Molecular Biology
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Module - 04
Central Dogma of Molecular Biology
Lecture-17 Genetic Material (Part 1)

Hello everyone, this is Dr. Vishal Trivedi from the Department of Biosciences and Bioengineering IIT Guwahati. And what we were discussing we were discussing about the different properties of the cell in the course molecular biology. So far what we have discussed we have discussed about the basic properties of the biological system where we have discussed about the cellular structures, we discussed how the cells are dividing and then we also discussed how the cells are dying through a process known as apoptosis. And in the previous module we were discussing about the different types of bio molecules. So we have discussed about the DNA, we have discussed about RNA and we also discussed about the protein and the enzyme.

So with this brief discussion about the biological system we have discussed about the bio molecules we would like to you know ask the questions how the information from the one generation to another generation is passing and what are the different types of molecules which could be responsible for passing the information from the one generation to another generation. Now what you see is that I am sure you might have noticed that some of your own traits are matching with your parents. Similarly the traits what are present in the plants they are also of mixed traits right they are also having the some information from the one parent and the some information from the other parents. And on the other hand you might have seen that some of the diseases which are which are propagating within a particular type of families.

For example, I am sure you might have noticed the traits like height, eye color and other kinds of phenomena like the hair colors and the way you speak and the way you actually you know behave is all being transferred from the parents to the child. Similarly you might have seen that the seeds from a red color flowering plant always produce red color flowers naturally right and then you might have seen also the different kinds of variation like if you have the cross breeding of a white flower and the red flower you will see that they were actually having the pink flower and so on. And there is a classical examples of the hemophilia also where which actually runs in different types of families from generation to generation. Now the first question comes that how does it happens and the answer to this question is that it is all because of the hereditary. So what is heredity? So heredity or also called as inheritance is the passing on the traits from the parental generation to the offsprings either through the asexual reproduction or the sexual

reproduction.

So the offspring of the cells obtain the genetic information of their parents. So because of the hereditary or the inheritance you are acquiring the traits or you are acquiring the phenomena or acquiring the phenotypes from your parents. Definitely when it is if it is asexual reproduction the traits are going to be completely 100% intact. But if it is asexual reproduction then it is actually going to be mixed because you are going to have the 50% traits from your mother and the 50% traits from your father actually. And depending upon who which trait is dominating and which type is recessive it is actually going to show you the phenotype.

So we are not going to get into the detail of the hereditary or we are not going to get into the genetics part. So because that is beyond the scope of this particular course and that be that for that you can actually go through some of the most courses on the genetic material on the genetics itself and that may help you to understand this particular phenomena that how the traits are getting you know expressed in some generation and they are actually being not expressed in other generation as well. So the first question comes that if it is actually the thing that you are actually going to acquire the traits from the mother and the father how this particular type of phenomena is happening and who is responsible for that. So who is responsible for carrying the information from one generation to another generation and the responsible the molecule which is responsible for this particular information or what for this particular phenomena is called as the genome or I will say genetic material because it is actually going from one generation to another generation and because of that this particular molecule is being called as the genetic material not the genome actually. And I am sure when we were discussing about the cell and even in the previous lecture also when we were talking about the biomolecule if you see the cell the cell is very complicated right it actually has a nucleus it has the cytoplasm it actually has different types of organ is in the prokaryotic system also you have all those things but not the membrane bound right.

So you also have the miniaturized level of or the primitive conditions of the electron transport chains you also have the other kinds of things. So basically if you think about the wherever the information can be stored there are multiple possibilities one is in a cell it can be nucleus or I will say the genome or I will say DNA because we know that the nucleus contains the genome which is made up of the DNA. The second possibility is the cytosol or I will say cytosol actually right and cytosol is mainly been contain one molecule which is called as protein and plus RNA right. So RNA is also present in cytosol then you also have the membrane bound organelles. So membrane bound organelles are also been made up of the protein and RN lipids right because the membrane and lipid right.

