Neuroscience of Human Movement
Department of Multidisciplinary
Indian Institute of Technology, Madras

Lecture – 24
Spine and Spinal Cord

Hello all. Welcome to this class on Neuroscience of Human Movement. Today we will be talking about Spine and Spinal Cord.

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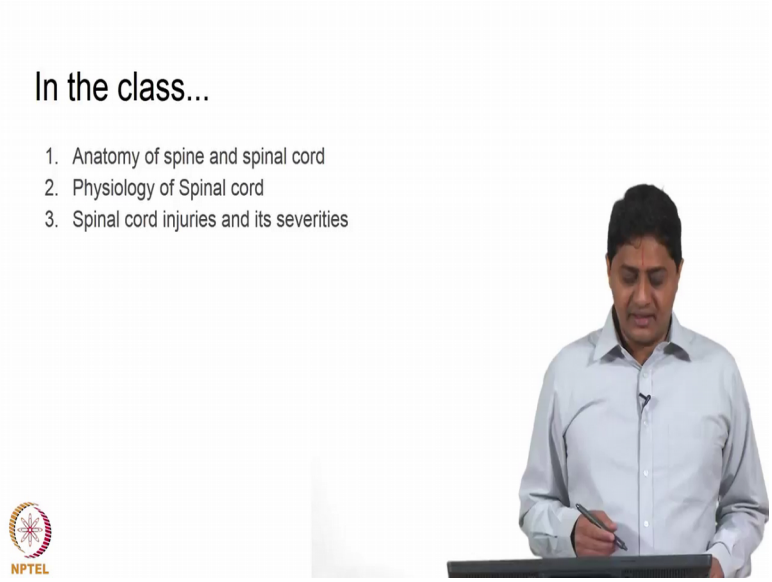

And discuss some of the functions of spinal cord in terms of the physiology of spinal cord, and what could have go wrong injury to spinal cord cause'; and what are the consequences.

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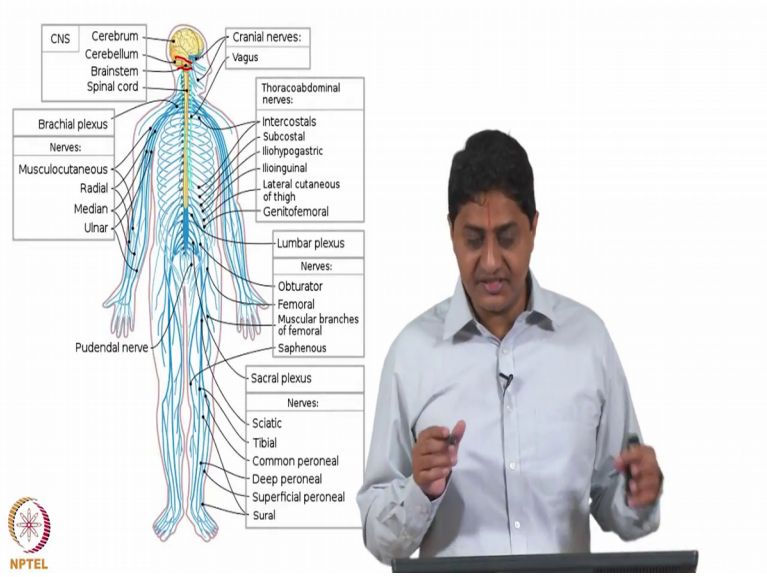

But for now it is sufficient for you to know that the brainstem is composed of three parts medulla, pons and midbrain. So, above these three parts how it is called a cerebrum, but brainstem itself is composed of midbrain medulla and pons.

