>> March 13th, 2017. This is actually lecture 10, but it's the first lecture of this unit, which is basically the nervous system. So naturally, today we'll talk about some of the general features, the cells that make up the nervous system. And, of course, you're aware that those are none other than nerve cells. Nerve cells also known as neurons, also known as nerve fibers. Let's begin by talking about a general sort of garden variety neuron, if there is such a thing. Certainly that's something you recall and have come to recognize with your laboratory experience. Because nerve cells are very often stellate, that means star-like or at least star-shaped. Not all of them are that way, but many are, and therefore form the basis of quick recognition, at least under the microscope. What are some features that are then typical for any given neuron? Certainly we're going to have a large congregation of cytoplasm that forms and creates the nerve cell body, also called the soma. In some cases, this may be smooth, in some cases it may be very polygonal, meaning star-like or stellate. This one happens to be stellate. And, of course, in textbooks, that's the usual description of a typical nerve cell. Inside the soma, you'd find the dominate organelle which contains the chromatin. What's that? Nucleus. And inside that, you'd expect to find the nucleolus. So these are features, these are organelles that we've spoke of before. There is also in the cytoplasm a smattering of granules that can be seen with the microscope. These were first described by an investigator, his name was Franz Nissl. So in his honor, some books still call it Nissl substance. Whenever you see a capital letter, you're probably looking at a name, aren't you? And these are throughout anatomy called eponyms. An eponym is a name given for a person. Probably the most familiar eponym that I can think of that you would know is Fallopian tube, right? But Nissl substance, obviously named after a person, is not very helpful because it's just an honorary description. So we're going to call it instead chromatophilic. And you might say, well, that's worse. I can't make anything out of that. But chromato-, meaning color, -philic means to like. And so under the microscope, this is a colored mass of actual granules. Which it turns out are basically just ribosomes engaged in the process of protein synthesis. So after all of that discussion, the bottom line, Nissl substance is essentially a bunch of ribosomes which help the cell manufacture protein. Now especially through the more delicate extensions, which we'll name momentarily, we find reinforcing organelles that are really nothing more than neuro filaments but actually fundamentally microtubules. Remember microtubules, a bundled, hollow, straight group of organelles? And these provide not only strength and reinforcement, especially along the delicate axon. But as you know, microtubules provide a passageway for materials. So this provides a kind of highway or conduit, especially down the lengthy structure known as an axon. And also within the soma are many mitochondria. Remember, these are the organelles that convert glucose into usable energy ATP. And naturally, neurons are heavy consumers of ATP, therefore, many, many mitochondria. Now wherever we have a collection of soma, many soma, there's a name for that. And one of two of these applies. You can call them ganglia or nuclei. Now nuclei is plural and so is ganglia. So the singular version would be ganglion, and this would be nucleus. Nucleus is confusing because when you hear that you think

