ST. CATHERINE UNIVERSITY

Endocrine

Communication Overview

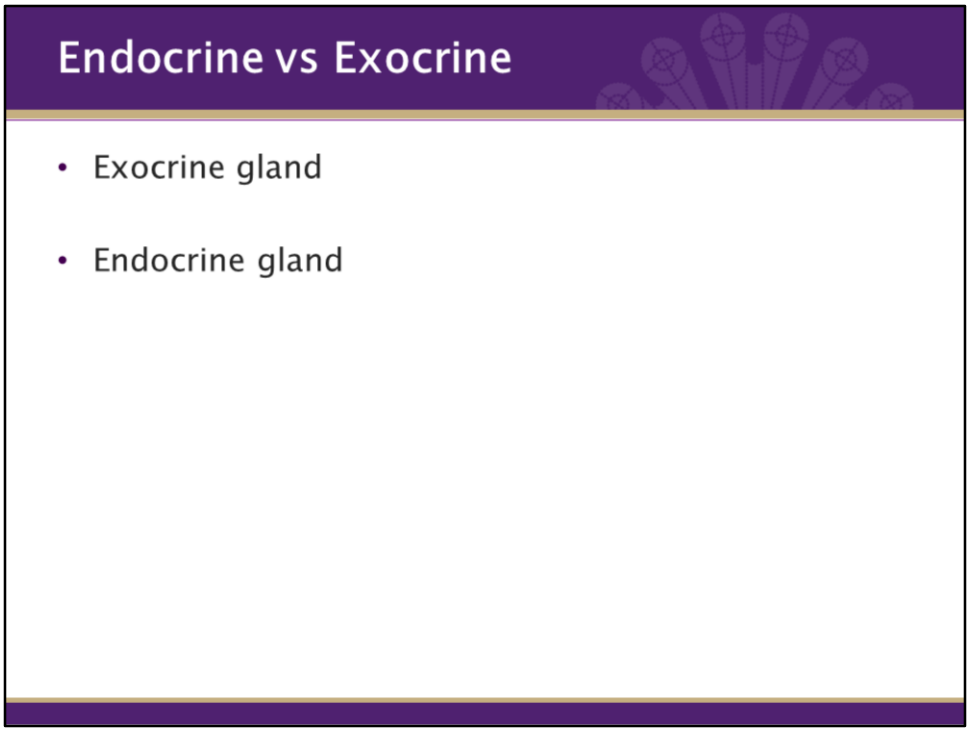
- Gap Junctions
- Neurotransmitters
- Paracrines
- Hormones

We have talked about many ways in which different cells and parts of the body communicate with one another. To review, gap junctions enable cells to pass nutrients, electrolytes, and signals directly between each other. We saw this in the cardiovascular system with the gap junctions between cardiac muscle cells. Neurotransmitters are released by neurons and bind to receptors on a cell. We talked about neurotransmitters in our neuromuscular junction with ACH. Paracrines are secreted by a cell to communicate with neighboring cells. This is a form of localized communication. For example, when mast cells release histamine to stimulate the smooth muscle of a blood vessel to relax and allows for vasodilation. The final form of communication is through hormones. We are going to spend the rest of this presentation talking about various hormones, where they are produced, what they target, and what they do.

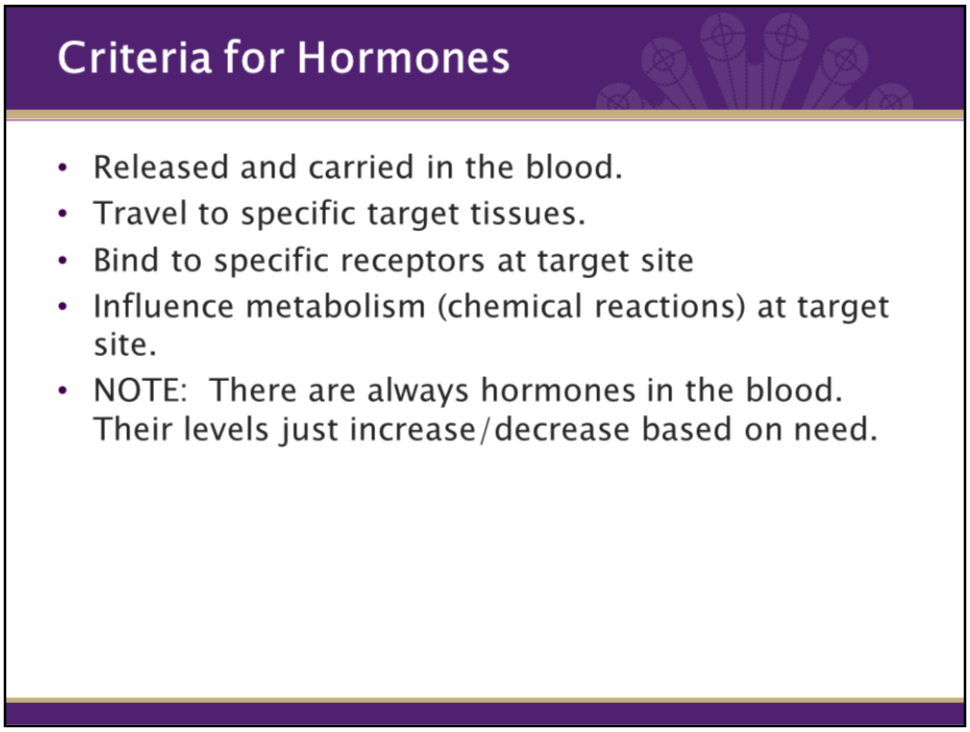
Nervous vs Endocrine System

Nervous	Endocrine
Communicate via electrical signals and neurotransmitters.	Communicates via hormones.
Releases neurotransmitters at synapses at specific target cells.	Releases hormones into bloodstream for general distribution throughout the body.
Usually relatively local, specific effects.	Sometimes has very general, widespread effects.
Reacts quickly to stimuli, usually within 1–10 ms.	Reacts more slowly to stimuli, often taking seconds to days.
Stops quickly when stimulus stops.	May continue responding long after stimulus stops.
Adapts relatively quickly to continual stimulation.	Adapts relatively slowly; may respond for days to weeks.

