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

Lecture – 09
Action Potential - Part 5

So, welcome to this class on Neuroscience of Human Movement. This class will be discussing about Myelination as part of our discussion on Action Potentials.

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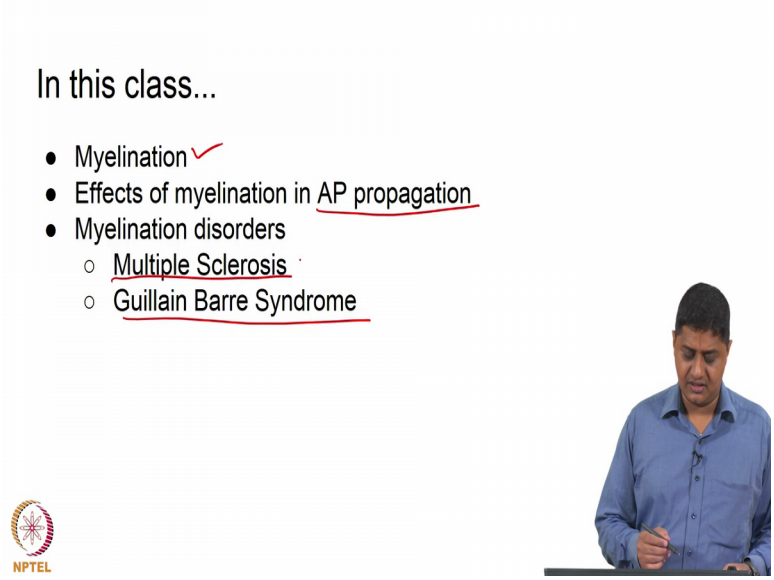

So, we introduce myelination in the previous class and in today's class we will discuss myelination and the effects of myelination in action potential propagation. We said that it helps to increase the conduction velocity and what happens if myelination is compromise themselves, at least we will take two examples; multiple sclerosis and Guillan Barre syndrome and discuss disorders of myelination or demyelinating disorders.

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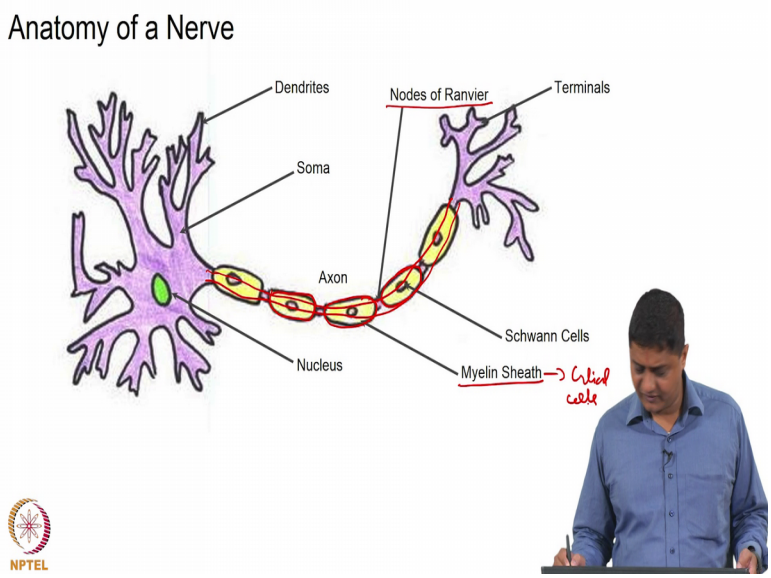

So, we said earlier that there is the neuronal acts on which is this long cable like structure are the output structure of the neuron. And there is myelination of this neuron and in between, in between you have the node of Ranvier. This myelin sheath it is basically composed of glial cells and there are different forms of Glial cells right.

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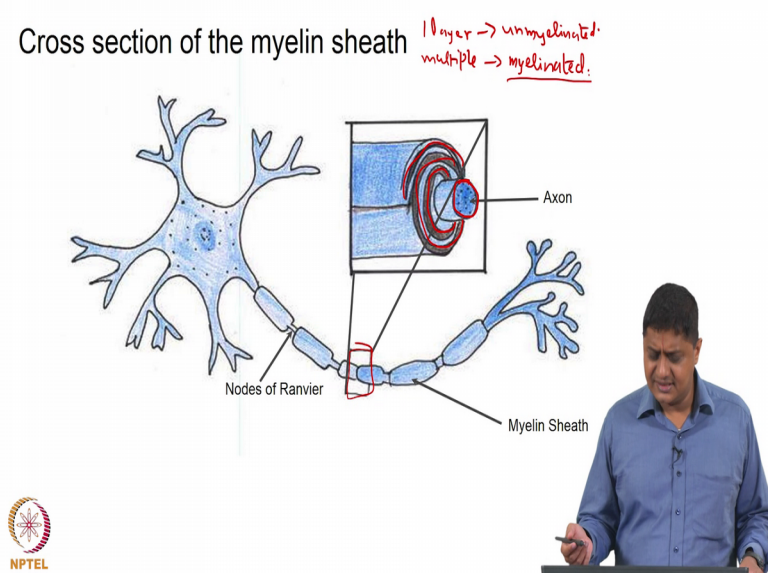

