The Endocrine System

Objectives
- Become familiar with the major endocrine glands and their location.
- Learn some of the hormones produced by each gland.
- Become familiar with the anatomy of some of the endocrine glands.
- Observe how a hormone can affect the heart.

Introduction
The body uses two major systems to regulate and coordinate its activity. Utilizing electrochemical impulses, the nervous system provides a means of rapid and usually reversible control. The second system, the endocrine system, uses chemical messengers called hormones that are released into and transported by the blood. The responses initiated by the hormones of the endocrine system are usually slower acting and longer lived than those responses caused by the nervous system. The endocrine responses may not be reversible.

This exercise examines the major endocrine glands of the body and some of the hormones these glands produce. The second activity illustrates how a hormone can influence heart rate. To begin this exercise, go to the Endocrine System simulation on the BiologyOne DVD.
Activity 31.1  
Endocrine Glands

There are several glands in the body responsible for producing hormones. In the Endocrine System simulation, after the introductory screen, click on the gland names to view each gland.

In the Results Section, label the endocrine glands in the illustration.

Pituitary  
The pituitary gland is sometimes referred to as the mater endocrine gland because it produces a number of hormones that regulate the action of other endocrine glands. The pituitary is attached to and controlled by the hypothalamus of the brain.

The pituitary gland consists of two anatomically and functionally distinct portions, the anterior pituitary and posterior pituitary.

The anterior portion of the pituitary gland is the larger portion. Some of the hormones produced by the anterior pituitary are: human growth hormone (hGH) regulates the growth of body cells and protein production; thyroid-stimulating hormone (TSH) controls the secretion of the thyroid hormones produced by the thyroid gland; adrenocorticotropic hormone (ACTH) controls the secretion of some hormones from the cortex of the adrenal gland; follicle-stimulating hormone (FSH) that inhibits egg development in the ovaries, promotes estrogen secretion, and stimulates sperm production in the testes; and prolactin (PRL) that helps promote milk secretion by the mammary glands in females.

The posterior portion of the pituitary gland does not directly synthesize hormones, but it does store and release two hormones, oxytocin and antiuretic hormone. These hormones are produced in the hypothalamus. Oxytocin (OT) stimulates the contraction of the smooth muscle cells of the uterine wall during labor and promotes the release of milk from the mammary glands. Antidiuretic hormone (ADH) works to decrease the urine volume produced by the urinary system and to constrict arteries. These actions increases blood pressure in the body.

In the simulation, click on the microscope icon to view the microscopic structure of the pituitary.

Thyroid  
The thyroid is located on the anterior side of the trachea, just below the larynx. Three hormones are produced by the thyroid; triiodothyronine or T3, thyroxine or T4, and calcitonin. Triiodothyronine and thyroxine regulate the body’s metabolism, growth and development, and activity of the nervous system. Calcitonin regulates blood calcium and phosphate levels by stimulating their absorption into bone, thus lowering the blood calcium levels.

Iodine is required for the production of the T3 and T4 hormones. If iodine is deficient in the diet, low levels of T3 and T4 will be present, stimulating the thyroid to attempt to produce more of these hormones. This leads enlargement of the thyroid, a goiter.

In the simulation, click on the microscope icon to view the microscopic structures of the thyroid.

Parathyroid  
The parathyroid glands are small masses of tissue attached to the posterior surfaces of the thyroid, two on each side. These glands produce the hormone parathyroid hormone (PTH). Parathyroid hormone is used to increase the levels of calcium and magnesium in the blood while decreasing the levels of phosphate. It does this by promoting the breakdown of bone tissue, releasing calcium. It also influences kidney function, causing more calcium and magnesium to be retained by the body and more phosphate to be expelled.

In the simulation, click on the microscope icon to view the microscopic structures of the parathyroid.

Thymus  
The thymus gland is important to the body’s immune system, serving as the site of maturation of T cells that destroy foreign microbes and substances. But the thymus also produces several hormones that promote the proliferation and maturation of T cells. These hormones are thymosin, thymic humoral factor (THF), thymic factor (TF), and thymopoietin.

The thymus is located centrally in the chest between the heart and the sternum.
Adrenal Gland
The adrenal glands are located superior to each kidney. Structurally and functionally, each kidney is divided into two regions, the outer adrenal cortex and the inner adrenal medulla.

