

THE ENDOCRINE SYSTEM

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Preview

Goals and Objectives:

As an allied health practitioner it is essential that you have a good foundation with the systems of the body and how they function and interact with each other. This home study unit will be focused on the endocrine system and the circulatory system.

Think of the endocrine system as a 'ball game'! Imagine that the players are glands, and the body represents the playing field. Its players or members are positioned throughout the field. Each team player (gland) has a specific purpose or area of expertise, which the game requires to be able to function effectively (homeostasis). The head coach of this team is the hypothalamus, which is located in the brain.

Goals of this study unit are:

- Identify the endocrine glands and their hormones
- Understand the functions of the hormones in the body
- Learn the abbreviations relative to both systems

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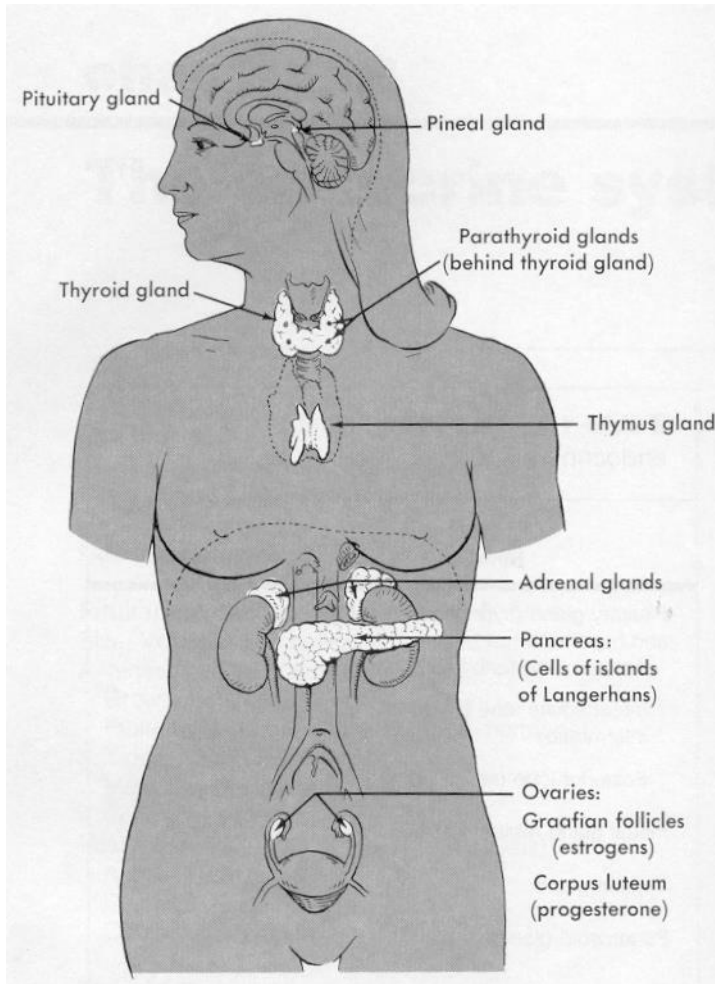
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Exam

INTRODUCTION TO THE ENDOCRINE SYSTEM

The mission of the endocrine system is to circulate minute quantities of specific ‘chemical messengers’ that we know as hormones. Hormones (from the Greek root *hormaein*, “to excite”) are secreted from endocrine gland cells and are placed directly into the bloodstream. From there they circulate throughout all parts of the body. Despite their wide distribution in the body, some particular hormones such as thyroid and growth hormones are highly specific in their action. The endocrine system and the nervous system are partners in this “exciting” job: both systems control the body’s physiology. The nerves send both electrical as well as chemical messages (hormones) and the endocrine glands send only chemical messages. All of this action ensures the proper development and operation of the body to maintain homeostasis.

