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

Lecture - 06
Action Potential - Part 1

Welcome to this class on Neuroscience of Human Movement. So, this lecture will be our first lecture on Action Potential, right.

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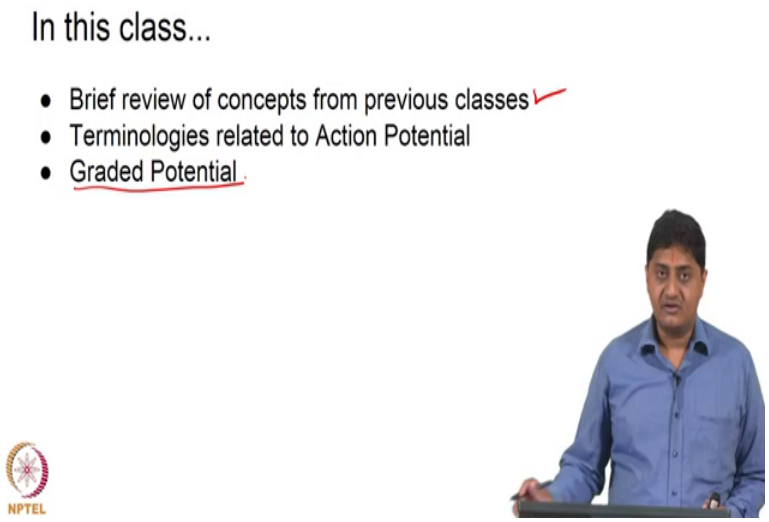

So, in today's class we will review what we learnt in previous classes. So, it will be very brief review of concepts from previous classes. And we will discuss terminologies related to action potential. And we will discuss graded potential for this class. We will continue the action potential in the next video.

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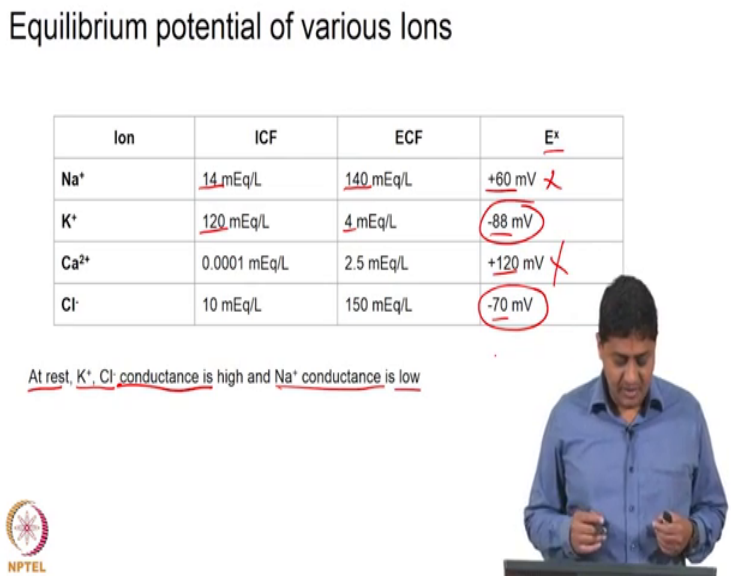

So, in the previous classes we have seen that the sodium concentration inside and outside are very different. In other words, the sodium concentration outside is much higher than the concentration inside, and the potassium concentration inside is much higher than the concentration outside and so on and so forth. And depending on that we also said that the equilibrium potential which is the Nernst potential is different for these different ions, is it not?

And we also derived or we also briefly discussed that depending on the contribution, that an ion makes towards total conductance the equilibrium potential of that ion is expected to be closer or further away from the membrane potential. This is something that we saw. And following is true at rest potassium and chloride conductance is relatively high and sodium conductance is relatively low. And that make sense. So, usually then the membrane potential is closer to that value and that values, but not these values. So, in another words the membrane potential is closer to minus 70 or minus 88 millivolts. So, that means, these conductances are higher at rest right. So, what happens at of rest periods is of interest for us, but at rest this is the situation, right.