of the organelle inside the soma. But on a larger scale, a nucleus is simply a concentration of many soma. Now that doesn't have to be confusing, so let's make it as simple as possible. Here's just a piece of wire that's bent up. And so this would be the soma, right? And then here's another one, there's the soma. And here's another one, there's the soma. So wherever you have a bunch of soma together in one spot, that's called a ganglia or a nucleus, ganglion or nucleus. It's a generic term then for any concentrated area of nerve cell bodies. But what about these extensions which are so characteristic of a neuron? Essentially, they are described as either dendrites or axons. So what then is a dendrite? The word dendrite is Latin. It refers to a branch or a tree which contains many branches. So these are, as you can read, short, highly-branched extensions which are connected to the cell body. So where would those be in this illustration? All of these are dendrites. And as a rule these carry impulses not away from the cell body but into the cell body. So naturally, if you were conveying that – let's go to the sketch I already have. This is the cell body. What's the other name for it? Soma. And that must be the nucleus. And this is the Nissl substance, let's say. So these are dendrites. And you'd probably want to show by using an arrow that these carry or convey signals into the cell body. That's their functional distinction between themselves and what's called an axon. The word axon actually also is Latin, it means an axle, a-x-l-e, which refers to something long and straight. So obviously if you're labeling – and I hope you are – this is the axon, long, slender extensions, typically one which carries signals which way, you think? Away from. Away from the cell body. The sketch that you have on your paper there is, however, a bit misleading because it implies somehow that the axon is only a few times larger than the cell body. But notice there's a gap or break deliberately shown there. So back to my sketch. This is the soma. These are what? And this would be the axon. But it actually wouldn't be that at all. It would go from here all the way out to the parking lot. All the way out to where? So when we say long, we mean really long. And this sketch doesn't really convey that very well. But sooner or later it does terminate and splinter and forms these highly branched ends which are called terminal filaments. Because they are filaments at the end. Terminal meaning at the end of something. Terminal filaments provide the opportunity to shake hands with other neurons and form connections, at least functional connections, which we'll describe in a moment as synapses. In fact, when these terminal filaments connect to another neuron as shown here, then all of these connections are referred to as synapses. The ironic thing about that word, synapse, is that it's really a misnomer. Because literally the word synapse means to connect. But in fact, most synapses don't. That is, there's an actual gap. And so it's not a physical connection, but a functional connection. There's communication across a synapse, but no actual physical contact between the terminal filaments and the succeeding cell. An interesting fact. In some cases, terminal filaments join with the muscle, especially in mostly skeletal muscle. And where that's the case, another kind of synapse is made, except they're not called synapses, they're called neuro muscular junctions. So to be clear, all of these that are shown here above, all of those are synapses. But if these would connect to a muscle, then instead they would be the neuromuscular junctions. So here's yet just another illustration of a nerve. We see the cell body, we see the nucleus. To repeat, these short, highly branched processes are called... and this long one is called an axon. Axons carry signals away from the cell body. Dendrites carry signals toward or into the cell body. Axons especially are insulated further by a separate and independent group of cells collectively called neuroglia. Glia meaning glue, g-l-u-e. And these come in at least a couple or more varieties, which we'll discuss in a minute. But basically, as you can see from this illustration, these glia cells wrap themselves around the axon. So this isn't hard to visualize, but I brought in an analogy. This dowel would be the a- word. The what?

[Inaudible Speaker]

And this towel, we could simply wrap around here many, many times. And that would represent a sheath or insulating layer created by cells called neuroglia. And when we say to insulate, we don't mean keep them warm, we mean keep them from short-circuiting with other adjacent axons, just as wires in appliance have to be insulated from each other in a lamp cord or something like that. So these are some basic terms starting with cell body and its various parts: dendrites, axons, and finally the split ends which are called terminal filaments. An interesting sort of factoid as we close out this page is that nerve cells are not capable of what?

[Inaudible Speakers]

At least not in adulthood. So if you were to lose 10,000 neurons in your brain, would those be replaced tomorrow?

>> No.

>> Ever?

>> No.

>> So they are amitotic. And this can be devastating in spinal cord injury, in brain injury. So obviously, preserving the number of neurons that you have is worth considering. Let's move on. We spoke of neuroglia, what are the ones that are important by name and by location. First we have those called Schwann cells. Again, that's a capital S, so guess what? Who discovered Schwann cells? Schwann. And since we don't have a better name for them, we're going to call them Schwann cells. These are very much like pancakes, if you were to see one by itself. But they don't exist by themselves. They wrap themselves around the axon many, many times. So again, this is like taking this towel and wrapping it around the dowel many, many times. On this dowel, we've shown the axon in yellow, yes? And I've used Duct Tape to represent and create these wrappings which create something known as the myelin sheath, m-y-e-l-i-n. The creation of this sheath is called myelination, and it serves the same function as insulation does for electric cords in any sort of appliance or electronic device. So here's a cutaway of an axon showing the manty wrappings

