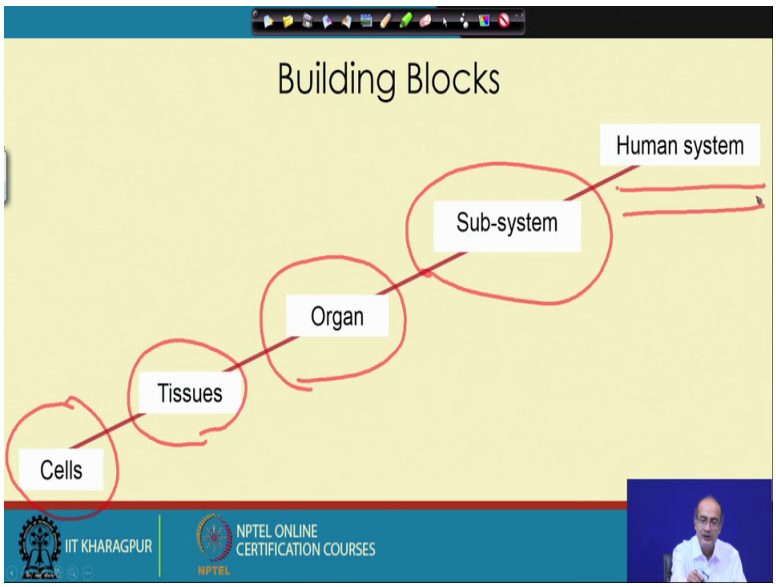
Biomedical Signal Processing
Prof. Sudipta Mukhopadhyay
Department of Electrical and Electronics Communication Engineering
Indian Institute of Technology, Kharagpur

Lecture – 02
Preliminaries

(Refer Slide Time: 00:21)



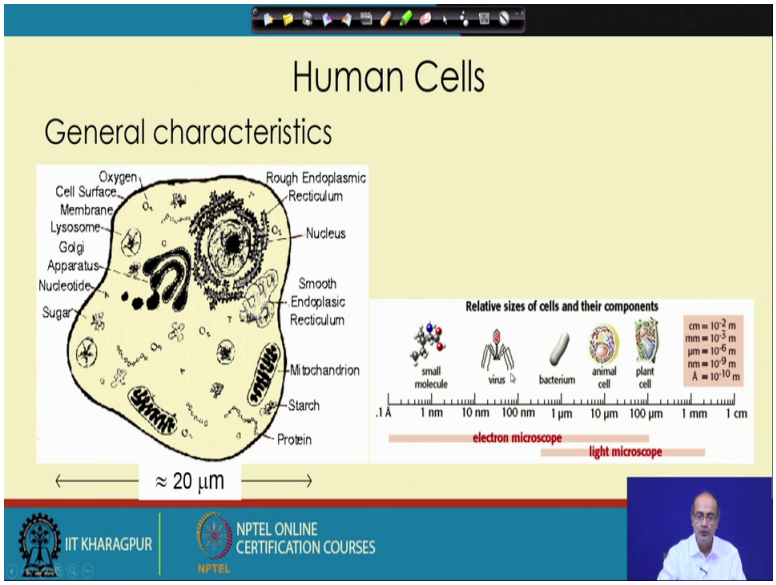
So, now let us get into the preliminaries of this subject. So, first we will look at the organization of it at the lowest level of the body that we get the cells are there. So, which are the basics constituents of the human body and in a human body for an adult, we have about 100 trillion cells and it is more interesting to know that out of them that every day 50 million they dies and another 50 million comes back actually are generated to take their position. So, that the body does not degrade or degenerate. So, that is the way they actually make up for the loss and this cells are the basic building block they are full of that the fluids and we can also say that outside the cell there are fluids. So, you can say they are also floating in the that the liquid.