If we zoom in and see say this myelin sheath, this area of the myelin sheath this is going to look like this. So, that is the axon and then there are these glial cells that are surrounding this axon in multiple layers, if an axon has only one layer of Glial cell

surrounding it or one layer of myelination that is called as a unmyelinated axons, important to remember.

Almost all axons are myelinated to at least one layer. So, if there is only one layer of myelination that is called as an unmyelinated axon. So, by definition whenever we say unmyelinated axon, it does not mean that there are zero layers or there is no myelination, when there is only one layer of myelination it is called as unmyelinated axon. When there are multiple layers we are called as myelinated axons, slight difference in terminology between regular English and neuroscience ok. So, when there are multiple layers of myelination surrounding an axon it is called as a myelinated axon and this myelination is basically due to glial cells and what are these glial cells.

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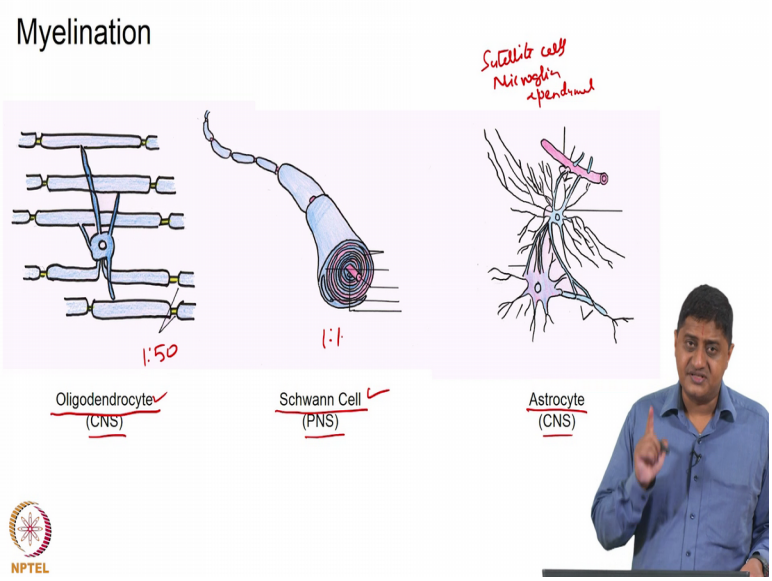

There are different types of Glial cells; for the purpose of this class we will discuss a few oligodendrocytes in the central nervous system, Schwann cells in the peripheral nervous system and then others such as astrocytes in central nervous system was not discussed is basically a satellite cells, microglia, ependymal cells, etcetera etcetera etcetera right, will take two cases right. Will take the case of oligodendrocyte and Schwann cell for the purpose of this course and discuss them. It turns out that oligodendrocytes are myelinating cells in the central nervous system, each oligodendrocyte can myelinate up to 50 axons 1 is to 50, a smaller number of glial cells can actually myelinate multiple axons in the central nervous system.

This is an efficient arrangement, whereas, in the peripheral nerves system you have Schwann cells, where 1 Schwann cell myelinates axons, basically 1 axon 1 Schwann cell myelinates basically one axon of an axon using Schwann cell multiple layers you see there are so many layers, layers and layers of myelins.

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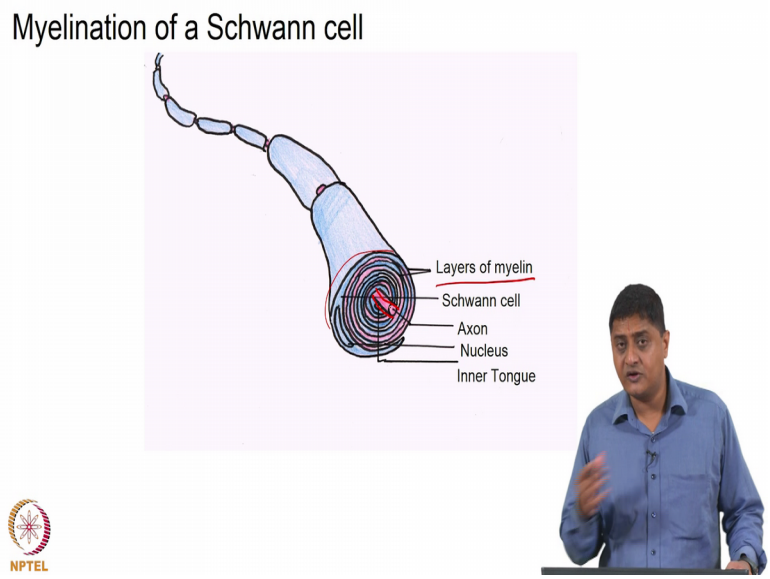