of, in this case, a Schwann cell which creates some form, some degree of thickness called the myelin sheath. Now notice that these Schwann cells are not without interruption. That is to say, there are gaps between Schwann cells. So in this model that I'm holding, how many Schwann cells apparently are there? We got one, two, three, four, five and six. And there are naked spots where the axon can be seen, and those are referred to as a node, n-o-d-e, the proper term node of Ranvier. Again, capital R suggests it must've been an eponym. These are gaps between Schwann cells. Very important, because here and only here are the nerve signals reproduced. That is, created, recreated, created, recreated, so that these signals actually jump or move from node to node to node. The value of this is that it provides for quicker velocity, faster speed. And is speed important in the nervous system? Do we want information to come from our toes sometimes today or right now? Right now. And so clearly speed is enhanced by the presence of myelin, which improves the velocity along axons, and remember, also shields one neuron from the next. If you've heard the term myelination, you might've heard it in a negative context. What would you call removing or absence or reduction in myelin? Demyelination. And demyelinating diseases are familiar at least in one or two forms. We've all heard of multiple sclerosis, a demyelinating disease, and also ALS, another demyelinating disease. So the function of myelin is twofold: it improves the speed and it prevents nerve signals from jumping or otherwise moving from neuron to neuron. That is, it keeps them on track and prevents any aberrant nerve conduction pathways. Now remember, Schwann cells are found where? It says right here, around peripheral neurons. Peripheral means any neuron outside the central nervous system. And so what then do we find inside the brain or spinal cord? We find a different type of glia. This is called an oligodendrocyte. Oligo- means little or short. And so these are short little dendrites. And illustrated here you can see that a single oligodendrocyte wraps itself around many axons, whereas a single Schwann cell is devoted to and found only on one axon. So what's forming this is a single – a single what? Schwann cell. But if this were a central nerve, then this might be one and over here might be another and here's the cell body. I'm representing the oligodendrocyte. So in contrast, where do you find oligodendrocytes? Central nervous system. What's their fundamental difference from a Schwann cell? A single oligodendrocyte can wrap itself around many axons, therefore be responsible for myelinating more than one axon. Here again, a side-by-side comparison. This must be an oligodendrocyte because it's forming myelin not along one but more than one axon. And where do you find them? Where do you find oligodendrocytes? Central nervous system. But basically, apart from that, they create these gaps, these naked spots, which are called nodes. And that provides them the same function to the central nervous system than that found in the peripheral nervous system. This is maybe a hard to see illustration showing a nerve cell body. And here, of course, the axon which is surrounded by and insulated by oligodendrocytes. The third type. The third type of glia found only in the central nervous system are called astrocytes. Astro- a reference to a star because these are kind of starry appearing. They have many short branches, as seen in this illustration. And I like to compare these to the packing material you'll sometimes see when you order something and you receive a box and there's all those little Styrofoam peanuts in there. So essentially, astrocytes are filler. They occupy and fill space, especially between capillaries and the neurons which are everywhere in the central nervous system. As such, their function then is to support – that means physically prevent injury to the neurons and to link neurons – to what? To link them to blood capillaries. So here's a blood capillary. What's it contain? Blood. What is the gas which is necessary for the metabolism and survival of neurons? It's oxygen. How does it get to these nearby neurons? It has to travel through the astrocyte. So the astrocyte is kind of a linker vessel a linker neuron or neuroglia cell which allows for or at least enhances the delivery of oxygen. But more important, the function of these astrocytes is to regulate and screen material which might be harmful, molecules which might be injurious to the neurons. And what did we just say a moment ago about a neuron's capacity to be replaced? So is there good reason to protect the neurons that we have from injurious substances in the blood? And what is the filter, what is the means, to screen or block or at least control the diffusion of materials from blood to these neurons? It's the astrocytes. In fact, astrocytes make up most of the weight of the brain and as a result have this important function of creating what's called a blood-brain barrier. Maybe you've heard the term blood-brain barrier. It tends to block the passage of toxic or injurious materials which otherwise might reach and have a negative effect on the neurons. In fact, though, the blood-brain barrier is sometimes, shall we say, unwelcome. Are there at times tumors or issues in the brain that should be treated medically? Anything you put into the blood, however, may not make it to the what? May not make it to the neurons because it will be blocked by the astrocytes, which create this what? Blood-brain barrier. This barrier's not perfect. In fact, it notoriously allows some offensive materials to cross. What about alcohol? Does alcohol get into your blood? Yes. Does it reach nerve cells? Apparently so. And does it therefore surpass or somehow get through the blood-brain barrier? Yes. And so whether it's neurotoxins, whether it's alcohol, whether it's chemotherapy, the blood-brain barrier can be an asset or it can be a liability. That is, it can protect at times or it can actually block things that you might want to get through. So in medicine at least, the blood-brain barrier is sometimes unwelcome because it blocks the passage