Neuroscience of Human Movement
Indian Institute of Technology, Kanpur

Lecture - 55
Cerebellum Part - 4

So, welcome to this class on Neuroscience of Human Movement.

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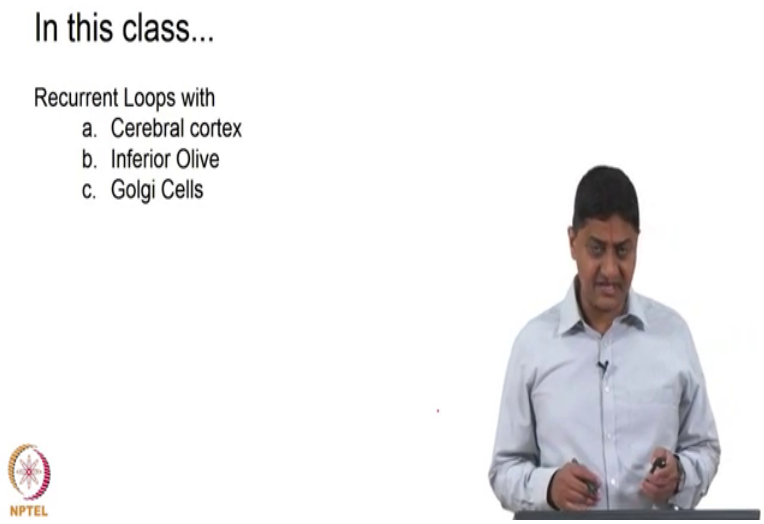

So, in this class will continue our discussion on Cerebellum. So, this is part 4 of our discussion on cerebellum. So, in this class will be talking about recurrent loops that cerebellum has with cerebral cortex, inferior olive and golgi cells. We briefly mentioned this in the previous class; we will discuss that with some details in this class.

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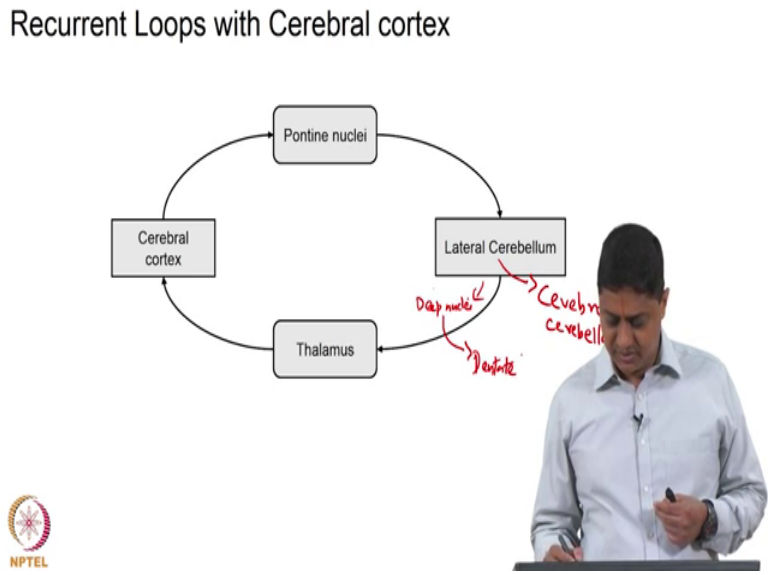

So, a major recurrent loop with the cerebral cortex, so the cerebral cortex sends information to the cerebellum not directly it is not like that, but rather through pontine nucleus or through pons, right. So, route that as shown here. So, pons serves as an important source of input to the lateral cerebellum. What do we mean by lateral cerebellum? Lateral cerebellum means cerebro cerebellum, is it not that is the reason this cerebral this region of the cerebellum is also called as cerebro cerebellum, right.

So, the more medial regions are spinal cerebellum, and the flocculonodular lobe is the vestibular cerebellum. You have seen this in the previous classes. So, and the output from the lateral cerebellum goes via the deep nucleus, so actually not shown here is the deep cerebella nuclei. In particular what is the nucleus that is responsible for sending outputs to the cortex or processing information from the cerebellum, so that is the dentate nucleus. So, from the lateral cerebellum projection is to the dentate nucleus and from the dentate nucleus to the thalamus, more specifically to the ventral lateral nucleus of the thalamus.