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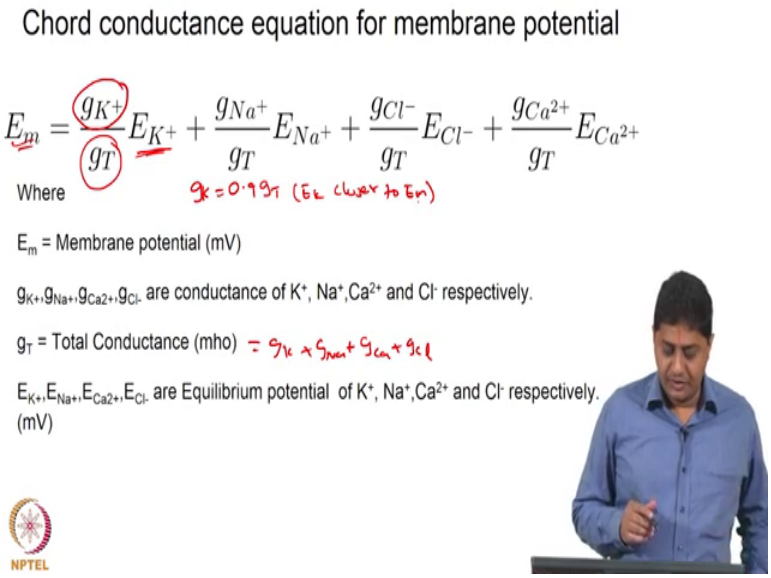

And we also saw where this comes from right. So, this is the chord conductance equation.

And we said that the conductance or the total conductance is basically the sum of the potassium, sodium, calcium and chloride conductance, is it not? So, to what extant potassium itself contributes to the total conductance is computed. And that weights the potassium equilibrium potential. So, if lot of total conductance comes from g K; say, say g T or say g K is equal to 0.9 times g T approximately. It a 90 percent of the conductance comes from the potassium conductance. In that case, then you would expect E K to be closer to E m right.

So, E K will be closer to E m, this is an expectation, is it not? So, likewise for other ions also; so this means that those ions that whose conductances are high at rest right are going to contribute the greatest to the membrane potential or them their equilibrium potentials are closest to the membrane potentials, right.

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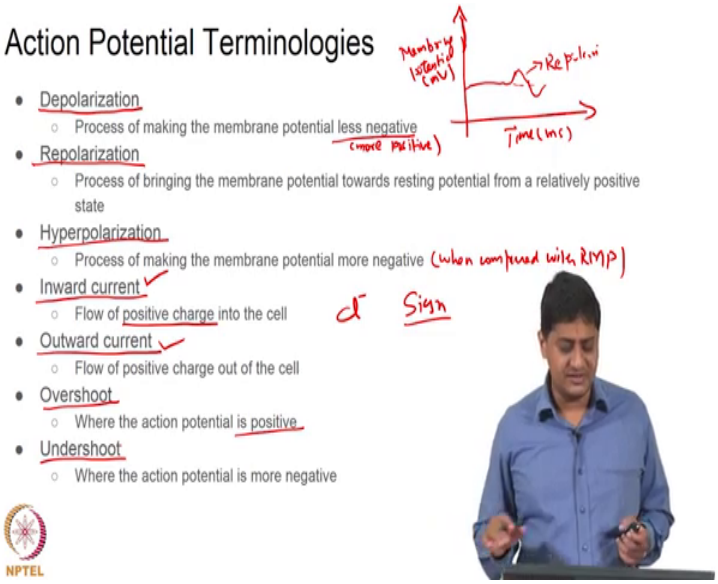

So, then we have the situation with action potential will have to discuss what this is in a bit. So, suppose the membrane potential let us suppose let us take a let us take the case of membrane potential, here membrane potential in millivolts, this is time say in milli seconds, right. Suppose, the membrane is at rest and so, that is the value that you are having.

And suppose the membrane becomes slightly less negative, less negative means what? Slightly more positive, is it not? If it is goes like that slightly, then that is called depolarization. Note that at rest the membrane is already having a negative potential or minus 55 miilivolts approximately or minus 65 miilivolts. So, if you make a slightly more positive, you are basically depolarizing the membrane. This is the process of making the membrane potential less negative or more positive,.

Now, if I am bringing the membrane potential towards the resting membrane potential from a relatively more positive values. So now, it is already more positive, I am bringing it back like that to the resting membranes potential. That is repolarization, ok. That the process of bringing the membrane potential toward the resting membrane potential from a relatively less negative state or more positive state is called the repolorization, right.

If I make the membrane potential to go lower than the resting membrane potential, that is called as hyperpolorization. So, this is the process of making the membrane potential, more negative in general when compared with resting membrane potential. So, if I make

more negative than the resting membrane potential then that is called hyperpolorization. So, if a lot of positive charge flows into the cell, then what happens? Then this then the membrane potential becomes less negative or more positive.