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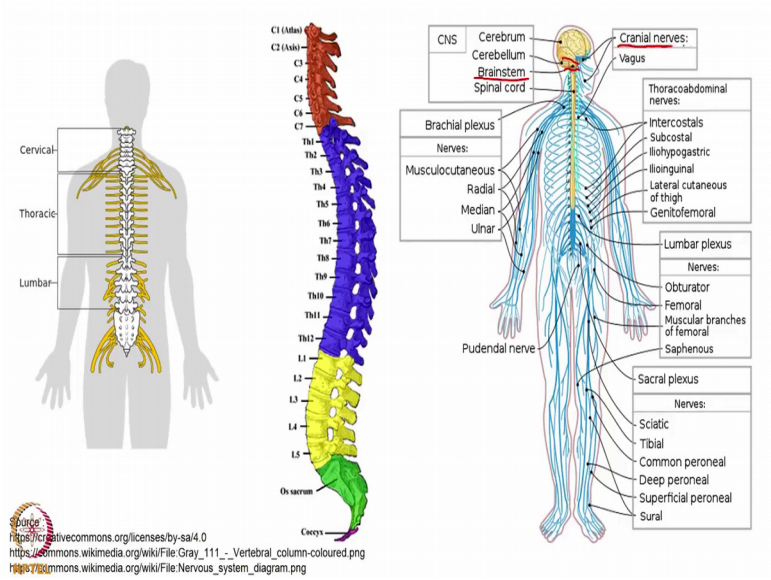

So, what does this do? This serves as the first precursor to spinal cord. What this does is, its supplies nerves are bundles of neurons that could be purely afferent. Afferent means purely sensory, or purely efferent or purely motor, or it could be a mix of two ,or one bundle of nerves one bundle of neurons can contain both sensory as well as motor neurons. It is not necessary for nerve to be purely motor or purely sensory it can be a mix.

So, since our face houses many of the senses. What are the senses? Vision, olfaction, taste, audition; all these are housed in the face in the head. The sensory information from these senses reach the brain via what are called as cranial nerves. There are also motor parts within the face. For example, mouth movement of the jars and movement of the vocal cord movement of at least tongue and parts within the head.

So, that involves motor neurons. They are also supplied by cranial nerves. Each cranial now has a specific function and there are several of this, you could check that out what are these divisions of a cranial nose and how are they classified; some of these are purely sensory, some of these are purely motor, some of these are mix etcetera. This brainstem does serves as the first precursor to the spinal cord. It starts carrying sensory and motor information from the brain to the face to the head. But as I descend there is the neck and there is the trunk and there are the legs and hands.

So, as we descend from the head, we are interested in receiving sensory information from the hands. So, when I mean manipulating objects an important evolution evolutionary function want to manipulate and pick up objects right or perform manipulations are with tools in such a way to build something. So, that involves a combination of sensory as well as motor functions. So, these must somehow be carried right. So, that is carried with the help of nerves from the cervical spinal cord are the set of vertebrae or the set of nerves that arise from the neck ok.

And then we will go down, but before we do that will start with the difference between vertebral column and spinal cord. Vertebral column is this bony structure that is performing the protective function of protecting the neurons are neuronal cell bodies axons or nerve bundles that pass through them. So, in other words you see these tubes of, you see these tubes that carry cables; for example, many places where non concealed wiring is performed.

What you see is that there is a PVC pipe in the inside that there are these cables. Why does the PVC pipe you exist? To protect the cables; the cables themselves are the carriers of information or current whatever depending on if it is a for example; if it is a data cable right. Then it is carrying you know information digitally analog whatever or it can simply be a carrier of electrical current right. But the protective function is performed by the PVC pipe, is it not?

Likewise so, we have, but in comparison just that our vertebral column is very stronger than a PVC pipe, much stronger than a PVC pipe. So, the performance and the comparison ends just that, because the PVC pipe is one long single structure whereas, what we have is a vertebral column that is made of several vertebrae that is placed one and top of another. So, the comparison should not be stretched.

The point is that these perform the vertebral column performs the protective function of carrying the nerve bundles the within the. And these vertebral column is composed of several individual vertebrae, will talk about what this vertebrae are in the next slides. Seven of these vertebrae together from C1 to C7 together called as a cervical vertebrae. These are located in the neck ok. They are located in the neck; C1 to C7. Below C7, what you have about you have 12 thoracic vertebra; T 1 to T 12 and below the thoracic vertebra, you have five lumbar vertebrae L 1 to L 5.

And below this depending on classification, you have S 1 to S 5 or just S 1. Some classifying some classification methods use sacrum as having 5 vertebrae, some say it is only a single vertebrae and then you have what is called as the coccyx or the tailbone. And each of these have spinous process is from which the nerves exit and enter and. So, information is carried by these nerves are bundles of neurons whereas, the bony structure itself performs the function of protecting this protecting these bundles.