So, half of the body is actually made of liquids and cells of a particular type in terms of their that function as well as their constitution they form the tissues for example, we have that muscles we have the that skin. So, these are different kind of tissue are there. So, then multiple tissues; that means, two or more issues they give raise to one functional unit that is called organ for example, kidney or we can take the pump in the body that is

heart. So, these are the organs and multiple organs together they give rise to one sub system. So, sub systems like that that what we covered in the previous the talk, we told about the digestive system nervous system. So, there are lot of sub systems like that and all such system sub system when they act in a harmonious way we get the existence called the human system ok.

So, this is very important for us and we would like to learn about it and. So, we will go ahead with these thing. So, next we would like to look at that the human cells.

(Refer Slide Time: 03:08)



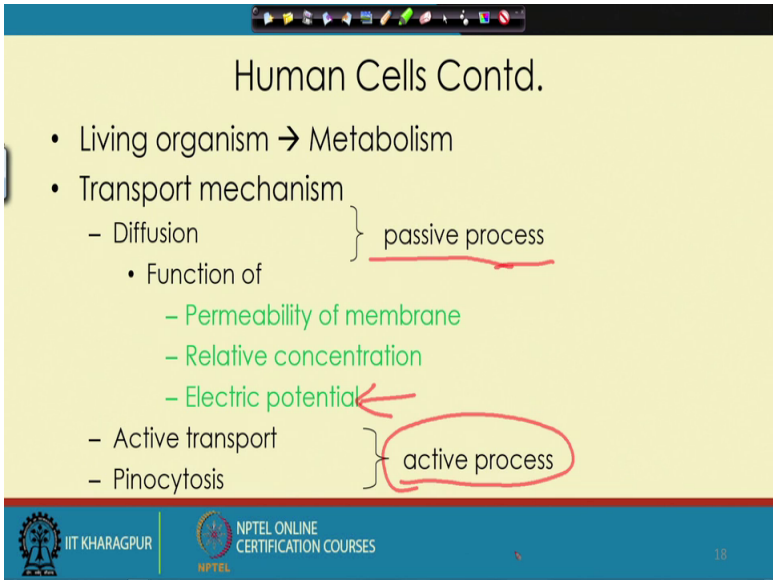
So, first let us look at in this scale that of that the size, that the smallest things could be the molecules which are inert, the small molecule they are inert then we get the virus little bigger than them and there in the border of actually the living being and the inert objects outside they cannot procurate. So, they are like inert objects, but once they get into a cell they can actually create the replica and create a very difficult situation for the cell to survive.

Then we have the bacteria's they are living being and after that the animal cell or the human cell for which we are interested and little bigger than the human cells are the plant cells. And here usually when we talk about the cells we use this unit angstrom which is 10 to the power minus 10 meter. So, in terms of angstrom usually we talk about and we get this cells is that animal cell is in diameter about 20 the micrometer and it is actually covered by it is surrounded by one semi permeable membrane and within this

membrane, we have some liquid called cytoplasm and outside also some liquids are there, that is called that interstitial liquid we can say. So, both the sides the liquids are there and within this we have lot of objects some of them they are living they are called organals all to in together for example, mitochondria that is the power house of the body and then another organal is actually the nucleus which is the controlling unit apart from that they are actually there are many inanimate objects like we have the proteins, we have the starch which are required for actually generation of the power as well as for the building of the that the cell or repairing of the cell.

And within in the nucleus that we get first of all a boundary and inside that there is that we get some fluid called nucleoplasm and we get some circular objects within that. So, they are called nucleoli they are filled with R N A or ribonucleic acid and this nucleus also carries something very important which are D N A, that D N A's are the keys that whatever the characteristics of the cell is there for that person that the characteristics are there that is encoded in the D N A and these D N A's are or the genes are actually consisted consisting of the that D N A or deoxyribonucleic acid**. So,** this is in short about the cells.

