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BIOL 244L HUMAN ANATOMY AND PHYSIOLOGY LABORATORY
ENDOCRINE SYSTEM HISTOLOGY

The endocrine system and the nervous system are communication systems coordinating body functions. The nervous system is in effect "hard wired", and controlling signals travel along specific pathways of nerves to target tissues. In the endocrine system, chemical communication signals (molecules) are released into the blood stream and distributed throughout the body. While the nervous system is like a telephone network, the endocrine system is like broadcast radio; the signal is everywhere, and the target tissues "tune in" with receptors to receive the message. Endocrine organs are glands, but they contrast with **exocrine glands** which release secretions via ducts to the skin surface or the lumen of organs such as the stomach or uterus. **Endocrine glands** secrete their products to the circulation. There is usually a negative feedback control mechanism adjusting hormone concentration based on the effect of the hormone to control a variable. For example, the hormone, insulin, stimulates a target tissue (eg liver and other body cells) to change conditions (remove blood glucose from circulation), and the changed conditions (blood glucose returning to normal set point level) inhibits secretion of the hormone. Sometimes the negative feedback control on hormone secretion is based on the blood concentration of the hormone itself or on the concentration of another hormone produced in a successive chain of actions. For example, estrogen levels on the blood feed back on secretion of gonadotropic releasing hormone from the hypothalamus. We have already encountered some of the larger endocrine glands, the pituitary and adrenal (suprarenal in the cat), in our earlier dissections.

A. THYROID GLAND.

This is one of the easiest endocrine glands to identify, because it consists mostly of large, round, bubble-like **thyroid follicles**. The textbook shows a photograph and diagram in Chapter 18 to help you interpret the slide, at first with the 10X objective. Each follicle is filled with material that is pink staining material called **colloid**. This is a protein mixture that contains the stored thyroid hormone in an inactive polymer form. There are several small variations of the thyroid hormone, **thyroxine**, and the function of thyroid hormones is to regulate metabolic rate, cellular metabolism, and also to influence growth rate. Thyroxine, and also of course the colloid precursor of thyroxine, contains iodine, and most of the iodine in the body is in the thyroid gland. This large store of hormone is unusual and amounts to about a 100 day supply in case you get on an iodine-deficient diet. This is no problem near the ocean; sea salt and ocean fish are loaded with plenty of iodine. A **cuboidal epithelium** forms the wall of each follicle and secretes the colloid as well as taking it out of storage and cutting it up to make active thyroid hormones to release to the blood stream.

B. PARATHYROID.

The **parathyroid glands** are several (usually 4) small masses attached to the thyroid gland. The abundance of closely spaced nuclei (the usual purple staining dots) identifies this gland among the thyroid follicles. It suggests the appearance of lymphatic tissue; but the pale cytoplasm shows more than in lymphatic tissue, and, in some areas, the cells are strung along connective tissue strands. The textbook shows a photograph of a small area of parathyroid gland, as seen with high power (but, as always, you should **START FIRST** with lower (10X) objective power). **Parathyroid hormone (PTH)** regulates calcium ion concentrations, and blood Ca^{+2} is carefully controlled because of its role in muscle contraction and cell signaling. Parathyroid glands respond

to lower blood Ca^{+2} levels by releasing PTH, which stimulates osteoclasts to increase bone breakdown thus releasing calcium. PTH also promotes recovery of Ca^{+2} by the kidney from the forming urine.

C. PANCREATIC ISLETS ("OF LANGERHANS").

First, look at the slide without the microscope, and you should see tiny cracks in the tissue that divide it into **lobules** (= "little lobes"). Now with the microscope at 10X objective power, most of the pancreas (exocrine) gland tissue consists of thousands of clusters of cells, with about 8-12 cells per cluster. These clusters are called **acini**, and they secrete pancreatic juice headed for the duodenum. Acinus/Acini are a general terms for this kind of cellular organization, and you may remember we saw acini in the organization of the salivary gland. Occasionally, the array of pancreatic acini is interrupted by the presence of an "island" made of different types of cells. These "islands" are the **Islets of Langerhans** and are nowadays called **Pancreatic Islets**. The textbook photograph in Chapter 18 shows one islet at high power. The pancreatic islets secrete **insulin** and **glucagon** which together regulate blood glucose levels. Falling glucose levels stimulate release of glucagon, which stimulates the liver to convert the glycogen store to glucose and release it to the blood stream. Rising glucose, say from digesting a meal, stimulates release of insulin, which stimulates uptake of glucose by body cells and conversion of glucose to glycogen.

D. ADRENAL GLAND.

Without the microscope, one can clearly see that the interior (**adrenal medulla**) of the adrenal gland looks different from the outer layer (**adrenal cortex**). The textbook (Chapter 18) shows a low power view of an adrenal gland, and this may be of some help.

