How The Brain Creates Mind
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Lecture - 07
Dynamics-1

We left at the synapse and the chemistry; I hope you would get an idea of how the neurons talk to each other. Let us move on to the first part what I said electro chemical thing, but I actually want to skip this electrical thing and before electrical thing you will got the whole thing about at the chemical stuff.

Let me see if I will want to talk about the electricity in the brain may be. So, what do you know about electricity? We know electricity that electricity is right. So, we have it here electricity is the flow of electrons you put wires there is a voltage difference electrons flowing the direction of the current opposite to the flow of electrons, which is basic physics is the electricity in the brain same or different.

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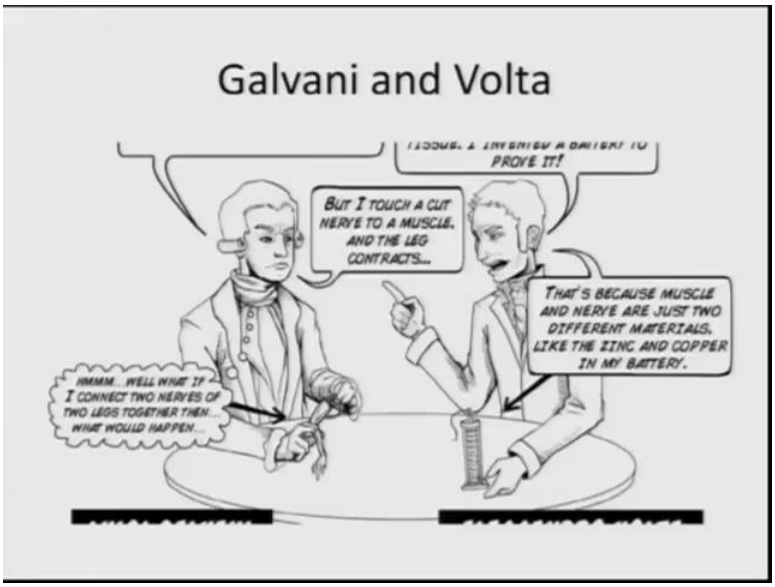

Two very important people - Galvani and Volta, you have heard about them. Volta is the man who created batteries voltmeter Galvani in an experiment with frog he was peeling them and there was loose wire and that touched the muscles of the frog and the frog jumped. It gave an idea to Galvani that there must be electricity they must be a transmission of that electricity to the muscle or nerves. So, he did he took out a cut nerve

and then touched it, again jumped. Experiment was repeated, there was experiment where frog was kept in the electricity this lightning electricity was transmitted to it and again jumped.

So, Galvani thought that and he thought correctly that nerves system has electricity. So, I told you chemistry first, but what came out first was the understanding the electricity. Volta added to it, but he always thought that the animal electricity is different from the normal electricity. It was Volta said that it is probably the same electricity. Electricity is electricity is a flow of current when you measure it.

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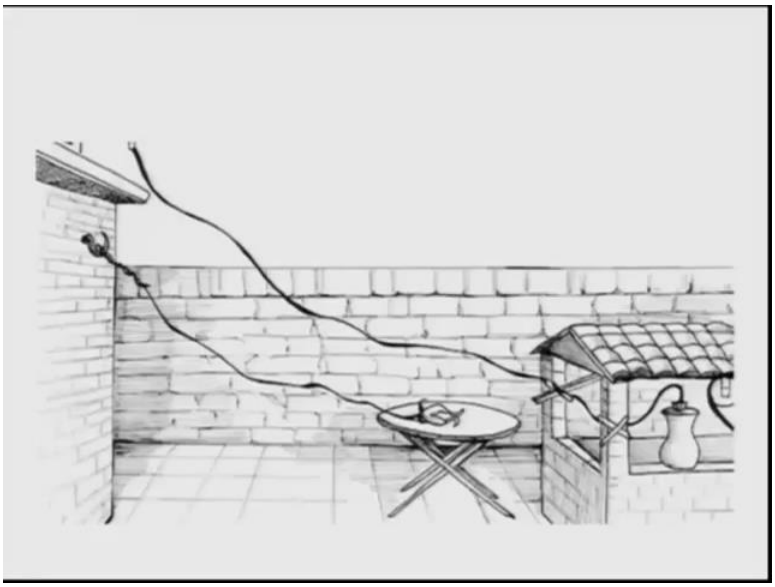

So, this was experiment in lightening and. So, you should understand that the whole thing of.

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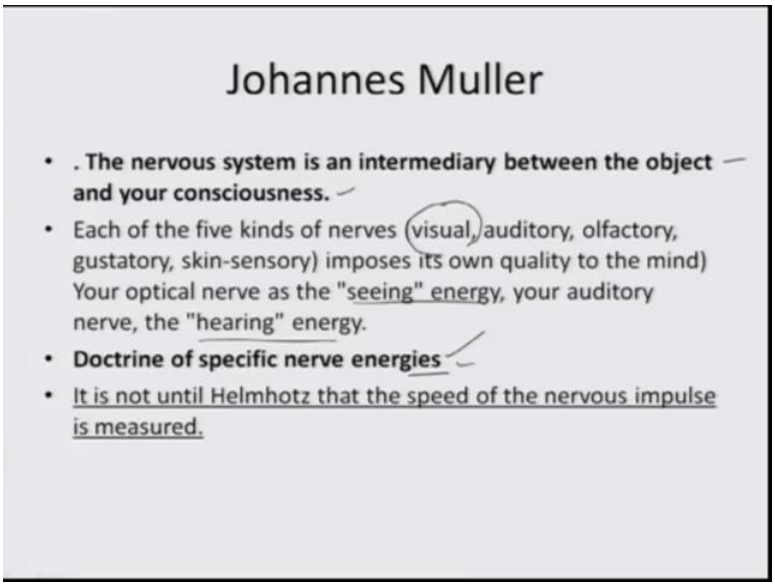

See this, the next person to add to this information and knowledge was Muller and Muller actually brought out this doctrine of specific nerve energy.

