Applied Environmental Microbiology
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Lecture - 28
Virus I

Dear students, in today's class, we are going to talk about virus and virus are very very interesting particles because they present to us microbiologist and to other environmental scientists a very interesting question; what is life and what is the absence of life? How do we classify living systems from non living systems or living beings, from non living beings, what makes them different for if it is the ability to replicate then virus are non living, but put them inside a host and now they can replicate themselves.

So, now, they are living and thus virus many microbiologist believe that virus hold the key from when the non life or the abiotic became biotic and how the life initially evolved and now the latest theories in viral evolution suggest that it is quite possible that virus existed much before the cellular life came and it was only when the virus became more complicated developed more specialized protein surrounded membrane surrounded it transformed into proto cells or the earlier versions of cells.

And this theory has some good evidence behind it and as we will briefly talk about in this lecture, but from it applied environmental microbiology perspective viruses are very very important because well they are very important because many of our geographical and seasonal diseases which are airborne or waterborne are viral for example, hepatitis a hepatitis e are viral waterborne diseases which wreak havoc across the developing countries including India every now and then and then we have h 1 n 1, swine flu and other airborne viral diseases that again for environmental engineers very important we want to understand the humidity temperature the transportation of air and how long they persist in the airborne particles. So, all this study comes under environmental engineering they are viral diseases these h one n one swine flu etcetera.

So, from public health perspective virus is very very important, but unfortunately very poorly understood. So, there is still very high impact and rapid research that is being that is being conducted in the field of viral pathogens and transportation of viral pathogens. From another point of view virus are important for us because they interact with our microbes that help us solve our environmental problems. For example, there are these viruses that are called bacteria farge which are bacterial viruses and cells that they infect bacteria and when they infect bacteria they can cause their lysis means they can cause the cell to break away and then they can destroy the bacterial populations and if they destroy the bacterial populations that are helping us remediate something for example, in this water treatment plant then we will not have our the efficiency of wastewater treatment will go down because of the viral infection. So, dear students we are not the only ones who get infected by virus, but even the bacteria the archaea, they also get viral infections and that affect our environmental processes.

Now, there are many theories around in the country right now about water from certain rivers that are considered to be sacred to have some healing properties or to have antibacterial or bacterial cider properties and one of the hypotheses proposed recently is that the water from these sacred rivers have certain bacteriophage in them which kill other bacteria at this stage I want to warn you students that do not take all these stories in with pinch of a salt there is no scientific evidence suggesting that.

So, we are still waiting on it the jury is not out yet, but we do know that bacteria watch the virus that infect bacteria and virus that. In fact, us play a very important role and it just happens to be a sheer coincidence that as I am giving you this lecture what virus there is a viral flu going on around it Roorkee campus right now and just the last weekend I myself got I might have got infected by a virus I do not know what it is, but then I am recovering and I am here for the lecture.

So, let us begin, all right. So, what is a virus and as I mentioned earlier that virus is in the transition zone from the living to non living because it cannot replicate or in do its activities outside a host, but inside a house it is an; it has a mind of its own it can hijack the cellular processes it can cause the cell to replicate the viral genome. So, talking about life and the absence of life one of the key parameters of defining something is alive a living being versus a non living being is that a living being can replicate in a living being can carry out the essential functions for survival now these little.

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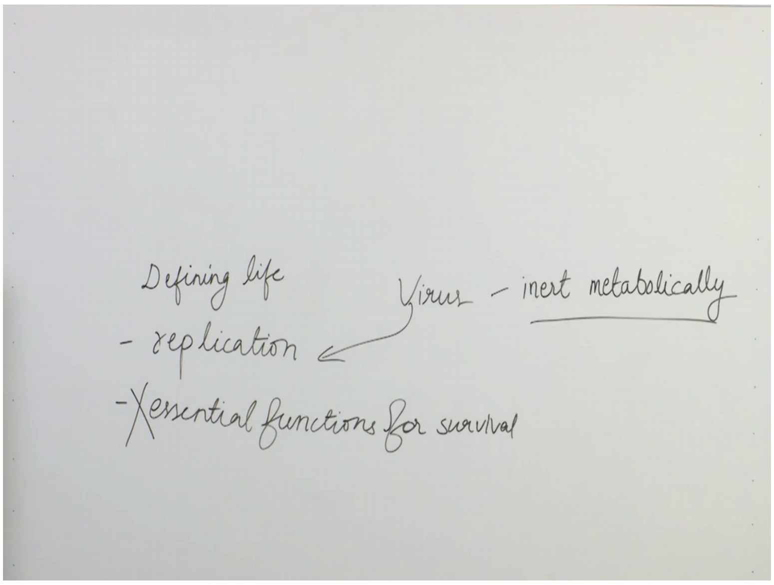

Let me write it down, all right. So, there are many parameters that are used to define life and I remember in elementary school in my part of the country we would talk about a living being something that can grow that can make the own food or get food from somewhere and most of them can move, but there are exceptions to each of these parameters it all boils down towards 2 major parameters ability to replicate and ability to carry out the essential functions to survive.

Now, if you look at the ability to carry out essential functions to survive we have talked about this there many pathogens that cannot carry out all the essential functions to survive they need to be present inside a host. In fact, most of our pathogens the reason that they in fact, us is because they need they need a host to survive and to carry out all essential functions and not just pathogens, but even the commensal microbes or the symbiotic organisms who are in symbiosis with each other many of them have lost the ability to carry out the functions that they depend upon the other organism. So, it does not mean that they are not alive they are alive, but they cannot carry all the essential functions for survival out.

So, we see that this is again not a fool proof definition of an alive being if you look at the ability to replicate well even if these special symbiotic microbes or commensal microbes or pathogens they cannot carry all the essential functions for survival then the argument is at least they know how to replicate. So, if they can replicate on their own, then it is alive and that is a very good definition and it was a very good definition until the virus came in challenge state.