So we basically have the candidate molecules which are responsible for carrying the information but because the technique was not evolved or how the people have find out the who is actually responsible for carrying the information is a very long journey right. So let us first so what are the molecules we have? We have the DNA we have the potential target potential molecules like the DNA we have the proteins we have the RNA and these are the molecule which are actually having the sequence which having the stored information. For example you know that the DNA is made up of the nucleotides so that also is actually providing the sequence of nucleotides so that also can actually carry the in homogeneous amount of information. I am sure you can calculate if you have 4 nucleotides how many different types of random combinations could be possible to give you the different types of random DNA sequences. Similarly you have the protein which are made up of the 20 amino acids and all these 20 amino acids random combinations can give you the enormous information so that is how and the RNA also right the same way the RNA.

So these 3 molecules are actually having the similar kind of nature apart from that you also have the lipid but lipid does not have that kind of flexibility of storing the information. So that is why the lipid is straightforward is being discarded by the scientist what they were focusing on the DNA protein and RNA. But before that the people have done the crude experiment because until the people have not discovered the DNA protein and RNA they were under the you know the they were not having the technology. So they were doing the experiment they were trying to identify the carrier molecules which actually carries the information from one generation to another generation and that is how they have done multiple type of experiment. So let us see how we have you know we have done the what is the history of identifying the genetic material and then we will talk going to discuss about the different types of classical experiments how people have you know figure out whether the DNA is the genetic material or protein or RNA.

So the first experiment is been done by the Astrea scientist or I will say the priest Gert-John Wendell. So he is considered to be the father of genetics and he actually has done extensive experiment with the pea plants and where he has taken the combination of traits and that is how we have come up with the classical rules of the genetic the classical rules of the genetics and so what is the history of the genetic material. So it is well known that the qualities are passed down from one generation to the next the offspring shares certain characteristic with both of their parents. But the question is who is responsible for this? It was first time on the basis of its interest in the plant hybridization studies on the sweet pea the piscine satayabam monk in a monastery in Austria Gregor John Mendel try to find out this answer he proposed that the some factors. So in when the Gregor John Mendel was doing the experiment there was no technology of

involvement there were no technique available to say that DNA, RNA or protein but he said that there are factors and he used the term factors that carry the information on the manifestation of a characteristic or phenotype and how the traits are being passed from one generation to another generation.

So since he gave the clue about this particular factor and he said that this factor could be dominant factor and recessive factors and so on and all that and all these law of genetics you might have studied in some of the textbooks. So then people have started you know identifying this particular factor. So in the late 90s century by the three biologists, Thumodouvris, Karl Kornes and the Eric Vaughan worked on the Mendel works and proposed that different characters have individual hereditary carriers and the inheritance of specific traits in an organism called particles. So Dviris actually called these units as the pan genes and he actually come up with the theorem of the theory also that so he actually discovered that these factors which the Mendel was talking about is nothing but it is actually the pan genes which actually go and if the pan genes can move from one generation to another generation they are actually going to carry the that particular characteristic or the quality. Then in the almost 20 years later when the William Johnson and William Batson actually proposed the term gene and the genetics respectively but Edwards, Tranberger and the other continued to refer to the basic physical and functional unit of hereditary as the pan gene.

So basically from the pan gene it becomes gene and the gene was being considered to be a responsible factor. So genes are present in chromosome which are evenly distributed between the two daughter cells during the cell division and the biochemical study showed that the chromosomes are consist of protein and the DNA. So it is clear that the gene is present in chromosome and we are going to discuss about this nuclear packing and all that when we are going to talk about genetic material and the chromosome is made up of two parts the protein part or the DNA part. So the first question is that is the genetic material proteins or the DNA which means out of this chromosome which one is more responsible the protein part or the DNA part because it has the both the components. So until 1940s the proteins were thought of a genetic material because proteins are polymer made up of the 20 different types of amino acids which are abundant and encode the diverse information and you can easily calculate in fact you can actually go with that activity right.

How many different types of amino acid compositions or how many amino acid combination could be possible if you have the 20 different types of amino acids. So for example you have a very small protein of 100 amino acid if you have a small protein of 100 amino acid and you can have the 20 different random combinations you can actually be able to calculate that number that number is going to be very very very big actually.

However based on the certain experiments that have been conducted from the time time it was finally shown that the DNA not the protein actually carry the genetic material but we are actually going to discuss in detail about this particular these experiments and conclusion comes that it is a DNA which is actually being the molecule present within the chromosome and that is actually going to carry the information from one generation to another generation. Now the first question comes what could be the properties of the genetic material what could be the possible or the probable properties you should have or a molecule should have then only you can say okay this is the genetic material. So the properties of the genetic material okay so for a molecule to be considered as the genetic material because you can have the some requisite parameters to accomplish the its task right what is the task? Task is to carry the information from one generation to next generation right that is the task of a genetic material and that is why it should have a repeat circuit conditions.