So, he said that this whole nervous system is between you and the object the external world and you. So, you do not know the world unless there is a nervous system and what he said what was specialized that, if you stimulate certain nerves like if you stimulate visual, what you will always, whether you stimulate the visual nerve, you can experience this if can put pressure in to your eyes, what you will feel is two things one you will feel the pressure on this eye lid, but what you will also see with pressure is image in the back of the mind, because whether you are giving pressure or whether you are giving touch or view of giving anything the nerves which are getting stimulated will always create a imaginary. So, whatever you do with your ear do this, you will hear a sound that is the doctrine of specific. So, that also gives a fill up to the area of a specialization.

So, your optical nerve is will always see, your auditory nerve will always hear now some people say that the brain is plastic and you must heard you going to replace one neuron to the other and if you put it there in there and it will take up the function that can happen, but that can only happen when there is a critical period of growth happening, when they have really not the nerve have not taken up the specialized work till that time in the critical period very early in life if you can replace then may be auditory neurons can see or the visual neurons can hear. It also happens in something in a different type of

hallucination, where the people can hear a rose, hear red color you cannot hear a red color, you can see a red color, but some people when they hallucinate this called Synesthesia. A one area of the brain when it is stimulated triggers of the other area and people start feeling that perception where it should not be there normally this is says Sheshadri. If you read Ramachandran's book vs Ramachandran tell tale brain and (Refer Time: 05:54) then you will find that this is he talking about Synesthesia, whether you have understood this thing, but he has detailed it very well.

Now, the next question will be what speed? This nervous impulse is measured. Let me ask you just do a small exercise. Suppose I ask you to by some hypothetical mechanism that you want to see something in London right now and if I give you a light source which will go fallen big Ben and you can see the image hypothetically, will it take some time it will because light will have to travel or you forget that if, even if you have to want to see just 500 yard from here you can send a light. Light will reflect it will take some time, but if I ask you to just think about big Ben, your big Ben is there. Your grandmother sitting in the village and I ask you to I give you a mechanism by which you can shoot a light which will it is all labeled it will go to grandmother fall from her face and you can see your grandmother.

We will takes some time 3 to 3 into 10 to the power eight that is speed of light, but if I ask you to just you want to see your mother, grandmother close your eyes that is the real mystery we still have not answered. You can close your eyes, you memory and maps of your mother a grandmother will immediately will flash.

May be of the people you do not know may be, but all that has to be in your mind. These are the maps and memories, which create image first other light speed or even a thought. If you really look at this speed at it which the whole thing is going on it will still take some time, but thoughts really goes on really fast. That is a hard problem of research which we will talk about towards the last lecture when the may be we will decide about 100 years, next 100 years.

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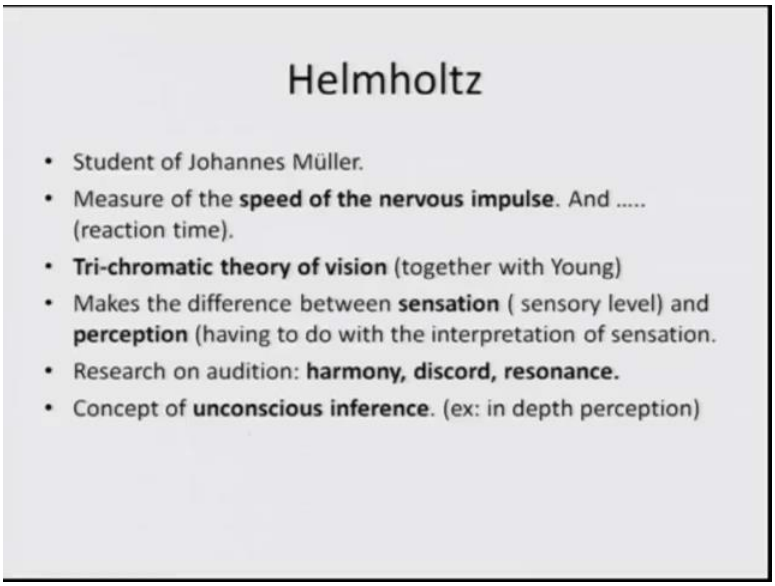

So, Helmholtz, this is a very important character you should read about him and he was a very bright guy. He measured the speed of the nervous system because speed of the nervous system is it has to be something that will determine your reaction time. Something comes suddenly within that time it has to really and that is speed in the brain varies from 0.5 to 120 meters per second. 0.5 is for neurons, which connect within the cortex very slow, 120 meter second are the long distance neurons which are covered in myelin sheet, so will talk about it.