Now, virus they have a situational ability to replicate depends on the context depends on the situation. So, if they are within the host cell they have the ability to replicate their genome and thus they alive, but outside the host cell they cannot replicate the genome and their particles and that is why many times in this lecture you will notice that I will not call virus just virus, but I will call them viral particles and in fact, I am currently working on some viral particles and I noticed that outside the host they actually behave like particles most of them are not unable to be metabolically active.

So, it is very important for you to understand that not only can virus not replicate unless they have a host cell, but their metabolism also goes to 0 stay are inert. So, metabolically they are inert outside the cell. So, there is no activity going on there just a particle, but bring them inside the cell and they are thriving hijacking the cell at times hijacking the entire organism.

So, we can define virus as sub cellular genetic element.

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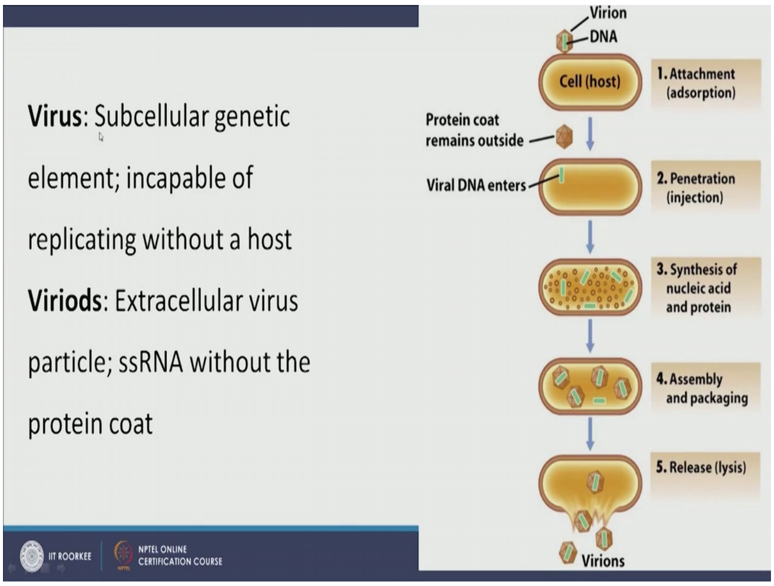

Now, this is a very interesting term sub cellular genetic element sub cellular here talks about that it is not that it does not; it is not a cell virus does not have all the essential components of the cell it might in some cases not have a membrane it might not have proteins. So, it might not have RNA or DNA, it might not have some other essential components that are typically present in a bacterial archaeal or eukaryotic cell, but it does have genetic elements that is very important and the beauty of viruses that they might have DNA based genetic element.

They might have RNA based genetic element they are incapable of replicating without a host. So, let us look at the viral replication here you have viral virion. So, single viral particle and there is this green DNA inside it and this viral, we have attachment or adsorption to the cellular membrane it will inject this viral will inject its DNA inside and the protein code this is the coat of the protein it is called Capsid and the proteins are called capsomeres, we will talk about them.

So, the viral DNA is injected inside and once its injected inside its transcribed and then translated. So, transcription means if it is not remember this, we are talking about DNA virus. So, it is transcribed first. So, it m RNA is made from this and then it is converted into protein and then these are the capsomeres.

So, proteins that will make the capsid the coat protein coat and then next thing we know the cell is full of virions and then these virions will be released out after breaking the cell this is basically viral infection. So, when you have viral flu viral infection something like this is going on inside the body now because we are eukaryotic organisms viral infection looks slightly different some viruses will only replicate in the cytoplasm some will go attack our nucleus the nuclear nucleic acids in our nucleus.

But it for a prokaryotic cell this is the basic outline the other particle we will be talking about in this class or if not this one then definitely the next class next lecture our viriods these are extracellular virus particles. So, they are viral particles, but they do not have anything else except RNA single stranded RNA. So, here if you note this virion has a protein coat which is capsid and it has DNA, but if it were a viriod it would only have single stranded RNA and no protein no DNA, it is a very interesting particle in we will talk about it.

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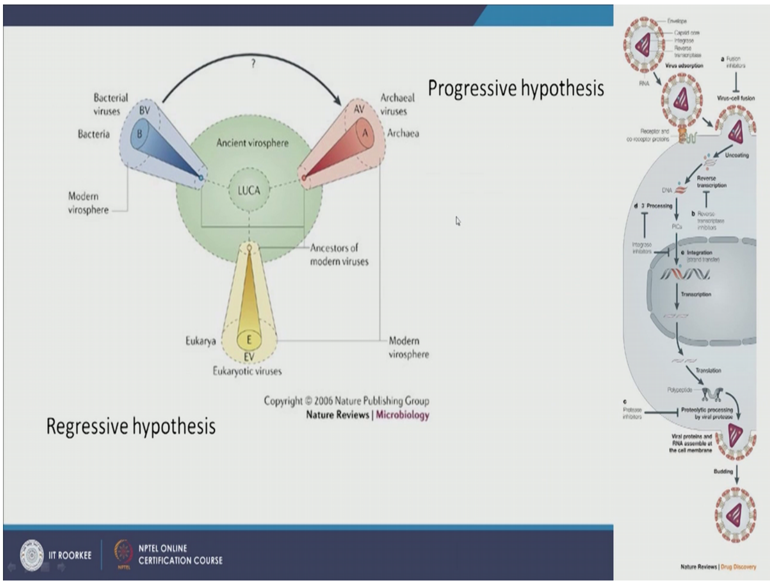

Already where did virus come from I briefly mentioned in the introduction that there is a recent hypotheses that virus were the first agents able to replicate themselves that evolved or proto virus. So, even before the luca even before the last universal common ancestor arrived, we assume the luca is a cellular ancestor virus arrived. So, and then there many theories about how virus arrived we will talk about them, but the latest theory and this is this was published in nature in 2 thousand six a very nice journal I highly encourage you to go through nature reviews in nature every now and then.