What are the conditions number 1 is stability number 2 is it should be editable and expression number 3 it should have the mutations and a number 4 it should be getting replicated. So stability it must contain all the biologically useful information in a stable form which means it should be stable it should be you know it should be the distance for any kind of damages and if it there is a damage it should have a mechanism to recover from that particular damages then it should be having the irritability and the expression. So it should process a hereditary units which follow the Mendelian inheritance and control the expression of a particular phenotype. So it should have the components we should have the and I think all these you are going to understand when we are going to talk about the transcription and translation that how there are different components which are present within the genetic material and that actually controls the expression of a particular gene. And so you should have these kind of switches you can have these kind of switches so that you can actually be able to modulate the expression of the particular gene and that is how you are actually going to modulate the overall phenotype of that particular organisms.

I am sure you might have noticed when you are going into the sun and it is very hot outside you always start sweating. So that sweating occurs because there is a you know there is a expression profiling changes within your body and that is how they started you know throwing the sweat. Same is true when you are entering into a you know into a cold room or entering into a place where you have AC and then you actually you know all your set is disappeared and then you also feel cold right and when you feel cold you find that the skin is actually you know becoming more you know the contract actually. So these things actually been you know done simply by the information what is present inside the genetic material. Then the third property is about the mutations right.

So genetic material is also going to acquire the mutations some of the mutations could be good some of the mutations could be wrong and that is how the mutation accumulation of mutation is actually going to result into a change in the phenotype and that will be responsible for evolution right. So mutation is the random change which may occur and that may be a chance for evolution actually. And then number four is replication because as I said you know genetic material is you are going to have only one copy of genetic material. So that genetic material has to be replicated and that is why you are going to have two copies of genetic material and then you can actually be able to in a situation that you can be able to share. Remember that when we were talking about the cell cycle we said that during the S phase the DNA is actually going to be duplicated right and then only it is actually going to be shared between the cell.

And the same is true for between the parents and the offspring as well that you are going to have the two copy of genome and then when you are going to share one copy with your offspring and the so on. So that should have the ability to synthesize its own copies. This replication is actually what we are going to discuss in our subsequent module we are going to talk about the replication transcription and translation. Now there are some direct evidences or experimental evidences and there are some indirect evidences which prove that the DNA as a genetic material. So there are direct as well as indirect evidences which have ruled out the protein or the RNA as a genetic material and that has proved that the DNA is actually the most acceptable genetic material which is present starting from the prokaryotes to mammals.

There are exceptions and these exceptions also we are going to discuss. So in 1928, Friedrich Griffith actually performed an experiment for the bacterial transformation and by doing these experiments he proved that actually the information what is being present in the DNA is actually carried from one bacteria to another bacteria and that is how it is actually going to change its phenotype and that is how it is actually going to be responsible for the death of the mice. Then in 1944, the Oswald, Averi and McLeod and McCarty actually done the experiment on the transformations and that also has proved that it is actually going to be the DNA which is going to be responsible factor. And then we have the Alfred Hershey and the Chase experiment on the T-even bacteriophage and that is how it that also has proved that the DNA is a genetic material. So if you go by the timeline in 1869, the Friedrich-Mateur actually isolated the nucleic acid or I will say the genetic material from a white blood cells.

Then in 1928, so, almost after 50 years or 60 years, the Friedrich Griffith actually demonstrated that the genetic information from the one bacteria goes into another bacteria through a phenomena which is called as the transformations. Then in the year of 1944, the McLeod and McCarty actually identified that the DNA is actually a

transforming agents, it actually carries the genetic information and then it actually can change the phenotype of the other bacteria. Then in the case of 1952, Hershey and Chase actually confirmed that the DNA is a genetic material with the help of the viruses. And then in 1962, the Watson, Crick and all those people have got the Nobel Prize because when they have discovered the structure of the DNA. So, let us first discuss about the Griffith's experiment to understand that the DNA is the genetic material and then we will talk about the McLeod and McCarty's experiment and then ultimate and at the end we are going to discuss about the Hershey and Chase experiments.