Both the nervous and endocrine systems communicate with the body in order to respond to stimulus and maintain homeostasis, but they do so in very different ways. This chart compares the two systems and can be found on page 632 in your book as well. The nervous system uses electrical signals and neurotransmitters to communicate to a very specific target cells at a synapse. These communications are local and have a specific effects. The nervous system also have a very quick response time and the communication stops quickly once the stimulus has stopped. This allows for our nervous system to adapt quickly to continual stimulation. In contrast, the endocrine system uses hormones to communicate. Hormones are released into the blood supply and travel throughout the body. Therefore, they can have widespread effects. The endocrine system is also much slower to respond to a stimulus and slower to stop. Therefore, it is rather slow to adapt.



In the beginning of the semester, we discussed the difference between exocrine and endocrine glands. To refresh, exocrine glands use ducts to transport their products while endocrine glands use the blood supply. Some glands, like we will see with the pancreas, may have both an exocrine and endocrine function.



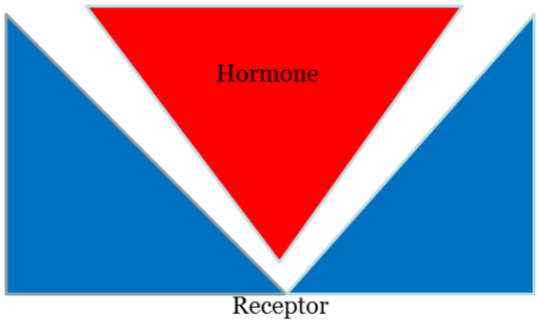
Hormones are chemical messengers that carry info from one part of the body to another.
There are a number of chemicals in the body, but in order to be considered a hormone, those chemicals must meat the following criteria.

1. They must be released into and carried in the blood.
2. They must travel to a specific target tissues.
3. They must bind to specific receptors at the target site.
4. They must influence metabolism (or chemical reactions) at target site.

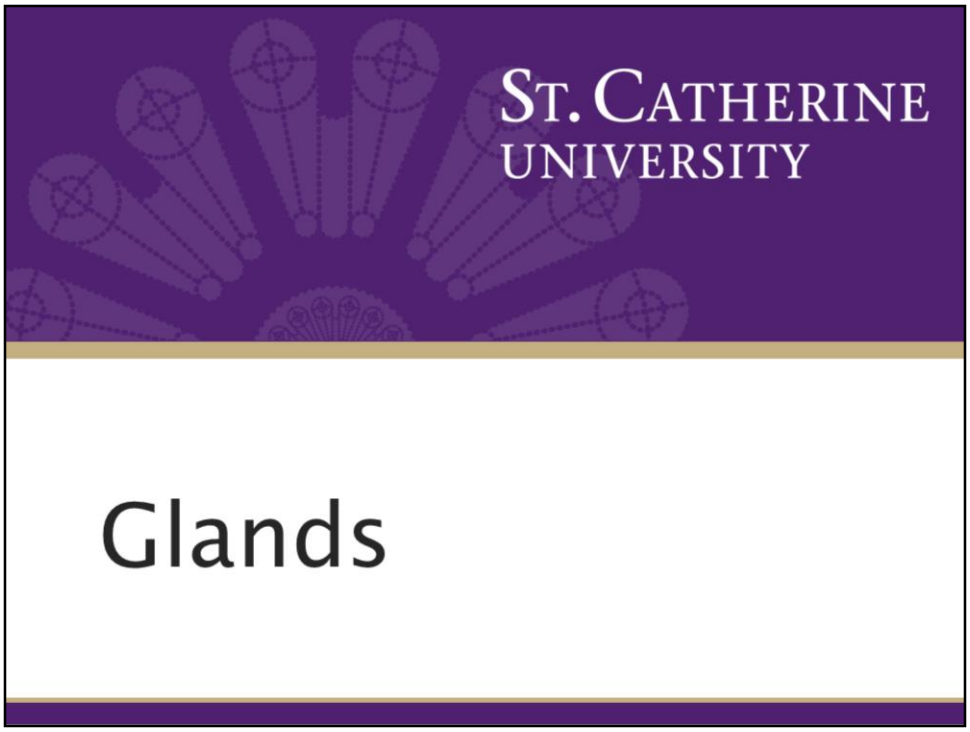
NOTE: There are always hormones in the blood. The do not act like an on/off switch, their levels just increase or decrease based on need.

Target Specificity

- Lock ‘n Key action
- Hormone–Receptor Complex



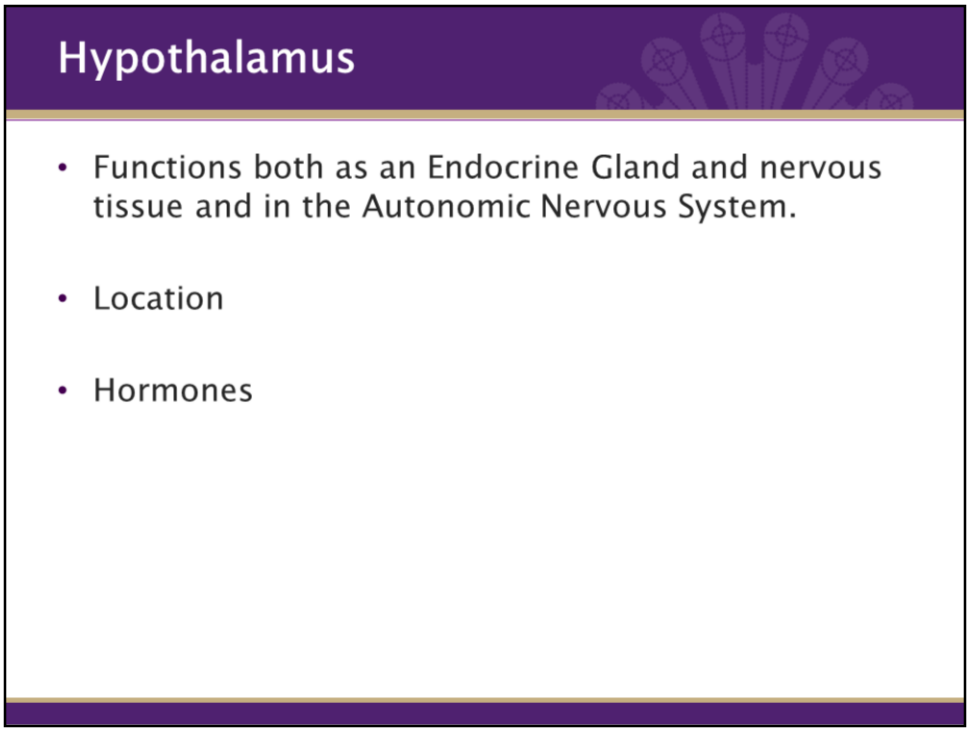
Hormones have target specificity, meaning a hormone targets a particular site and receptor. Each hormone has a matching receptor. Only the hormones matching that receptor can bind to it. It is kind of like a Lock ‘n Key. One key, opens one door. Your house key cannot open your car and visa versa. This relationship is called the Hormone-Receptor Complex.