So, even before the luca arrived, we had an ancient virosphere and basically these proteins are in this DNA and RNA the nucleic acids started interacting with each other with themselves and they started replicating and from here we had evolution into bacterial virus and archaeal virus and eukaryotic virus and these form the modern virus. So, this is what we have now in the ancient virosphere is absent it is gone there are some questions that still need to be explained in this theory for example, how come some archaeal viruses are very similar to bacterial viruses how did this relationship happen the other question that is very important to understand if there were no host present before the ancient virus were emerged; however, the virus replicating.

And now there are some rational explanation that scientists have given how they could have been doing, but and this is a very interesting topic; there in your home work there is a paper that you have to read and you have to answer some questions related to it. So, I will leave it for your homework, but there is some very beautiful research going on in the evolution of virus now this theory this particular approach to viral evolution or even the evolution of life to begin with is a regressive hypothesis another hypothesis is that the cells started before virus started, but the cells they would lose some of the DNA essential DNA we should be captured by other cells neighbouring cells and then they would replicate it and make more stable forms of DNA or RNA that could survive out in the environment.

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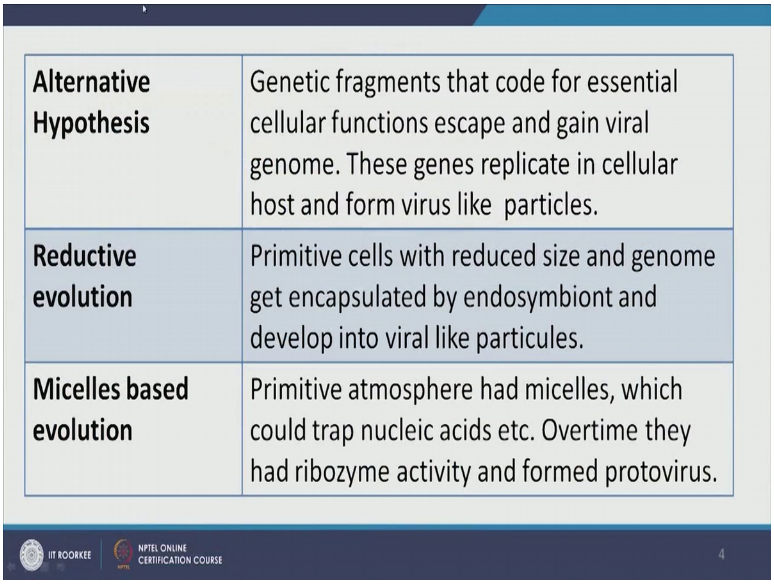

Alternative Hypothesis	Genetic fragments that code for essential cellular functions escape and gain viral genome. These genes replicate in cellular host and form virus like particles.
Reductive evolution	Primitive cells with reduced size and genome get encapsulated by endosymbiont and develop into viral like particules.
Micelles based evolution	Primitive atmosphere had micelles, which could trap nucleic acids etc. Overtime they had ribozyme activity and formed protovirus.

So, let us look at how the virus came into picture there are 3 f theory that we will talk about the first one says that which I just mentioned genetic fragments that were coding for essential cellular functions they escaped and the viral genome was gained and that these genes inside the cellular host they formed virus like particles and these were more stable in the external environment then there is reductive evolution which is primitive cells they kept on undergoing deletion of their nucleic acids because they were either in endosymbiont with their hosts or they were in very ill.

I given some symbiotic relationship, they kept on losing their size and their genome; until they reduced to viral particles and this is your reductive evolution, then you have micelle based evolution this is wonderful evolutionary theory where we believe that the proto earth or the earth in the primitive times you know lot of years ago had lot of micelles and these missiles were the ideal compartments where chemistry could be such that we would have nucleic acids RNA or DNA single stranded or double stranded that could form and then they were enough amino acids for them to make proteins and they these are trapped nucleic acids they eventually had the ability to translate into proteins and they formed proto virus. So, I have written here primitive atmosphere had micelles which would trap nucleic etcetera over time they had ribozyme activity and they formed protovirus.

So, these are the 3 theories on how the virus evolved again as I said this is the point of contention for scientific community we are still figuring this out, but at the same time because it is we do not know about it. It is a very very exciting field for research all right.

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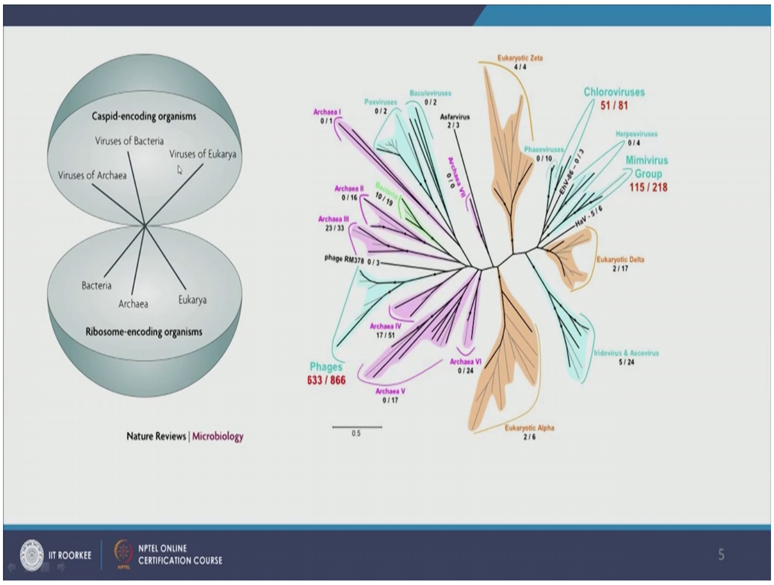

So, coming back to the evolutionary theories if you remember, I mentioned that the protein coat of the virus is called capsid, we noticed that there are we can divide the life or you know beings micro microbes into 2 different groups one are the ribosome encoding organisms which encode ribosome which will allow them to translate and make their own proteins. So, the key feature for virus is that they cannot make their own essential proteins, they will beat there is an exception because some viruses have their own enzymes, but most of them they require a host to make a protein.