It is almost impossible to exaggerate the importance of hormones. As boys and girls enter puberty obvious changes are easily observed between the two sexes. This period in our development shows a very clear example of how important a role the endocrine system plays in the development and regulation of body functions. Changes in the brain signal the production and release of sex hormones. Boys experience an increase in the synthesis of protein which builds muscle mass. Girls start to accumulate fatty tissue in their hips and breasts. Excesses or deficiencies of hormones can make the difference between normalcy and all sorts of abnormalities such as dwarfism, gigantism, and even sterility. These are just a few examples of how important the role of the hormones can play.



The two types of glands that secrete hormones into the bloodstream are the *exocrine* and the *endocrine* glands.

Exocrine (*ex* = out; *krinein* = to secrete) **glands** secrete their products into ducts, and the ducts then distribute those secretions into their appropriate places.

Exocrine Glands

- Digestive
- Mucous
- Sebaceous (oil)
- Sudoriferous (sweat)

Since they have no duct system the **endocrine glands** are usually referred to as “ductless glands” and are sited throughout the body. Endocrine glands differ from exocrine glands in that they secrete their hormones into the extracellular spaces of the cells rather than into ducts. These secretions are diffused into capillaries and then carried by the bloodstream. Some organs in the body can produce hormones but are not exclusively endocrine glands.

Endocrine Glands

- Adrenal
- Parathyroid
- Pineal
- Pituitary
- Thyroid

Organs that can produce hormones

- Heart
- Hypothalamus
- Kidneys
- Liver
- Ovaries
- Pancreas
- Placenta
- Small Intestine
- Stomach
- Testes

HORMONE FUNCTIONS

- * Regulate the chemical composition and volume of the internal environment. (extracellular fluid)
- * Help regulate metabolism and energy balance.
- * Help regulate contraction of smooth and cardiac muscle fibers and secretion by glands.
- * Help maintain homeostasis despite disruptions such as infection, trauma, emotional stress, dehydration, starvation, hemorrhage, and temperature extremes.
- * Regulate certain activities of the immune system.
- * Play a role in the smooth, sequential integration of growth and development.
- * Contribute to the basic processes of reproduction, including gamete (oocyte and sperm) production, fertilization, nourishment of the newborn.

Hormones that pass into the blood and act on distant target cells are called circulating hormones or endocrines. Hormones that act locally without first entering the bloodstream are called local hormones. Those that act on neighboring cells are called paracrines (*para* = beside). Local hormones that act on the same cell that secreted them are called autocrines (*auto* = self).

There has been much research to discover how hormones target specific cells to cause them to respond in particular ways. Dr. Earl W. Sutherland was awarded the Nobel Prize in 1971 for his work with hormones.

To summarize, hormones serve as first messengers, providing communication between endocrine and target cells.

THE ANATOMY AND PHYSIOLOGY OF THE ENDOCRINE SYSTEM

Pituitary Gland

The pea-sized pituitary gland may be small, but it extremely important! At its largest diameter, it measures only about ½ inch. Its weight is even less impressive—only about 1/60 ounce. Despite its size it has the largest job in the endocrine system, and is often referred to as the “master gland”.

One of its primary functions is to manufacture *tropic hormones* that stimulate certain other endocrine glands to secrete specific hormones. All of the tropic hormones perform the same general function—they stimulate other endocrine glands to grow and secrete their hormones at a faster rate. Each tropic hormone seems to affect only one structure as if, like a bullet, it had been aimed at a target, hence the name “target gland”.

The individual tropic hormones perform the following functions:

1. ***Thyrotropin*** produces thyroid-stimulating hormone (TSH), which promotes and maintains growth and development of its target gland, the thyroid, and stimulates it to secrete thyroid hormone.
2. ***Somatotrophin*** produces human growth hormone (HGH), which stimulates general body growth and regulates aspects of metabolism.
3. ***Gonadotrophs*** produce two major hormones—follicle stimulating hormone (FSH) and luteinizing hormone (LH). Together FSH and LH stimulate secretion of estrogens and progesterone and maturation of oocytes in the ovaries and secretion of testosterone and production of sperm in the testes.
 - a. Follicle stimulating hormone (FSH) stimulates primary graafian follicles to start growing and to continue developing to maturity, that is, to the point of ovulation. FSH also stimulates follicle cells to secrete estrogens—a type of female hormones. In the male, FSH stimulates development of the seminiferous tubules and maintains spermatogenesis by them.
 - b. Lutenizing hormone (LH in the female and ICSH in the male) stimulates the formation of the corpus luteum. Prior to this, LH acts with FSH to bring about complete maturation of the follicle. LH then produces ovulation and stimulates formation of the corpus luteum in the ruptured follicle. Finally, LH in females