Then he brought out he was such a bright guy tri chromatic theory, that I is have cons which differentiate between the basic colors. He made out the difference between sensation and perception. There is a difference sensation is just sensation giving a meaning to it is perception. So, giving perception happens in the higher centers of the brain, sensation happen at the very neural level and then in the whole Helmholtz you must have study those you know hormones and. So, this is the guy, now he must have been really bright guy to do so many things. So, this is again a neuron.

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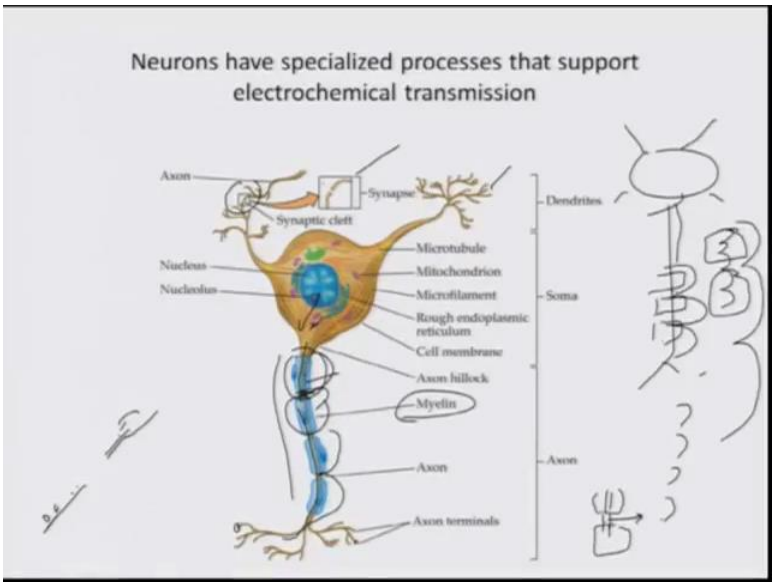

Now, let us show a glory because you know by you know lots of things. So, you know that this fine thing here is projected here called synapse, with a synaptic cleft, these are dendrites the lot of intracellular structures we are not bothered about that right now. Here what do you form are neuro transmitter, which go through what you call micro tubules; some of you who have heard of roger Penrose. The mathematician from I think he is an Oxford. So, Penrose has with a guy called Stuart Hameroff has stocked lot about the basis of consciousness, based on micro tubules and all.

So, this transmitter is like micro tubules, neuro transmitter they just ride over, it like a scaffolding they keep moving like small (Refer Time: 10:21) you have seen and they come to here, here they go to this end of this end of this is axon terminal, current comes here. Now what is this blue thing? Normally if you see this cell body and axon the current go slow, how it goes I will tell you, but this is call myelin sheet.

Now this myelin sheet, if you remember I was talking about the wiring and we talked that if you make the wire thick, the size will increase the speed will also increase, but you cannot, that you cannot fit, so many sizes. So, not all neurons are myelinated. Most of the long distance neuron which have to come from brain to say hand or to spinal cord they are myelinated. White matter the six layer where the white matter started that some of them are myelinated some of them are not because where it is not myelinated it has to be the current has to go on like this which is still consuming thing.

In myelinated the current jumps between this you see the yellow things between blue current jumps like this. So, between this makes the whole thing faster and these are called saltatory conduction jumping salutatory conduction. Otherwise non myelinated, it goes on like a continuity this area is myelinated this area is myelinated; that means, all the receptor activity is happening in this areas which are not myelinated right. This area, all the sodium potassium is going on in and out.

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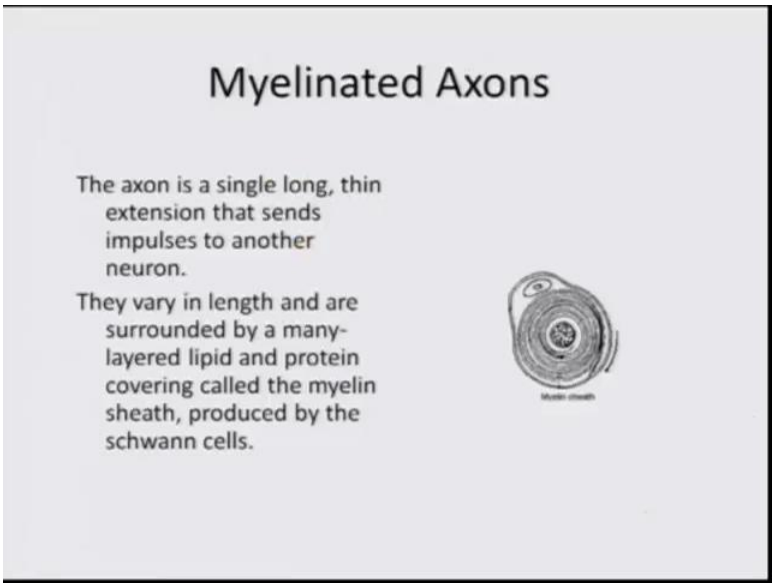