So, this is Schwann cell that covers that axon, sorry see the axon is in the middle that is relatively small when compared with the amount of myelin; that is there in the in this case right.

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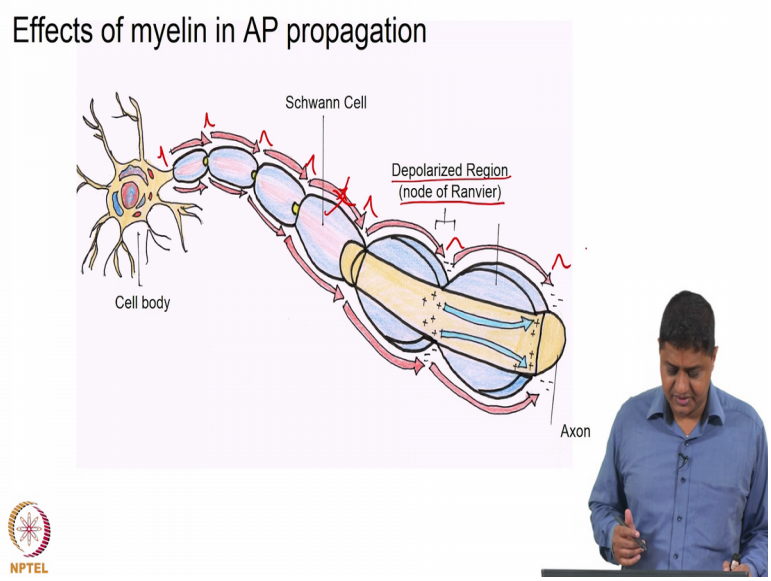

What does this do due to the action potential propagation itself we discussed in the previous class basically when action potential is generated it is jumping between one node of Ranvier to another node of Ranvier through the salutatory conduction right.

The depolarized region is just present in the nodes of Ranvier right and since ions cannot escape through the myelin that is not possible, ions cannot escape through the myelin, they must diffuse through and cause depolarization in the next node of Ranvier and let us remember that there is an increased density of voltage gated sodium and potassium channels in the nodes of Ranvier when compared with the rest of the membrane ok.

So, this increases the probability that there is going to be an action potential at the node of Ranvier, so this is what happens. So, basically myelin increases the probability that an action potential is going to be propagated. Actually it increases that by a very high number right. So, basically it increases conduction velocity, it also increases the length constant right.

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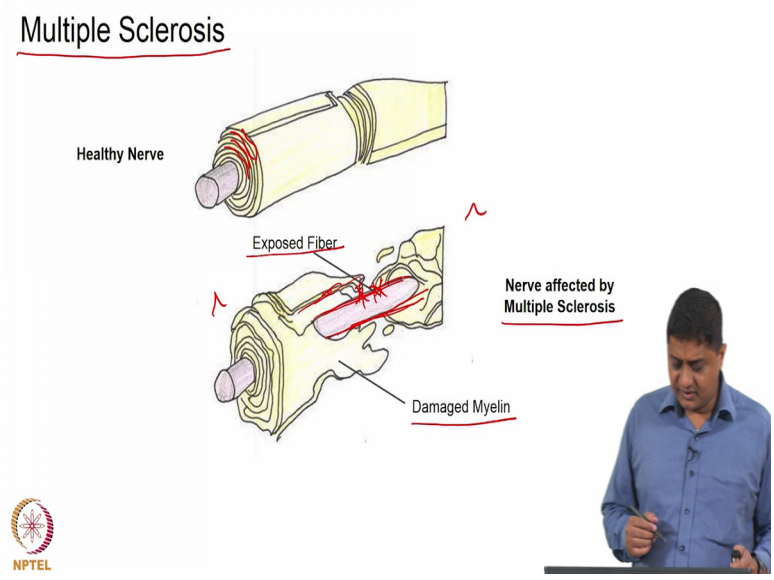

So, what could go wrong right; a healthy neuron has multiple layers of myelins surrounding it, but in some cases, in some diseases such as multiple sclerosis what happens is that, this axon becomes exposed; myelin structure and function is compromise such that action potentials are not carried from one point, from one node of Ranvier to say the next node of Ranvier, because myelin is damaged and just the axon itself is getting exposed and there are not many voltage gated channels in this exposed region. A

question is what causes the damage to this myelin; that is the question. Actually we know what causes it, but we do not know why it is caused, what causes this situation let us go back and analyse the situation.

