Bio-energetics of Life Processes

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Lecture - 05
Charge transfer across membrane: Key terms

Welcome back to the fifth lecture of the Bioenergetics of Life Processes. So, in the last class; one interesting concealence or theme which we discussed or which has emerged over evolution is; most if not all, the membranes are double membranous made up of lipid bilayers and inherently there is an asymmetry in the membranes; whether it is a animal cell membrane, whether it is a plant cell membrane, whether it is the membrane of the organelles; like mitochondria, chloroplasts and all these things.

So, second aspect what emerged is that; these membranes are asymmetric in nature, they are semi permeable, they are asymmetric in nature; in terms of they only allow certain molecules to pass through them. And that is governed by specialized proteins, which has evolved in the form of pores, in the form of fine channels across them, third aspect which we discussed; about talking about them, they all can replicate and the inner and outer composition is different in terms of the inorganic salt.

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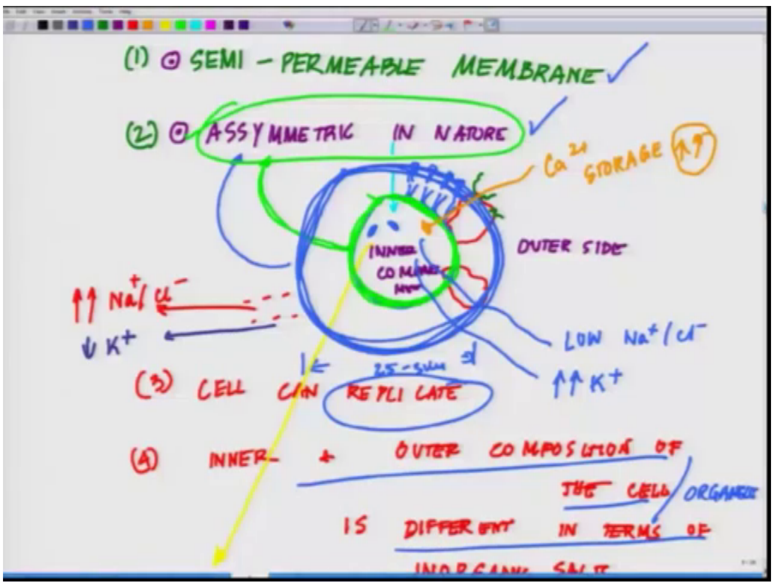

So, these are the four aspects what we had discussed about the membranes in the last class. So, why this is very important for us? Because most of our bio energetic, what we will be talking about in the next three weeks to come will be exclusively will be on the membrane.

So, that is why I am kind of devoting this time of; slowly taking you towards thinking more about the membrane and how the membranes have evolved? And what are those unique features? Now today, we will talk about some of the basic terms; what we will be using in terms of studying the bio energetics processes. So, let us again start from the cell; so, we are into lecture 4 of 20.

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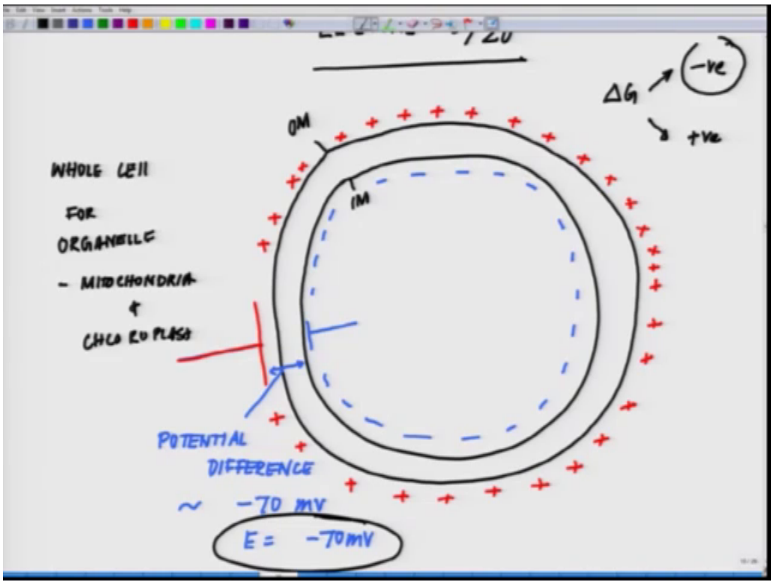

So, if we look at the cellular structure here; if this is the membrane, now this is OM is the outer membrane, this is the inner membrane and there is an asymmetry across it. So, with respect to outside; a cell maintains a potential difference. So, outside it is positive whereas, inside it is negative and across the cell membrane, it maintains a potential difference; in general barring aside few cells around minus 70 approximately and around minus 70 millivolt.