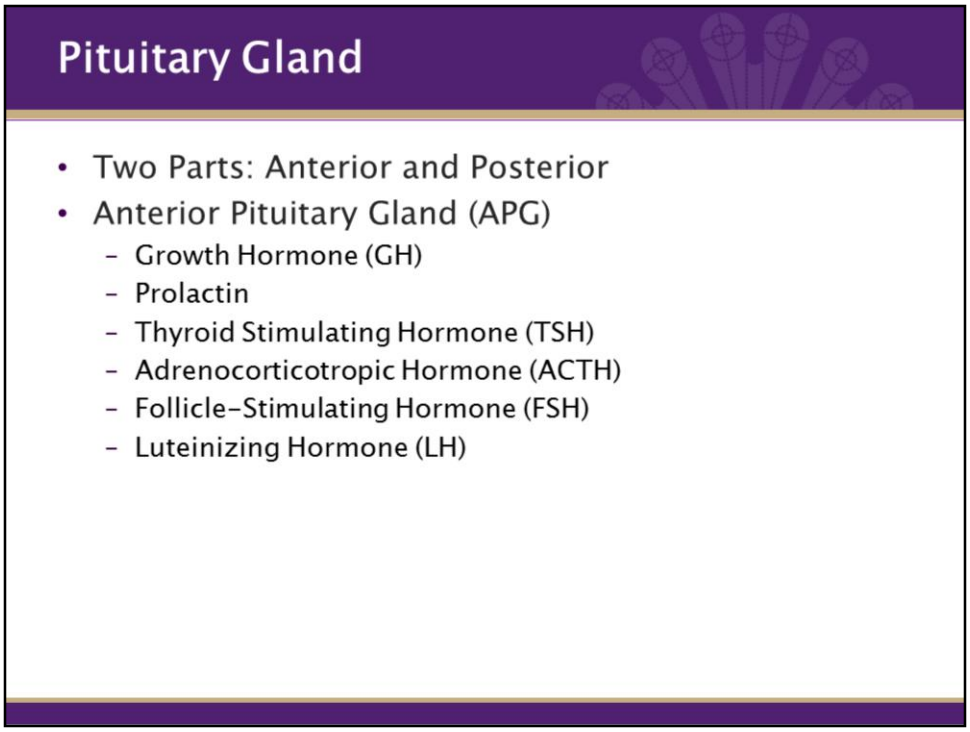
In the endocrine system, the glands are the primary organs. We are going to go through the various glands and the hormones they produce.

By the end of this unit, you should be able to:

1. Know where a hormone is produced and/or secreted.
2. Know the target cells for the hormone.
3. The function of that hormone. In other words, what change does that hormone facilitate.