So, they require a host to get the protein coat and to have multiple copies of their own, but then the ribosome are encoding organisms do not need it. So, the ribosome encoding organisms are bacteria can you carrier we know a lot about bacteria thankfully we know play pretty much about eukaryotes archaea, we are figuring out. So, we know a lot about ribozyme encoding organisms, but then there are some organisms they do not encode for ribosome they encode for capsid, we do not want to translate anything, but you take our genes you take our RNA and make a capsid for us make a protein coat for us.

So, these are archaea viruses bacterial viruses in eukaryotic viruses and on the right panel here we have a tree of life for virus. So, what I want you to note here is that virus is a very diverse very very diverse, I mean not only in their structure not only in their shape and in their behaviour, but also in their genes and the nucleic acids I have mentioned this casually in this lecture earlier, but please note some viruses only have DNA some viruses have only RNA most viruses do not have any enzymes or proteins in them.

So, we have DNA based viruses RNA based even among them we have single stranded double stranded DNA based viruses or single stranded and double stranded RNA based viruses despite this immense diversity which is unimaginable in bacterial archeal eukaryotic kingdom we noticed that these viruses they have certain conserved domains. So, they exhibit homology basically they point out towards shared ancestors. So, we can actually make trees like this.

So, we have baculovirus pox virus we have archeal viruses bacterial viruses we have herpes virus. So, and all these viruses we know that they have homology and we can make such taxonomic ancestry trees with them hinting that perhaps all the viruses started from some proto virus and we do not know yet if the virus came before or the microbe came before, but the evidence is gathering in favour that virus came before ok.

So, the point key take home message from this right panel is that capsid proteins.

Show homology across both DNA and RNA viruses ok.

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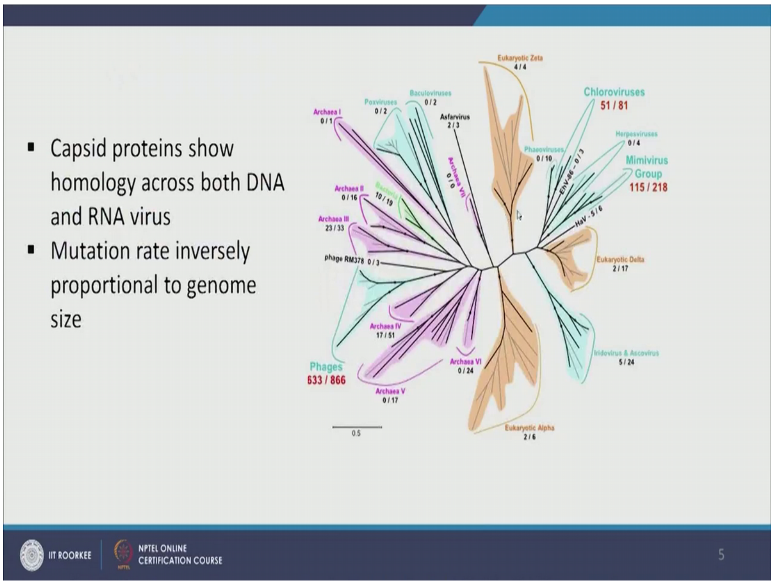

Some of the viruses here are DNA some of them are RNA viruses, but all of them have some homology and also occur for both the other thing is mutation rate is inversely proportional to genome size. So, the smaller the virus is the faster it will mutate and the larger viruses are a more stable again the DNA based viruses will be more stable their mutation rate would be lower the RNA based viruses would mutate it faster similarly single stranded viruses will have faster mutation rate double stranded viruses will have slower mutation rate this gives us an idea of how the evolution of virus might have happened perhaps it started from really small.

You know, proto viruses that were RNA based they eventually evolved to the most stable DNA based viruses grooves a size in genome grew the size of the genome moved from single stranded viruses to double stranded viruses, but the evolution has not obliterated yet the viruses that are single stranded or have smaller genome because high mutation rates might give them evolutionary advantages in unpredictable in new circumstances which is very common, all right, the other way we can classify the viruses is that.

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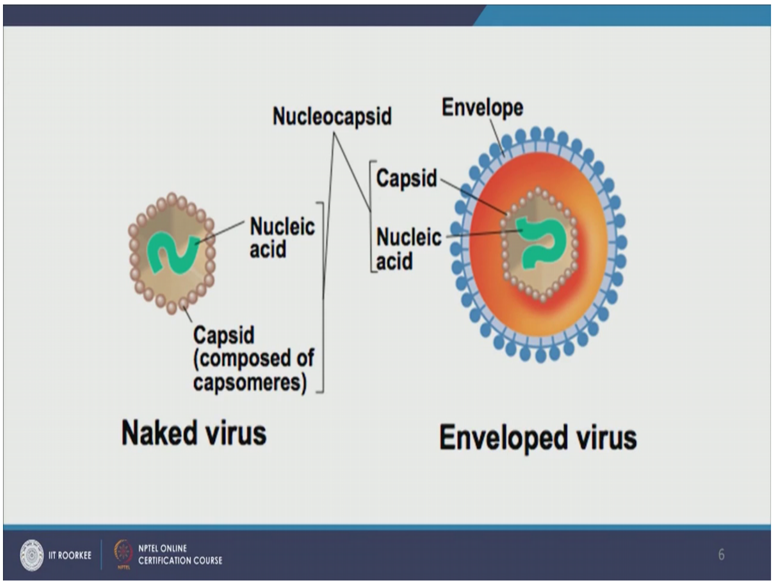

And we are not talking about the generating material only expire there is morphology they basically 2 kinds of viruses when is naked virus and the other is enveloped virus.

So, naked virus just has a protein coat capsid, it has nucleus and this is your naked virus no other business is going on in an envelope virus you have a protein envelope which is inside which you have a cap set much like this one inside that you had a nucleic acid. So, if you remember difference between prokaryotes and eukaryotes the prokaryotes do not have nucleus eukaryotes have nucleus similarly naked virus do not have the envelope, but envelope virus have the envelope and this place where inside the capsid including the capsid is called nucleocapsid. So, removed the envelop and you can make it virus ok.