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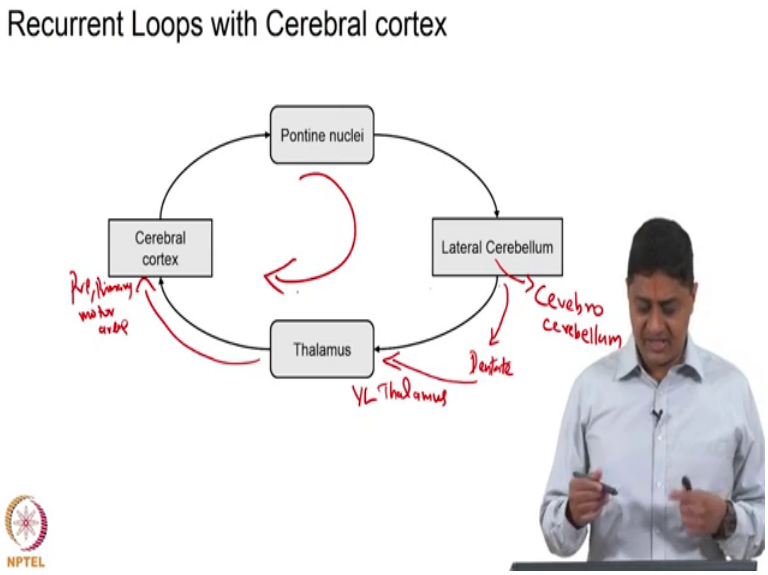

So, the thalamus then relays information back to the pre and primary motor areas, so effectively completing a loop. So, the information starts from the cerebral cortex from multiple regions of the cerebral cortex and reaches the cerebellum, where the bonds and that is processed in the cerebral are cortex, and via the dentate nucleus it reaches the ventral lateral thalamus and from the thalamus back to the pre and primary motor cortex. So, this is one recurrent loop. And this is one of the prominent recurrent loops that the cerebellum has with the cerebral cortex.

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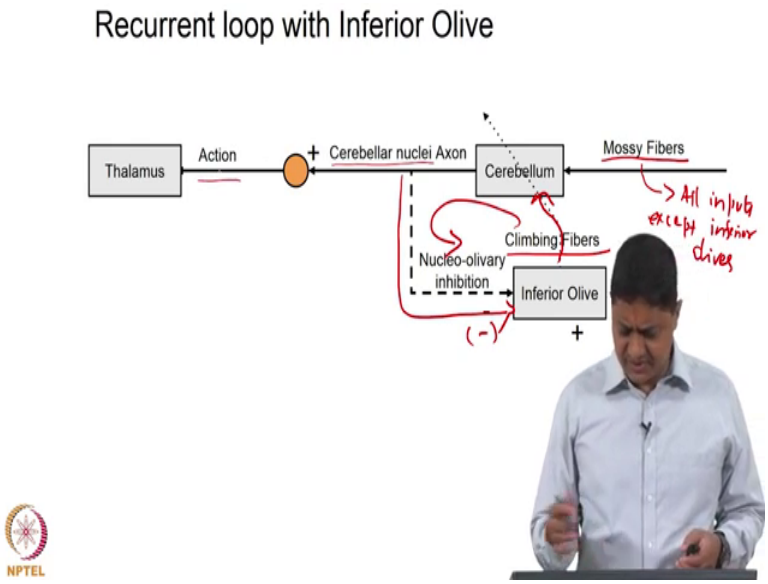

Then the other recurrent loop is with inferior olive, we have said this inferior olive is one of the powerful or primary sources of input. So, there are two sources, of two major sources of input to the cerebellum these are mossy fibers and climbing fibers.

Mossy fibers include all the inputs, all inputs except inferior olive; this may be from pons, this may be from. So, inputs that originated from pons input that originate from spinal cord and any other region are called mossy fibers. Inputs that originate from inferior olive are called as claiming famous. Vision; what is a special feature of this climbing fibers? Climbing fibers claim through the granular layer they do not make they do not make synapses with the granule cells, but rather they directly synapse with the purkinje cells, make hundreds of synapses with each with one purkinje cell for example and in a powerful manner influence the output of the purkinje cells.

And we also saw that you know one claiming cell can innervate up to ten purkinje cells, but a given purkinje cell receives input from only one claiming fiber, right. So, that information is a very powerful source of information is the climbing fiber. And it turns out that the deep cerebellar nuclei can also negatively are inhibit, can also inhibit the inferior olive.

So, in other words the cerebellum can regulate the inputs that it receives from where and what kind of information it is going to be receiving, right. A note also we discussed that inferior olive neurons are electronically coupled or in other words there is there are gap junctions information communication within inferiorly between some groups of cells is electronic or electrical through gap junctions; this we discussed earlier. So, this involves another recurrent loop. Of course, then the output goes why are the syllable nucleus to thalamus etcetera, is the story that is not mentioned.

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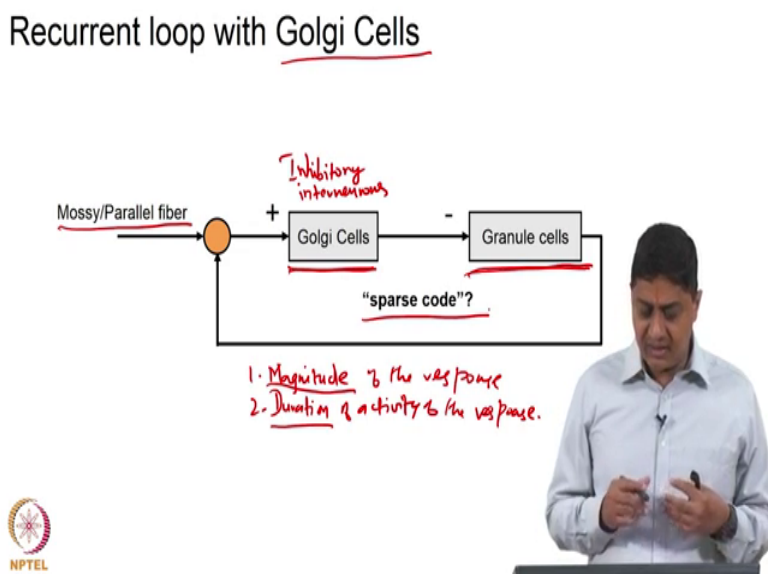