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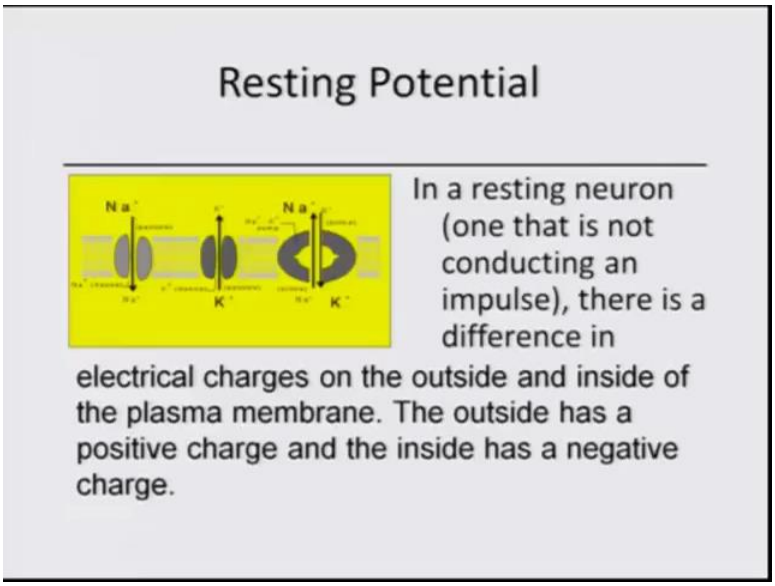

So, the axon single long this is the myelin sheet. What is this actual electrical activity in the brain? So neurons once they get activated, they remain they may not be firing, they may not be achieving anything, but they are electrically active. So, that is the definition which we will come to later.

So, there is something call resting potential. Now remember I told you a lipid layer, protein layer, potassium channel, sodium channel. So this is what is happening, there is a huge dynamics we will not go into detail of it because that contains another set of information, but read it, in a resting neuron one that is not conducting an impulse there is a difference in electrical charges on the outside and inside, sodium and potassium, potassium is going in sodium is coming out. Why sodium potassium ATPase, the outside has a positive charge and inside has a negative charger.

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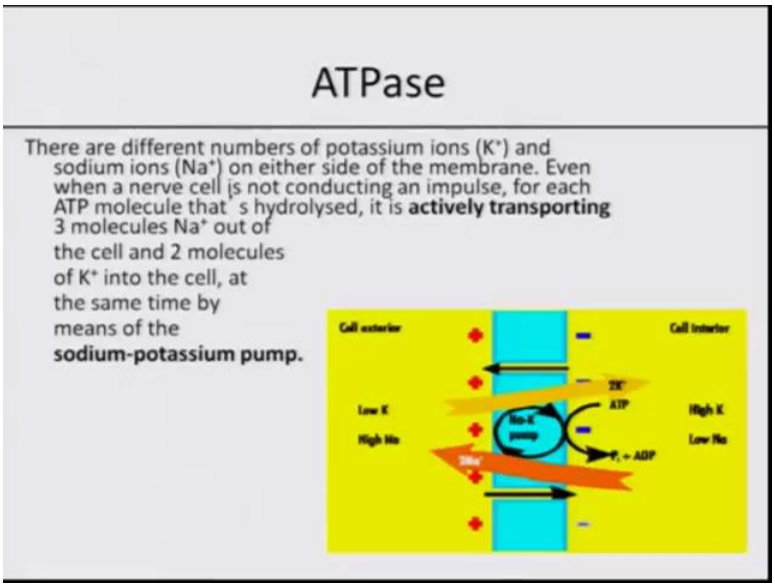

This enzyme it I mentioned it, there is a difference number of potassium and sodium on either side, so 3 molecules of sodium outside two molecules of potassium in. So, this is called a sodium potassium pump in. One way I think, once this shuts off that may be death, we really do not know the nothing transfer.

So, cell exterior is a see is a low potassium high Na here and this has become because the lot of potassium initially at, there is lot of potassium outside. So, it keeps going inside. So, that has to be brought out.

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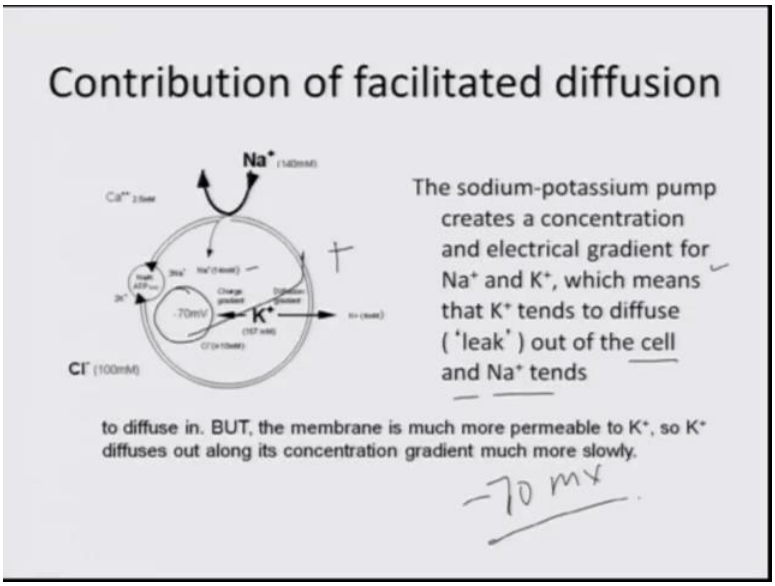

Sodium potassium pump energizes it. This is again the same creates a concentration and electrical gradient for sodium potassium which means that k tends to diffuse out of the cell and sodium tends diffuse in, but the membrane is much more permeable to potassium. So, the concept this whole game creates a resting membrane potential of minus 70 milli volt. This is the resting membrane potential. This much electrical activity is happening in each neuron on the base line nothing is beyond this. So, this is also electrical activity.