(Refer Slide Time: 06:47)



Now, we should move forward we should go for that how the cell actually acts as a living being. So, for the living of the cell metabolism is important or in simple what we can say we need to release the energy what is required for the operation of the cell. And

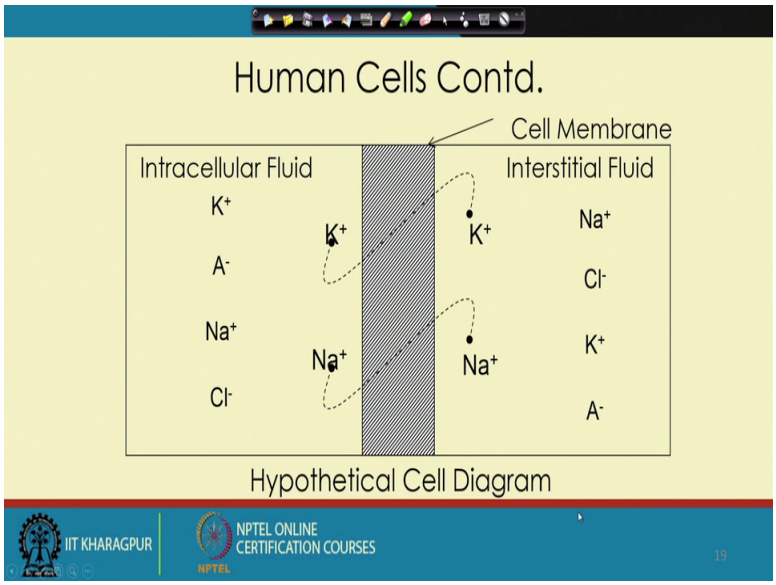
for that what we need we need to say glucose for liberating the energy and the oxygen and as we need them and we need to burn them in the power house is mitochondria which helps to release that energy, after that that we need to for that to continuously generate that we need a supply of these two things the glucose and that oxygen and also after that that in product that is generated out of it that is carbon dioxide we need to get rid of the body.

So, all these things we need to do. So, we needed transport mechanism for that and this transportation of different things are primarily happening or most of the parties happening through diffusion and it is a passive process the first thing we should note that it is a passive process this our diffusion and how it works, the first thing which makes it possible that we told that cell membrane it is a permeable or semi permeable we would say. So, that permeability allows for the, that diffusion of different kind of that ions and particles that is a first point. Second point is the diffusion is a is possible because there is a difference in relative concentration; that means, inside the cell and outside the cell for a particular kind of say ion that must have difference in concentration without that diffusion is not possible.

In fact, in the nature there is a tendency to go towards the, that the lowest energy state or the what we call that equilibrium and for that what happens that from the high concentration some of the that particles you can say that ions they would leave and go towards the lower concentration. So, they are trying to go towards the uniformity or balance in concentration and another thing comes into play in this diffusion that is the electrical impulse or electrical potential I would say and how that happens, when we are talking about the diffusion of that the ions and there is a imbalance of charge inside the body and outside sorry inside the cell body and outside the cell body that that give raise to some potential difference.

Now, that potential difference or that potential gradient it actually motivates some of the actually repluses some of the ions and attract some of the ions. So, they also influence the process of diffusion and in the later part today we will see that how that actually take part in the diffusion. Apart from the diffusion we have that other two things that active transportation which is an active process and we have a specialization of it called pinocytosis in this active processes, that the cell spins a little amount of energy where as for the diffusion no energy is spend by the cell.