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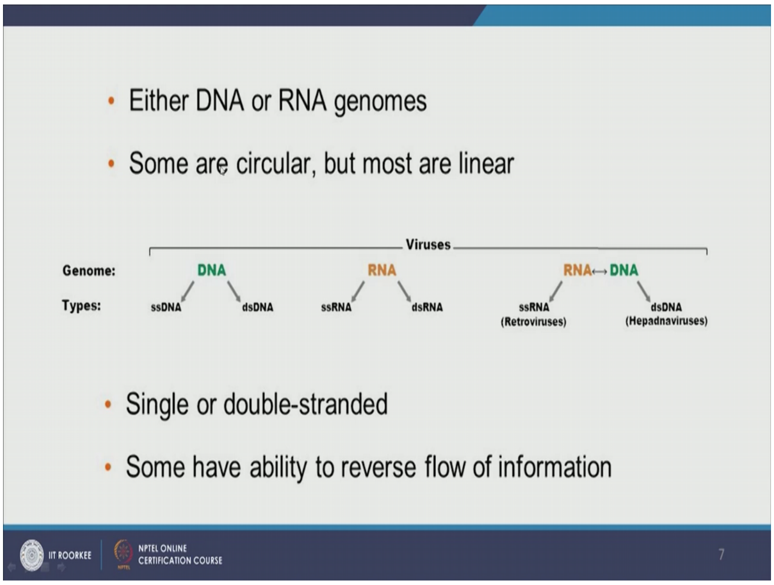

Virus can be both DNA and RNA as I mentioned already some of the viral genetic material can be arranged in a circular manner, but most of them are linear because they are linear does not mean that you will actually see you long hair strand in there, but because it is even though its linear they are usually a tightly packed and arranged in some convoluted 3 d conformation viruses can be classified into DNA RNA RNA DNA viruses DNA viruses can be both single stranded double standard similarly RNA viruses can be single stranded double standard some rare viruses have both single standard would be retroviruses and then they become hepadnaviruses double stranded d n a.

So, they can actually these viruses can actually switch from RNA to DNA and back all right.

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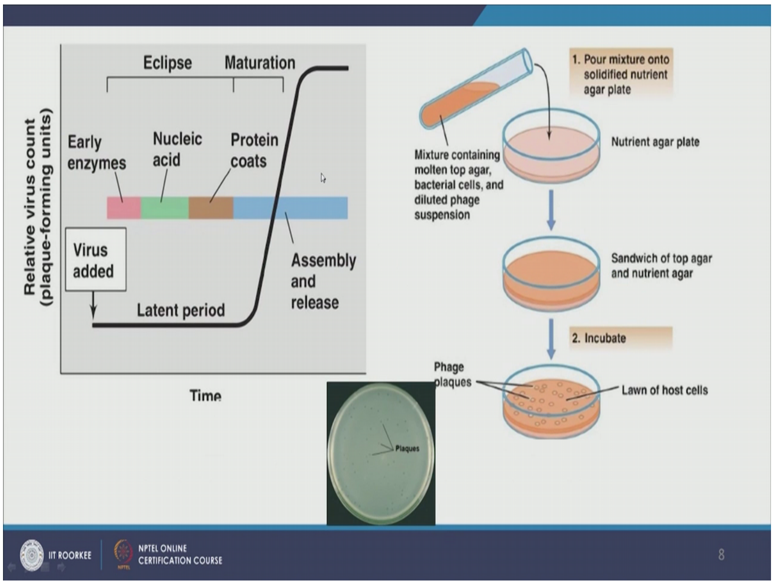

Now, let us look at viral growth how do we study virus. So, I want to study virus, but here is the thing they do not go outside of host cell right. So, for bacteria I give them food I plate a bacteria and the bacteria will eat food and it will grow on its own, but the virus will not do it; it needs a host. So, the first step for growing a virus in lab is to grow a line of cells. So, for example, if I want to grow hepatitis a virus in my lab, but if you want to grow up human pathogenic virus such as hepatitis a virus in your lab then first you have to grow a cell line.

So, cell nine is basically a plate on which your human cells are growing. So, for hepatitis a you might have the interse the liver cells growing for flu virus you might have endothelium cells growing. So, once you have a nutrient agar plate and in the top you have your cells that are growing this is for pathogenic virus cells right. So, your cell would look very strange you need to look very strange our plate of some media plate upon which your endothelium is growing your human cells are growing if you are growing bacteria first the viruses that home use bacteria as a host then you need to grow bacteria in your plate.

So, if you remember how bacteria grow in the plate they make colonies, but now instead of making colonies you may show that the entire plate is covered with bacteria. So, you do not see colonies, but you just see a film of bacteria. So, you put lot of your inoculums. So, when you the step one is you take your nutrient. So, if you are growing bacteria for you take a nutrient agar plate you take a mixture of top agar molten top agar bacterial cells and diluted phage suspension. So, this also has bacteria it has ager and it has phage; phage here is virus no virus that attack bacteria are called bacteriophage or phage.

So, you have phage here and then when you pour it in this; the sandwich off will get a sandwich of top agar and the nutrient agar at the bottom after a vial of incubation you will notice that you will have these plaques that will form in your plate. So, everywhere else because the entire media was had was full of bacteria everywhere as bacteria will grow, but wherever there was a viral particle that could infect bacteria it will infect the bacteria and the bacteria will die out in that region. So, after a while you will see these holes.

So, for example, even we are growing bacteria we talk about c f u colony forming units right how many colonies we have formed, but in case of virus we call it plaques forming you need units p f u how many p f u already. So, this is how you grow virus in lab and if you remember we had a turbidity measurement with our bacterial growth here we have related viral count how as virus increases how viral count increases as it under goes different stages.

So, as the time proceeds from here there will be latent period this is a eclipsed period and at the time of recording I must say recently there was a solar eclipse in us and it was in the other part of the world it was a big news there. So, similarly the virus has an eclipse period maybe we do not see any growth in virus. So, you will not see any growth in virus. In fact, you might just see bacteria growing everywhere depending on the bacteria and its growth rate.