stimulates the corpus luteum to secrete progesterone and estrogens. The male pituitary gland also secretes LH, but it is called interstitial cell-stimulating hormone (ICSH) because it stimulates interstitial cells in the testes to develop and secrete testosterone.

4. **Adrenocorticotropin** (ACTH) promotes and maintains normal growth and development of the adrenal cortex and stimulates it to secrete cortisol and other glucocorticoids.
5. **Lactotrophs** synthesize prolactin (PRL), which initiates milk production in suitably prepared mammary glands.
6. **Corticotrophins** synthesize adrenocorticotrophic hormone (ACTH), which stimulates the adrenal cortex to secrete glucocorticoids. Some corticotrophs, remnants of the par intermedia, also secrete melanocyte-stimulating hormone (MSH), which affects skin pigmentation. The MSH influences the formation of melanin and causes an increase of pigmentation in the skin. This is observed only when hypersecretion of the hormone occurs.

Thyroid Gland

The largest of the endocrine glands, the thyroid gland is made up of two lobes located on the right and left side of the trachea, just below the “Adam’s apple”. A narrow strip of glandular tissue connects the two lobes and is called the *isthmus*.

Thyroxine or *tetraiodothyronine* (T_4) and *triiodothyronine* (T_3) are two of the hormones that are secreted by the thyroid gland. These hormones are synthesized from iodine and their abbreviations represent the number of iodine atoms in their structure. T_4 and T_3 are required to maintain a normal level of metabolism in all body cells. All cells require oxygen for metabolic processes and when T_4 and T_3 are present in the bloodstream, the body’s cells are allowed to consume oxygen faster. Thyroid hormones assist cells in their ability to use oxygen and therefore are critical in the metabolic rate of the body. When thyroid hormone levels are deficient it causes a lower metabolic rate, heat loss, and poor physical and mental development.

Another hormone secreted by the thyroid is *calcitonin* (*thyrocalcitonin*). This hormone is secreted when calcium levels in the body are high. Calcitonin stimulates calcium to leave the bloodstream and enter the bones. When calcitonin is present in the bloodstream it also keeps the bones from releasing much needed calcium.

The thyroid gland is the only endocrine gland that stores its products in large quantity—normally about a 100-day supply. The main physiological actions of thyroid hormone are to regulate the metabolic rate or the growth process. It also stimulates tissue development. Thyroid hormone secretion levels are controlled in two ways: (1) how much iodine is present in the thyroid gland and (2) by a ‘negative feedback’ system which involves both the hypothalamus and the pituitary gland. We know that iodine is required for the thyroid to function, but too much iodine will suppress the release of thyroid hormones.

Too much thyroid hormone secretion, or *hypersecretion* creates the disease *exophthalmic goiter*. This is also called Graves’ disease, or Basedow’s disease. Symptoms of this disease are an increase in metabolism, an increase in appetite but loss of weight, and nervous irritability. Graves’ disease is the most common form of hyperthyroidism and is an auto-immune disorder.

One of the most common symptoms is an enlarged thyroid, which may be two to three times larger than its original size. Graves' patients will many times have edema behind their eyes, making the eyes protrude.

Too little production of thyroid hormone or *hyposecretion* during the developmental years can cause malformations such as dwarfism or *cretinism*. This is caused by a low metabolic rate, which causes stunted growth and sexual development. The lack of thyroid hormone during development actually keeps organs such as the brain and the reproductive organs from developing. As the individual ages the lack of thyroid hormone will cause a disease called *myxedema*. This condition is characterized by less mental and physical vigor, weight gain, hair loss, and a thickening of the skin due to the accumulation of fluid in the tissues.