So, in other word E is equal to minus 70 millivolts; which is with respect to outside inside is negative. So, in terms of the charge; so, you will see lot more negative charge, yes inside whether the negatively charged proteins, negatively charged amino acids, negatively charged nucleic acid, negatively charged ions likewise. So, with respect to outside inside is negative; so now this is the first concept one has to realize.

So, whenever there is a flow of ions; so, there are two kinds of cells which has evolved and in terms of organelles also. So this model; what you are observing holds true for a whole cell, for organelles; what we will be dealing with like; mitochondria and chloroplast. So, there is a potential difference across them and this potential difference of course, here we are only talking about the cellular potential difference, but this potential difference will always be there across, if we see a mitochondria like this.

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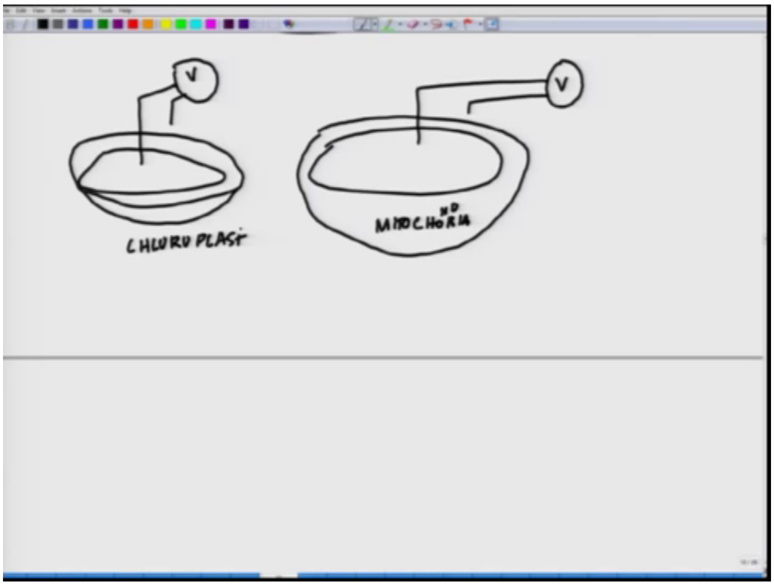

And if you have a way to put electrode inside with respect to an electrode outside, we will see a voltage difference; mitochondria or similarly for chloroplast we will observe the same voltage across the chloroplast. Now, few terms which are very essential; what we have to; we will be using it very frequently, is one term which is your delta G or free energy.

This free energy concept is extremely essential; so, either you could have a delta G; negative value or a delta G positive value. A delta G negative value means, there will be a spontaneous reaction; so, it means something will happen spontaneously.

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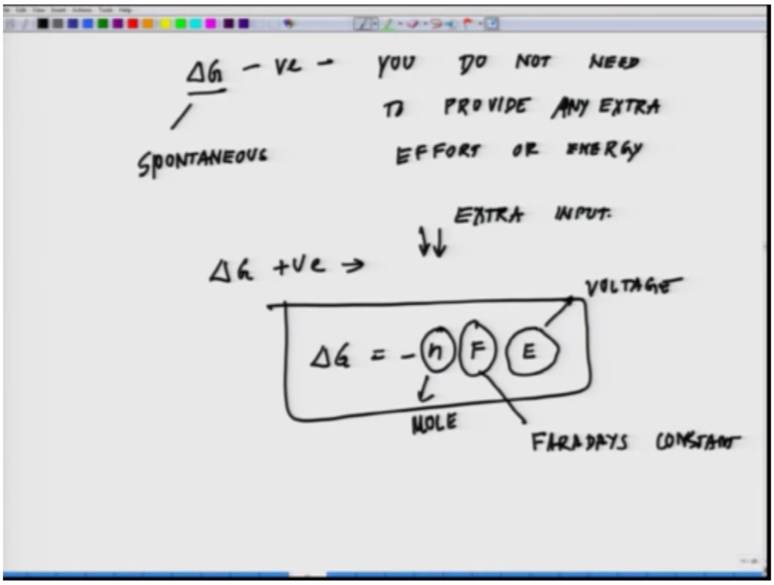

In other words; delta G negative means you do not need to provide any extra effort or energy because this is an spontaneous reaction. Whereas, delta G positive; essentially means you have to put that extra input and when we talk about delta G; when we have to calculate delta G, this is one formula which you will have to remember n F E; where E is your voltage; what we have talked about, if you remember out here see; this is that E value, delta G and n is the mole; molarity of the molecules what we will be talking about and F is the Faraday's constant. These are some of the relations which will come very handy; delta G is equal to minus n F E.