So, what happens in this eclipse period is that the virus has attached to the cell because it the bacteria is present it has attached to the cells it has absorbed to the cellular membrane it has even injected its DNA inside the cell and, but it has not made the viral it has not made the viral particles yet. So, its undergoing the transcription if its DNA virus and translation and waiting for the proteins to assemble and make capsids its only when the protein coat is ready its only when the envelope is ready when all the replicas of the genome genetic material of virus is ready that it will assemble and it will lysis the cell break the cell and you will see a sudden increase in viral particles. So, in the latent period you have the early enzymes you right that are.

We will go through this very soon, but how that are making a port an entry port for divided DNA to go inside the cell you will have nucleic acid activity. So, you have transcription or translation or both and then you have protein coats being formed. So, your translation work is happening here in a very short maturation period you will have assembly of all this proteins that form the virus and the genetic material that forms a virus and lysis of the cell and then the release. So, in very very fast uprising in the number of cells and then it will be constituted of the infection done do not find any host the first step in cellular infection of viruses attachment adhesion to the cellular membrane.

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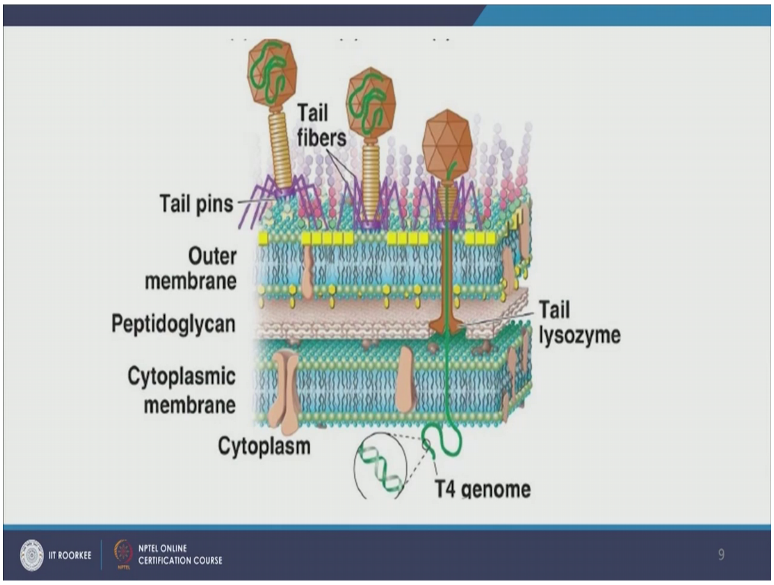

If you remember bacterial viruses how they are they are bi layer. So, this is lipid bi layer and in this particular case we had this has lipid bi layer by the first layer second layer in this, this is outer membrane in the cytoplasmic membrane. So, you know what kind of bacteria this is and this is your peptidoglycan layer.

The first step is that the tail pin the tail pin comes in sits on the virus and there is an adsorption here and then the tail fibers they actually get attached to the cell then using its certain enzyme it creates a port in cellular in the outer membrane and then. So, this is the lysozyme which lies the membrane. So, that peptidoglycan layer could be broken and all this could be broken and the port be made and then it is in it injects its entire genome this is an example of T 4 virus. Now note here this cap set now has no genome left it has released all the genome it had.

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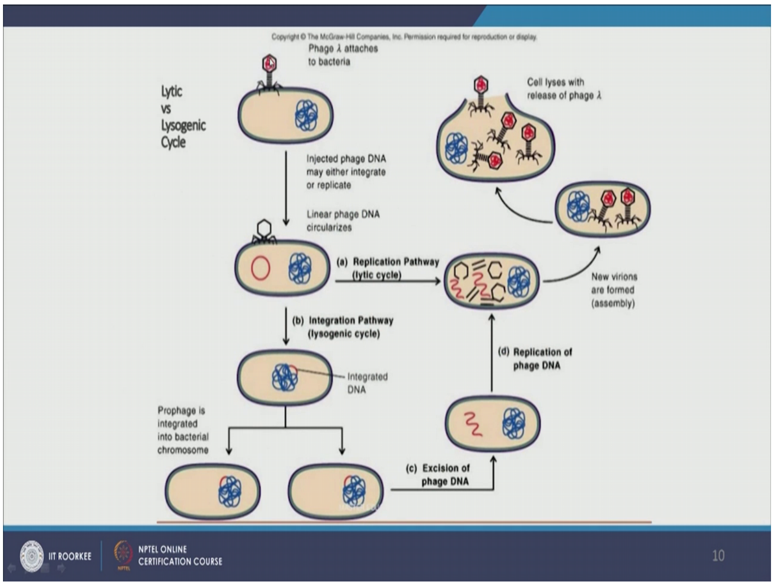

Now, once it has released all the genome. So, this was a chromosomal material of you prokaryote your bacteria your virus came sat on it got adsorbed to it I had some interesting chemistry going on between its tail pins tail fibers and as outer membrane then it had lysozyme activity they using which it made ports in the cellular membrane it released its virus here the viral DNA is a circular.

And here it is linear remember mostly it is linear some of them are circular and then it will typically it can undergo 2 pathways we are talking about one of the pathways here it undergoes the lighted pathway which is where now this will be transcribed and translated and so, transcribed translated and replicated both. So, we will have multiple copies of genome we will have the capsid proteins we'd have the tail fibers all these proteins being assemble. So, all this is eclipsed stage and then in the maturation stage they have assembled they have lysis the cell broken the cell and now they are escaping.

Um we will come back to the integration pathway in a bit. So, I will come back to this slide, but for all lets (Refer Time: 27:38) ok.