And this goes on. So, their function depends on where they are located, which particular vertebrae is located. This has important consequences will discuss later. That means, in the cervical level for example, hand and the arm or the upper limbs are supplied by the cervical region. Supply starts for the thorax and for the upper thigh at the level of T 12 for example or L 1 depending on where you are talking about.

And as you go down you want to supply or receive information from the foot for example, right. Reasonable arrangement of nerve supply depending on as you descend from the top to the bottom as you go from the brain, from the neck to the tailbone. This supply moves from the say from that upper limb to the lower limb and to the foot ok. Actually towards the end you only have axons towards the end or towards around that point around L 5 S 1. For example, you do not have any more cell bodies, you only have axons those that supply the lower limb this. So, after this there are not any more cell bodies that are lying within this. So, these this final cord contains cell bodies neuronal

and cell bodies. So, it is not that they would not, they are only carriers of wire that should that example should not be taken to an extreme.

So, in other words they can they also servers spaces from which neurons can originate. So, neuronal cell bodies lie in this can lie in these spinous processes which we will see in the next few slides.

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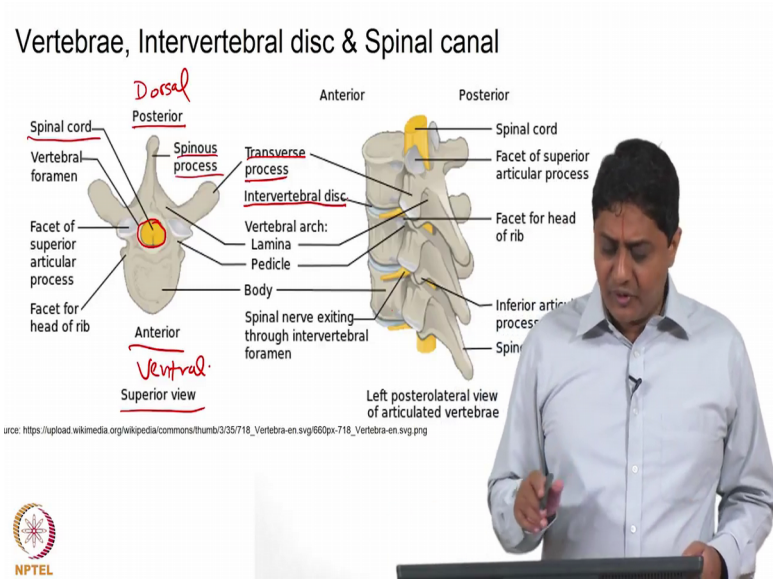

So, an example of a vertebrae and its process its anatomy to this will discuss this very briefly. So, in the in the center you have the spinal cord which is the bundle of nerves that I was talking about that is going to be carried and there are processes. There are transverse processes and other spinous processes that are carried on node. How is this looking? This is the posterior side or the dorsal side, this is the anterior side or the ventral side or the back side is called as the posterior side and the front side is called as the anterior side. Please check this terminology for more clarity.

And it turns out that this is one, view superior view of the vertebrae. But when I play several of this vertebrae one on top of another, it turns out there is a need for interfacing them with the help of a relatively compressible disc. This disc is called as the intervertebral disc. And then which is which performs an important function of compressing when needed and not doing that when not needed; so, critical function, critical anatomical function. Again problems with this could cause important

consequences, critical consequences for people affected by this problem. Proceed with this.