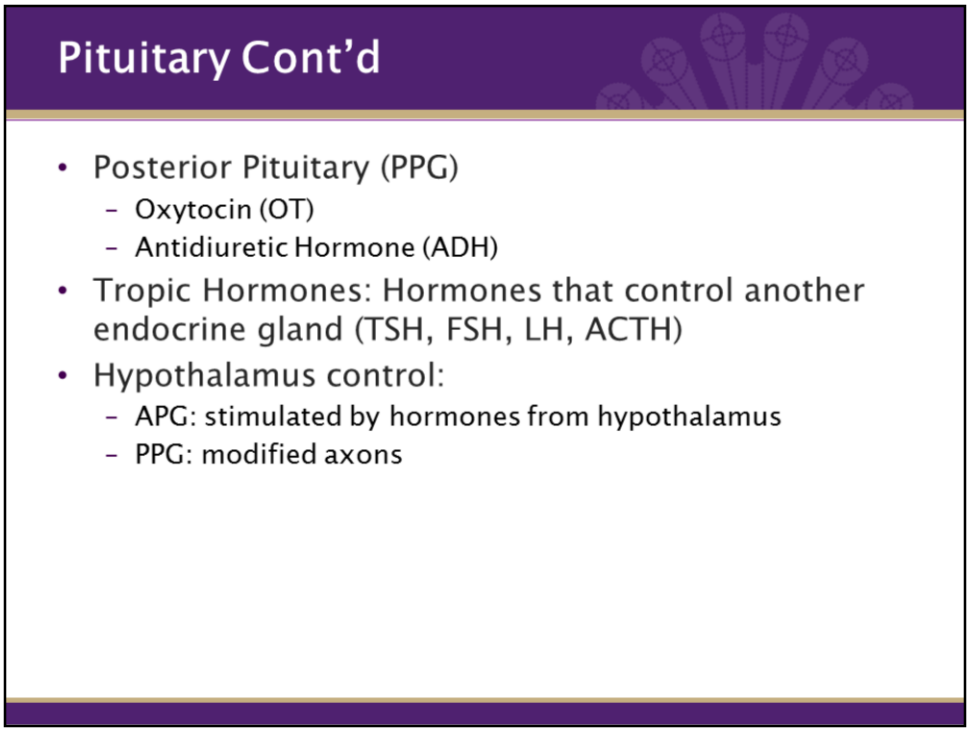


The hypothalamus is both an endocrine gland and nervous tissue. It controls other glands by controlling the pituitary gland via various hormones. I think of the hypothalamus as the power behind the throne. Recall the module on the central nervous system. The Hypothalamus is part of the Diencephalon in the brain. It controls the Autonomic Nervous System and influences all other major endocrine glands. The hypothalamus produces two hormones, Oxytocin and Antidiuretic Hormone. These hormones are then released by the Posterior Pituitary gland. The Hypothalamus also secretes a set of hormones that controls the Anterior Pituitary gland. We'll go into greater detail on that in a moment. But, the hypothalamus is the first place that we encounter tropic hormones. Tropic hormones are hormones that are released by an endocrine gland and function to stimulate another gland to produce and release their specific hormones. The primary ones being Thyroid Stimulating Hormone (TSH), Follicle Stimulating Hormone (FSH), Luteinizing Hormone (LH), and Adrenocorticotropic Hormone (ACTH) and are produced by the Anterior Pituitary Gland.



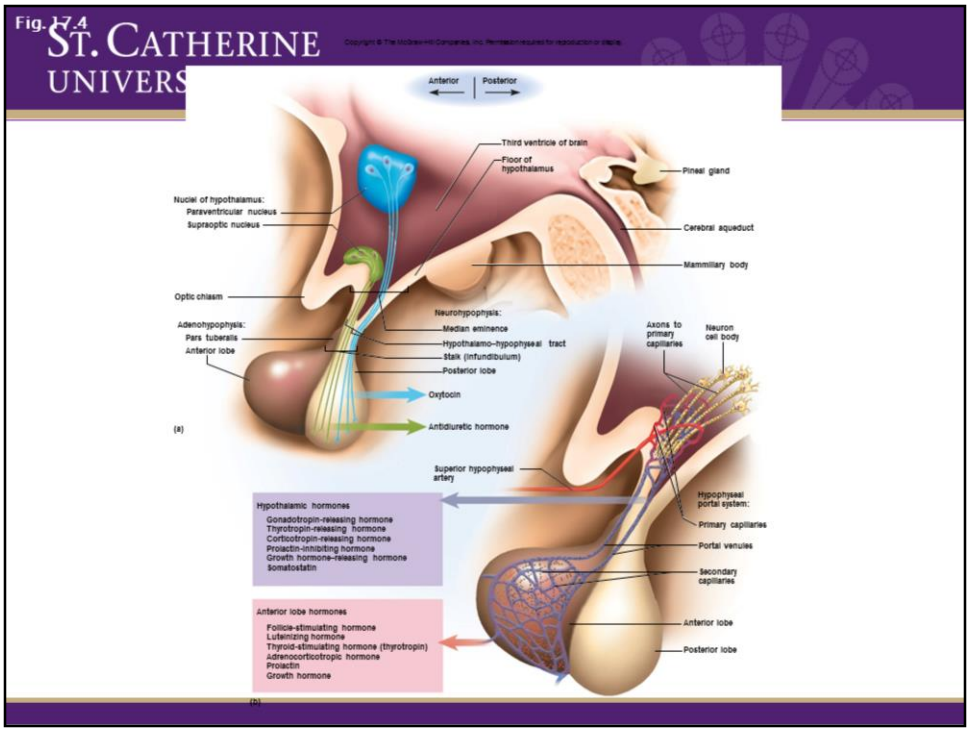
The pituitary gland is located underneath the hypothalamus and two parts: the Anterior and Posterior Pituitary Gland.
The Anterior Pituitary Gland (APG) releases the following hormones:

1. Growth Hormone (GH): this affects all cells of the body, it doesn't have a specific target tissue. GH causes cells to increase in size and number. The highest levels of GH are found during puberty.
2. Prolactin: affects mammary glands and influences milk production. The levels are highest after childbirth. In males, it increases LH sensitivity and testosterone secretion.
3. Thyroid Stimulating Hormone (TSH): stimulates the thyroid to release thyroid hormones.
4. Adrenocorticotropic Hormone (ACTH): stimulates adrenal glands to produce and release cortisol.
5. Follicle-Stimulating Hormone (FSH): targets sex organs. FSH stimulates sperm and egg production.
6. Luteinizing Hormone (LH): targets sex organs and stimulates ovulation and testosterone secretion.



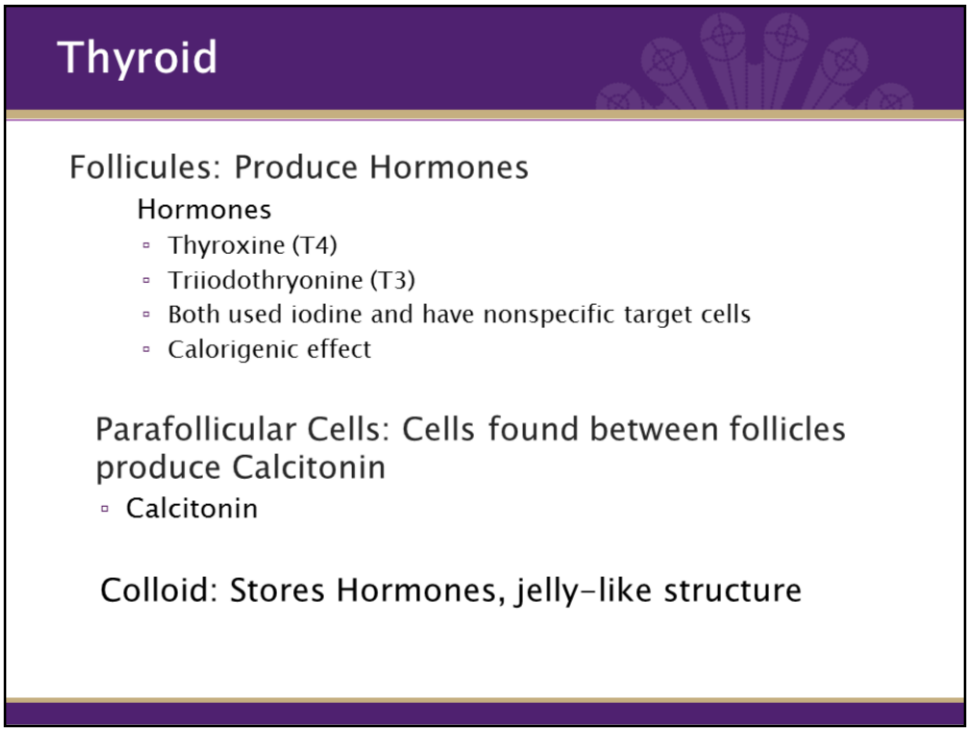
The posterior pituitary gland (PPG) releases oxytocin (OT) and antidiuretic hormone (ADH). OT targets the uterus and causes contractions for childbirth. it also targets the mammary glands to release milk from the glands into the nipples. In males, it aids in the propulsion of semen. OT also facilitates an emotional bond between mother and infant. ADH targets the collecting duct and affects H2O reabsorption, increases BP by putting more H2O into the blood.