So, if the two rest that you, switch off the lights there is no light or a take out the plug your machine computer is off, but does the computer go off, computer does not go off, otherwise you know what will happen, every time you put it on you will have to reset the time, your computer has a in a clock which keeps it on. Minus 70 milli volt is the basic rusting potential, such a membrane is called polarized. So, positive negative minus 70 milli volt this is polarized rusting polarized state.

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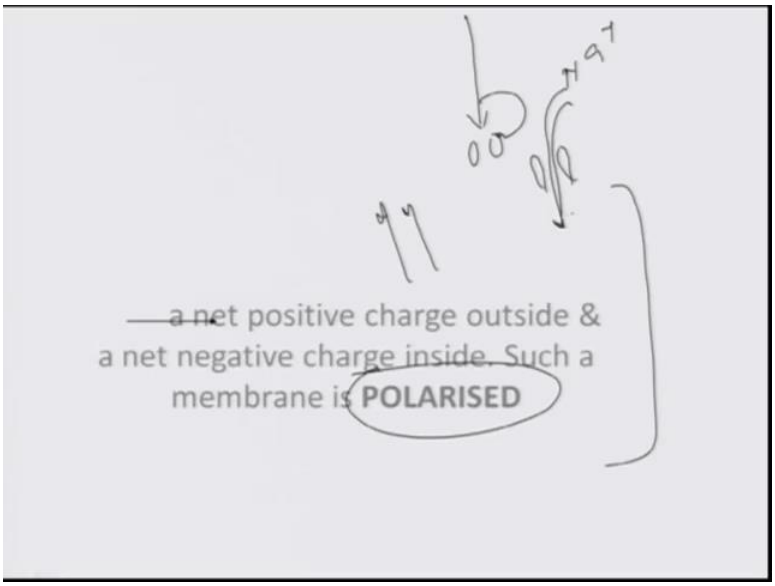

What happens is a electric current is coming, this is say one dendrite, one axon this is the receptor here, neuro chemical comes here, it binds changes the chemistry, the shape sodium which was normally coming out flows in, after one sodium flows in what start happening, is that the inside starts becoming positive. This is the change in the permeability of the membrane to sodium.

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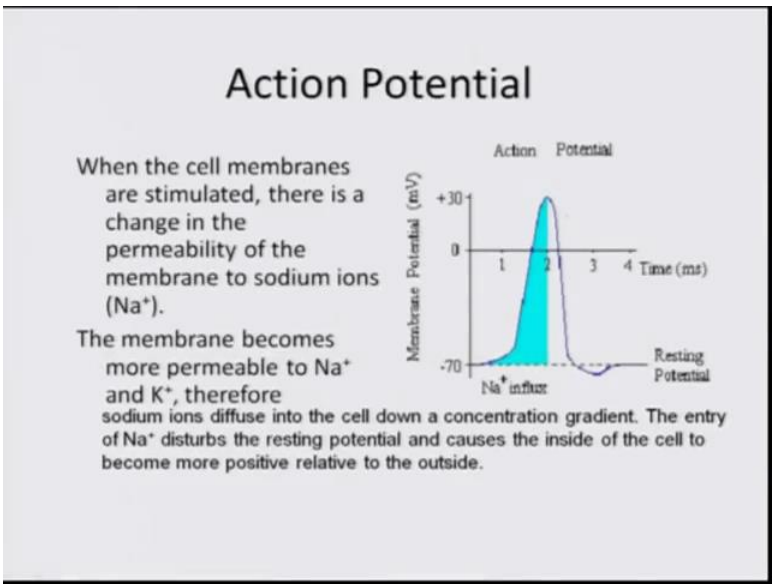

Now, if you remember, if the membrane is more permeable to potassium. So, potassium is doing it concentration gradient on it is own, but why I am telling you all this is a basic

once you understand this then you can build up what is happening in the brain or without this otherwise you will not know what is happening. So, suddenly when the legion gated or voltage gated channel open, suddenly there is sodium which goes in. As it goes in the lot of voltage gated channel also open up it is like sudden information like you know, if you know what we call quantum entanglement where it is just information goes faster firing very fast, it is still at the final despite not at the light speed.

It opens up and suddenly it goes in again and again. The moment this start happening because more permeable to sodium, the entry of this sodium disturbs this resting potential which is minus 70 volt and it goes up to it is starts rising because inside becomes positive, this state of inside becoming positive and outside become negative is called Depolarisation.