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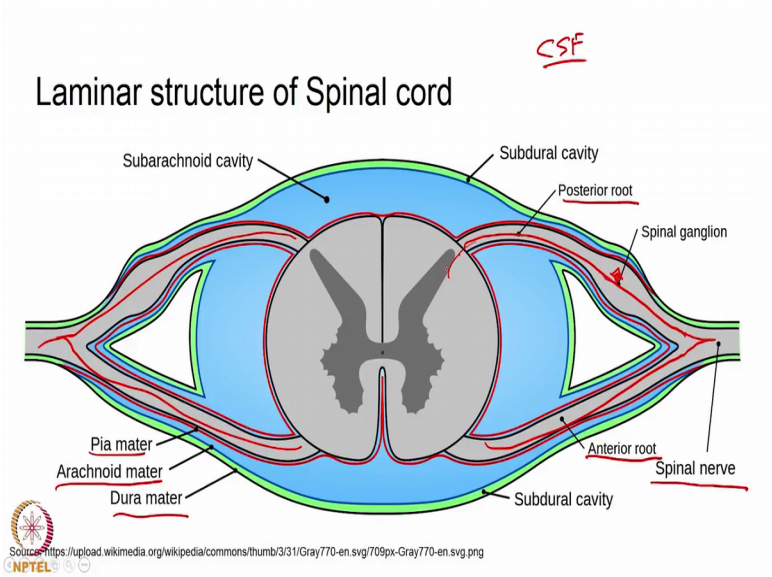

So, one other view of this: so remember as I said this is a continuation of brain structure. So, brainstem starts the as the precursor to spinal cord and then descends down so; that means, this structure is non-different from brain. The sense that there exist several protective layers there exist Dura mater Arachnoid membrane and Pia mater.

So, there are several layers of protective membrane. There is the fluid in which these neurons are suspended right. So, this fluid is called as the cerebrospinal fluid CSF cerebrospinal fluid. So, it is not that the cerebrospinal fluid how is protecting only the brain, it also protects it also covers the spinal cord as well right. So, also note that in cases of surgeries involving the lower parts of the body. For example, where the general anesthesia is not given right, in such cases it is these layers that are punctured and spinal injections are given right.

So, when that is given, so these are called as a epidural injection and so on and so forth. Please check those if you are interested right. So, when this happens for example, in some cases it is possible that CSF could actually leak and would not stop leaking for a while. This causes what are called as spinal headaches. You could just Google for that those who are interested can Google for that. This is due to this is also called as just spinal headache what happens is that when the person gets up and stands vertically like

this like I am now standing if the person is standing up he feels headache severe headache.

However, when the person lies down like in the sleeping posture on a bed, no headache perfectly fine like this: this onset of this headache is pretty quick within a few seconds immediately after getting up, what happens is it the pressure because there is a small hole that has not yet healed, because of the epidural or because of the injection the spinal injection the CS of fluid starts leaking in small amount causing a drop of fluid pressure CSF pressure in the head causing severe headache for the person; Google for just if you are interested ok.

So, as I was talking about there are there exists this cerebrospinal fluid and in which this entire new nerve structures are suspended right. And there are two roots: the dorsal root or the posterior root and the ventral root or the anterior root. Note what happens here. So, the anterior root or the ventral root contains mostly motor neurons, the dorsal root contains sensory neurons. They both combine together here to form one nerve bundle.

So; that means, that nerve is going to depending on which particular nerve it is, that nerve is going to carry both sensory as well as well as motor information or in other words is both afferent and efferent likewise. So, that for one side of the body; say for example, that for the left side of the body. And for the right side of the body is this right; a once again can this side of the body takes both the sensory and motor information; both afferent and efferent information. What is not discussed is what is happening within here right. It turns out that some of these axons could terminate and interneurons.

So, the spinal ganglion here; in other words the neuronal cell bodies may lie here for example, some neuronal cell bodies can lie here. Their axons can terminate here or there may be cases where there are neurons that start from one point in the spinal cord and end at another point in the spinal cord. These are called as spinal interneurons many of the, or most of the neurons within the spinal cord are actually interneurons.

So, they start from one part of the spinal cord and end in another part of the spinal cord, what is their function? So, depending on the specifics their function varies. We will discuss some of the cases of spinal interneurons in future slides and future classes.

So, some of them cross over and terminate on the other side from the dorsal side to the ventral side performing important functions, crucial functions such as reflexes; what is it that they are doing. We will have to see in future classes.

