>> Today's date March 29th, in anatomy. This lecture 15. A system that's really a subsystem of your nervous system. Perhaps known to you already as the autonomic nervous system. Chapter 17 of your textbook. Now, the word autonomic is not the same as automatic. Autonomic roughly translates to self-governing, implying that it's somewhat autonomous. Actually, that's not true. It takes a lot of commands from the central nervous system. So, even though its name suggests that it's self-governing. It's not entirely separate. Certainly not independent of the CNS. So, before we get to the anatomy. Let's just lay out the responsibilities of the autonomic nervous system. First, it basically controls such things as heart rate, the tone of smooth muscle. The secretion of many, but not all endocrine glands. It's working silently and efficiently in the background. Essentially maintaining what's called vegetative stabilization. Actually, you know it as a better word. You've heard the term homeostasis. Maintaining status quo. Taking care of ordinary housekeeping and not bothering you with the details. So, we say it exerts vegetative, control, regulation over basic life support systems. With that function put aside what are some of the anatomical features of this system. What are the general features? First, it's essentially almost entirely motor. That is, it exerts primary control over cardiac and smooth muscle. And unlike the somatic nervous system, two neurons are required to reach the effector, the thing that's being altered. And so, we say this fact, two neurons involved between CNS and effector. I think this diagram helps. This is the spinal cord, right? Out here is some smooth muscle. How many neurons does it take to reach that destination? Two. And so obviously there has to be a synapse between the first one and the second. And wherever you have a congregation of synapses, wherever you have a bunch of nerve cell bodies outside the central nervous system, you know that's referred to as the G word, ganglion. So, there's going to be some ganglia either close in, or far from the CNS. And that's just an anatomical feature. You can't ask me why that is. Because I can't answer that. It just is. And so, how many neurons are required to reach the effector? Two. And the first one then is going to be called preganglionic, because it is. And the second one is called postganglionic, because it is. Post, meaning after. Pre, meaning before. Now this is quite in contrast to the somatic nervous system. As you know, the somatic nervous system controls skeletal muscle for voluntary movement. And actually, in that case, there's only one, only one neuron required to reach a skeletal muscle, no matter how far it might be from the spinal cord. So, in the somatic nervous system, there's no G, no what? No ganglion. But in the autonomic nervous system, two neurons are required. Thus, synapses are necessitated and the ganglia will be found somewhere between the spinal cord or brain, and the effector itself. So again, we don't want to make a big deal out of it. It's just an anatomical fact. But one of the characteristic features of the autonomic nervous system. The other feature that you knew, or probably were aware of is that this system is actually divisible into two subsystems, which are said to be antagonistic. What does that mean? When something's antagonistic? All right, they work in opposite ways. And so, these are the sympathetic versus the parasympathetic. In biology, you've heard this referred to as kind of the gas pedal. It accelerates things. It that makes

activity of cardiac smooth muscle typically accelerated. So, but notice the word here, not always but usually excitatory. Parasympathetic. These are often described as the brakes because they bring about inhibition. They slow things down, in general. So, you want to emphasize the word usually because there are some important exceptions. This idea, this relationship is called dual motor innervation. Which means that every effector is supplied with one sympathetic and one parasympathetic. Now, if you stop to think of it, that's certainly an advantage. If you want to control the speed of something would it be better to have one or two ways to do that. Think of your car. Do you have two ways to control its speed? You can either put your foot on the gas, or take your foot off the brake. And so, that's a good analogy. And the beauty of dual motor innervation is that it allows prompter, quicker change in activity. It can bring about very quick changes in heart rate, blood pressure, peristalsis, and so forth. So, what's this concept? Dual motor innervation. Every effector is going receive one sympathetic and one parasympathetic. There are some exceptions. Wouldn't you know. And these are some. For instance, the adrenal gland, sweat glands and most blood vessels receive only sympathetic. That means they don't have parasympathetic. Also, the arrector pili. You might've forgotten, but the arrector pili is that smooth muscle that's attached to hair follicles and causes your hairs to stick up. So, anyway that's also an exception. These are exceptions to what rule? To this rule of duel motor innervation. How are they exceptions? Well, they don't