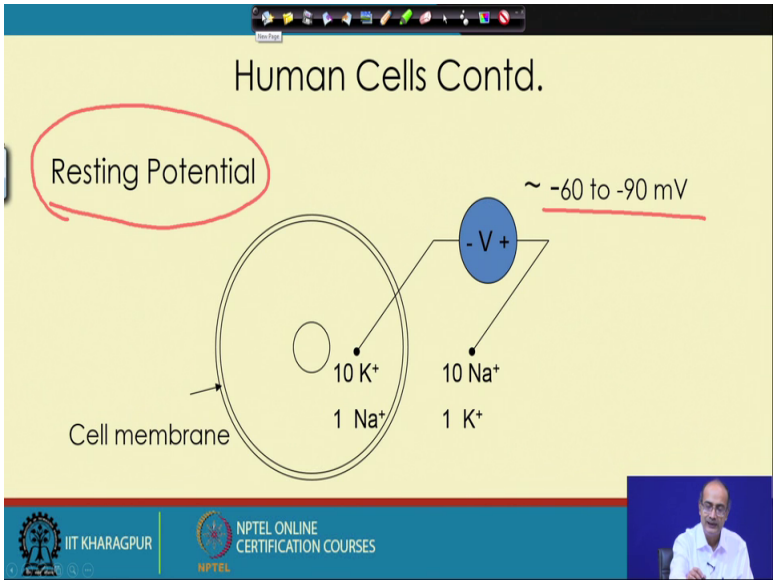
(Refer Slide Time: 11:06)



So, now we look at go to the next part let us see that how this diffusion takes place. So, here we are have a hypothetical cell diagram, the left hand side that we have the intracellular fluid or the cytoplasm we can say and outside the fluid it is the actually the liquid of the that we can say that interstitial fluid or that the fluid which is stored in the tissue, now both of them they have concentration of sodium, potassium, chlorine and other enhances.

Inside the cell we get actually the concentration of the potassium ion and the bigger enhances they are more compared to the outside and outside the cell we have more concentration on sodium ion and chlorine ion and because of that there is actually a concentration difference in two parts, that means within the cell and outside the cell and cell membrane being semi permeable it allows the movement of the potassium and say from the higher concentration to the lower concentration that is went outside and for the that sodium ion to go from outside to inside.

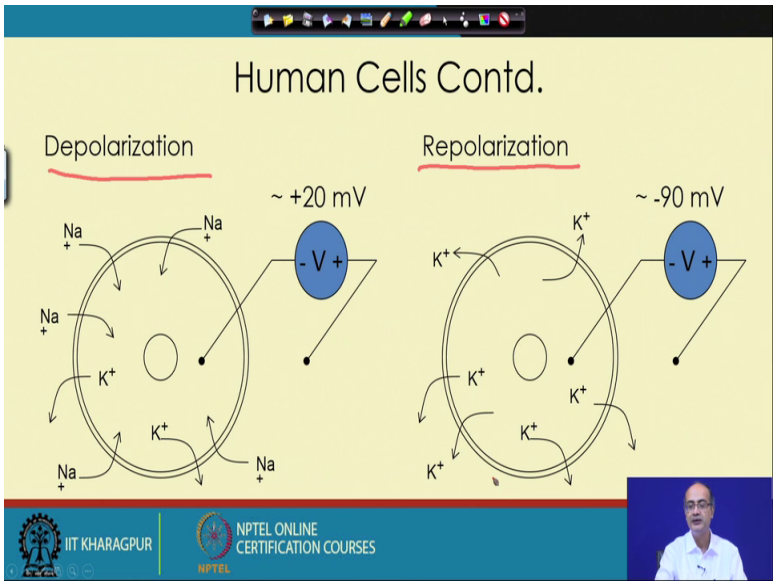
(Refer Slide Time: 13:28)



However that cell membrane is not actually impartial in this game, it has an important role and what we find that it is very much partial the way it is allowing the potassium ion to get out of the cell they are not allowing the sodium ions to get inside in the same way and as a result of it what happens that is inside the cell that we lose the that positive ions. And it gets into a state of actually negative potential and what happens in that case as it gets into the negative potential of the range of minus say 60 to minus 90 volt or sometimes if you are asked to tell about one single voltage, then we can say minus 70 micro volt a sorry millivolt.