This is essentially is; you will have to remember it. Now whenever we talk about a charge across it and there is a movement of charge across; say mitochondria or a chloroplast or a membrane itself. So, we are essentially talking about across this membrane, across any membrane there is a potential difference.

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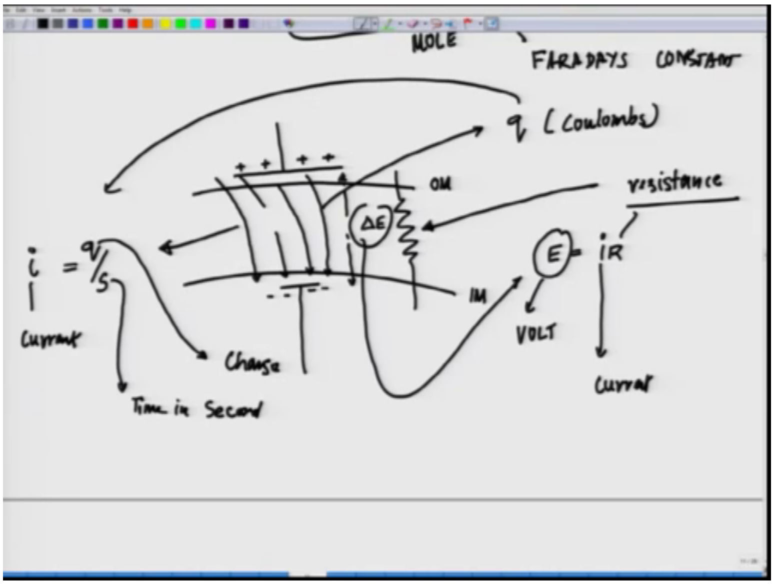

So, this is say outer membrane and this is say inner membrane and if I consider outside as positive and inside as negative; positive, positive, positive, positive. So, across this I have a delta E, or there is a difference; potential difference across it. If there is a potential difference across it, it means a charge can flow along with it.

And those charges are denoted by q; which is expressed in coulombs. Now, what is important for you to understand the rate of flow of charge per unit time; so, say for example, there is a movement of charge happening across it.

So, per second this rate of flow of this charge is per second is your current and this is your charge and this is the time in second. So, that is what defines the current; i is equal to q upon S; there is another expression across this membrane as well in a we will be studying; we may need or may not need, but you should know it. That is your Ohms law; E is equal to IR, where E is your in volt, I is what we just now defined; the current and R is the resistance across the membrane or across the structure.

So, if this structure has a resistance then this is denoted by it and the flow of current; I have already told and the E across it is out here. And they are linked to each other through this thermo dynamical parameter delta G or the actual work done. Work done if you have to talk about; what is the work done across it, across a membrane then it is basically the product of potential difference; which is E and the charge, which is the q work done is equal to E q.

So these terms will come very handy while we will be talking about the motion or movement of charges.

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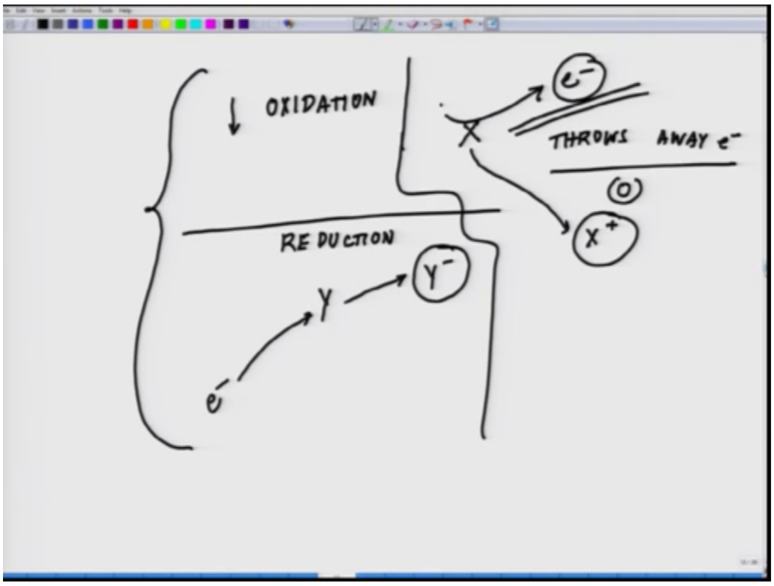

And the second thing what I have to highlight here these terms will be coming time and again is two things; one oxidation and other one is reduction. So, oxidation is essentially when some protein or something; any species it loses, throws away electron; it throws away electron that is what is oxidation.