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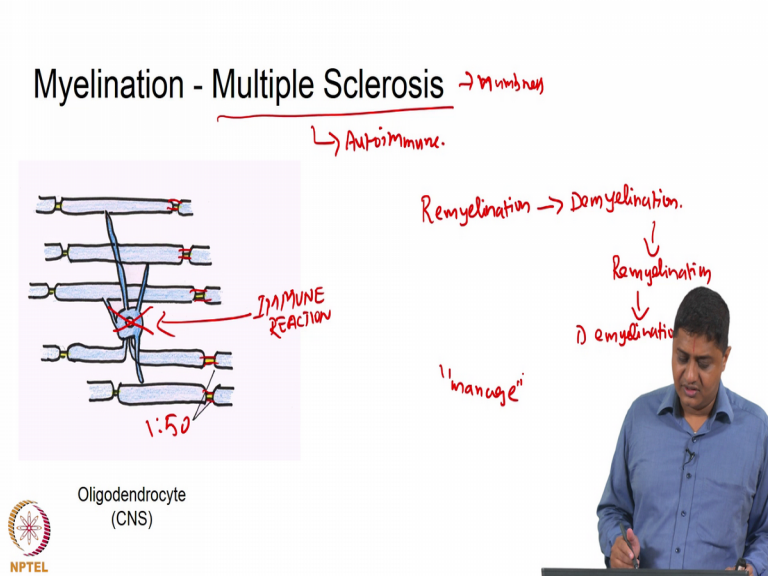

Remember the oligodendrocyte, 1 oligodendrocyte myelinats about 50 axons we said that earlier, if so; that means, we said, we also said that this is an efficient arrangement that you know 1 Glial cell myelinats 50 axons, it is a great and efficient arrangement, but the baggage that comes with this is that if for whatever reason this oligodendrocyte is dead, then all these axons become unmyelinated, the question is, why would this oligodendrocyte die, what could damage this oligodendrocyte? Actually it is due to multiple reasons; one reason is the immune systems reaction; if the immune system for whatever reason suspects or classifies this oligodendrocyte as an external agent.

Let us remember the immune systems main role is to prevent the entry of external agency into the system, if for whatever reason the oligodendrocyte is classified as an external agent, then the immune system attacks the oligodendrocyte and kills it thus demyelinating all the axons myelinated by that oligodendrocyte that may be up to 50 axons right.

So, the question is then why does the immune system perceive this to be an external agent; that is the question actually we do not know the answer. So, this situation is called as multiple sclerosis. There are many reasons why this happens. One main reason why

this happens is immune system reaction are one major type of multiple sclerosis, is basically autoimmune type of multiples.

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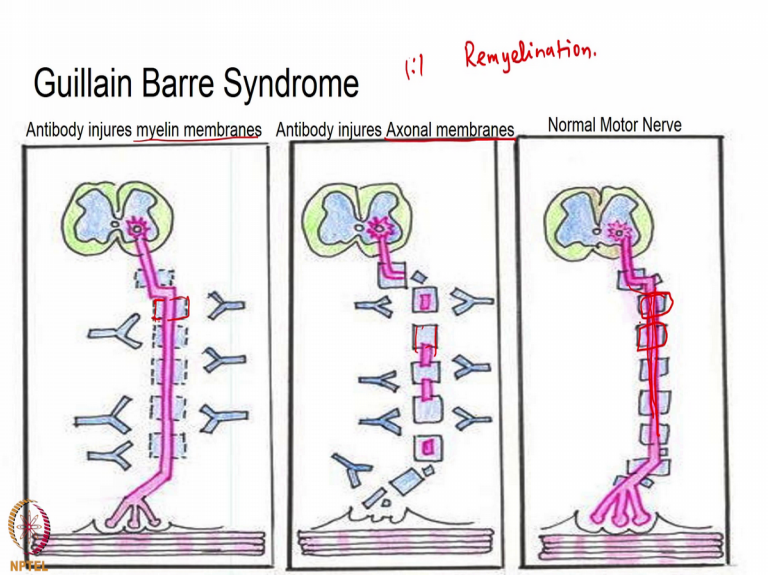

Now, if this is what happens in the central nervous system, what could happen in the peripheral nervous system. In the peripheral nervous system we said that the myelination happens in the ratio 1 is to 1. So, 1 Schwann cell myelinates 1 axon, this is what we said, but that does not by itself protect does it the axon, because it is possible for that Schwann cell to be killed, say by an autoimmune reaction, when this affects layers of myelination and when this affects the axonal membranes, basically what you have is, broken axonal membrane right what this will do? Basically this prevents communication from one point to another in the peripheral nervous system.