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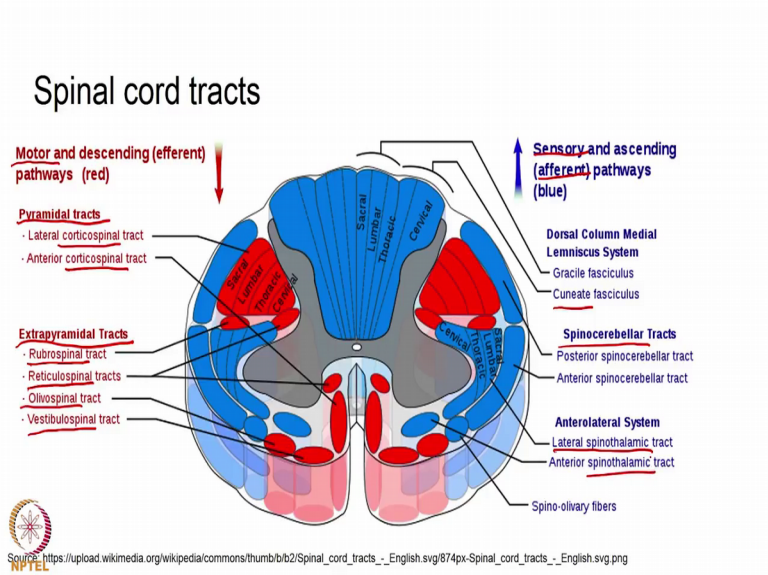

So, here are here is a topography, rough map this in perfect, but a relatively reasonable topography of, how information from various segments of the spinal cord is routed right. But so, you see different tracks coming from different places. So, you have what are called as the corticospinal tract. So, let us from to remind ourselves of what this is. So, there is the cortex are that outer fold, outer portion of the brain that is generally seen as the brain by people whenever a show picture of a brain is shown to you. What you are seeing is usually the cortex. This is called as is also called as a cerebral cortex right.

So, these cortex from the cortex tracts are several bundles of neurons reach to the spinal cord. And an important source is from, what are called as pyramidal neurons? This pyramidal neurons are so, named because of their shape; they are pyramid shaped. So, these pyramidal neurons form together form what are called as pyramidal tracts. So, there are different pyramidal tracts called as lateral and anterior corticospinal tract. And some of these arise from different brain structures other than the cortex. If it arises from say the red nucleus, it is called as the rubrospinal tract. If it arises from the reticular formation, it is called as a reticulospinal tract. If it arises from the vestibulos nucleus, it is called as a vestibulosspinal tract. If it arises from the early, it is called as the olivospinal

tract. These are outside the cortical systems or these are not necessarily pyramidal that is the reason. They are called as extra pyramidal tracts.

And note many of these are motor tracts. So, it is not that the motor function is performed only by the cortex, but there are other structures that participate in critical motor functions especially in the maintenance of posture. So, there are other structures, other than the contexts that are responsible for maintenance of posture we will see that in future classes.

So, then there is also; so, this is motor function are descending pathways or commands that are given for specific motor acts to be performed are originated from the brain and distributed to other parts of the body. But then, we also spoke in the earlier classes about information going from the senses, from the limbs, from the peripheries to the brain for processing right. These are afferent or sensory pathways or the ascending pathways, the details and skipping now. We will see that in future classes and there are several of these some of these that originate in the cervical region. We named this as a Cuneate, this goes where the Cuneate nuclear. We said the Cuneate fasciculus.

And some information goes to the cerebellum through the spinocerebellar tracks. So, it starts from the spine and ends in the cerebellum spinocerebellar tract. Look at the naming convention, if it starts from a particular point say the cortex. So, then the word will be cortico; if it ends in spinal, then the second half of the word will be spinal. So, by reading the name corticospinal, I am able to say that cartex is the origin and spine is the destination. Likewise, if I am saying spinocerebellar, I am able to say that the spine or spinal cord is the origin and cerebellum is the destination. Likewise, right information also goes to the thalamus which is the main relay center through spinothalamic tract, two of these and spinoolivary information.

So, these are sensory ok; so, these are the sensory pathways ok.

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So, let us take a look at injury to the spinal cord. One particular manner in which injury to the spinal cord may be cause is shown here. An important cause for injuries to the spinal cord involved accidents or trauma. In particular those that involve motorcycles right or motor vehicles in general in particular motorcycles. What could cause? This could be due to forces that are exerted in such a way that could cause hyperflexion, hyperextension stress in the lateral direction rotation are too much compression. Any of these could lead to physical changes to the integrity of the vertebral column on the spinal cord.

