Welcome to our discussion of the endocrine system. So the endocrine system is our second control system of the body. And as it releases chemicals called hormones, those hormones are detected by certain body tissues that respond to that particular hormone. And then they change their behavior. So hormones are released by endocrine glands. And if you remember back to our discussion of tissues and glands, we talked about endocrine glands not having a duct. So they just dump the hormone outside and the hormones find their way into the bloodstream to travel throughout the body. So hormones regulate processes like growth and metabolism and reproduction. And so we’re going to spend some time talking about how hormones work. Also which organs or glands are producing which hormones, and what those hormones do. Now, this might look like a really short learning outcome list, but if you read these statements, you’re listing hormones produced by each of the endocrine glands discussed and learning what the target organs and functions are for each hormone. And then we’re also thinking about the homeostatic imbalances for hormones, whether it’s too much of that hormone or not enough. Oh, before I forget, remind me or your instructor, most of us have some sort table that we can provide to help you organize this information. Um, if it isn't available online, readily, definitely ask because I know I have one. Um, and I'm pretty sure that most of the other instructors who teach this course have a version as well.

So the endocrine system, we said, is the second control system of the body, but it still operates under the direction of the nervous system, which is that first, fast control system. Again, in the endocrine system, we're using chemical signals, not electrical impulses. And we release these into the blood. So an endocrine gland does not have a duct. An exocrine gland has an exit, or a duct. So hormones control the processes listed here, and these are very general, right? So all of reproduction is regulated by hormones, growth and development of which there are a lot of things going on, their mobilization of body defenses, so your immune responses are regulated by hormones. Maintaining homeostasis is hormone regulated, in many cases, and regulating metabolism and energy balance, again, regulated by the interplay of hormones.

So hormones are produced by special cells and those cells exist in structures called glands. So remember, the definition of a gland is a structure where the cells secrete a common product. So all of the cells in a gland that are able to make a particular hormone, they all make that same hormone. Now, there could be a gland where there are multiple cell types that each secrete a different hormone, but they would probably only be located in that type of gland. Hopefully that makes sense. You'll see examples as we go.

The hormones are secreted into extracellular fluids and then find their way into the bloodstream, where they travel throughout the body to their target cells. Now, a comment on target cells. For a cell to be a target of a hormone, let's just say for the sake of argument, let's just say growth hormone. A cell has to have a receptor for growth hormone, otherwise it just ignores growth hormone. If I don't have a
receptor for growth hormone, I don’t even worry about growth hormone being there, because it has nothing to do with me. So keep that in mind that when we talk about a target cell, a target cell has a receptor for the hormone and is able to respond to the hormone. And again, those hormones modify the activity of cells. So perhaps it would change the membrane permeability, let something in or out, um, perhaps it would change the way that cell uses energy, increase or decrease its metabolism, and so forth.

Now, hormones come in a couple of different varieties, so there are amino acid-based hormones, also called protein, peptide or amine hormones. And there are steroid hormones made from cholesterol and then modified from there. There’s a third category, which we’re just going to mention for clarity. Prostaglandins, which are highly active lipids. So these are lipid communication molecules, but not necessarily steroids, and these tend to act locally. So for example, there might be a prostaglandin within the liver that tells another location in the liver something's going on, but typically prostaglandins are not sent from one area of the body to target a whole other organ in the body.

Now, there are a couple of different mechanisms of hormone action. We’re going to go over sort of the key components of these mechanisms. Hormones can only affect certain tissues. We just mentioned that, and those tissues are the ones that have a specific receptor for that hormone. Those are the target cells. Hormones binding those receptors will change behaviors and/or functions of that cell. So here are some of the effects that hormones can cause. Hormones don’t cause all of these to happen in every cell, but they’re just some of the possibilities. So perhaps a membrane permeability change, or a membrane potential change, changing the electrical state of a membrane by opening or closing ion channels in response to a hormone. Maybe transcription of certain genes is turned on or off. So transcription of a gene means a protein will be made, so we’re turning on or off production of certain proteins. We could activate or inactivate certain enzymes and there are thousands of those. We could stimulate or inhibit mitosis. We could promote or inhibit secreting something. So there’s a variety of examples that are very general and you can imagine there are literally tens of thousands of specific examples of what could be happening in a particular target tissue or target cell.