So, that kind of voltage that we get across the cell membrane, that negative potential now into actually resist the flow of the positive ions outside. So, equilibrium is set this electrical potential that is forcing the, or repulsing the potassium ions to go out and we get an actually imbalance like these that the 10 is to 1 concentration of potassium ions from inside to outside and just the opposite for the sodium ion. That 10 is to 1 from outside to inside the concentration difference actually we get and this potential is maintained. So, long this equilibrium is not disturbed and that is why we call this potential as a resting potential. Now let us see that how these actually equilibrium can be disturbed.

(Refer Slide Time: 15:20)



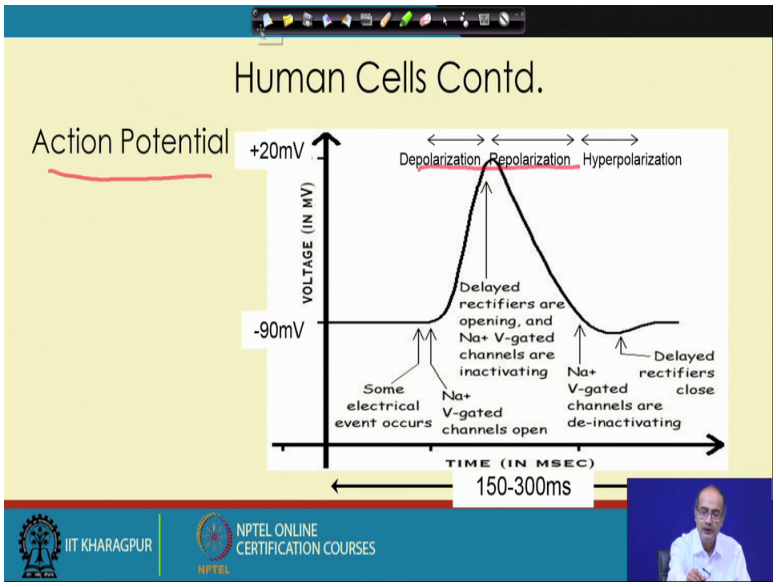
Now, if there is a stimulus given to the cell membrane which could be an electrical actually stimulus or a chemical stimulus, suddenly from one point that the permeability of the cell membrane change and it spreads all over the place and cell membrane suddenly become sensitive to the actually the plight of the sodium ion and they start allowing them to come inside, you can and that happens naturally by diffusion because outside the sodium ion concentration is much more than the inside and at the same time the potassium ions also they are getting out of the cell, but it is not coming out in the same rate.

Now, as if they are favoring the sodium ions more to pass the boundary. So, now, because of that that in flow of the sodium the negative potential within the cell that keeps on increasing and it stops to a actually level, when it reaches about 20 millivolt or plus 20 millivolt with respect to the outside and this process of change in voltage we called as depolarization this is a depolarization. So, we call it depolarization next once it reaches to that plus 20 millivolt inside then suddenly that the characteristics of the that cell membrane changes and again it becomes impervious for the that sodium ion.

So, what happens at that stage now it is allowing only the potassium alloy and to get out of the that cell membrane. So, as they leave the cell body or the cell boundary again the potential inside the cell start dropping and it can go as low as minus 90 millivolt and this next process it is called repolarization and here in this along with the diffusion another

thing we should actually keep in mind that there is something called sodium potassium pump, which actually is an active process where it is using spending some amount of energy to take three sodium ions inside and pushing some potassium on outside. So, they are taking some sodium ion and throwing out the potassium ion. So, that is the way they interchanging the thing. So, that is called that the sodium potassium pump gets an active process.