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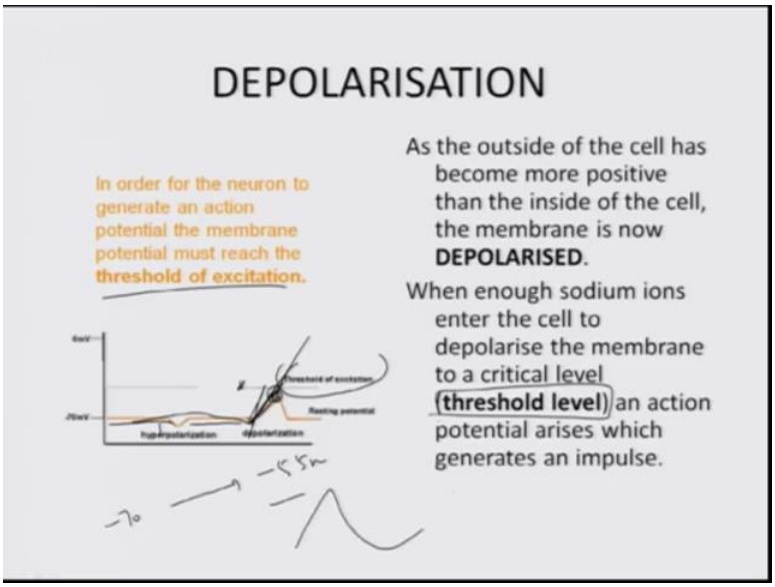

Now, if from seventy milli volt the whole gradient goes up to minus 55 milli volt, then neurons become excited. So, this is called a Threshold level. Now Threshold level if you look at this graph, it is going from 70 milli volt, there is a hyper polarization, maybe there is more sodium outside and this at almost like if you come it comes here, it has to fire from here it is to fire threshold. The threshold of excitation is around minus 55 milli volt. From there what it fires is called an action potential.

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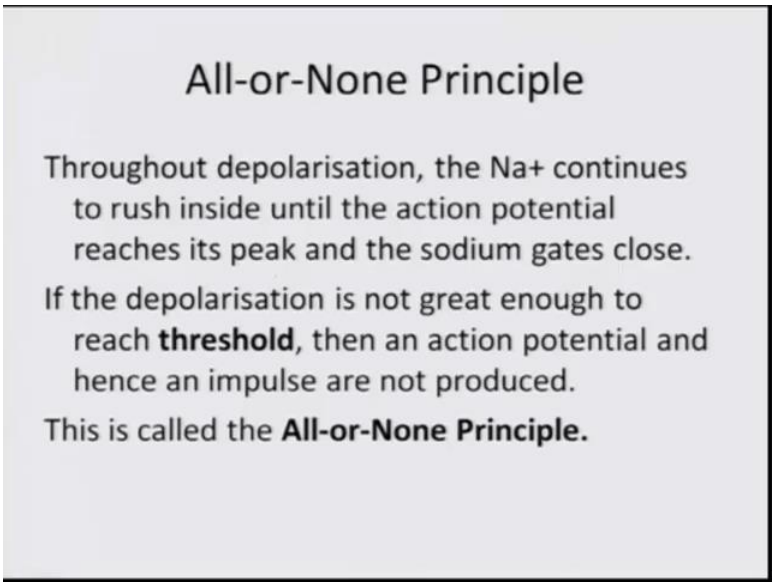

So, action potential cannot happen partially, either it will happen or that the whole thing will go and finish it. This threshold of excitation, if this depolarization crosses it here it comes here it goes beyond this which may be around minus 55, then it will fire if it goes and dies below that, now how does it die and now how does it excite, if there are enough excitement, enough glutamate, enough number of I remember 1000 to 10000 neurons, if most of them are sending a firing excitatory single it will fire, if there are more inhibitory it will not it will not fire. So, if the Depolarization is not great enough to reach threshold then an action potential are not produced, but if it crosses then it will fire. So, it will send this wave of action potential through the axon.

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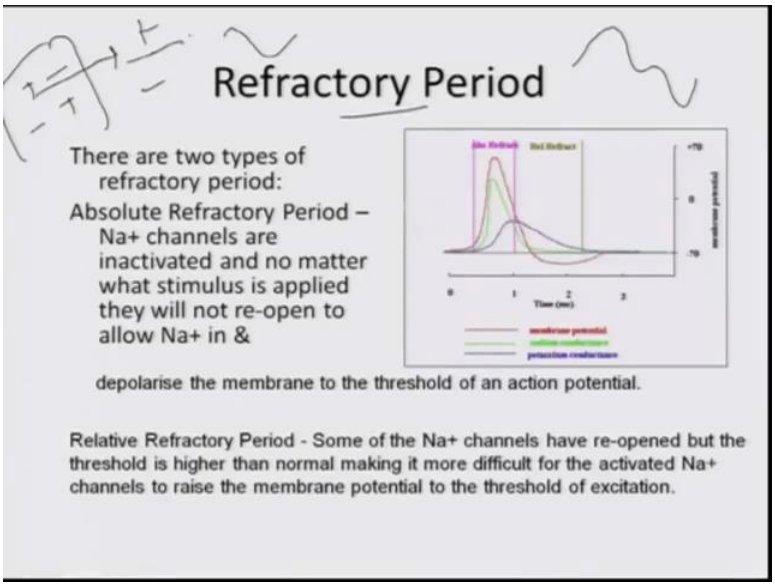

Now, what happens, as the part of it is gets depolarized it very soon gets repolarised also. So, one patch it is here, suddenly this becomes depolarized right, this is a patch. It will again go on to it will become positive again, negative again, but this wave of depolarization would have passed to the next adjoining area. So, this part which has become repolarised, will not respond for a certain period that is called a Refractory Period. So no amount of signaling which you send will work.