Now, the two ways that hormones cause their effects are those mechanisms that I said we’d talk about. The first is called direct gene activation. Now take this name literally: direct gene activation. Where are genes located? Genes are found in DNA. DNA is located in the nucleus of a cell, so direct gene activation means a fat-soluble hormone, like steroid hormone, or the unique case of thyroid hormone, which is a peptide, but lipid-soluble, go into the target cell and speak directly with the DNA. Now these typically involve a receptor, so there’s still a receptor, but it’s inside the nucleus. So there would be an escort, so to speak. The hormone would bind to the receptor inside the nucleus and then be escorted to the DNA where would directly talk to the gene.

A second messenger system is just a way of saying the hormone can’t get in there. So typically these are protein or peptide-based hormones that are water-soluble and cannot go through the membrane directly. Some steroid hormones, we’ve recently discovered, can also use the second messenger system. Okay, so think of it in terms of the hormone, for whatever reason, cannot get in, so it has to
communicate through a receptor on the surface of the cell, and then send another messenger, the second messenger, to talk to the DNA. Now, those second messengers are things like cyclic AMP, so cAMP is the short term for that. Let's look at how those work. For direct gene activation, a hormone that's fat-soluble can go directly through the cell membrane into the nucleus to bind the receptor, and then be escorted to the DNA to speak with it. This is all of course analogy, but “speaking” in this case, happens via direct contact. Now for a second messenger system, because the hormone cannot get in, and the hormone is implied to be the first messenger, it binds to a receptor and a series of reactions happen involving enzymes and proteins called G proteins, which create this second messenger – in this case, cAMP, and then cyclic AMP will go on and talk to whatever part of the cell the hormone would like to communicate with. So I would make note of these two mechanisms and at least understand those basic differences. Does the hormone get in the cell? Yes, in direct gene activation, but not in a second messenger mechanism. What communicates with the DNA directly in direct gene activation? The hormone bound to the receptor. In second messengers, it's the second messenger.

Now hormones are released based on several different potential types of stimuli. So a hormone level in the blood is maintained typically by negative feedback, whereas a stimulus or low hormone level, would trigger the release of more hormone. And then once the issue is fixed, so the stimulus would be gone or less, or the hormone level would be higher, then hormone release stops. So there are three kinds of stimuli that cause hormones to be released. One is hormonal, so hormones can stimulate the release of other hormones. One is humoral, so be careful you don't mix these two up. Humors, remember, are body fluids. So humoral stimulus would be a level of something in the body fluids, for example, electrolyte levels. And finally a neural stimulus where a nerve directly stimulates the gland to release its hormone. So let's go through these. A hormonal stimulus would be, for example, a hypothalamus hormone which tells the thyroid gland hormone to be released or an adrenal cortex hormone to be released. We're going to talk about these examples more. These are called tropic hormones, so a hormone from one place that stimulates another gland to release its hormone is a tropic hormone. So a hormone stimulates release of another hormone. There are also hormonal stimuli that inhibit release, so there are things called inhibiting hormones that come from the hypothalamus and, again, regulate other endocrine glands. Humoral stimulus, so a changing blood level of an ion, for example. In this case, calcium, so if we have low calcium, parathyroid glands will release parathyroid hormone which will cause blood calcium to go up. And finally a neural stimulus. So there are a few places in the endocrine system where nerves innervate the actual glands and cause release of hormones when a nerve action potential reaches that tissue, in this case, the adrenal medulla. Now a good point, not one that I hammer on really, but a good point, is that most of these neural stimuli are under sympathetic nervous system controls, so fight or flight control.

For the last part of this particular video segment, I just want you to look at the major endocrine organs and make note of their locations. So starting with the pineal gland, which we mentioned in our discussion of nervous system, part of the endocrine system. The hypothalamus and the pituitary gland, the thyroid gland, the parathyroid glands, which are located on the surface, actually the posterior surface, of the thyroid gland. The thymus gland, make note, thymus and thyroid are different but often
get confused. The adrenal glands, the pancreas, the kidneys, and the ovaries for women and the testes for males.