Parathyroid Glands

Embedded into the connective tissue that holds the thyroid in place, you will find the parathyroid glands. These tiny glands appear in pairs and there can be as few as two (one pair) or as many as ten. The parathyroid hormone (PTH) *parathormone* regulates the amount of calcium present in blood serum. Calcium (Ca) is the most abundant mineral in our bodies and is responsible for muscle function, blood clotting and the development and maintenance of bone and teeth. When levels of calcium in the bloodstream are high the production of PTH is low. But when we do not have enough calcium in our bloodstream PTH is released which triggers the release of stored calcium from our bones. When the calcium supply is replenished PTH production is decreased. PTH also increases the kidney's ability to retrieve stored calcium from urine so it can be used again. With respect to calcium levels in the blood, PTH and calcitonin have opposite actions.

Adrenal Glands

Located on top of the kidneys like a 'cap', your two adrenal glands are sometimes referred to as the *suprarenal glands*. They are composed of an outer *adrenal cortex*, which makes up the bulk of the gland and an inner *adrenal medulla*. Structurally they are parts of one organ, but they function as two separate glands.

* ADRENAL CORTEX

Made up of three distinct zones or layers, the adrenal cortex manufactures the hormones that we call steroids. There are three types of steroids called *corticosteroids* and each is secreted from their distinctive zone of the gland. Their names from the outside in are *mineralocorticoids* (zona glomerulosa), *glucocorticoids* (zona fasciculata), and *gonadocorticoids* (zona reticularis).

Mineralocorticoids

The primary mineralocorticoid that is produced is *aldosterone* and it stimulates the kidney to reabsorb sodium and excrete potassium to maintain a normal blood potassium concentration and a normal pH. Mineralocorticoids help control the balance of water in your body.

Aldosteronism is a condition that is caused by too much production of aldosterone and usually occurs as a result of a tumor in the zona glomerulosa. As sodium levels increase and potassium levels decrease there is an excessive retention of sodium and water. The added water increases the volume of the blood and causes high blood pressure (hypertension). Symptoms include weakness, cramps, and sometimes paralysis.

Glucocorticoids

These steroid hormones play a large part in the metabolism of fats, sugars, and proteins in all of the body's cells. They regulate metabolism and resistance to stress.

The most abundant and most important glucocorticoid hormone produced is called *cortisol* or *hydrocortisone*. The glucocorticoids have the following functions:

1. Protein catabolism. Glucocorticoids increase the rate in which proteins are broken down in muscle fibers, and released into the bloodstream as amino acids. These amino acids can be used by the liver to manufacture enzymes used for metabolic functions or used by other body cells for the production of ATP.
2. Formation of glucose. Cortisol stimulates the conversion of amino and fatty acids to glucose in the liver, which is called *gluconeogenesis* and increases the concentration of blood sugar.
3. Lypolysis. The breakdown of triglycerides releasing fatty acids from adipose (fat) tissue.
4. Anti-inflammatory effects. Glucocorticoids have anti-inflammatory properties that slow down the cells that are involved with the inflammatory response. They (a) reduce the number of mast cells which reduces the secretion of histamine; (b) slows the release of destructive enzymes by stabilizing lysosomal membranes; (c) decrease the permeability of blood capillaries; and (d) suppresses phagocytosis. Glucocorticoids used in high doses can be effective in the treatment of rheumatoid arthritis.
5. Depression of immune responses. Because high doses of glucocorticoids will suppress immune responses, they are used for organ transplant patients to help inhibit tissue rejection.

Cushing's syndrome, characterized by the redistribution of fat, is a result of the overproduction of cortisol and cortisone. Symptoms include a 'moon face', a 'buffalo hump' on the back, hanging abdomen, and spindly arms and legs. This individual bruises easily, heals poorly, has facial skin that is 'flushed' with color, and they usually have stretch marks on their abdomen. They will many times be diabetic, have high blood pressure, osteoporosis, mood swings, an increased inability to deal with stress, and are physically weak. Usually this condition occurs with the introduction of prednisone to organ transplant patients, asthma victims, or those who have a chronic inflammatory disorder.