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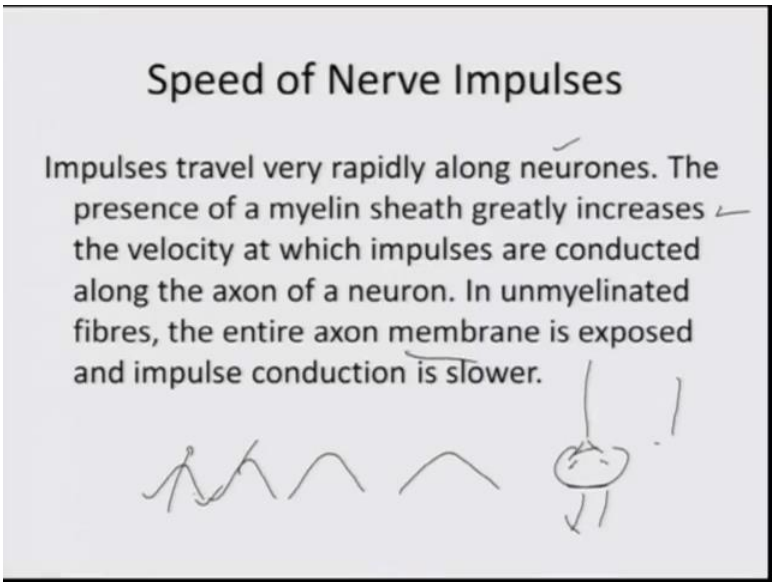

So, this is a type of game which happens. So, it almost, if you look at it almost carries like a wave of depolarization, repolarization and it moves, till it comes to again the axon terminal to pass it to the next neuron through chemical gating. This is how it works. Electrical activity, threshold crossing, sodium potassium, controlled by the chemical switching which can be altered through medication or anything, so they travel very rapidly. The presence of myelin I have already told you it increases the velocity at which impulses are conducted along the axon of the neuron in unmyelinated the entire membrane is exposed and impulses conduction is slower.

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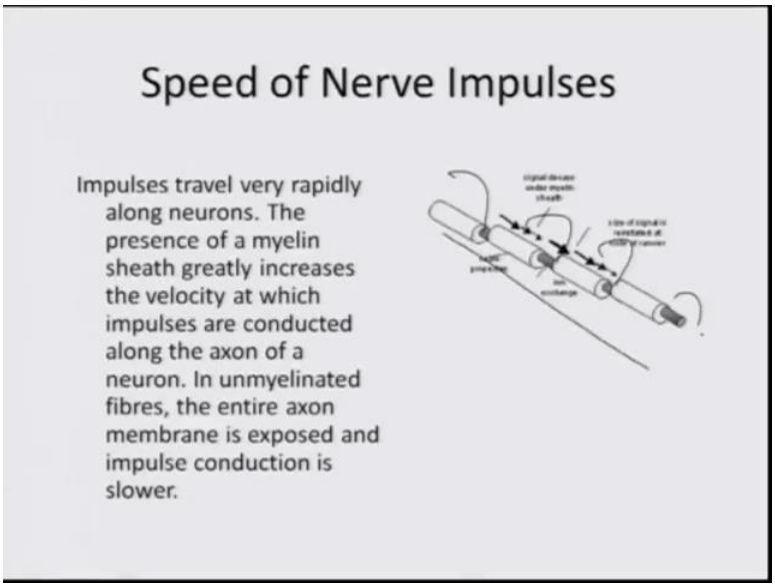

Speed as I said, there is a cable property to it jumps, otherwise it has to go continuously like this.

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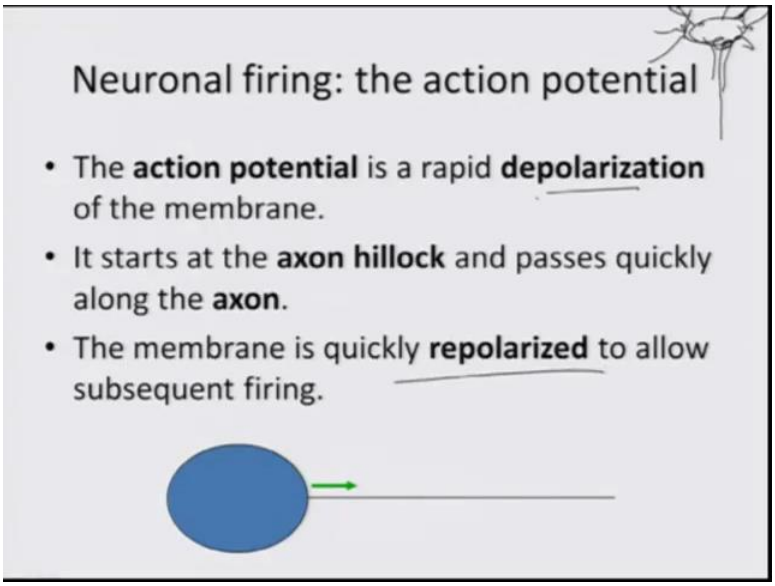

Again just to mention it. It starts at the axon hillock, this is a cell body here dipole all these dendrites which are coming here they transmit it and depolarization starts here. The membrane is quickly repolarized to allow what to allow the next see this.