Then the other recurrent loop is somewhat different from the previous loops. Note in the previous two cases the recurrent loops were formed with structures outside the cerebellum, these were cerebral cortex and inferior olive. But this recurrent loop the third one is with Golgi cells is situated entirely within the cerebellum.

So, it turns out that the Golgi cells are inhibitory interneurons. So, these are inhibitory interneurons that are excited by the mossy parallel system. So, in the glomerulus they are excited by the mossy fiber, and parallel fibers also excited the Golgi cells. And in turn these gorgeous cells inhibit the granule cells, right. What would be the purpose of such an arrangement is the question. Note that the number of let us remind ourselves that the number of granule cells is about 100 billion we said that.

So, if all of these cells are simultaneously active; it is not clear what is the meaning of that. So, because of this reason it is required for us to have excitatory inputs from only specific granule cells that need to be active so that means, there is a need to control which granule cells are firing when etc.

So, Golgi cells perform this crucial activity. What could be the effect of Golgi cell activity on granule cells? Well, there are two ways in which Golgi cells could affect the functioning of the granule cells, first is it could affect the magnitude of the total response, I will explain that in a minute and it could affect the duration of activity of the response.

So, when I say the response obviously, I am not talking about the response of individual granule cells, but rather when a bunch of granule cells are active simultaneously and some of them are inhibited when say 10 granule cells are simultaneously active and say 4 of them are inhibited then the sum total of their activity will reduce. So, when I say magnitude of the response will reduce I am talking about the response of the total response, of this system of the set of neurons under consideration.

So obviously, individual action potentials will not reduce the magnitude not duration will not change. So, that is known. So, that is the stereotypical nature of action potentials. That will continue for each individual cell, but when I turn of specific cell specific particularly by using Golgi cells the total output from a set of neurons will reduce and if I do not turn off then it will increase.

So, I could selectively modify the magnitude and duration of the response of multiple cells. One hypothesis about this function of Golgi cells is that in some sense the Golgi cells are encoding a form of sparse code, right. So, you want to keep a whole bunch of granule cells silent, and Golgi cells perform this crucial function. Only those granule cells that need to be active at a particular time are allowed to be active keeping all the other cells relatively silent because the number of granule cells is very large you cannot keep them active simultaneously in respond to their activity. So, probably the Golgi cells encode some form of sparse code. This is an interesting hypothesis continues to be discussed in the literature.

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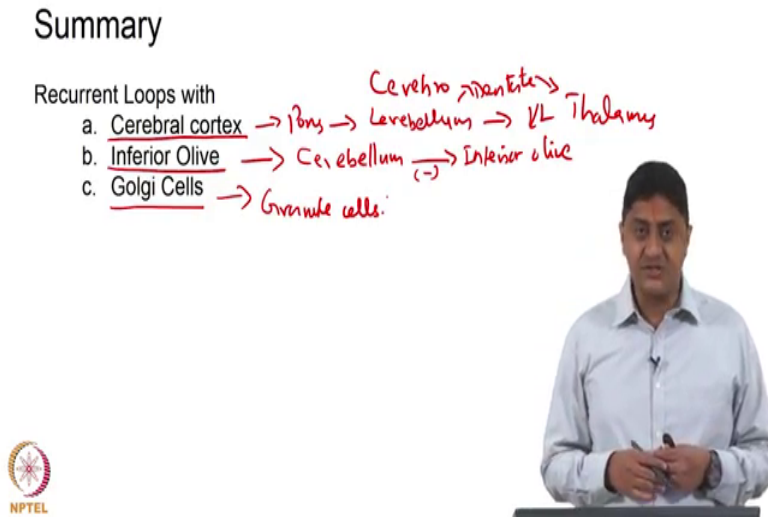

So, in this class we have seen recurrent loops that the cerebellum has, with cerebral cortex this is by pons, the cerebellum as in the lateral cerebellum or at the cerebro cerebellum and VL thalamus via the deep nucleus or by other by other dentate nucleus, ok. Then inferior olive, cerebellum it inhibits the inferior olive. So, cerebellum can control what kind of in or from what kind of input it is going to be see one to what action you can regulate its own inputs, Golgi cells regulate the function of granule cells.

So, with this we come to the end of this class. And in future classes will discuss vestibular cerebellum, spinocerebellar and cerebro cerebellum.

So, thank you very much for your attention.