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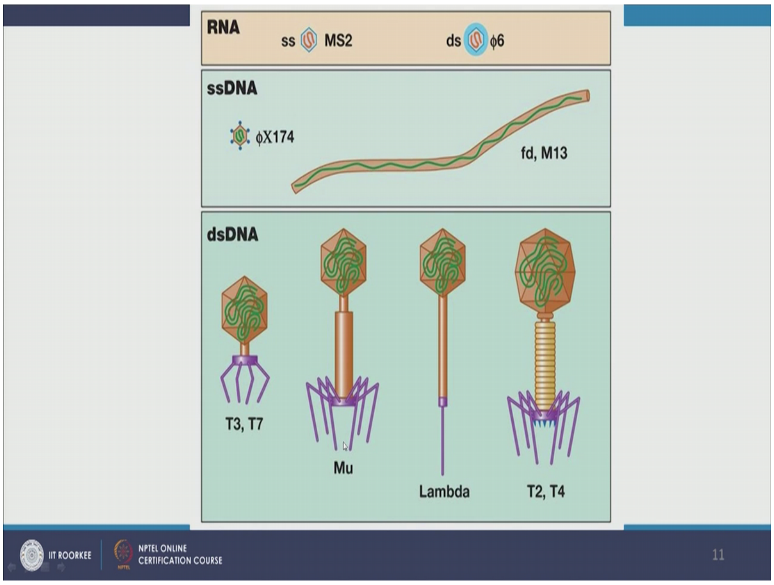

So, when you are talking about viruses I have already talked about it some of them are RNA viruses and these are a example single stranded m s 2 double strand phi six then some of them are single stranded DNA virus. So, we have phi x one seventy 4 we have f d m thirteen m thirteen for example, is used widely in lab all of these are used widely in life for different experiments and m thirteen to T 4 T 2 all these are used for cloning also. So, notice here linear, linear, linear and then double stranded DNA. So, we had double stranded DNA here some of the lambda mu T 3, T 7, T 2, T 4 is all of very very important microscopes of certain microbiological and techniques.

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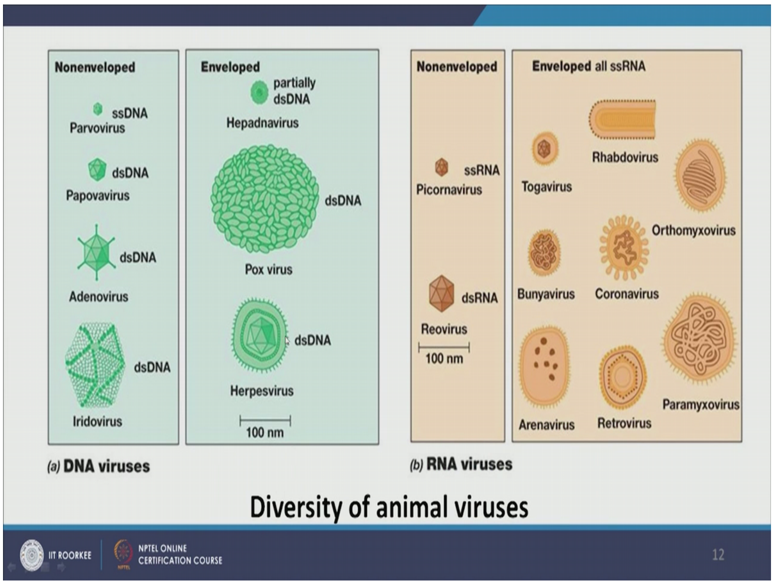

Now, if we are talking about animal viruses. So, these are not bacterial viruses, but these are eukaryotic viruses when we talk of eukaryotic viruses we have a more diversity. So, prokaryotes smaller cells you know if simpler we have not a diversity in pro bacterial bacterial phage, but when you come to different animals viruses is just immense. So, we have non enveloped we have enveloped DNA viruses we have non envelop and in envelop RNA viruses.

So, let us go through them. Let us look at this structure one by one. So, this is single stranded parvovirus; parvovirus also causes a very bad disease in young puppies then we have a papovavirus which is double stranded slightly bigger in size then we have adenovirus iridovirus. So, you see how the morphology changes in enveloped virus we have partially double stranded DNA.

This is hepadnavirus this has a wonderful capacity to switch from RNA to DNA then we have the pox virus. So, all pox diseases and if you remember smallpox has been eliminated long term will go. So, this is pox virus rubble it has double stranded DNA then the herpes virus and herpes is a very common disease and it is not necessarily obvious symptom again even when it is symptom it we just pass it off as a pimple that is coming up herpes chicken shingles are one of the kinds of herpes virus it is double strand it has a more complicated structure.

Now let us look at RNA viruses we have picornavirus single standard we have reovirus double standard we have all these are enveloped single stranded RNA viruses coronavirus bunyavirus retrovirus very important we will talk about retrovirus and then paramyxovirus is very funny virus also, ok.

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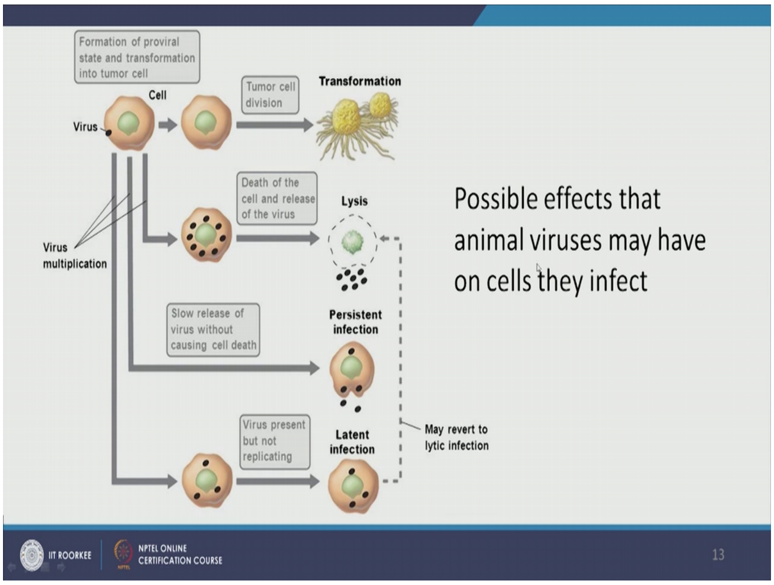

Now let us talk about the different effects that animal viruses may have on the cells. In fact, and this is where I go back to the previous slide that I said I will come back to. So, if you look here the one pathway for the virus is to undergo the lytic cell pathway. So, in lytic cell pathway what it does its making its multiple copies multiple copies of its genetic material of its proteins it then they are assembling into virion viral particles inside the cell they break the cell membrane they break outer membrane and they are released now they can go and infect other cells.