So, flow of positive charge into the cell is called inward current, and flow of positive charge out of the cell is called outward current. So that means, we already described that there are channels that are open at certain times, and suppose there is a sodium channel that is open right. So, the amount of sodium outside the cell is more than the amount of sodium is inside, because of this reason sodium will enter inside the cell from outside that is an inward current.

Let us suppose a potassium channel is open let us also remember that the amount of potassium inside is greater than the amount potassium outside. Now that will lead the flow of potassium from inside to the outside when the potassium channel is open. This is called as an outward current. Now let us take the case of chloride for example. If you take the case of chloride, chloride is an anion, right.

So, essentially if for example, chloride is flowing from outside to inside essentially what has happened is that one negative charge has gone from outside to inside; that is equivalent to one positive charge going from inside to the outside. Essentially that is an outward current. So, inward current outward current definition depends on the sign, s i g n sign or whether we are talking about anion circuit ions. It is important to note it is not about whether something is going inside or outside. The charge whether it is a positive charge and negative charge matters in this case.

And the period during which the action potential is positive is called as an overshoot we will discuss this later. And the period during which the action potential is more negative say than the resting membrane potential is called as undershoot, ok. These are some terminologies will be using in this class and in future classes right.

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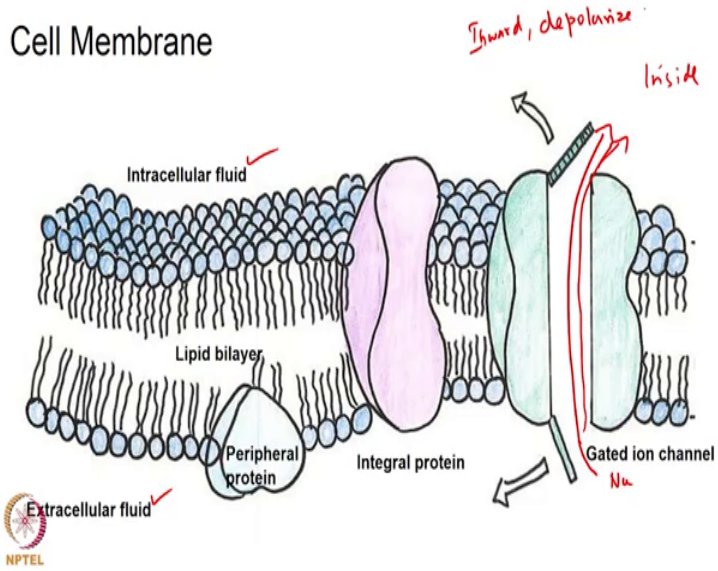

So, let us remember the case of the cell membrane there are multiple channels. So, there are some integral protein there are some gated ion channels such as this one. And this might be voltage gated or this might be Ligand-gated, this might be temperature sensitive, this might be mechanically sensitive, it might be chemically sensitive. So, there are so, these are receptors. So, these are channels that open in response to particular kind of stimuli, say for examples this is sodium channel. So, and this is the extracellular fluid and this is the intracellular fluid. So, this is the inside of the cell is it not so; that means, amount of sodium is less on the inside.

So, if there is a lot of sodium outside, the flow is going to be directed in that direction is it not. So, it is going to flow from outside to the inside like that, right so, something to remember. So, what would this do? Suppose sodium goes from outside to inside, that is essentially an inward current and that would depolarize the membrane, that would make the membrane more positive or slightly less negative right. So, that would essentially depolarized the membrane right.

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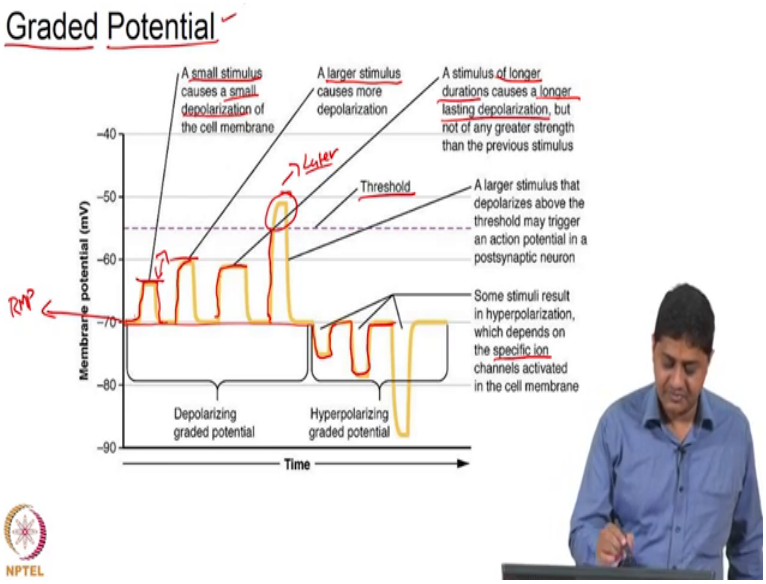

So, what are the various things that could happen in this case? We will discusses some cases. So, here we are discussing about a graded potential. Suppose there is a small stimulus of some kind. And this stimulus causes a small amount of depolarization. So, that means, this stimulus causes a small amount of sodium to enter inside right. So, a small stimulus causes a relatively small depolarization to into.