So, essentially leading to weakness and paralysis, usually in this case in Guillain Barre syndrome what happens is the symptom is that the paralysis is starting from the food and this ascending, when this paralysis reaches the muscles of the lungs that are responsible for breathing, then you get to a life threatening situation. If by that time this is diagnose and properly treated, say for example, with ventilators then this person can be revived and usually there is remyelination that happens remyelination is basically referring to repair. So, the nervous system can repair itself, basically the axon can be regenerated and the myelination using Schwann cell can also be regenerated when that happens or until such time that happens if the person is put in a ventilator the person can survive right.

Usually this takes a few days of ventilator support for breathing, after that the person will usually survive and get back to relatively normal activities right. What happens in multiple sclerosis is again remyelination does happen in multiple sclerosis, unfortunately by that time another attack by the immune system causing one more demyelination and this is followed by remyelination, which is again followed by demyelination.

So, basically there is a fight between the nervous system for its own integrity and the immune system that is trying to attack it. So, there is a cycle of remyelination and demyelination, but by the time the patient presents to the doctor with the first symptom. There are symptoms for this diseases basically numbness, lack of sensation, inability to move, weakness etcetera right.

By the time the patient actually present to a general physician or to you a neurologist, it turns out that the damage is done. You can only do so many cycles of remyelination. A fter sometime remyelination is not able to catch up with demyelination at some point the immune system wins over the ability of the nervous system to remyelinate itself, it is only after this happens, the first symptoms appear for the patient.

So, by that time the patient present damages are already done, unfortunately after that there is only possibility to manage the symptoms, but not actually cured that is an unfortunate situation with the multiple scleroses. With the GBS of course, it is possible to revive the patient through ventilation and usually these patients are able to survive and continue with the work right so, slightly different cases.

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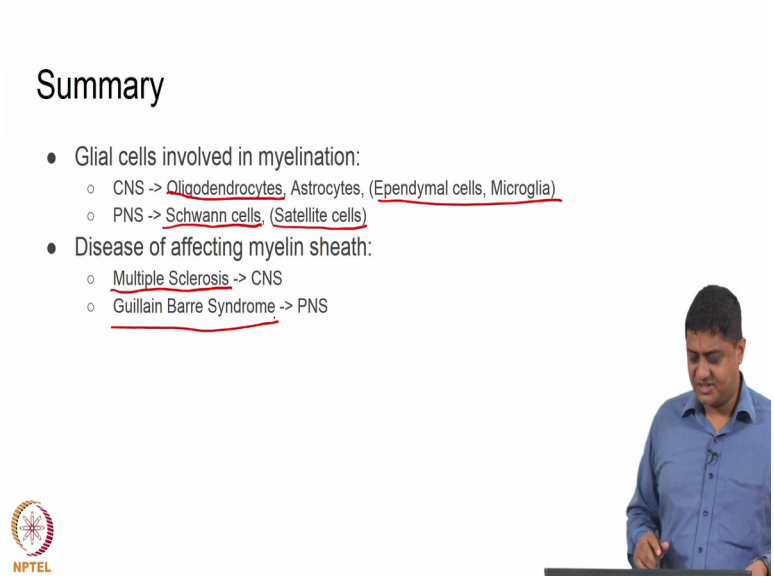

In summary we saw that in the CNS you have oligodendrocyte, astrocytes and others right, others cells that myelinate and in the peripheral nervous system, there are Schwann cells and other cells that myelinate the cells and if the myelin sheath is compromise for whatever reason, usually due to an autoimmune reaction right.

You have multiple sclerosis in the central nervous system, if the neurons, if the axons in the central nervous system, if there myelin sheath is affected due to an autoimmune reaction, it leads to multiple sclerosis. If in the peripheral nervous system the Schwann cells and their integrity is compromise for whatever reason, it leads to Guillain Barre syndrome as to why multiple sclerosis happens, as to why the immune system makes or believes that their Schwann cell or the oligodendrocyte, the Glial cell as an enemy. It is not clear, we are still not sure of why this happens. We know the mechanism what happens, but we do not know why it happens.

So, with this we come to the end of this class, we will continue our discussion in future classes.

Thank you very much.