Gonadocorticoids

Gonadocorticoids are the sex hormones and include *androgens, estrogens, and progestins*. These are the hormones that are responsible for the male and female sexual characteristics such as beard and breast development, and reproductive functions. In addition to being produced in the adrenal gland, these hormones are also produced in the ovaries and testes. Overproduction of adrenal androgens in females will cause *virilism* or the occurrence of male characteristics. Overproduction of adrenal androgens in males will cause feminization or the occurrence of female characteristics.

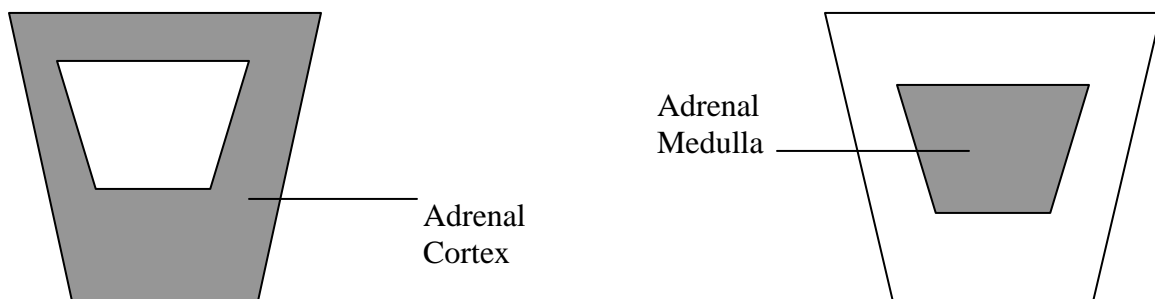
Androgens are secreted in small amounts from the adrenal cortex. These are male sex hormones that give masculinizing effects. The most prevalent androgen that is produced by the adrenal glands is *dehydroepiandrosterone* or *DHEA*. Another androgen, which is produced in the testes, is testosterone. The amount of androgens produced in the adrenal gland of males is usually insignificant. Female adrenal androgens can be important to their sex drive (libido) and other sexual behavior. They can be converted into estrogens, which becomes important during menopause when estrogen production diminishes. Androgens are also important in the growth spurt that is experienced during puberty, as well as the development of sexual hair such as in the axillary and pubic regions of both boys and girls.