If you recall, the hypothalamus controls the release of hormones from the pituitary gland. It stimulates the APG and PPG by different means. The APG is stimulated by hormones released from the hypothalamus. The PPG is stimulated by modified axons.



In the top portion of the picture, we can see the modified axons (in blue and green) originating in the hypothalamus and running down to the PPG. The hypothalamus actually makes OT and ADH. The hormones then travel down the axons (like someone going down a water slide or chute) into the PPG. The PPG then releases the hormones.

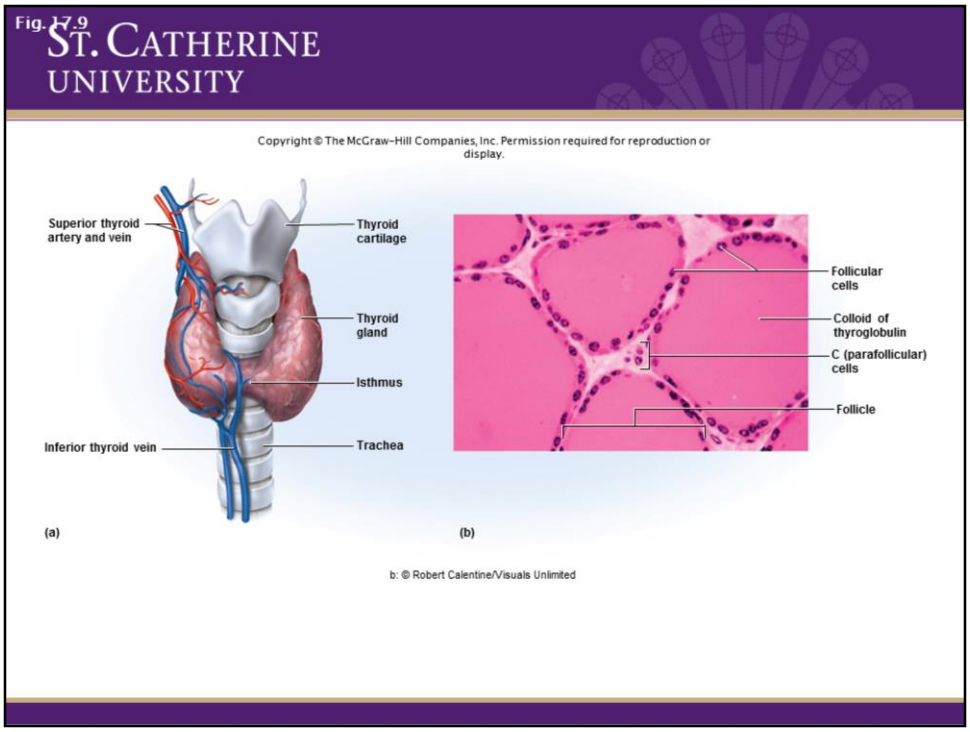
In the bottom half of the diagram, we see the APG. The APG is linked to the hypothalamus through a special network of blood vessels. The hypothalamus releases hormones into this network to stimulate the APG.



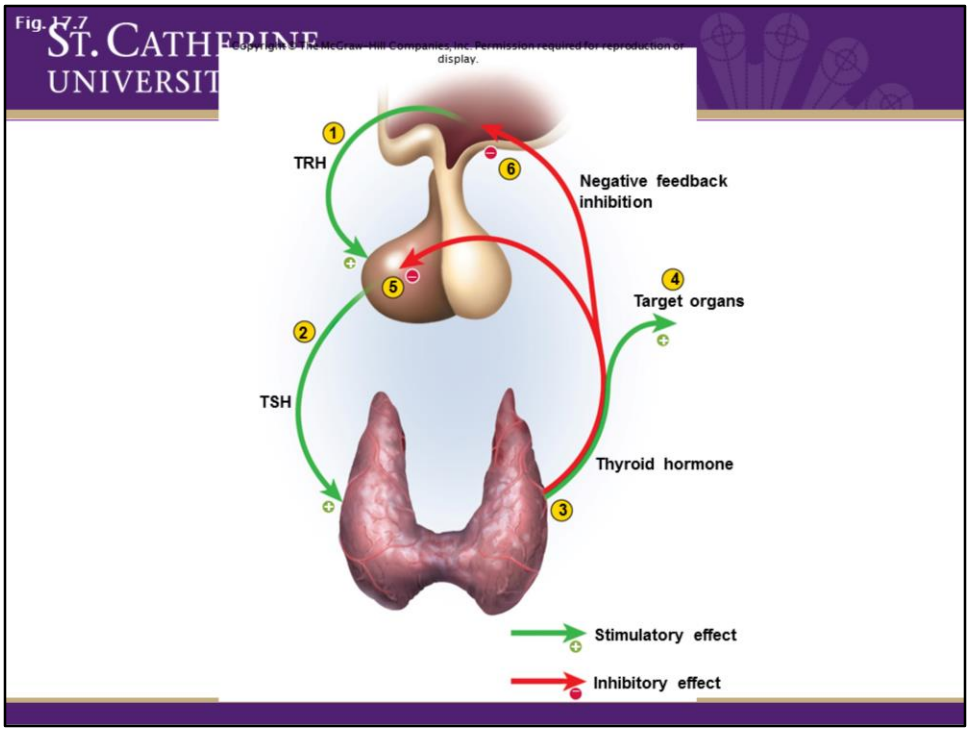
The thyroid is a h-shaped gland. The cross section that connects the two outer portions is called the isthmus. Within the thyroid, there are two primary areas, the follicles and the colloid. The follicules produce the hormones and the colloid stores them. The follicle cells of the thyroid produce the hormones thyroxine (T4) and triiodothryonine (T3) and are collectively called thyroid hormone. Both have iodine within their composition and have nonspecific target cells They have a calorigenic effect on the body, meaning they increase body metabolism. They are responsible for influencing the regulation of body temperature and weight.