So, the Griffith's experiment, so, he has used a bacteria which is called as pneumococcus. This pneumococcus is actually called so, he has used the bacteria which is called as streptococcus pneumonia and he has used the two different types of strain, S strain and the R strain. So, S strain and the R strain is also going to be called as, so, the S strain which is a virulent pathogenic strain that is S strain because called as smooth strain or the S third strain and the R strain is a recessive strain. So, R strain is the a virulent strain and it is non-pathogenic strain known as the R virulent or the rough strain or the R2. So, S strain is actually going to cause the disease whereas R is not going to cause a disease.

So, if the S is going to cause a disease S is actually going to kill the mice's whereas R is not going to kill the mice's. So, S strain has a smooth outer coat of the polysaccharides and the R strain lacks this polysaccharide coat and therefore, its surface appears rough. S3 strain was virulent possessed a lipopolysaccharide capsule and could kill mice by causing a disease pneumonia and made round colonies on a cultural plate. Whereas the R2 strain was a virulent and lacked a lipopolysaccharide capsule giving life to the rough shape colonies onto the cultural plate. So, these are the some of the properties given.

So, serotypically it can be SR2 or the S3 and morphologically the R strain is a rough strain whereas the S strain is a smooth strain. Then capsule was absent in the case of R strain whereas it is present in the case of S strain and R strain is virulent. What is mean by virulent is that it is not going to cause the disease whereas in the case of S strain it is virulent. So, it is actually going to cause the disease and what disease it is going to cause? It is going to cause the pneumonia and ultimately it is actually going to cause the death of mice. So, this is the experiment what he has done.

So, he has done the experiment using the four different types of conditions. So, case 1, case 2, case 3, case 4. So, in the case 1 what he has done is he has taken the S type of bacteria and that he has injected into a healthy mice and after some time the healthy mice is gone because he developed the disease pneumonia he has developed the pneumonia and that is how he actually died. And the case 2 he has injected the R type of bacteria.

So, R type of bacteria is virulent bacteria.

So, it is actually not going to cause any kind of disease and that is how this particular mice is actually going to grow and that is how the mice is actually going to live. Then the third experiment what he has done is he has actually denatured the S type of bacteria. So, he has heat killed the S type of bacteria and then he injected that into a healthy mice and that also has not caused any disease and that is how the mice is survived. Then the third is he has taken a heat killed S type of bacteria. So, a virulent bacteria he has heat killed.

So, this is not live bacteria and then he added the R type bacteria which is live. So, this is live this is dead bacteria and then he mixed them together and in the case 4 and then he injected them into a healthy mice and when he done that he actually found that the mice have developed the disease and he they also died. So, this was very interesting that something which was not infective because in the case 2 you see that the R stain is not killing, but in the case of in the case 4 the R stain is killing the mice if it is being mixed with the heat killed S2 or S3 actually. So, these are the 4 different types of conditions and then what he has done is he has isolated the blood. He isolated the blood from this case number 4 and what he found that there was no R bacteria present it was all the S type of bacteria what is been isolated.

So, all the R type of bacteria is actually being converted into the S type bacteria in the case 4 and that is how he said that the material or the material which actually carries the information from this bacteria gone into this material gone from the heat killed bacteria into R type bacteria and that is how the R type bacteria got converted into S type bacteria. So, there is a and then that is that is how he actually pointed the term that this phenomena is going to be called as transformations. So, when the Griffith has injected a mixture of heat killed and live bacteria the mice died and living living S bacteria recovered from the dead mice. So, remember that he actually he has killed the he has actually injected a heat killed S type bacteria that he got the live S type bacteria because the genetic material what are present in the S type bacteria heat killed bacteria were gone into the R type bacteria and that has convert or that has actually started expressing its own genome and that is how it is actually going to cause the generation of S type bacteria. So, Griffith concluded that the R type bacteria had somehow transformed by the heat killed strain bacteria some transforming principle transferred from the heat killed S strain had enabled the R strain to synthesize a smooth polysaccharide code and become the S strain this must be due to the transfer of the genetic material from the S type bacteria to the R type bacteria.