have parasympathetic, they just sympathetic. Again, you can't ask me why that is because my answer would be, I don't know. But it's the way it is. So now, now that we've got the general functions on the table. And some of the very broad anatomical ideas, let's talk about how this system is controlled. Because we alluded to the fact that it's not entirely autonomous. It's not independent of the CNS. And so, the questions are where exactly is the headquarters of the autonomic nervous system. Where does it live? Where is the White House so-to-speak. And it turns out that that is in the brain, specifically in the hypothalamus, which you know is below the thalamus. The hypothalamus is not a new discussion and in this context, we're simply reminding you that its action is to control much of the autonomic nervous system, because it exerts influence over the medulla, containing vital centers for many of your vegetative functions. And so, as you already know, the hypothalamus controls, not just the medulla. It regulates body temperature. It determines appetite. It determines thirst. And these are among many of the autonomic functions. The hypothalamus, just to put a finer point on it, is below the thalamus. Just above this gland, which you recall is the pituitary. And you recall, the hypothalamus is essentially at the floor of the third ventricle. Now we're going to tell you little bit more, the hypothalamus is divisible into front part and back part. The posterior part, the posterior hypothalamus is mainly a center which regulates sympathetic action. And the anterior is in charge of parasympathetic. Why is that important to know? Let's say somebody had a lesion injury which destroyed the anterior hypothalamus. That would wipe out what? And what would that leave unchecked? What would that leave in charge? What would that leave out of control? Obviously, it would leave the sympathetic and that would cause changes such as a racing a heart rate, and high blood pressure, and so forth. So, this division of labor; posterior anterior hypothalamus could have clinical significance. If one or the other of these were destroyed as a result of injury or disease. Hypothalamus is not alone. We would say though that the hypothalamus controls most of the autonomic nervous system. But we implied just a minute ago that it has a lot to say about the medulla. The medulla is not part of the forebrain. You know it to be part of the hind brain. And you know that it contains vital centers, which regulate breathing that is controlled breathing rate. Control heart rate, HR. Also, BP. What's that? blood pressure. And these are certainly important homeostatic mechanisms. And aside from that, the medulla also controls a lot of gastrointestinal activity, including its secretions. So, the medulla is under the thumb of the hypothalamus and executes these activities on these many vegetative functions. Before we leave the topic of control over the autonomic nervous system, we sort of suggested that the autonomic nervous system works in the background. You don't really worry about it. Do you think about your blood pressure? Your heart rate? Your gastrointestinal secretions? Do you sometimes find yourself saying, sorry I can't concentrate, I've got to worry about my heart rate right now. So, clearly the cerebral cortex is not usually involved in the business of the autonomic system. But can it be? And if so, why and what are some of the ramifications? Certain voluntary or involuntary psychological states can exert an overlying influence on the ANS. Perhaps you've heard of biofeedback. I know you've heard of yoga. Yoga is supposed to put you in this what? This transcendental mindset where you're relaxed and composed, and get in tune with your body and all of that. Biofeedback is a little more scientific. It's designed to help you get a grip on certain things that might be out of control. Are there people with high blood pressure? Do they take medication? Yeah. Would it be better if they could control the blood pressure themselves? And so, biofeedback techniques can allow them to get a better sense of controlling their ANS, and this requires training and the involvement of the cerebral cortex. On a more out-of-control level, is it possible for somebody to come onto a crime scene, a bystander and be appalled at the carnage there, and the blood and so forth. And be so overwhelmed that they faint. And that is an autonomic reflex, right? But it's a psychological reaction to the setting there. On another level. What's a blush? People say, oh you're blushing. That means what? You're embarrassed for whatever reason. What is a blush? It's a flood of blood into your skin. And that is an autonomic response. But is that the result of the cerebral cortex? Yeah, because you just did something or said something that's embarrassing. And that causes that to be more or less telegraphed to your skin. It's also easy to be demonstrated in the case of the pupil. This is the pupil, right? A normal pupil and a what? Dilated pupil. The pupil, the size of the pupil is under the influence of smooth muscle. And when you're frightened, or when you're passionate sympathetic action takes over and your pupils do what? Dilate. So, if you're