This has tremendous consequences for these individuals what happens is that depending on where the injuries, depending on the location of the injury and depending on the severity of the injury, depending on the severity of the case and the location the consequences may vary. It could be from slight loss of sensation to complete paralysis; to cases where the person is not at all able to move the four limbs that is, also possible. You could see this cases, if you whenever you are visiting, we have hospitals. You could see these individuals relatively young between 20 and 30 years usually. And completely wheelchair bound; not able to work, not able to do anything.

So, stuck these and you will be wondering what could really go wrong for these individuals. You would think that you know at this age, it is not possible for them to have say and you generated disorder or the stroke that is what you would think. Actually what happens is these in many of these individuals are from the spine clinic. They are usually affected because of motorcycle falls right motorcycle trauma. Some of these individuals

recover, many of them do not recover; so critical for us to be cautious while riding motorcycles.

So, the in many cases the damage is irreversible, stuck under this. And in some cases where falls may actually be on not necessarily involve motorcycles or vehicles, but just involve falling from stairs for example. That causes movement of the disc or improper movement of the disc. Sometimes causes tremendous pain causing prolapse in many of these cases only management is possible or management of the problem, but no actual cure in many cases, this happens; surgery sometimes help some patients, but not all.

So, this structure that is the vertebral column and spine needs to be protected with care as the brain should be protected right. So, note the evolutions objective in protecting these structures from trauma and damage. So, the cranium which is a very strong boner set of strong bones that protect the brain. There is a very good evolutionary reason why the their protector likewise spine spinal cord; falling from trees, falling from motorcycles, falling from stairs could cause irreversible damage causing in some cases causing paralysis or depending on the severity. And the place the particular point on the spinal cord in which the damage is trauma is happening. Sometimes it happens in multiple places. So, the damage can also have multiple consequences.

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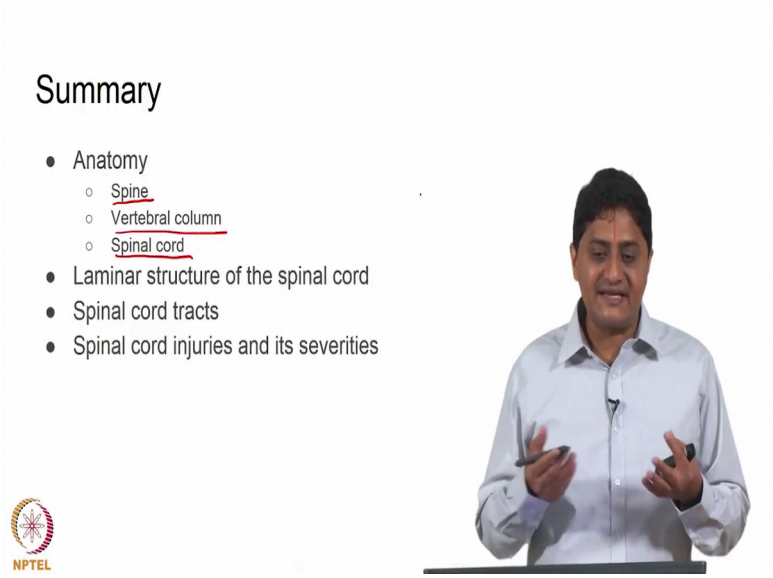

So, in summary what we have seen is in brief, summary of spine and spinal cord in vertebral column, the difference between a spinal cord in vertebral column, important

functions of vertebral column in protecting the, the spinal cord the laminar structure of the spinal cord and the what are the various tracks; at least we have introduced the ascending and descending tracks. And what could cause what could go wrong in the spinal cord injuries and how severe it can be.

So, with this we will stop this class on the spinal cord injury. So, what next? What happens within the spinal cord? We mentioned early on that there are interneurons that are responsible to communicate information from one part of the spinal cord to another part of the spinal cord. These form the majority of the neurons within the spinal cord. What do they do and what other functions are performed by the spinal cord.

So, in the next few classes we will be talking about how spinal cord performs its important role of exciting and inhibiting specific neurons. So, we will stop here.

Thank you very much for your attention.