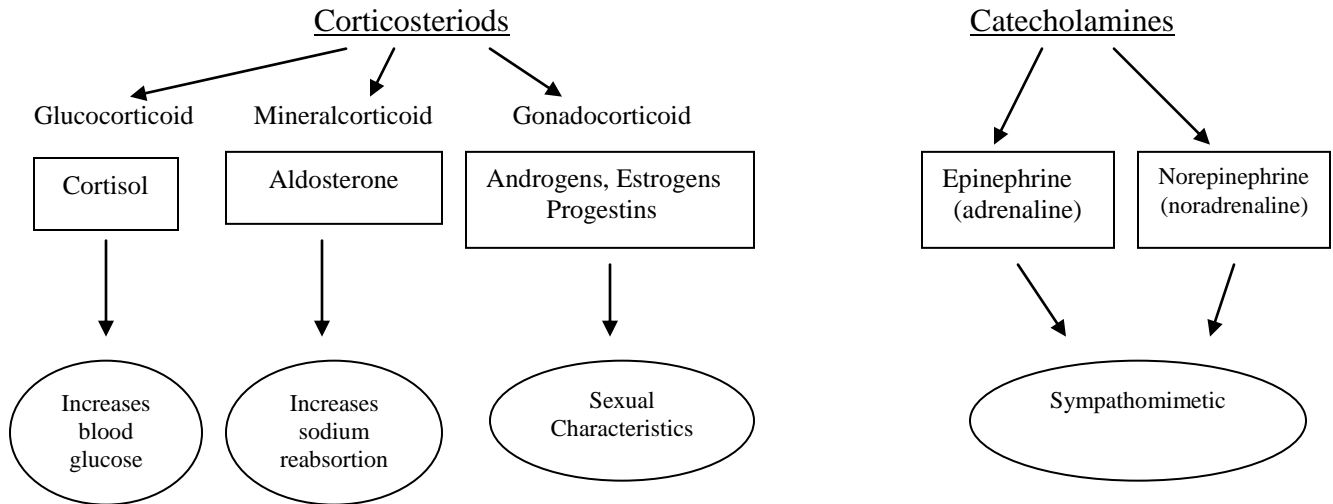
* ADRENAL MEDULLA

The adrenal medulla secretes two (2) hormones called *catecholamines*. We know them as epinephrine and norepinephrine. Both epinephrine and norepinephrine are called sympathomimetic agents because they mimic, or copy, the actions of the sympathetic nervous system. During times of stress, these hormones are secreted by the adrenal medulla in response to nervous stimulation. They help the body respond to crisis situations by raising blood pressure, increasing heartbeat and respiration, and bringing sugar out of storage in the cells.

Epinephrine (adrenaline) – increases cardiac rate, dilates bronchial tubes, and stimulates the production of glucose from a storage substance called glycogen when the body needs glucose.

Norepinephrine (noradrenaline) – constricts vessels and raises blood pressure.

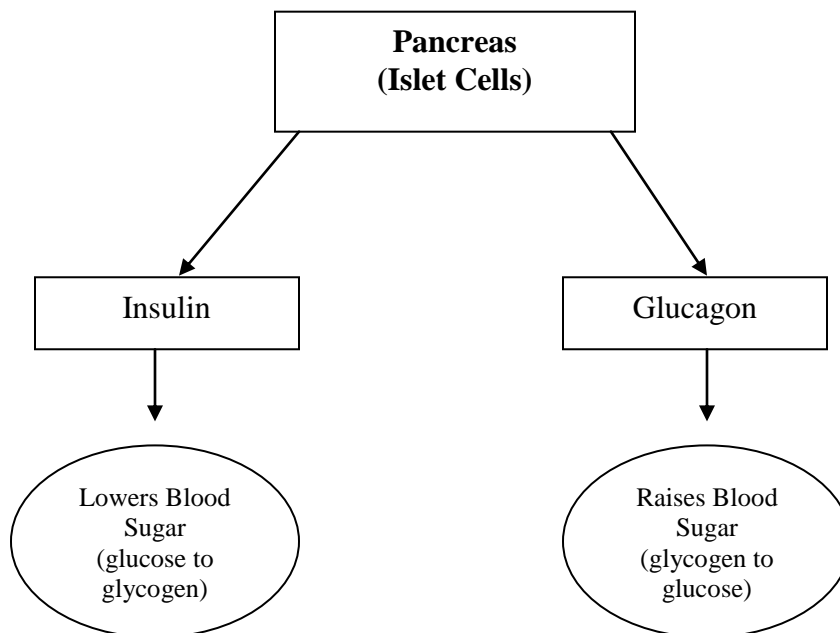




Pancreas

The pancreas is both an endocrine and an exocrine gland! Its exocrine functions are related to the digestive system. The pancreas is a flattened organ that measures about 4 ½ - 6 inches in length which is located near and partially behind the stomach. This specialized endocrine tissue consists of 1-2 million, hormone-producing cells called the *Islets of Langerhans*. More than 98% of the pancreas consists of exocrine cells (glands and ducts), which secrete digestive enzymes into the gastrointestinal tract.

The two (2) hormones that are secreted by the Islets of Langerhans are insulin and glucagon. Both of these hormones play a role in the proper metabolism of sugars and starches in the body. About 70% of these pancreatic islets secrete insulin, 20% secrete glucagon, 5% secrete somatostatin, and the remainder of the islet cells secrete pancreatic polypeptides.