ever face-to-face to somebody and they have dilated pupils, they either hate you or they love you. One or the other. But is that the cerebral cortex? Yeah because of an emotional thing that they're actually telegraphing to their iris in this particular case. So, in short hypothalamus, basically in charge, exerting control over the medulla. The cerebral cortex rarely gets involved, but does from time to time. So now, let's break out and look at each of these subdivisions anatomically, physiologically and then will overlap them as we conclude the conversation for the day. The sympathetic division is also called, and in my opinion better called, the thoracolumbar. Because if you stop to question, what does that even mean? Sympathetic. What's the sympathy here. I mean I don't even get it. But that's what it's called. Better to call it, in my opinion, thoracolumbar because at least that's something tangible. The reason thoracolumbar makes sense is that the sympathetic nerves exit, exit. They leave the spinal cord at the thoracic and lumbar areas. This is an anatomical fact. And remember how many neurons are required to reach the effector? Not one but two. So, there's got to be a ga, ga, ga, ga, ga, ganglia somewhere, right? Now the name of the neurotransmitter which is universally used in the postsynaptic neuron is called norepinephrine. Which incidentally is very chemically similar to adrenaline, a hormone produced by the adrenal glands. For that reason, these fibers are nicknamed. Their nickname is adrenergic. Why adrenergic? Because norepinephrine is very similar to adrenaline. Adrenergic fibers, because of their utility, or use of norepinephrine, generally are excitatory. We've mentioned this already. And let's put a finer point on it. What things are ramped up in the sympathetic episode Essentially a sympathetic discharge is preparing your body for some sort of crisis. Some sort of physical confrontation. And so it's preparing you for an emergency, or an immediate physical stressor of some kind. And so, these are the things that happen. Increased HR, what's that? Heart rate. Increased BP, blood pressure. Pupils dilate. What good is that? Allows more light in, allow you to see, see better, especially at night. But notice, it doesn't increase digestive activity, it reduces digestive activity. And it raises respiratory volume and respiratory rate. Are these things that would help you in a crisis. Indeed, there's a catchphrase, you've already heard for this kind of response. Fight or flight. Because whether you're going to stand and fight or turn and run it's all the same. It's going to require all of these things. Can these responses be lifesaving? Yeah. So, this is clearly a preparation for some sort of crisis which demands ramping up body functions which support fight or flight. But certainly, digestive activity is not important. So instead of being ramped up, that's actually inhibited. So, remember, we said sympathetic is generally excitatory. But what's the notable exception? Sympathetic actually reduces digestive activity, that means contraction and secretion. So now, let's look at the anatomy of this system. We just said a minute ago, it exits the CNS from where? Comes off of the thoracic and lumbar. Don't ask me why. I don't know. But because it does it's called the thoracolumbar division. Here's a familiar cut through the spinal cord. And we recognize some of the structures that we've already discussed. So, I'm going to be making a sort of ongoing diagram here. Spinal cord. The roots, what are the roots? That root there is the ventral root. That's the dorsal root. What's that thing there? Dorsal root ganglia. What's the merger of the two called? Spinal nerve. Okay so that's old stuff, you know about that. Running parallel, indeed bilateral to the spinal cord is what's called the sympathetic chain, also known as the paravertebral ganglia. Because they are. They are what? Para vertebral. What's para mean? Para means alongside. Alongside what? The vertebrate. So, what are these bulges here? There's one. There's one. There's one. Those are the paravertebral ganglia. In a cross-section, this is what they look like. They're also called sympathetic ganglia because they are. In other words, this is where the pre-and postganglionic fibers synapse. There are 12 of these in thoracic area, there are 3 in the lumbar, which is consistent with the alternative name for this system. What is the alternative name for the sympathetic nervous system? Thoracolumbar. So, there are 12 pairs of thoracic, 3 pairs of lumbar. Now, remember, just to be reminding how many neurons are there between CNS and destination? Two. The first one is called preganglionic. The one after that? Postganglionic. So, I'm going to use two different colors. We'll use red for pre, and green for post. Hardly matters. The preganglionic fiber originates in the anterior horn of the gray matter. And remember these nerves are motor, right? So, are they going to be found in the dorsal root or the ventral root? Let's see the dorsal root is entirely S word. So obviously, these are going to exit from or along and through the ventral root. Red is preganglionic, right. All right. And the preganglionic fibers are