of medicines that might be therapeutic or otherwise useful in the nervous system. As we leave this page then, it was all about what? Neuroglia. What are the glia cells that are found outside the central nervous system and form these gaps or spaces here that form the myelin? That's Schwann cells. Those that are found inside the central nervous system are similar in that they form nodes. But they wrap around more than one axon. And their name are? Oligodendrocytes. And then finally, responsible for the blood-brain barrier are? Astrocytes. Here's some imaging which probably is easy enough to appreciate. This is an axon and these little gaps or creases here must be – what's this? The nodes. MS, if you can see it from way back there, is not multiple sclerosis. MS is myelin sheath, which is the result of wrapping an axon many, many times. That's a cross-section. This is a longitudinal section. And so the arrows are pointing out these gaps or naked spots which are nodes, nodes of Ranvier. Here's a colorized version of the same thing. The purple is the axon and the white is the myelin. Speaking of that, myelin is white. So wherever we have a bunch of myelin, the tissue is going to be white. Wherever we don't have a lot of myelin, the tissue is going to be not white and in other words gray. So with that said, there are obviously neuroglia which insulates axons. So wherever you have axons, you're going to have white matter. Dendrites, as a rule, are not myelinated and neither are cell bodies. So wherever you have these, the tissue's not going to be white. And what's the name for that? Gray. So maybe already you've heard those terms white matter and gray matter. White matter is wherever you have a bunch of myelin and gray matter is wherever you don't. One demyelinating disease we mentioned a moment ago is ALS, amyotrophic later sclerosis. And Stephen Hawking is the oldest known survivor of that. He's now 74, world famous scientist, and he has been reduced to essentially a sensory machine. That is, the effect targets not sensory nerves but only motor nerves. So he's completely paralyzed, can't speak, and breathes only with assistance. So he has to communicate with adaptive devices which compensate for his inability to speak. It's a very – obviously, tragic and usually very quickly fatal disease. Most people with ALS succumb within five years. Moving on. There are, as it turns out, only actually three types of neurons from a functional standpoint, and here they are. The first so-called sensory nerves. Again, this is not an anatomical description, this is a functional description because sensation is a functional concept. Sensory nerves are also called afferent. The word afferent means to travel into. And so these sensory nerves are bringing signals into the central nervous system, into the spinal cord or brain. And so the signals are being carried from the periphery – that is, elsewhere in the body – toward the spinal cord and brain. So they originate throughout the body, especially in the skin where they're associated with receptors that respond to touch or temperature or pain, and then they carry these signals into the brain and spinal cord. Clearly, if you injured a sensory nerve you would be lacking – s word – sensation. And that would lead to some degree of numbness or anesthesia. The flip side, the opposite of a sensory nerve is one that carries signals out of the spinal cord typically toward some destination, some effector. And the effector is very often a muscle. And indeed, what's the word motor imply? Motor implies some degree of movement. And so clearly motor nerves are responsible for physical motion; that is, contraction of skeletal muscle, and also secretion from some glands. Either of those are some response that's carried out then by motor nerves. Sensory were called – what was it? Afferent. Motor are referred to as efferent. That means to travel away from the spinal cord or brain. And pretty obviously, if you injured a motor nerve, you would lack the ability to bring about movement or secretion. And so naturally, that would be paralysis or some degree of weakness. The third type of neuron resides only in the central nervous system and serves to connect through a multitude of synapses all of the neurons within the spinal cord and brain and enable the brain the function as a very sophisticated computer which does more than just receive sensation but rather analyzes that sensation, makes sense of it, makes decisions about it, and then decides or not to execute some response. All of those decisions, all of those processing efforts, are made possible by a third type then association neurons also called what? Interneurons, because essentially they link and communicate among all the neurons within the central nervous system. Far and away, most of the neurons in your brain are not sensory. They're not motor. They're mostly what? Association. Which allows the human brain to do a lot more than a rat's brain, right? In other words, highly sophisticated computations, analyses, judgments. And then to execute very sophisticated motor movements like writing your name or writing sheet music or whatever it might be. So what makes this distinctly human, different from other animals, is not sensory, not motor, but the vast and complicated number of association neurons. In a typical and simplistic diagram of these, we show the spinal cord – which is a dominant feature of the central nervous system – and those fibers which carry signals in, those are called afferent. Another word is? Sensory. Those that are limited to and bridge or connect neurons within the central nervous system are so-called association, and those that carry signals out to muscles or glands and bring about some response, those are called motor. To summarize again, if you damage sensory nerves you're obviously going to be lacking or missing some degree of sensation. If you cut or injure motor nerves, you're going to have some movement disorder or other weakness or p word, paralysis. And if you damage association neurons, you're going to fundamentally be unable to process information. Your ability to make decisions or execute memories might be severely impaired. What?