The primary function of glucagon is to increase blood glucose levels when they fall below normal. Insulin, on the other hand, helps adjust blood glucose levels by decreasing the level if necessary. Insulin is necessary in the bloodstream so that sugars can pass from the blood into the cells of the body where they are burned and released as energy. When blood sugar (glucose) is above normal levels, insulin is released by the pancreas. Insulin causes glucose to enter body cells to be used for energy and stimulates the conversion of glucose to glycogen (a starch-storage form of sugar) in the liver. In this way, sugar can leave the blood to be stored (as glycogen) or used to release energy. Glucagon, the opposite ‘twin’ of insulin, is released into the blood when sugar levels are below normal. It causes the breakdown of stored liver glycogen to glucose so that there is a rise in the sugar content of blood leaving the liver.

Ovaries

The ovaries are two small glands that are located in the female pelvic cavity. They produce hormones called estrogens and progesterone. Along with the gonadotropic hormones of the pituitary gland, these sexual hormones regulate the female reproductive cycle, maintain pregnancy, and prepare the mammary glands for lactation.

Progesterone is responsible for the preparation and maintenance of the uterus in pregnancy.

Estrogen is primarily produced by our ovaries, although a small amount does come from our adrenal glands. We actually produce three different kinds of estrogen. They are estradiol, estriol and estrone. The most powerful and constant of the estrogens is estradiol, which is produced by the ovaries during each menstrual cycle. Estradiol is responsible for the development and maintenance of secondary sex characteristics, such as hair and breast development. Estriol is produced in large amounts only during pregnancy. Estrone – a weaker estrogen – is found in most postmenopausal women, but in much smaller amounts than the amount of estradiol that circulates in a woman’s body during her reproductive years.

Testes

The testes are two oval glands in the male called gonads and produce the primary androgen testosterone. Testosterone regulates the production of sperm and stimulates the development and maintenance of masculine secondary sex characteristics such as beard growth.

Pineal Gland

The pineal gland is considered an endocrine gland because it is ductless, but little is known about it. This small cone shaped gland about 1cm long is located in the central portion of the brain and is believed to secrete melatonin. It is believed to have an influence on the rate of gonad (ovaries and testes) maturation.

Thymus

The thymus is considered to be the primary organ of the lymphatic system. Weighing about an ounce, the endocrine function of the thymus is essential to the overall body immune system. The thymus secretes the hormone thymosin, which plays a critical role in the development of the immune system. For individuals who have a weak immune system, an injection of thymosin has been found to increase lymphocyte production of "T cells" and activates the immune system.

ENDOCRINE GLAND	HORMONE	ACTION
Thyroid	Thyroxine, Triiodothyronine Calcitonin	Regulates metabolism in body cells Stimulates passage of calcium into bones from blood.
Parathyroids	Parathyroid hormone	Regulates calcium in the blood
Adrenals		
Cortex	Aldosterone (mineralocorticoid)	Regulates the amount of salts in the body Regulates the quantities of sugars, Fats and proteins in cells
Medulla	Androgens, estrogens, and Progestins Epinephrine (adrenaline) Norepinephrine (noradrenaline)	Maintain secondary sex characteristics Mimic the sympathetic nervous system's response
Pancreas		
Islet cells	Insulin Glucagon	Regulates the transport of glucose to the body cells Increases blood sugar by causing conversion of glycogen to glucose
Pituitary		
Anterior lobe	Growth hormone Thyroid-stimulating hormone Adrenocorticotrophic hormone Gonadotropins Follicle-stimulating hormone (FSH) Lutenizing hormone (LH) Prolactin (PRL) Melanocyte-stimulating hormone	Increases bone & tissue growth Stimulates production of thyroxine & growth of the thyroid gland Stimulates secretion of hormones the adrenal cortex, esp. cortisol Stimulates growth of eggs and ovarian hormone secretion Promotes ovulation; male hormone Secretion (ICSH) Promotes growth of breast tissue and milk secretion Increases pigmentation of the skin
Posterior lobe	Antidiuretic hormone (ADH; vasopressin) Oxytocin	Stimulates reabsorption of water by kidney tubes Stimulates contraction of the uterus during labor and childbirth
Ovaries	Estradiol Progesterone	Develops & maintains secondary Sex characteristics in females Prepares & maintains the uterus in pregnancy
Testes	Testosterone	Promotes growth & maintenance of secondary sex characteristics in the male