Also within the thyroid are the parafollicular cells. These cells are found between the follicles produce calcitonin. Calcitonin decreases levels of blood calcium by stimulating osteoblast activity for bone formation. It also restricts osteoclast activity so less calcium is removed from the bone matrix and placed into the blood. This hormone is primarily active in children and is not commonly found in adults. . It is also thought that calcitonin may prevent pregnant and nursing women from loosing bone matrix.

The colloid has a jelly-like structure and functions to store the hormones that the follicles produce.



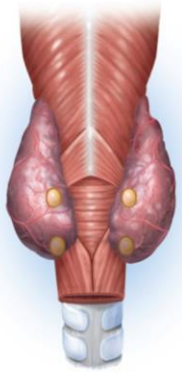
The thyroid gland. The follicular cells and colloid almost form a jelly donut like structure. The follicular cells are the dough and colloid is the jelly filling. The parafollicular cells are found between the “donuts”.



This diagram demonstrates how the hypothalamus stimulates the APG to release of the tropic hormone TSH. TSH then stimulates the thyroid to release thyroid hormone. Thyroid hormone then goes out to the target tissues. It also goes up to the hypothalamus and APG to tell them to stop the stimulation. This cycle is a great example of negative feedback.

Parathyroid Gland

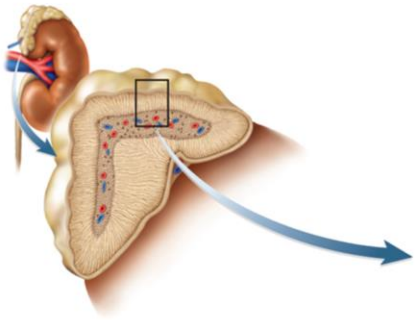
- Location
- Parathyroid Hormone (PTH)



The parathyroid glands are 4 small circular glands on the posterior side of the thyroid. They release parathyroid hormone (PTH) which functions in increasing levels of calcium in the blood via stimulation of osteoclasts to release calcium from bone tissue. It is the antagonist to calcitonin. Additionally, PTH inhibits osteoblasts from synthesizing collagen which inhibits how much bone matrix is formed by the osteoblasts. PTH also stimulates the kidneys to reabsorp more calcium so less is loss in urine and it promotes the synthesis of calcitriol.

Adrenal Glands

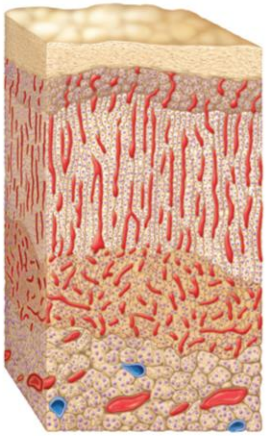
- Sits on top of each Kidney
- Receives a lot of Blood from Renal Artery
- 2 sections:
  - Medulla: Inner Layer
  - Cortex: Outer layer, has sub-layers or zones.



The adrenal glands sit on top of each kidney. They have a rather large blood supply because of their proximity to the Renal Artery. The adrenal glands are broken into two sections, the medulla and the cortex. The medulla is the inner Layer and the cortex is the outer layer. The cortex also has sub-layers or zones.

Adrenal Cortex

- Mineralcorticoids
  - Produced in outer zone
  - Regulate Electrolytes
  - Aldosterone
- Glucocorticoids
  - Produced in middle zone
  - Regulate metabolism and glucose
  - Cortisol
- Gonadocorticoids
  - Produced in inner zone
  - Sex steroids
  - Androgens, estradial, testosterone