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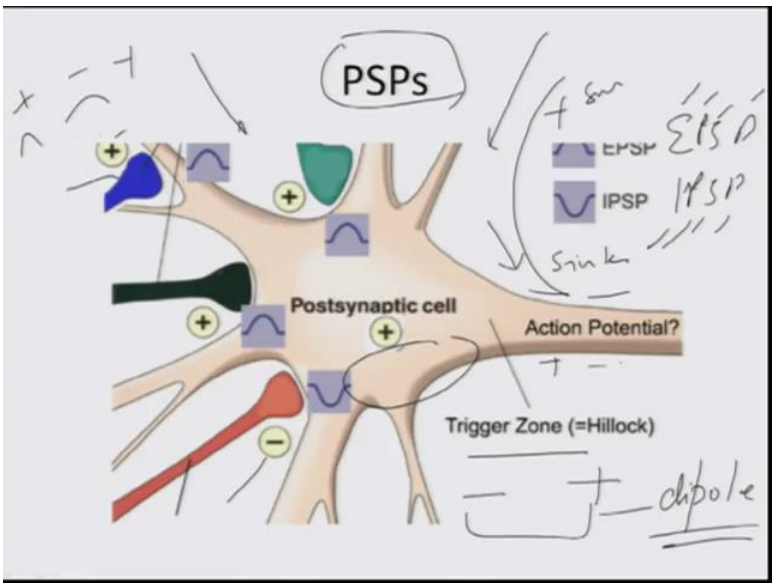

Now, comes the interesting part if you have. So, many in inhibitory excitatory all sort of stuff going on, how does neuron actually get to it there is something called postsynaptic potential. There is something called EPSP and there is something called IPSP. On the surface it may appear as a linear process, but I think there is lot of non-linearity which

goes in because the number of things which are coming, some are excitatory, some are inhibitory, some are rays and trigger zone is, this where action potential to happen all this excitatory postsynaptic potentials, this is inhibitory postsynaptic potential. They summit and this summit here, if you see this lot of them are coming.

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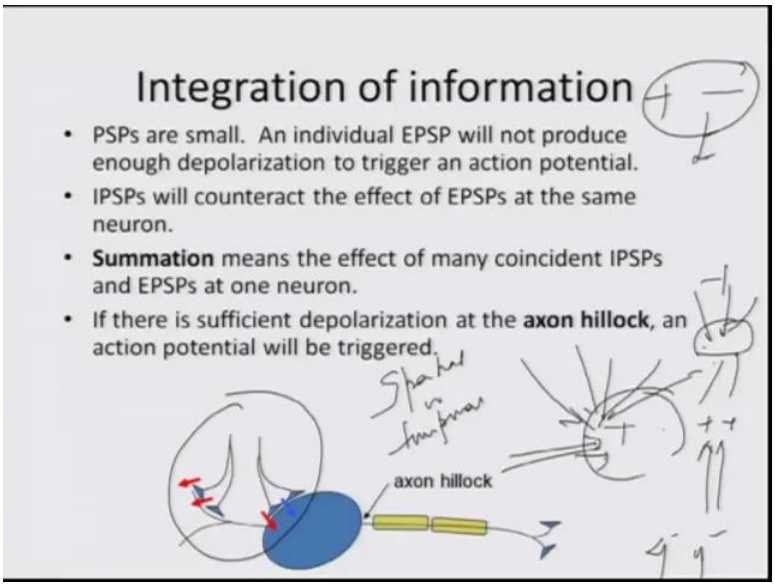

So, these are these are very small currents, very small currents. These currents in individually if you send to one neuron and some EPSP by one neuron it will not happen. So, because if there is excitement, there is inhibition also this may actually cancel each other. What happens the sub multiple neurons fire, remember 10000 to 10000 synapses. Suppose these many are giving positive and these many are giving negative. So, there is a summation. A summation can be of two type summation is either it is Spatial summation or Temporal. Spatial means within a given space, there are certain numbers of neurons which are positive; there are certain numbers which are negative.

So, they will counteract depending on the neuro transmitter which is going gaba is more or glutamate is more or there may be that certain neurons are firing positive, after that there is are negative, after that there is a positive, that will also determine. So, either there can be a temporal summation or. So, the whole story boils down to this chemical gating and electrical signaling. Now before we come to this I would also like to tell you how may be we talk of EG then probably I can tell you let me see if I have EG in this, what happens is that when see if this is a axon let me see this. When it is depolarized

negative outside and positive inside, it will cause what you call a sink and the positive if there is a positive outside (Refer Time: 25:33) this will call a source, that is I think the conventional definition.

The multiple neurons in the cortex in those 6 layers on the surface of it, there are multiple sinks and sources. This forms what you all know is called a dipole. Now over the surface of the brain is dipole which are existing and which are dynamic dipole it keep moving with the sinks and sources. This is what gives you, when you put plane simple electrodes on the head silver, it picks up these currents, now it is it does not directly pick up. So, you can when I talk about measurement I will tell you how to investigate in the next lecture you just pick up these currents and it is a dynamic moving current from the surface of the head and this current is coming from Brain, Brain has 3 coverings, it has lot of blood vessels, then it has huge thick skull, it has hair over it. So, may be the amplitude decreases, this is a basis of EG also there is lot of when the current is flowing.

So, remember brain current is not electron current, it is a ironic current. This and obviously, if there is a current there has to be a magnetic field around it. So, there is actually electro magnetism in the brain. So, we come nearer to the nature physics there is electro magnetism is one of the force of life. Now whether our brain is affected by gravity it is oriented to gravity through the magnetic field, we do not know, but obviously there must be some electromagnetic activity. We will talk about this in the next lecture and we will talk about how to really peep into it.

Thank you.