very heavily myelinated. Therefore, what color would they be if they're heavily myelinated? White. And they travel through a branch which actually enters the paravertebral ganglia. Something like this. And that, then ends the preganglionic fiber. That branch that I just drew that red line through is called a white ramus. Ramus is singular. What's the plural form? Rami. So, the white rami. You've got this in front of you. So, if you've got colored pencils, you can go to work at this. And show, whatever color you'd like, the preganglionic fiber. To remind you again, how many fibers are needed to reach your destination? This one is pre, so the next one is going to be called post. And its cell body actually originates here in the paravertebral ganglia. And exits, exits through another branch which bridges over to the spinal nerve. That one's called the gray ramus. Gray ramus. Why gray? Why white? The white rami are white because they contain myelinated preganglionic fibers. And the gray contain, well un or relatively low myelinated postganglionic fibers. Where's this fiber going to go? Well, we don't know it's going to go to some smooth muscle or cardiac muscle. We'll leave it undisclosed. But wherever it goes, it's going to be some distance from the spinal cord. So, here's an important anatomical distinction. In the sympathetic system, which of the two fibers is longest? Physically longest. The red or the green? Green. The first one is preganglionic so it's quite a bit shorter. It needs only to go as far as the ganglion, which is right outside, right alongside the spinal cord. Now, as you can tell the postganglionic fiber, the green fiber is now going to mingle with, that means travel with other fibers of the spinal nerve. And let's remember a spinal nerve is a mixed nerve. Meaning it contains what? Sensory and motor. And now, it also contains, may contain, sympathetic fibers. Which are, of course, going to smooth muscle or cardiac muscle. So, in this particular scenario, that green fiber will be going to some effector. Maybe cardiac muscle, maybe smooth muscle. Now there are an exception, that is, there are special departures from this theme, especially when it comes to what are called splanchnics. Because think about the intestine, which of course are not in your arms or legs, but rather in the abdominal cavity. Think about this, would it make sense to send a sympathetic fiber out to the arm, only to come back and end up in the abdomen. No. So, for those cases where the effectors are midline, or in the abdomen, there's a separate route. That is, they don't travel with spinal nerves. And they're part of a network called the splanchnics, basically pass through the paravertebral ganglia and innervate abdominal organs. So, to make that clear, or at least to try, we use a different color. This is going to be kind of purple. And this is going to be a preganglionic fiber. So, naturally it would leave the spinal cord again through the ventral root. But this one is associated with the gut, with the abdomen. And as such, it's going to pass right through the paravertebral ganglia. It's going to be part of the white rami, but it's going to go through and find its own ganglia, which is usually near or somewhere within the abdominal cavity. So, that purple one was again preganglionic. And is there one more to go? Yep. That's going to be the green, that's going to be the postganglionic. So, I know this is complicated. And then it's going to take you some time to digest and absorb this information. But, these are the salient features then of the sympathetic nervous system. So, let's compare. that is, I should say let's translate all of this onto an illustration. Which of course, you're horrified to see. And you say OMG. I'm going to have to draw that. N-o. No. Why is it there? Just to help. And if you understood what we've just said, this starts, or can start to crystallize this information. This is the spinal cord here, right? And what's shown in yellow are the thoracic and lumbar segments. These purple little bulbs here are the paravertebral ganglia. Also, known as the sympathetic ganglia. And notice we have solid lines and dotted lines. A reminder again that how many neurons are needed between CNS and effector? The solid ones are preganglionic. The dotted lines are postganglionic. So, notice that the ganglia are essentially the synaptic points of pre-and postganglionic fibers. What have we said about the preganglionic in terms of their links? Are the solid lines here longer or shorter than most of the dotted lines? Shorter. So, as a general anatomical rule, the preganglionic fibers are short. Postganglionic fibers are long. Here's a depiction of the various effectors. Is the heart on the list? Yes. Are smooth muscle associated with digestion there as well? Right. And just to remind you, what's the name and nature of the neurotransmitter which is released postganglionicly? What's the name of that neurotransmitter? It's right there on the paper. It's norepinephrine. And does it have a universal or a variable effect? Variable. It will increase heart rate, but it will cause relaxation of the smooth muscle. So, please don't spend any time attempting to draw this, but rather try to