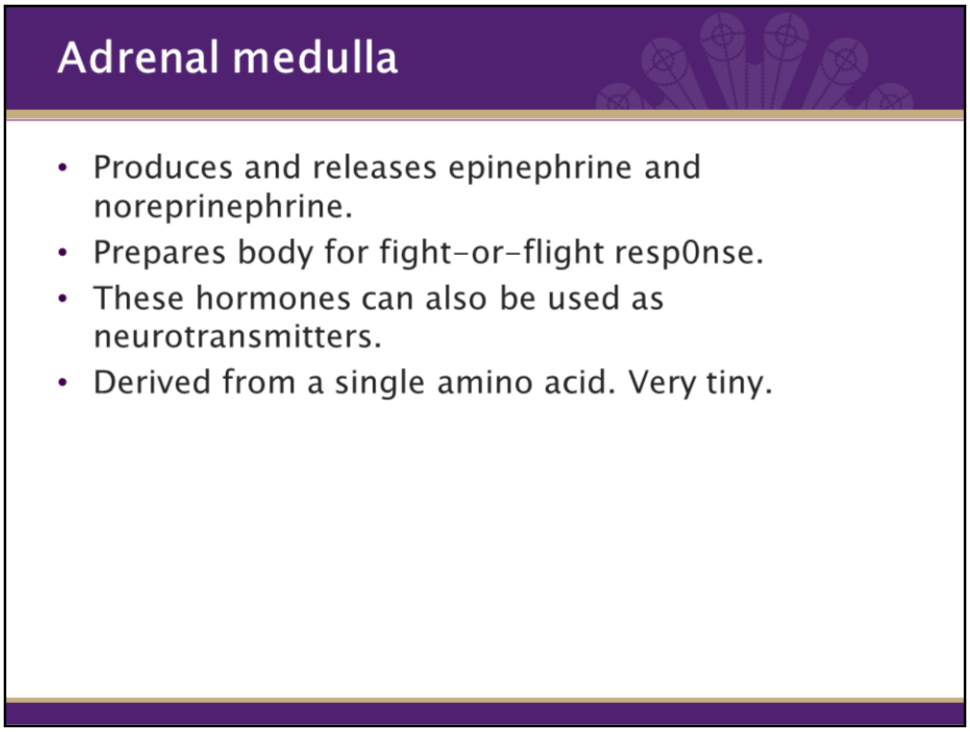


The cortex produces 3 categories of hormones.

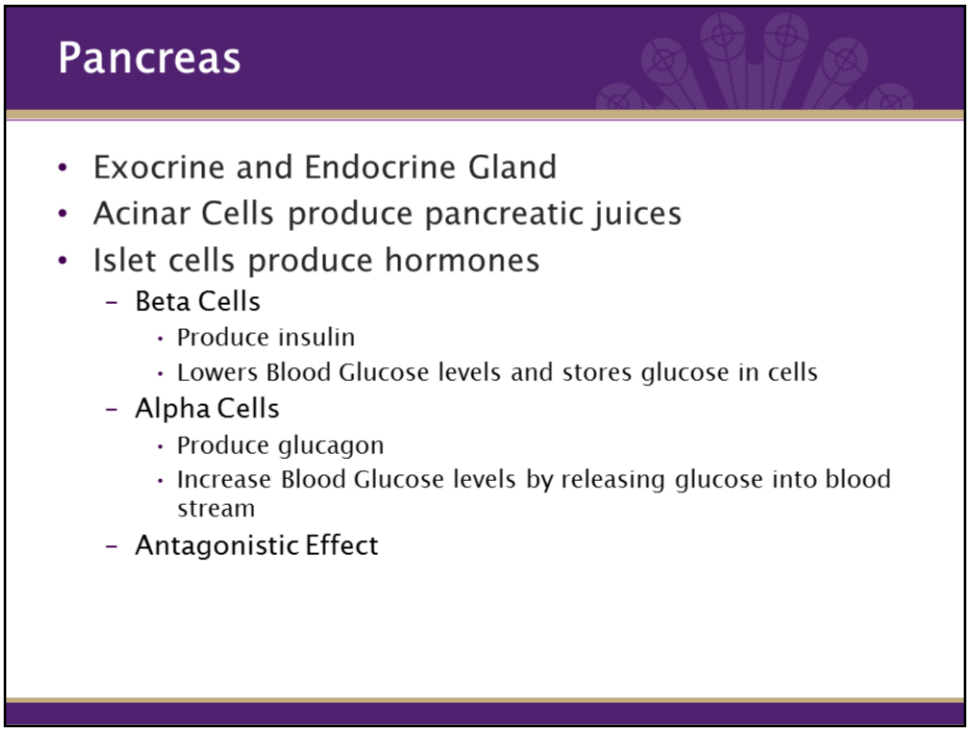
1. Mineralcorticoids are produced in the outer zone (Zona Glomerulosa) and regulate electrolytes. An example is Aldosterone. Aldosterone controls Na+ levels in the body which in turn influences water volume and BP. It targets nephrons and causes them to actively transport Na+ faster, increasing reabsorption. As discussed in the urinary system, the movement of water is connected to the movement of Na+. Since Aldosterone causes Na+ to move, it inadvertently causes water to move and be reabsorbed, therefore it also has an antidiuretic affect.

2. Glucocorticoids are produced in the middle zone (Zona Fasciculata) and regulate metabolism and glucose. An example is cortisol. Cortisol does not have a specific target tissue. It is released under stressful conditions and allows one to overcome that particular stressor by stocking up on readily useable sources of energy. It does so by stimulating glucose production from proteins and fats to provide extra energy. In the short term, this is not a problem. When we are in a chronic stressful conditions, the continued release of cortisol causes the body to burn structural proteins and lipids that are found in muscle and connective tissue and converts them to fats to be stored for further energy use. It can also have an anti-inflammatory function, but again, when excessively used, it can suppress the immune system too much.