(Refer Slide Time: 18:53)



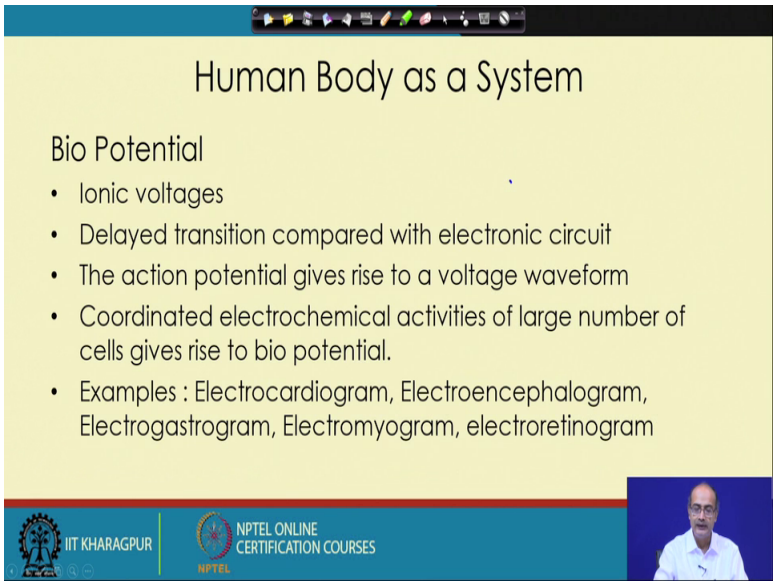
So, let us go next. So, here we show that the electrical the process over the time, that the change in the potential actually is recorded over the time the we are looking at the change in the potential of the cell inside the cell with respect to that outside fluid. So, initially it is at the resting potential and as some stimulus is added here.

Suddenly the characteristics or the permeability of the cell membrane changes at the depolarization starts and it reaches to a level of about plus 20 millivolt inside and then it stops or a equilibrium is reached and after that it does not stay there for much more time that the rivers running starts and it goes to the process of repolarization and coming actually near the again the resting potential. In fact, there is an over shoot which is called that hyperpolarization this phase and it slowly goes back to the resting potential.

And here another thing we should know that for the muscle cells the depolarization phase is associated with contraction and these electrical pulse as it is going to the body that is important for many activity and the signals what actually the knob carries is

through these process of electrical activity and how that send the signal as a nerve signals along the length, this current actually flows from inside the body through the cytoplasm and outside the body through the interstitial fluid and that is why how the current flows or the signal flows from that one point other along the length of the nerve.

(Refer Slide Time: 21:13)



And now we look at the characteristics of this potential. So, first let us look at that the nature of this potential this cells now what we get that it is act as a small battery and the source of these battery or the energy is the it is a ionic voltage, that means the current flow what we get that is happening because of the movement of the ions at the charged particles ok just like any that battery what we use.

Next if we look at that the rate of flow or the transition of the action potential or the frequency of the action potential that it is a very delayed compared to the electronic circuit and here another thing we should tell that the action potential where we should go back one step to tell that the, that here that when we are talking about this action potential this action potential once a stimulus is given when is going through there is no way to stop it and the amount of this voltage that say minus 70 millivolt to plus 20 millivolt this change it is not depending on the stimulus or the level of stimulus.

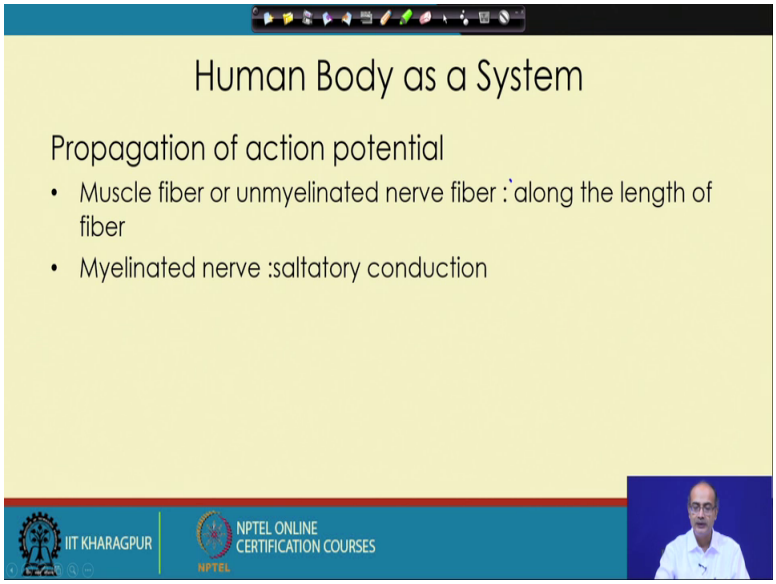
When a stimulus is applied it is like a threshold function, that means the stimulus should be above some thresholds if it is above the threshold this depolarization will start now once it will start you cannot stop it till it goes to the end, however by applying much