make sense of it. Appreciating what we've already said. That the preganglionic are short. Postganglionic are long. And after all, the ganglia are mostly paravertebral, except for these. What are these ganglia? These are called the collateral ganglia, which are associated with the splanchnic fibers. Basically, those that provide innervation to abdominal structures. All right, I know that that's still unsettled, but let's move on and take a look at parasympathetic. And we'll wrap up a comparison in the end. Parasympathetic at least make some sense. Because para means around. And so, the idea here is that it's around, specifically above and below the sympathetic. So, if I'm not making sense, what did we just say about the sympathetic? It's thoracolumbar. So, where would the parasympathetic exit, if their name has any meaning at all? Above and below. So, as odd as it seems, the parasympathetic exits, it exits from the brain and not again until the sacral level of the spinal cord. This is very odd. And I can't answer why. I can only tell you that that's the way it is. The transmitter, the neurotransmitter is very different. It's not norepinephrine, it's called acetylcholine. Universally used at the post ganglionic nerve terminals. And for that reason, these fibers are called cholinergic. This will have a lot of significance later in nursing, as you talk about adrenergic drugs and cholinergic drugs. But for now, cholinergic is a synonym for parasympathetic. And we already knew this. This system is generally what? Generally suppressive. It tends to slow things down. And what would that mean? Well, in terms of heart rate, it would tend to decrease heart rate. It would tend to lower blood pressure. What would it do to the pupils, which might've been dilated in the sympathetic episode, they constrict. What's it expected to do for respiration? Bring it down. Not necessarily lower, but at least bring it back to normal values. And this system also enables sexual arousal. Which is an interesting side note. So overall, this system helps maintain quiet, normal status quo. In other words, normal day-to-day levels of activity. Something called also, metabolic recovery, recovering from a fight or flight confrontation or episode. But we really need a catchphrase here. What was our catchphrase for sympathetic? Fight or flight. So, we need a catchphrase here. There two. You can have your pick. One is called rest and repose. Not my favorite. The other is called feed and breed. Which is my favorite. What does that mean? Feed and breed. It's involved in digestive activity and sexual activity. So, have your pick. So, parasympathetic is obviously the counterpoint to sympathetic. And that's what we said from the outset. These systems are a-word, antagonistic. So, some important anatomical facts, unlike sympathetic fibers, parasympathetic fibers do not merge or travel in what? Spinal nerves. Just an anatomical fact. There's not any rhyme or reason to that. So, I can't say well, this is because. No. Actually, I can say that. This is because. I just don't know what to add to that. In other words, that catchphrase today, well what's the phrase. It's the way it is. So anyway, cranial, wait a minute let's finish this up. Do not travel or mingle with what? But are there other nerves? Are there those that exit the brain? They're called? So, we're going to see that indeed, some of these parasympathetic fibers are found in some cranial nerves. In the case of those parts of the parasympathetic which exit the brain, the preganglionic fibers are relatively long. The postganglionic fibers are relatively short. And you can memorize that, but what does it mean? Where's the ganglia with respect to the brain? If the preganglionic are what? Long, that means the ganglia is going to be what? Way out here. And the effector is going to be nearby. So, this information not only states a fact, but it places the ganglia at some distance from the CNS. These arise in the brain and they're part of, that is they mingle with some of the cranial nerves. How many cranial nerves are there? Only these four contain parasympathetic fibers; oculomotor, facial, glossopharyngeal in vagus. And yes, I'm afraid you just have to memorize that. So, as we might, we said all right the optic nerve. Does the optic nerve contain any parasympathetic fibers? No. Does it contain any sympathetic fibers? No. Because remember sympathetic come off of the thoraco and lumbar area. There are ganglia of course, as we just said and they're some distance from the brain. But they're still within the head. And they're relatively near the visceral effector. The postganglionic fibers of these cranial parasympathetic nerves innervate these structures. The iris, which controls your pupil size, salivary glands, the heart, which of course is fairly distant from the brain. Bronchioles. What are bronchioles? Airways in the lungs. GI tract that stands gastrointestinal, not government issued. And finally, what? The gallbladder. We said this system was called, what was the alternative name? It was called the craniosacral. So, the sacral fibers, by definition come off of the sacral cord. And these also have long, pre, and relatively short, postganglionic fibers. Putting