So, this is the lytic replication pathway the other is lysogenic pathway in lysogenic pathway they do not damage the cell like this they become inherent part of the cell the way it works is that this genetic material from the virus will actually become will get integrated in the chromosome of the bacteria.

So, it gets integrated into DNA. It is just highlighted better and red and as the bacteria replicates the virus will keep replicating. So, see which is quietly replicate and the bacteria will not notice except that its replication energy demand would increase it requires a little more energy node to replicate because it has slightly longer fragment of genetic material to replicate it is quite possible that at a given time this integrated viral genome will be excised it will be removed from the chromosome like this and then the cell might kill it or it might be transcribed replicated and translated and then it will undergo a lytic cycle. So, both are possible first lytic cycle then lysogenic and the lysogenic can also come back to lytic cycle.

So, let us look at what happens when animal viruses infect the animal cell. So, now, what we are going to look into is what happens when a virus infects an animal cell now this is a special kind of virus this is a virus that actually when it infects the animal cell it causes tumour. So, there are certain cancers or certain tumours that can be viral cause for example, the human papillomavirus, it is found, it is also cats are a carrier of it to when they infect a human we can cause tumour, we can cause cancers.

So, these viruses that cause cancer. So, they internal and healthy cell and what they can undergo multiple pathways one of the pathway is that it can directly affect the nucleic acids of the cell and cause it to become transformed into tumour cells or this is tumour cell the other pathway is that it can go it can form multiple copies.

So, it can undergo lysis pathway you can form multiple copies cause the cell to die and release the virus now these viruses are free to go and infect other cells the third, but wait can undergo is it will undergo replication, but instead of killing the cell if you undergo slow release of viral particles. So, this it will not allow the cell to die. So, the cell function is compromised cell is not happy cell is weak, but the virus are being released and replicated inside it at a slower rate.

The fourth possibility is that the virus enters the cell, but it is not replicating this is latent infection. So, this is very common with human papillomavirus all of these stages many a times people have it, but does not cause tumour directly, but after a while it might revert to lytic infection in they start feeling sick because now their cells are dying it is also possible that if it is a tumour based virus and is quite potent it will transform these viral particles will transform healthy cells into tumour cells which are which suck all the nutrients from the body.

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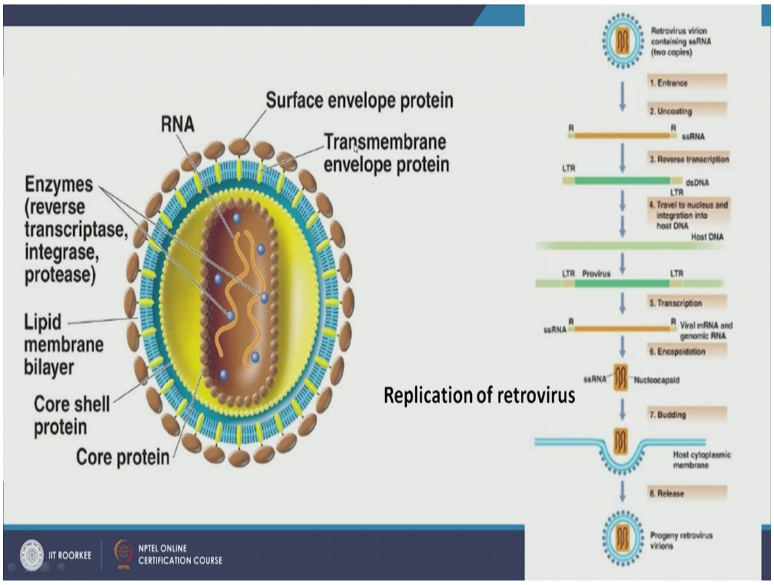

The other interesting kind of virus that we want to study in this lecture and I think this is the last kind of virus you study in this lecture are retroviruses. So, the beauty of retroviruses is that they have r n a. So, their replication this is a typical retrovirus. So, you notice that there their surface and all proteins and then you have the transmembrane proteins you have RNA you have these enzymes usually they are reverse transcriptase integrase or protease.

So, reverse transcriptase allow the reverse transcription integrates are allow integration with other integration into other genetic material if need be and then you have lipid membrane bilayer you have a core shell protein here and then you have the core protein here how does retrovirus replicate. So, the first step of retrovirus is that it will enter it will the cell and then they will be uncoating. So, all the codes will be removed and now you have a let us say single stranded RNA.

So, the reverse transcriptase will allow the single stranded RNA because remember these are single stranded RNA viruses they allow them to undergo reverse transcription. So, now, they have double stranded DNA. Now this double stranded DNA will enter the nucleus. So, we are assuming this is. In fact, a nucleus eukaryotic cells animal cells. So, it enters the nucleus and then it becomes part of your nucleic material.

So, remember the integrators they will allow the double stranded DNA that has been the reverse transcript the reverse transcribed from the single; single stranded RNA to become essential part of DNA. So, it is not undergoing the lytic pathway, but the lysogenic pathway and now here we have provirus and then this will be transcribed and then this is part of the dental material undergoes transcription I know you have viral m RNA and remember this is a single stranded RNA.

So, when you have viral m RNA after transcription of genetic material you basically have virus now this virus can be translated it will make all its proteins it will be ready it will make the; it will get out of the host cytoplasmic cell membrane will be released out now it has prove virion progenies.

So, dear students I think this is a good place to stop a lecture for today in next lecture we will talk about viral diseases we will also briefly go through some other pathogens which are neither bacterial or kill you cordial or viral like viroids which are slightly different from virus, but are immensely powerful when it comes to infections in plants and will briefly talk about it.

Thank you so much.