Slide 2

The endocrine operates to regulate internal functions. It does so, via the use of hormones, or chemical messengers. Hormones travel in the blood from the site of production to distant target cells and bind to highly specific receptors at the target site.

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.

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 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 has 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 comparison to the nervous system.

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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.

Slide 4

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.

Slide 5

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 stored and released by the posterior pituitary gland. The hypothalamus also secretes a set of hormones that controls the anterior pituitary gland. The hypothalamic releasing hormones travel to the anterior

pituitary and influence the release of other hormones. 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.

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The pituitary gland is located underneath and stimulated by the hypothalamus. It is connected by a stalk called the infundibulum. There are 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.
3. Thyroid Stimulating Hormone (TSH): stimulates the thyroid to release thyroid hormones.
4. Adrenocorticotropic Hormone (ACTH): stimulates adrenal cortex 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.

Thyroid stimulating hormone (TSH), follicle stimulating hormone (FSH), luteinizing hormone (LH), and adrenocorticotropic hormone (ACTH) are considered tropic hormones.

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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 is possibly involved in sperm release and transport. OT also facilitates an emotional bond between mother and infant. ADH targets the collecting duct in the kidney 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 nerve impulses to release the stored hormones.

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In the top portion of the picture, we can see the 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 modified nerve cells through the infundibulum 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.

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The thyroid is a h-shaped gland located in the neck. The two outer portions, or lobes, are connected by a cross section that connects them called the isthmus. Within the thyroid there are the follicles and the colloid. The follicles produce the hormones and the colloid stores them. The follicle is a small sac like structure that is surrounded by simple cuboidal cells while the colloid is the more gel-like structure in the middle of the sac. 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, T4 has 4 iodine atoms and T3 has 3. They have a calorigenic effect on the body, meaning they increase body metabolism, and effect almost all body cells. They are responsible for influencing the regulation of body temperature and weight, increasing cardiac output and respiratory rate, and stimulates appetite. The colloid has a jelly-like structure and functions to store the hormones that the follicles produce.

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 losing bone matrix.

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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".

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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.

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The parathyroid glands are 4 small glands on the posterior side of the thyroid. They release parathyroid hormone (PTH) which is released in response to low blood calcium levels. It functions by increasing levels of calcium in the blood via stimulation of osteoclasts to release calcium from bone tissue.

Slide 13

The adrenal glands are paired glands that 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 surround by a fibrous capsule and 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.

Slide 14

The cortex produces 3 categories of hormones.

1. Aldosterone is produced in the outer zone (Zona Glomerulosa) and regulates electrolytes. Aldosterone controls Na+ levels in the body which in turn influences water volume and BP. It targets nephrons and causes them to retain Na+, 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 causes water to move and be reabsorbed, therefore it also has an antidiuretic affect.

2. Cortisol is produced in the middle zone (Zona Fasciculata) and regulates metabolism and glucose. Cortisol does not have a specific target tissue. It is released in response to ACTH from the anterior pituitary 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, gluconeogenesis, 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. Androgens are produced in the inner zone (Zona Reticularis) and are 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. Additionally, they influence erythropoiesis, stimulate hair growth, and play a role in sexual behavior.

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The medulla produces and releases epinephrine and noreprinephrine, also known as adrenaline and noradrenaline. These chemicals are synthesized by modified nerve cells and released into the blood stream as hormones. They have similar functions and are responsible for:

1. Gluconeogenesis, production of new glucose molecules from fats and proteins

2. Glycogenolysis: the breakdown of glycogen

3. Increased cardiac function, or raise the heart rate

4. Increased blood flow to muscles

5. Increased pulmonary ventilation

Slide 16

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, small groups of cells called pancreatic islet cells are the primary hormone producers. There are two cell types, beta and alpha, that produce the

majority of the hormones. Beta cells produce insulin in response to hyperglycemia (high blood sugar) and stimulates the liver and skeletal muscles to absorb glucose to lower blood sugar levels. Insulin also promotes glucose storage by stimulating the formation of glycogen. Conversely, alpha cells produce glucagon. Glucagon increases blood glucose by stimulating glycogenesis and releasing glucose from the liver and skeletal muscles. This is in response to hypoglycemia, or low blood sugar. The two hormones have antagonistic effects, counteracting each other, to maintain 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 levels.