However, the biochemical nature of genetic material was not defined from this

particular type of experiment. So, we do not know still that what is actually being transferred whether the DNA or protein or RNA. So, then we did they did the further more experiments. So, in a meantime, the Oswald and McCarty and McElroy actually did the more specific experiment to ask whether the factors which are actually converted the R type bacteria into S type bacteria whether it is the DNA protein or RNA. So, it was believed that the genetic material was made up of the protein they work on the transforming principle in Griffith experiment to investigated its biochemical makeup.

So, to determine the biochemicals from the heat killed S type bacteria which could convert the live R type bacteria into S cell they isolated the biochemical like they isolated the proteins DNA and RNA from the S cell bacteria and finally, found that the DNA from the S bacteria was needed to convert the R type bacteria. So, what they have done and what they have used for this particular type of experiment they have used a three different types of enzymes they have used a DNases. So, the function of DNA is that it is actually going to digest the DNA. So, it is actually going to destroy DNA. So, if you take the DNase and if you take any reactions, it is actually going to destroy the DNA.

So, it is actually going to remove the DNA part. Similarly, they have the RNase. So, RNase the function is that it is actually going to digest the DNA which means it is actually going to destroy RNA part or I will say it is actually going to remove the RNA from the reactions. Similarly, you have the another enzyme which is called as proteases and the target substrate for the proteases is that it is actually going to digest the proteins and it is actually going to destroy the proteins because it is actually going to convert the protein into the amino acids. This means it is actually going to remove the protein components means if you have a reaction for example, if you have a reaction and if you treat this with the protease for example, so then this protein this reaction is going to be a reaction minus protein because you have treated with the protease and that is all you have removed the protein. So these are the some handy enzymes what these people have used to answer the questions which one which biomolecule is actually the genetic material.

So what they have done they have repeated the same experiment what the Griffith has done that where you have the heat killed S type bacteria and then you have the live R2 bacteria and then when they were taking the heat killed bacteria they have treated that heat killed bacteria with protease. So they have either treated it with the protease or treated it with the RNAs or treated with Ross okay, so, in these cases what you have done is you have removed the protein in this reaction you have removed the protein in this reaction you have removed the RNA and in this reaction you remove the DNA. This means in this reaction you have D protein and RNA present in this reaction, you have the

DNA and protein present. So what are the things present you have the DNA and RNA present, right? You have because the protein is already been removed because of you have treated with protease. Then in this one since you are removing the RNA, you are going to have the DNA and protein and in this one you are going to have the RNA and the protein because you have removed the DNA, right? And then he tested which in which condition the mouse is actually going to die.

So in this case when you have no protein you have no protein mice is dying, right? This means the protein is not responsible for converting the R bacteria into a rulant S bacteria, right? Similarly, when you have no RNA, right? Then also the bacteria of mice is dying because it is still the R type bacteria can be getting transformed into S type bacteria. And the third is when you would not have DNA, right? So when you remove the DNA, you are actually going to see that you are having a healthy mice, right? This means in this one you have the RNA and protein but still mouse is not getting the disease which means R strain is not getting converted into S strain and that is how the mouse is actually healthy. And what you see it even at the cultural level also when they culture the bacteria what they found that they could be able to recover the live S bacteria in the absence of protein and RNA but they could not be able to isolate the live S bacteria instead they are actually getting the R type bacteria R2 in the case of the third condition when the DNA is not present. So this actually confirmatory we proved that DNA is the genetic material.

Now let us talk about the conclusions. So they found that both RNA and protein digesting enzyme had no effect on to the transformation proving that the molecule undergoing transformation were either protein or RNA, okay? Or neither a protein or RNA transformation was prevented by DNA digestion indicating that the DNA was the transformation is in. So they came to the conclusion that the DNA is the genetic material but not all biologists agreed with that, okay? And then the further experiment were done by the Alfred Hershey and Cshershy and Chase experiment. So in the Hershey Chase experiment the researchers on the virus that infect the E. coli provided additional evidence for the genetic importance of the DNA. The DNA core of the T2 bacteriophage is in placed in a protein code.