higher actually stimulus before it completes again you may start it there that is very rare phenomena. So, we can take as a simple explanation that it is a like a threshold you need. So, once the signal goes above the threshold this action potential is created and the voltage levels are independent of the input if the signal cross that threshold and you cannot stop that also in between.

So, that is one of the important thing and let us go back to that other characteristics of it. So, it give rise to a voltage waveform because it is acts like a battery and there is a coordinated electro chemical activity of large number of cells to get these bio potential or to record it as we get that each of this cells they have very little amount of energy or very little amount of current they can provide.

So, if we try to measure that activity or record that activity. So, we need some certain amount of actually power and that is possible only through that coordinated activity of large number of cells, and there are a large number of such signals generated out of this active potential of the cells they are say electrocardiogram or what we know as E C G or E K G then electroencephalogram that is known as E G, electrogastrogram, electromyogram. So, there are a number of them with us.

(Refer Slide Time: 25:20)

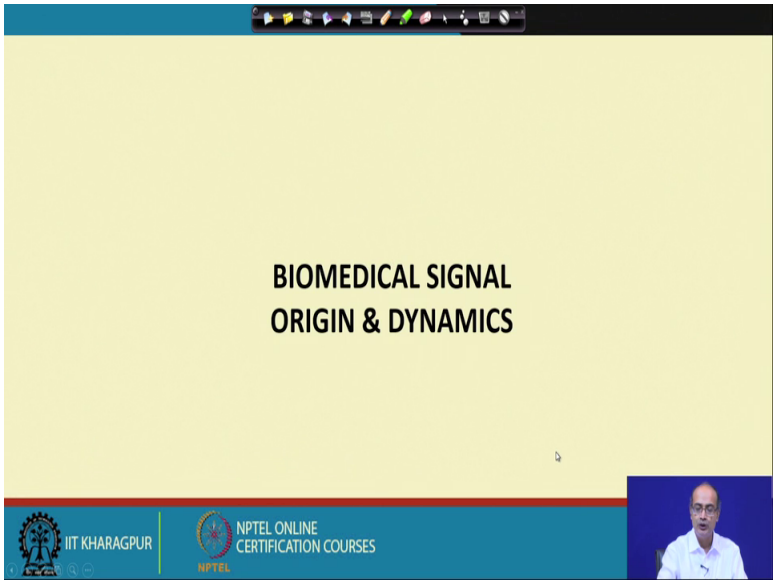


So, now let us move forward now you see that what are the things it can do that when it moves to the nerve fiber the nerve fibers they are actually protected by that myelin sheet, and after a small interval they are actually for myelinated nerve there is some gap and

that when it is covered by the myeline sheet, the myeline being actually lipid or fact they are actually acts as a electrical insulation and does not allow the transfer of the ion through the that the cell membrane there.

So, wherever the gaps are there the exchange of the ions can happen there. So, the electric potential actually jumps from one such node to the other node and that is how it actually moves to the that across the length of the fiber ok, and for the myelinated nerve such kind of conduction is called salutatory conduction this name particular name is given which makes it possible that the first conduction of the signal.

(Refer Slide Time: 26:54)



So, we have just covered the action potential now we complete that a small part here and Thank you for being with us.