[Inaudible Speaker]

>> Well, Alzheimer's is damage to association neurons, certainly, which leads to memory loss and so forth. Absolutely. Next, let's talk about structural types. This list was strictly what? Functional. So to repeat, what are the three functional types? They can be sensory, they can be motor, or they can be association. Structural types means what they look like under the microscope. And these then are more or less descriptions of their appearance. The first are called multipolar, multi- anything means many. And the diagram we gave you to begin with was a classic example of a typical multipolar neuron. Because it had many short what? And one very long axon. Multipolar are usually motor in function. And there then is a correlation. If we see a multipolar nerve, we'd suspect it's probably motor. A unipolar nerve is one that has a single process which splits near or at the cell body. And therefore essentially has a single axon as seen here, which is split at or near the cell body. So this piece of wire which I've bent and created into sort of an outline of a neuron, would this be multipolar or unipolar? Uni. And so this is, as seen, a single axon with dendrites at this end converting signals into or toward the cell body. Unipolar tend to be sensory. And so if we see a unipolar nerve as we do here, that would be a sensory nerve more often than not. Question in the back?

[Inaudible Speaker]

>> Right. What's the common name for inability to feel something? People

call it numbness. And so yes, any injury to a sensory nerve would cause some degree on sensory loss. The medical term for that, incidentally, is anesthesia. We think of anesthesia as being, well, unconscious as in a surgical room. But actually the word anesthesia means what it says, without sensation. So to answer your question, any injury to sensory nerves cause some degree of sensory loss. Any injury to motor nerves causes some degree of motor impairment. That means weakness or lack of coordination or maybe even some deficit in secretion. Because notice that some motor nerves innervate glands. So back on this page. What are the two types of structural neurons? Multipolar and unipolar. Unipolar are usually what function? And multipolar are usually motor. When we see a nerve – and you will see many in your dissections in lab – you're looking not at a single cell, of course, but a bundle of many. So once again, relying on my crude attempt here to create a visual aid. This might be a single nerve fiber, yes? And here's how many together? Three. Yeah. And this area where the cell bodies are is called a ganglion. At any rate, most nerves that you see in a dissection are thousands, thousands of axons. And the name for such a group is called a nerve bundle, also called a nerve trunk. A group of many mixed nerves – what's that mean mixed, you think? Sensory and motor, meaning afferent and efferent. And these are found and bundled outside the central nervous system. The gross anatomy of a nerve bundle is depicted here – and you have an illustration in front of you – which obviously or at least in some way resembles a cable. What's a cable that might be seen on a bridge or otherwise in some machinery? Is a cable a single wire or a group of hundreds of wires? So that's the analogy here. It's a cable-like collection of many fibers, some of which are sensory and some of which are motor. Now in cross-section, this anatomy is similar in organization, appearance, and even nomenclature to that of a cross-section through a muscle. Remember a muscle bundle had an outer layer, an inner layer and then some filler in between the individual cells. Remember that?

>> Mm-hmm.

>> The outer layer, you might recall, was called the epimysium. Then the paramecium, then the very deepest, the endo. The same words, the same prefixes, apply here. But this is not a muscle, this is a nerve bundle. So in yellow, the outer tortilla, if you want, is the outer layer of connective tissue, dense irregular connective tissues, which essentially is the reinforcing sheath or band or duct tape, whatever you want to call it, which is holding together these individual fibers. The epineurium provides strength but also allows flexibility. And even allows for a little bit of stretch. Nerves can be stretched a bit without injuring the internal neurons. Now notice that deep to the epineurium there are sub bundles which are isolated by their own connective tissue. And that connective tissue is called the perineurium. What was it called in a muscle? Perimysium. Here, it's called the perineurium. It's also made of dense, irregular connective tissue, and basically bundles up neurons of a single variety, a single functional type; that is, sensory versus motor. And so we say it surrounds neurons of similar origins or similar destinations. That means those that are

coming from a particular area or those that are going to a particular area. Deep within the confinement of a perineurium we have filler, which occupies the space between these individual axons. And that filler is loose connective tissue called the endoneurium. So this is complex, but yet it doesn't have to be. Let's look at an individual axon and first ask the question what insulates a given single axon are these – what are these? Schwann cells. Forming the m word?

>> Myelin.

>> Myelin. If we have a bunch of these side by side, what's the connective tissue that fills the voids between those? That's the endoneurium. And all of these that are bundled together form an f word. What – a fasciculus, which is wrapped up in the perineurium. And all of these are wrapped up in the big, outer sheath which is called the epineurium. So whether you go from inside out or from outside in, these are the relationships. Here's a textbook illustration showing the outer sheath. What's its name again? Epineurium. Then we have the sub bundles which are defined by the perineurium. Inside that we have the endoneurium, loose connective tissue filling the voids. Now that's an illustration which is simply an artist's rendering. This is an actual photograph. And although it might be a little too close, let's get down. NF stands for neuro filaments. That's the axon right there. What's the white stuff around the axon? Myelin sheath created by Schwann cells. Let's start again. Axon, Schwann cells. What's all this filler in here?