By throwing away electron this X becomes X plus; similarly reduction is a situation where say Y compound; it gains an electron and this Y becomes then Y negative. It is gaining an additional negative charge on it, that is a process of reduction. This will come very handy because much of these processes what we will be dealing; now onward in photosynthesis or electron transport chain will be dealt at the level of oxidation and reduction processes. In this oxidation reduction processes, there will be lot of transport of electrons and those electron transport will happen across the membrane, across those proteins like this.

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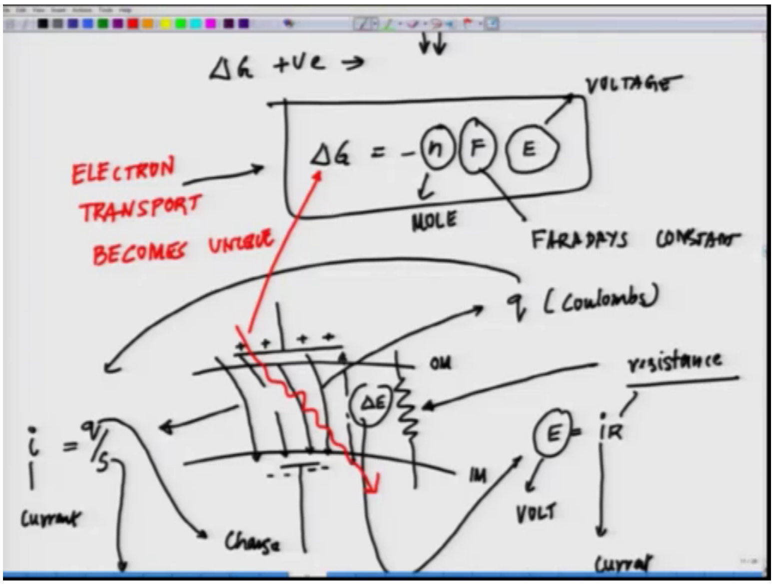

Where they will be doing a lot of work, which will be defined them in terms of delta G parameter; in terms of effective spontaneity of the reaction. Because there are several aspects by which much of the electron transport; in the biological system becomes fairly unique, becomes unique.

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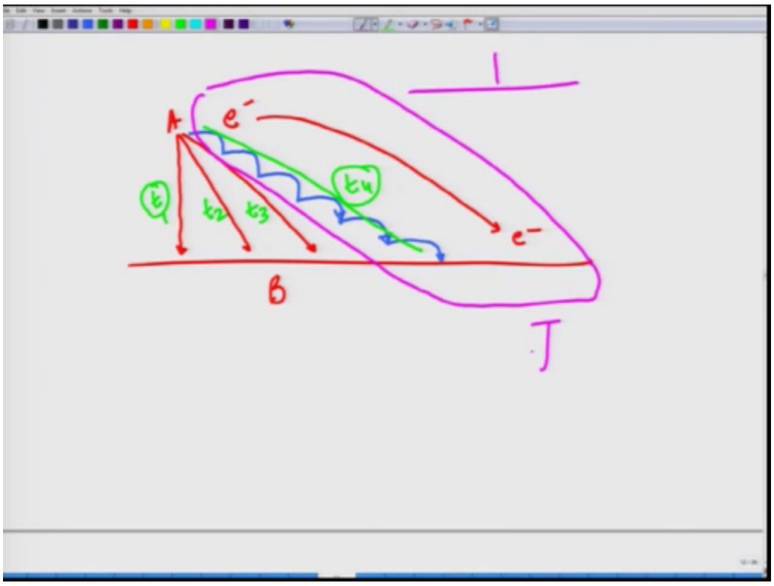

Because one thing which will be coming is; say for example, a electron has to travel from here to here. There are two options say for example, point A, point B; this is all point B. So, either it can travel like this straight coming to B or it can travel like this or it can travel like this or it can travel like this; as if it is hopping through.

So, if you look at all these transport; so, here what is the parameter which is varying? Here is the time t 1, time t 2, time t 3 and here the maximum time; time t 4. So, what we will be observing is the biological system, the transport process, a transport phenomena is something like this; where the electron hop point to point fairly slowly and in that process it maintains a potential drop across a membrane for a prolonged period of time.

Why biology prefers this kind of electron transport? Is what we will be discussing enormously in the electron transport chain of mitochondria and chloroplasts and what are the evolutionary advantages? So, with this first week background of different processes, closing this week and next week on, we will jump on to the chloroplasts and mitochondria and chemical synthesis and photosynthesis and the detail in depth bio energetics processes.

Thank you for your attention.