the ganglia some distance from the spinal cord. They exit from S2, S3, S4. Just matters of fact. But they don't mingle with spinal nerves. We've already said that. And so, they travel pretty much independently to the ganglia. Where do they go? Well, they go to structures of the pelvic viscera, reproductive structures for the most part, as well as the bladder and colon. Here's the big picture. And before you panic, it's really pretty simple. This is the spinal cord, right. This is the brain and down here is the sacral. So, what did we say? What was the alternative name for the parasympathetic system? Craniosacral. True or false all cranial nerves have autonomic fibers? False. Only how many of the 12? And only parasympathetic, never sympathetic. Because remember sympathetic come off of the thoracolumbar level only. As you see to this sketch, once again solid lines depict what? Solid lines depict preganglionic, broken lines postganglionic. So, notice the ganglia are at some distance from the central nervous system. I know this is hard to absorb because what makes something easy is if it makes some sense. And this doesn't make any sense. Again, there's no reason for it, it's just the way it is. And that makes it hard to remember because you just have to remember a fact, even though it can't be explained. So, what we want you to do and in fact what I'll get you started with here, is do what you should do in any situation like this. Let's say you were comparing Democrats to Republicans. What would you do? Well, never mind. But, you might take a piece of paper and fold it and say okay Democrats have these properties Republicans have these properties. Right? So, what are we comparing here today? Sympathetic versus parasympathetic. Are there some similarities? Yes. Are there some differences? So, by doing this, it really helps to focus your attention on how these are similar and how they are different. Your textbook does this. So, if we don't finish this, and we won't, you can finish that by going to your textbook. So, we're going to compare a few anatomical or functional features of these two systems. And when we're done, we can step back and say, oh, okay. Starting to see. Starting to see how they're similar, how they're different. Because that's what this topic is. That's what anatomy is. So, like it or not, this is a good way to go about it. So, here are some issues. We won't do them all. But you should. So, let's start. Point of exit from the central nervous system. That means where do these fibers leave the central nervous system? What was the alternative name for the sympathetic system? Thoracolumbar. Is that a clue? So, where do sympathetic fibers leave the central nervous system from the thoracic and what? Lumbar spinal cord. What about the parasympathetic? What was the alternative name for that? It was called craniosacral. Which means, of course, brain and the sacral level of the spinal cord. So again, these are anatomical distinctions, but that's the name and nature of this course. Next topic. Number of neurons between CNS and effector. How many neurons are required to reach the effector in the sympathetic case? And how many in the parasympathetic case? Two. That much is the same in both cases, right. And remember what do we call the first one? The first one is called pre-ganglionic. The second one is called postganglionic. So, the question that follows from that, where's the ganglia? If we say the preganglionic fiber is long, then obviously, the ganglia is going to be further from the central nervous system. If the preganglionic fibers are short then the ganglia is going to be close. That is physically closer to the brain or spinal column. And what was the general rule for sympathetic? Where are the ganglia to be exact? Remember, these are right alongside the spinal cord. And we gave you a term for that. Paravertebral. So, indeed they are paravertebral for the most part. In the case of the parasympathetic, they're on or near the visceral effector. Which means some distance from the central nervous system. The next two questions are essentially the same, and related to the ganglia. Because once again, let's just think about it. If the ganglia is far away from the central nervous system, then the preganglionic fiber is going to be what? Long. And the post is going to be short. On the other hand, if the ganglia is very near the central nervous system then the pre is going to be short and the post is going to be lone. So, in fact if you know where the ganglia are you can pretty much predict this. You don't have to memorize it. You can deduce it. So, in the case of the sympathetic, because the ganglia are close, close to the spinal cord, then naturally the preganglionic fibers are short, postganglionic fibers are long. The opposite is true. Whoops, yeah that's as far as we went on that. The opposite is true for the parasympathetic, because the ganglia are at some distance. The rest of that information is in your book, and I'm sorry, we are out of time. I deliberately want you to do some of that on your own to make it well, make it your own rather than memorizing what we spoke of. So, with that, have a great holiday be safe. We'll see you back after Easter.