[Inaudible Speaker]

Filler in there is what? The endoneurium. And then this p-e? Perineurium. And then if we get way back here, then the very outer enclosure, which is not even shown here, is the epineurium. F-a stands for fasciculus, which is a group of many, many neurons of similar origin or destination. What do you think BV is? BV, blood vessels, which are found throughout the nerve or nerve bundle. So when we say it's a bundle, it really is. It can be tens of thousands of individual axons, all of which are protected and isolated by this connective tissue. So let's do it one more time. The axon is shielded or surrounded by the myelin sheath. All of the voids in here are filled with this. And then this unit called a – is wrapped up and defined by the – and then many of those are wrapped up in an outer sheath which holds the whole thing together, that's the epineurium, a typical nerve bundle then. Next, as we leave and finish up for today, we wanted to return and comment a bit about synapses. We said that these aren't actual functional connections – I should say not actual physical connections but functional connections – that facilitate or what? Or inhibit the transmission of signals. So we want to realize that a synapse is not a physical point of contact, but an actual gap between one cell and another. And so here's an actual photograph of what appears to be a nerve cell body to remember what's this organ out here probably. Nucleus. And that's the nucleolus. And that's a gap between a terminal filament and the nerve cell bodies. So that's the s word right there. What? The synapse. Something that is incredibly small but yet used for chemical communication between one neuron and the next.

The one which delivers this information is called presynaptic. The one that responds is called postsynaptic. And these are described here. Naturally, this is more physiology than anatomy, but we want to at least give you a functional idea of what's going on here. The presynaptic fiber, or the terminal filament, contains vesicles of material called neurotransmitters. A vesicle is a tiny bubble, a membrane-wrapped enclosure. And the material in here is a neurotransmitter, which is then actually released as these vesicles rupture. And so the material is literally sprayed or disseminated across this void or gap. That gap is called the synaptic cleft. So on the presynaptic side, we have synaptic – v word – vesicles which release neuro – what – transmitters, which diffuse rapidly across this gap called the – and then activate recetors on the postsynaptic side, which bring about some response, some change, some activity, essentially a recreation of the signal. So without getting deeply involved in the physiology, we have an electric signal that arrives; it sets in motion and causes the release of neurotransmitters, which are cast out from these vesicles; and that action causes some response or reaction in the postsynaptic cell which then conveys that signal on. So in very simple terms, it's electric, then it becomes chemical, and then it becomes electric; electric, chemical, electric. Synapses are one-way streets where the signal comes from the presynaptic side and has an effect on the postsynaptic side. But remember this, they not only facilitate signals, they can also what? Inhibit or block. So there are two very, very different kinds of synapses, those that facilitate and those that block. In the days and weeks ahead, we're going to be essentially referring now to this menu. This is our agenda because it essentially outlines the organization of this system. We spoke earlier of the central nervous system. And as you probably know from other courses, that involves those portions of the system which are inside the cranium or spinal cavity, so that means the brain and the spinal cord. We'll have a couple of lectures on the brain and a lab devoted to it as well, and then we'll move from there down the spinal cord. Everything that's not the central nervous system belongs to the peripheral. And peripheral means anything which is coming into or leaving the spinal cord, and these are then so-called peripheral nerves. Nerve trunks, nerve bundles, which are going into or out of. Those that are coming in are afferent, those that are going out are efferent. As you know, efferent consists of motor fibers, afferent consists of sensory. The motor fibers are going to one of two destinations. Some go to skeletal muscle, others go to the other types. What are the other types of muscle? Cardiac and smooth. And those which are motor but which control heart or smooth muscle belong to the what? Autonomic nervous system. So the purpose of putting this up is to show you where we're going. Are we going to have a lecture on the brain? Then are we going to talk about the spinal cord? Then are we going to move out into the peripheral nervous system? You bet. So that's our organizational chart for the work that lies ahead.

>> Thank you.

>> Have a good afternoon.

[Indistinct Chatter]

>> That was fun.

>> Bye, David.

>> That was fun [laughs].

>> Well, it's a lot of terminology, but it's necessary to get your bearings before we...

[Inaudible Speaker]

>> No, not at all.

>> Just so I could, like, go through it. I used to have a rainbow [inaudible].

>> All right, so you know how to diagram, huh?

>> I got an A in his class, believe it or not.