The adrenal cortex secretes three groups of hormones; mineralocorticoids, glucocorticoids, and gonadocorticoids. The mineralocorticoid hormones help to control water and electrolyte balance. One of these, aldosterone, acts on the tubules of the kidneys, promoting retention of sodium ions and secretion of potassium ions. Glucocorticoid hormones regulate metabolism and responses to stress. Cortisol is the most abundant of these. Gonadocorticoids are estrogens and androgens, sex hormones. Estrogens are female sex hormones and androgens are male sex hormones. Normally, these are here in minimal amounts. The gonads, ovaries or testes, produce significantly more sex hormone.

The adrenal medulla secretes the hormones epinephrine and norepinephrine. These hormones stimulate what is often referred to as the fight or flight response, preparing the body for action. In response to these hormones, heart rate and blood pressure increase, respiration increases, actions of the digestive system slow but stored sugar is released to make it available for conversion to ATP.

In the simulation, click on the microscope icon to view the microscopic structures of the adrenal gland.

Pancreas
The pancreas, located just below the stomach, is both an exocrine gland as well as an endocrine gland. In its exocrine role, it produces digestive enzymes that are secreted into the small intestine. In its endocrine role, it produces hormones that play a significant role in regulating blood sugar levels in the body.

Cells of two general types are found in the pancreas. The darker stained cells are exocrine cells (acinar cells), producing enzymes that flow into the secretory ducts that connect to the small intestine. The clusters of lighter stained cells are endocrine cells. These clusters of cells constitute the islets of Langerhans. Within each islet, are alpha cells that produce glucagon and beta cells that synthesize insulin.

Without special staining you cannot tell the difference between alpha cells and beta cells. However, alpha cells tend to be somewhat smaller and more commonly found near the periphery of the islets while beta cells tend to be larger.

In the simulation, click on the microscope icon to view the microscopic structures of the pancreas.

Gonads
The female gonads are the ovaries, located in the pelvic cavity. The ovaries produce the sex hormones estrogen and progesterone. These hormones are responsible for the development of female sexual characteristics. Along with gonadotropic hormones from the pituitary, these hormones regulate the female reproductive cycle, maintain pregnancy and promote lactation by the mammary glands.

The male gonads are the testes. Initially formed in the pelvic cavity, the testes descend into the scrotal sac as they mature. The testes produce the male sex hormone testosterone. Testosterone is responsible for producing and maintaining male sexual characteristics and regulates the production of sperm.

In the simulation, click on the microscope icon to view the microscopic structures of the ovaries and testes.
Activity 31.2
Effect of Epinephrine

This simulation tests the effect of the hormone epinephrine on the heart. You will also be able to how the neurotransmitter acetylcholine and the plant alkaloid atropine influence heart rate. (Atropine competes for the acetylcholine binding site in muscle tissue.)

This experiment would use a frog that has had its nervous system destroyed (the head is quickly removed and a dissecting needle used to destroy the spinal cord). Laying the frog on its back, the body cavity is opened to expose the still beating heart.

Using the clock on the simulation screen, determine the normal number of heartbeats per minute.

Once you’ve determined the normal heart rate, click on the vial labeled epinephrine to inject epinephrine into the frog’s circulatory system. Again, using the screen timer, determine the heart rate. How has this changed?

Click on the New Experiment button to reset the heart rate to normal conditions.

Now click on the vial labeled acetylcholine to inject this to the frog’s system. How does the heart rate respond to acetylcholine? Based on these results, how would this neurotransmitter be used to regulate heart rate?

Next, without resetting the experiment, click on the vial labeled atropine to inject this drug to the system. What happens to the heart rate now?

Record your observations in the Report Section.
Results Section

Activity 31.1
Major Endocrine Glands

1. _____________________
2. _____________________
3. _____________________
4. _____________________ (male only)
5. _____________________ (small glands on larger gland)
6. _____________________
7. _____________________
8. _____________________ (female only)
Activity 31.2
Effect of Epinephrine

Normal Heart Rate: _____________ beats per minute

Heart Rate after injection of Epinephrine: _____________ beats per minute

Heart Rate after injection of acetylcholine: _____________ beats per minute

Heart Rate after injection of acetylcholine followed by aptropine: _____________ beats per minute

What is the effect of epinephrine on the frog’s heart rate?

What is the effect of acetylcholine on the frog’s heart rate?

How does the heart rate change when aptropine is injected after treatment with acetylcholine?