So, this is cause that is what is happen. Why is this happening? This is happening because a small amount of sodium has enter inside. Now let us say that stimulus is removed, when that stimulus is removed. So, this is the stimulus and then the stimulus is removed then the membrane potential goes back to the resting membrane potential note that that is the resting membrane potential.

Now, let us say that the stimulus amplitude is increased. In other words, there is a larger stimulus that. There this would essentially cause a larger response. So, smaller stimulus cause that response earlier and a larger stimulus causes that response. So, essentially there is a difference depending on the stimulus strength the response strength also varies. In other words, there is a graded response to stimuli gradation or in other words. Basically, there is a one on one relationship between stimulus amplitude and response amplitude.

So, and also and suppose the stimulus last for a longer duration the response also last for longer duration, right. Sometimes it is possible for the stimuli to last for several seconds

like that for example. The response will also last for so many seconds. So, contrast this with some topic that we are going to discuss in future which is action potential, that is going to be relatively brief. So, graded potentials can last for a relatively long period, ok.

So, stimulus of longer duration cause a long a longer lasting depolarization. And suppose the depolarization the stimulus causes the depolarization that is above a certain point which we are going to call as a threshold. Then it is going to cause what is called as an action potential that topic we will discuss later, this is for later. It is also possible for some stimuli to cause hyper polarization. Or in other words this could make the membrane potential to go more negative or less positive. So, earlier this is the resting membrane potential. Some stimuli can make it less negative or even less negative.

Note: here also there will be gradation, here also depending on the duration of the stimuli the response duration will vary. So, once again depending on the conditions, depending on the specific ion channels that are involved are activated, depending on the stimulus it is possible for the membrane to be depolarized or hyperpolarized, ok. So, the case where the response has a one on one relationship with this stimulus or the input is called as graded potential, ok.

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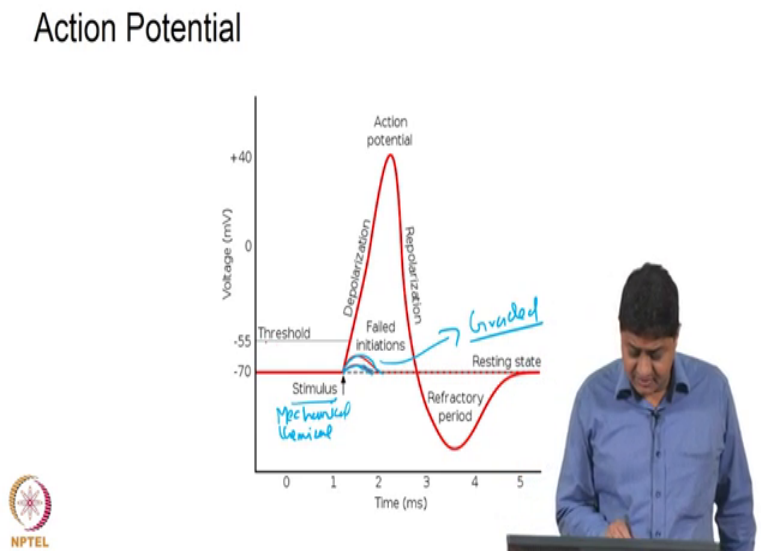

So another case, another example right, suppose stimulus has applied here, and that is having a particular strength say that much, right. That is the strength, then the response is

of some strength. Suppose I increases the stimulus strength, then the response strength also increases. These are graded potentials; these are graded potentials.

Now what are the kinds of thing things could act as a stimuli? Various things, I already mentioned, mechanical stimuli, chemical Ligand-gated channels and a whole bunch of factors could act as stimuli that could cause slight depolarization. Sometimes when it reaches the threshold magic will happen. Some magic will happen when it crosses the threshold, right. So, what happens when it crosses the threshold is something that we will have to see.

With this we come to the end of this lecture, I will continue in future classes.

Thank you.