1. With the microscope at 10X objective, you should note that in the **cortex** the cells are organized in faint rows (cords) extending from the surface inward toward the **medulla**. These cords show a bit better in some areas than they do in others, so look around the section for the best view. The cortex is subdivided into 3 apparent layers as you move down the cords from the outermost to the innermost segments. The outermost ends of the cords are often partly separated off as short segments near the surface of the gland. The cells in these outer segments secrete **mineral corticoids**, a group of steroid hormones that affect electrolyte mineral and water balance. Most of the activity is due to **aldosterone** which regulates sodium and potassium reabsorption in the kidney. The middle region of the cords, where the cells are especially light stained, secrete **glucocorticoids**. Glucocorticoids have a variety of effects involved in the response to and resistance to the effects of stress. These effects include making glucose more available by converting proteins (amino acids) and glycerol (from fats) to glucose (that is the "gluco" in "glucocorticoids"; the "corti" refers to the cortex of the adrenal gland). In addition glucocorticoids raise blood pressure and have anti-inflammatory effects, and inhibitory effects on immune responses. These latter two effects make glucocorticoid drugs (corticosteroids) valuable for suppressing allergic responses and for suppressing the immune rejection response to organ transplant surgeries. The innermost layer of the adrenal cortex produces **androgens** (male sex steroid hormones) in both males and females. It is the relative balance between levels of male and female sex hormones, not the absolute presence of one or the other, that control male and female primary and secondary sex characteristics.

2. The cells in the **adrenal medulla** are arranged in somewhat rounded clusters, and there is a fairly easily seen boundary between the medulla and the cortex. The adrenal medulla secretes the hormones **epinephrine (adrenaline)** and **norepinephrine (noradrenaline)**, and this secretion is

the hormonal part of the fight or flight response. The adrenal medulla and the cells doing the secretion are actually modified neural tissue. Recall that the fight or flight response is a rapid sympathetic nervous system activated alarm reaction that prepares the body for vigorous activity. Sympathetic nervous system activation stimulates the adrenal medulla to release both hormones which increase heart rate and cardiac output, depress digestion, dilate lung airways, increase metabolic rate, and increase blood glucose.

E. PITUITARY (HYPOPHYSIS).

You might expect this to be a complex tissue, and indeed it is. There are many different hormones secreted by this "master gland." With each cell type secreting only one or two of them, that is a lot of cell types. However, it takes special histologic staining techniques to show the diversity of different cell types. We will only consider a few of the hypophyseal hormones. Without the microscope, one can see that some of the tissue is more darkly stained than the rest; this darker tissue is the **adenohypophysis (anterior pituitary)**. Most of the light tissue is the **neurohypophysis (posterior pituitary)**. After earlier studying the sympathetic chain ganglia and the adrenal medulla, you are familiar with the appearance of neural tissue. See the illustration in Chapter 18, and recall that the pituitary develops as a joining of a down growth of the brain to become the neurohypophysis and an upward growing pouch of the roof of the mouth that pinches off to become the adenohypophysis. The adenohypophysis receives neurohormonal secretions from hypothalamic neurons via portal veins.

1. With the lower power objective (10X), view the light **neurohypophysis** first. The swirling appearance of **nerve fibers** (pink stained) make it easy to identify. There are purple nuclei scattered through it also. The neurohypophysis receives its secretory hormones via neurons coming from the hypothalamus. In addition to a variety of releasing hormones secreted to the portal veins going to the adenohypophysis, the neurohypophysis releases **antidiuretic hormone** (also called vasopressin) that causes water retention by the kidneys in response to high body fluid osmotic pressure. Body fluid osmotic pressure is sensed by osmoreceptors in the hypothalamus. The neurohypophysis also secretes **oxytocin** which promotes uterine contractions during birth and milk ejection from the breasts in reflex response to suckling by the infant.

2. The **adenohypophysis** contains loosely arranged purple nuclei, interrupted here and there by pink connective tissue strands and tiny blood vessels. With the 10X objective first, note that the cytoplasm of some groups of cells is purple, like the nuclei, and that of other cells is more pink, like ordinary cells. We will consider a few of the adenohypophyseal hormones. Some of the cells with purple cytoplasm secrete **thyroid-stimulating hormone** (which promotes secretion of thyroxine by the thyroid) and others of them secrete **gonadotropins: follicle stimulating hormone (FSH) and luteinizing hormone (LH)**. These hormones are produced in both males and females although they are named after their function in females. In females, they target the ovaries and regulate the ovarian cycle. In males, they target the testes and regulate spermatogenesis and secretion of testosterone. We will study reproductive system hormones in more detail in a future laboratory exercise. Some of the cells in the adenohypophysis with pink cytoplasm secrete **growth hormone**, and some secrete **prolactin**. Growth hormone controls body growth and anabolic processes in general, and prolactin promotes milk secretion by the mammary glands (note that while prolactin promotes secretion, it is oxytocin that causes contraction of smooth muscles to eject milk.

Study Questions
Microscopic Study of Endocrine System Tissues

What are endocrine *vs*. exocrine glands?
What are the special characteristics that allow you to identify thyroid gland?
What is the hormone secreted by the thyroid gland and what does it do?
How can you identify the parathyroid glands
What hormone do they secrete and what does it do?
How is the pancreatic tissue organized. How do you recognize it under the microscope?
What are the hormones secreted by the pancreatic islets (Islets of Langerhans) and what do they do?
What are the major anatomic divisions of the adrenal gland, and for the cortex, what are the hormones secreted by each of the tissue layers and what do they do?
What does the adrenal medulla secrete and how can you recognize the tissue?
What is the relationship of the neurohypophysis and adenohypophysis. How can you tell the difference microscopically?
What are the hormones each part secretes and what do they do?