ENDOCRINE SYSTEM ABBREVIATIONS

ACTH	adrenocorticotrophic hormone	MSH	melanocyte-stimulating hormone
ADA	American Diabetes Association	Na	sodium
ADH	antidiuretic hormone (vasopressin)	NIDDM	non-insulin-dependent diabetes mellitus
BMR	basal metabolic rate	NPH	neutral protamine Hagedorn insulin
CRH	corticotropin releasing hormone	17-OH	17-hydroxycorticosteroids
CT	calcitonin	OT	oxytocin
CZI	crystalline zinc insulin	PG	prostaglandins
DHEA	dehydroepiandrosterone	PIH	prolactin inhibiting hormone (dopamine)
DI	diabetes insipidus	PRL	prolactin
DM	diabetes mellitus	PRH	prolactin releasing hormone
FBG	fasting blood glucose	PTH	parathyroid hormone (parathormone)
FBS	fasting blood sugar	RAIU	radioactive iodine uptake
FSH	follicle-stimulating hormone	RIA	radioimmunoassay
GH	growth hormone (somatotropin)	SIADH	syndrome of inappropriate ADH
GTT	glucose tolerance test	T₃	triiodothyronine
GnRH	gonadotropin releasing hormone	T₄	thyroxine
ICSH	interstitial cell-stimulating hormone	T₃RU	triiodothyronine resin uptake
IDDM	insulin-dependent diabetes mellitus	TBG	thyroid-binding globulin
IGF	insulin-like growth factors (somatomedins)	TFT	thyroid function test
K	potassium	TGB	thyro-globulin
LH	luteinizing hormone	TRH	thyrotropin releasing hormone
		TSH	thyroid-stimulating hormone (thyrotropin)

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Endocrinology Exam

1. Too much thyroid secretion can cause a condition called Graves disease. Symptoms can include:
 - a. Enlarged thyroid
 - b. Hair loss
 - c. Stunted growth
 - d. Weight loss
2. Gonadotrophs produce two major hormones. They are:
 - a. ACTH & MSH
 - b. ACTH & PRL
 - c. FSH & LH
 - d. TSH & HGH
3. Exocrine glands secrete their products into ducts, and the ducts then distribute those secretions into their appropriate places. Which of the following is an exocrine gland?
 - a. Adrenal
 - b. Pituitary
 - c. Sebaceous
 - d. Thyroid
4. When calcitonin is present in the bloodstream it keeps the bones from releasing calcium.
 - a. True
 - b. False
5. Which hormone regulates the amount of calcium present in blood serum?
 - a. MSH
 - b. PRL
 - c. PTH
 - d. TSH
6. Which gland manufactures the hormones that we call steroids?
 - a. Adrenal Cortex
 - b. Adrenal Medulla
 - c. Pituitary
 - d. Thyroid
7. Steroids are hormones.
 - a. True
 - b. False
8. The most abundant and most important glucocorticoid hormone produced is called:
 - a. Aldosterone
 - b. Androgens
 - c. Calcitonin
 - d. Cortisol
9. Androgens, estrogens, and progestins are produced in the adrenal gland and are called:
 - a. Glucocorticoids
 - b. Gonadocorticoids
 - c. Hydrocorticoids
 - d. Mineralocorticoids
10. The master gland of the endocrine system is the:
 - a. Adrenal
 - b. Pineal
 - c. Pituitary
 - d. Thyroid

INSTRUCTIONS FOR SUBMITTING EXAMINATION ANSWERS

- **Please take the final exam on line!**
- **Use the same link that took you to the page that was sent/emailed to you to access the course.**
- **At the bottom of that page is a ‘button’ to click for taking the exam on the LaserBlazers website on the internet.**
- **When prompted, be sure to spell your name exactly the way you want it to appear on your certificate of completion.**
- **As soon as you have completed the exam, you will be sent an email with a certificate of completion ‘attached’ as a PDF file.**
- **The license number (if applicable) that you provide is the number that will be used to enter your hours/credit into CEBroker**
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