what you’d heard about it before, where you’d heard it, and what you have now learned. Topics might include:
  — Melatonin (Its use as a sleep supplement and in treating jet lag; its role in Seasonal Affective Disorder)
  — Endorphins (Can these so-called “feel good chemicals” be triggered by certain foods or activities? Do they really play a role in acupuncture?)
  — Anabolic steroids (The function of natural steroids compared to use of synthetic steroids; risks associated with anabolic steroid use)
  — Growth hormone (Medically accepted use of GH in children born GH-deficient; controversial use of GH supplements to increase muscle mass, reverse the effects of aging, promote weight loss, etc.)
  — Cortisol (Its role in stress, relaxation, and the immune system)
  — Estrogen (Its role in moods, as a heart-protective factor in premenopausal women, the risks and benefits of postmenopausal Hormone Replacement Therapy, etc.)
  — Electrolytes (How do sports drinks rehydrate athletes?)

For extra credit, explore ghrelin (a hormone produced in the stomach that controls food cravings) or oxytocin (the hormone implicated in social behaviors such as bonding, the feeling of falling in love, and the maternal instinct).

• Visit a Web site such as ScienceDaily.com, Sciam.com (Scientific American), or PhysOrg.com and enter “hormones” into the search box to find news on the latest endocrinological research. Print out any articles that interest you, and make copies to discuss as a class. Were you surprised by the range of topics included in this field? Do you think you’d like to pursue a career in some aspect of endocrinology? Some headlines from 2009 include:
  “Anticipating a Laugh Reduces Our Stress Hormones, Study Shows”
  “Naturally Produced Estrogen May Protect Women From Parkinson’s Disease”
  “New Web Site Maps Endocrine Disruptors to Human Development”
  “Longer-lived Rodents Have Lower Levels of Thyroid Hormone”
  “Common Herbicide Disrupts Human Hormone Activity in Cell Studies”
  “Crucial Hormonal Pathway to Bone Building Uncovered”
Quiz

1. The organs of the endocrine system are the hypothalamus, pituitary gland, pineal gland, thyroid, thymus, pancreas, adrenal glands, gonads, and the _____.
   a) kidneys
   b) adenoids
   c) spleen
   d) lymph nodes

2. The endocrine system is responsible for _____.
   a) cell growth
   b) regulating calcium content of the blood
   c) activating lymphocytes
   d) all of the above

3. In contrast to nerve impulses, hormones travel _____.
   a) rapidly, to respond to brain signals of immediate danger
   b) slowly, controlling responses that are less immediate but longer-lasting
   c) at a rate matching the intensity of stimuli
   d) at a rate that targets the rate of their specific receptor proteins

4. (Circle the correct term.) [Nonsteroid/Steroid] hormones are water-soluble. They cannot cross cell membranes (which are water-proof), so the protein receptor for this type of hormone is located on the outside of the target cell’s membrane. By contrast, [nonsteroid/steroid] hormones can easily enter cells, so the receptors for these hormones are inside of cells.

5. The _____ help(s) control hunger, thirst, and sexual behavior, while also controlling the pituitary gland.
   a) pineal gland
   b) gonads
   c) hypothalamus
   d) prostaglandins
6. The pituitary gland releases many hormones, including growth hormones and _____.
   a) endorphins
   b) cortisol
   c) melatonin
   d) insulin

7. The _____ secretes melatonin, which is involved in sleep cycles.
   a) hypothalamus
   b) pineal gland
   c) pituitary gland
   d) thyroid gland

8. (Circle the correct term.) Blood glucose level is maintained by insulin, which [lowsers/raises] the levels, and glucagon, which [lowsers/raises] the levels.

9. After a person eats carbohydrates, blood glucose levels _____.
   a) rise, triggering the production of fats
   b) drop, triggering the immune response
   c) drop, triggering the release of insulin into the blood
   d) rise, triggering the release of insulin into the blood

10. The two hormones most important in growth and development are growth hormone and _____.
    a) steroidal hormones
    b) testosterone
    c) thyroid hormone
    d) thymus hormones

11. Taking anabolic steroids to increase muscle development and performance can put you at risk of _____, as well as aggressive behavior, depression, and delusions.
    a) heart attack and stroke
    b) sterility
    c) cancer
    d) all of the above
12. When a person is exposed to danger, the adrenal gland releases adrenaline, also known as _____, which boost(s) heart and breathing rates as part of the fight-or-flight response.
   a) epinephrine
   b) noradrenaline
   c) endorphins
   d) ACTH

13. _____ raise(s) blood glucose levels when the body is exposed to danger or stress, and also _____ immune system response.
   a) Cortisol; suppresses
   b) Cortisol; boosts
   c) Glycogen; suppresses
   d) Steroid hormones; boost

14. Without _____ ions, blood will not clot adequately, and physiological processes such as nerve and muscle cell functioning and heartbeat would be disrupted.
   a) vitamin K
   b) endocrine
   c) calcium
   d) lithium

15. During exercise, the body can lose large amounts of water and _____ in the form of sweat. When this happens, the pituitary releases _____, which act(s) to reduce urine output, thus allowing more water to return to the bloodstream.
   a) glucose; electrolytes
   b) electrolytes; vasopressin
   c) glucose; calcitonin
   d) calcium; diuretics
Answers to Quiz

1. a) kidneys
2. d) all of the above
3. b) slowly, controlling responses that are less immediate but longer-lasting
4. Nonsteroid; steroid
5. c) hypothalamus
6. a) endorphins
7. b) pineal gland
8. lowers; raises
9. d) rise, triggering the release of insulin into the blood.
10. c) thyroid hormone
11. d) all of the above
12. a) epinephrine
13. a) Cortisol; suppresses
14. c) calcium
15. b) electrolytes; vasopressin

Please send comments, questions, and suggestions to custserv@films.com