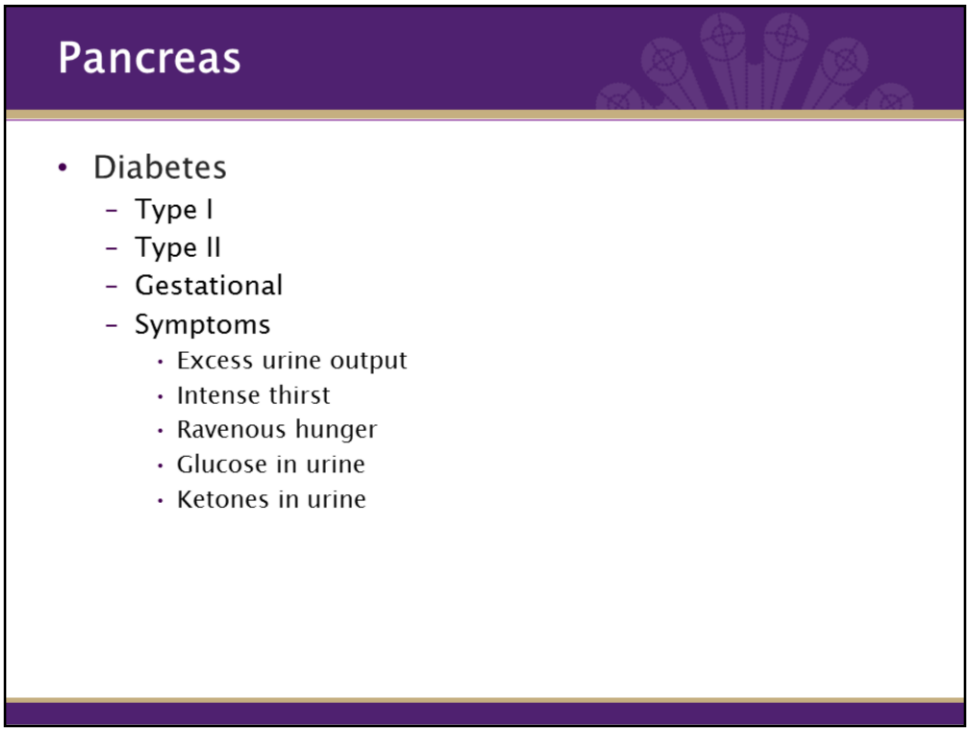
3. Gonadocorticoids are produced in the inner zone (Zona Reticularis) and are sex steroids such as androgens, estradial, testosterone. Most of the sex steroids are produced by the gonads (we'll get to those more later). The amount of sex hormones released from the adrenal gland is a drop in the bucket compared to the gonads, but they are essential for sustaining bone mass in adults and for bone growth in children. They are especially necessary for maintaining bone integrity in postmenopausal women.



The medulla produces and releases epinephrine and noreprinephrine, also known as adrenaline and noradrenaline. These prepare the body for fight-or-flight responses. They can also be used as neurotransmitters by the nervous system. They are derived from a single amino acid and are very, very tiny.



If you recall, the pancreas is both an exocrine and endocrine gland. Its exocrine functions are associated with the digestive system. The acinar cells of the pancreas produce pancreatic juices and the various pancreatic digestive enzymes. For the endocrine functions, they islet cells are the primary producers. There are two cell types, beta and alpha. Beta cells produce insulin which functions to take glucose out of blood stream. Conversely, alpha cells produce glucagon which releases glucose into blood stream. The two hormones have antagonistic effects, counteracting each other, to maintain proper blood sugar level. Remember, homeostasis is about maintaining a dynamic equilibrium around a set point. These two hormones work in conjunction with each other ensure that we have the proper Blood Glucose lebels.

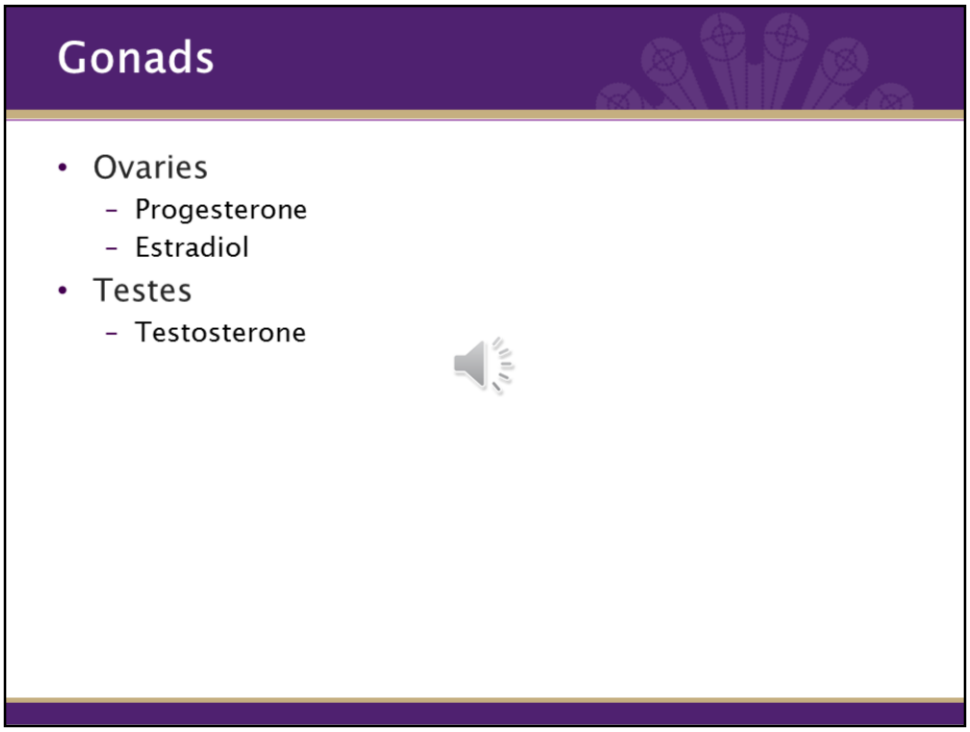


Diabetes is a disease that is a major concern for a growing portion of our population. There are two primary types, type I and type II.

Type I results from an inability to produce insulin and is classified as an autoimmune disorder. Since the body does not produce insulin, blood sugars rise and cannot be pulled out of the blood and stored. Most cases of diabetes, roughly 90%, are type II. Type II is when the liver and muscle cells do not respond to the hormones either through insulin receptor insensitivity or inadequate production of insulin. Adipose tissue can secret chemicals that indirectly interferes with bringing glucose into the cell as seen in increase risk of diabetes among obese individuals.. There is a genetic component to this form, but it is highly influenced by lifestyle. A third form a diabetes, called gestational diabetes, can occur in a small percentage of pregnant women. Hormones released during pregnancy reduces the mother's sensitivity to insulin, resulting in higher blood glucose levels. Most of the time, the situation rights itself after birth, but while pregnant the mother must be conscientious of her diet and exercise.

Symptoms include:

Excess urine output
Intense thirst
Ravenous hunger
Glucose in urine
Ketones (an organic compound that has double bound carbon and oyxgen bounded to 2 additional carbons) in urine



The gonads are the ovaries and testes of the female and male reproductive systems, respectively. The ovaries release progesterone and estradiol. The testes release testosterone. We will be going into greater detail in the reproductive system.