Alfred Hershey's and M.R.C. Chase put this theory to the test in the following manner. The radioactivity labeled T2 phase in either the protein which means the 35S or they have labeled the DNA with the help of 32P component before injecting them into the bacteria which means they are going to have the bacteriophage where they have labeled the protein or where they have labeled the DNA by the radioactivity. Similarly they infected the non radioactive E. coli with the radio labeled T2 bacteriophage. So in a T2 bacteriophage you can have the protein which is 35S which means sulphur labeled or you can have the DNA which is actually going to be the 32P right or the phosphate

labeled, okay? And that is how they have asked where or which molecule is going from one generation to another So they injected the bacteriophage bacteria with the T2 phase that has been radio labeled either in the DNA component or in a protein component.

The infected bacteria were agitated in a blender and the two fraction were separated by the centrifugations. One fraction contains the empty fast code that was released from the surface of the bacteria that consists of the protein and therefore carries the 35S radio label. The other fraction consists of the infected bacteria itself. Most of the 32P label was found into the infected bacteria which means when they were doing the agitation what they found is that the protein which is a part of the code was always been extracellular and it was not being carried within the bacteria right? It was not getting into the bacteria and so when the virus is infecting the it is code is remain outside and that is how it is actually going to be present outside. This means the radio labeled protein remain outside whereas radio labeled DNA remain inside.

So that is why there was no sulfur what has been associated with the bacterial cell whereas in the case of DNA all the DNA was present inside and that is why there after centrifugations the radio activity was associated with the bacteria. So by doing this experiment where they were doing the infection followed by blending and followed by centrifugations what they found is that the protein is extracellular whereas the DNA was associated with the bacterial system and by doing this experiment the Hershey and Chase concluded that the DNA is the genetic material. So by the observation they found that the most radioactive protein was released into the supernatant whereas 32P DNA remained within the bacteria. Since genetic material was injected and T2 progeny was produced DNA must have been carrying the genetic information for the T2. This means not only that when the bacteria got lysed it has reduced in homogeneous amount of viruses.

This means the genetic information was there inside the bacteria to produce the viruses and that was nothing but the DNA. As host or the code of the bacteriophas were not labeled with the 32P and only with 32S the result of the experiment clearly indicate that the only DNA and not the proteins entered the bacterial cell. Protein code is left outside all of the genetic data necessary for the creation of a new fast particle is carried by the DNA that entered the host cell. This undoubtedly demonstrated that the DNA not the protein serves as the bacteriophas genetic material. And that is how they have concluded that the genetic material is DNA not the protein.

Then there are several indirect evidences for DNA to be as genetic material. First evidence is that the DNA regularly present in the nuclei of all cell types. It is equal the amount of DNA present in all cells of an organisms and amount of DNA is proportional

to the ploidy of the cell. The ploid cells have the half amount of DNA than the diploid cells. Nuclear division occurs only after the DNA duplication during the S phase of the interface is anyway we have discussed when you are discussing about the cell division.

Then the different species have different amount of diploidy DNA. Out of all macromolecule DNA is metabolically more stable or the most stable molecule and that is a first criteria that the genetic material should be very stable. Indefinite number of combinations are possible with the four sub bases like ATGC. DNA has some same physical and chemical property in all organisms yet allowed to produce great diversity of the organisms. So this is was clear that the DNA is the genetic material. But this has been challenged when people have discovered that there is a phenomena which is called as the reverse transcriptase or reverse transcription.

When the people have discovered a phenomena which is called as reverse transcription. So what is mean by the reverse transcription is that the RNA is actually going to give rise to the DNA. So this reverse transcription was against the central dogma of molecular biology. It says that RNA can be able to produce the DNA and by doing so there was people who said that RNA is also made up of is very stable right RNA is also stable RNA is also can provide the diversity and since RNA can be converted into DNA is there is a possibility that the RNA would also be behaved like a genetic material right and then the same in under the exceptional cases or some other kinds of cases right. So then again the same debate started whether RNA could be a genetic material or not.

So to prove that the people have started doing this experiment okay. So RNA as a genetic material okay. So according to the RNA world hypothesis the RNA was the first genetic material that stored all genetic information and it is believed that the first life arose from it. RNA is thought to catalyze a number of chemical reaction in the primitive cell. The presence of the two hydroxyl group in ribose group increase their reactivity but this reactivity makes them unstable which makes the RNA unfavorable as a genetic material. So as a genetic material it should be well stable chemically and structurally.

So that was one of the drawback of RNA as a genetic material that it actually contains the two prime hydroxyl group and because of that it is actually having the more reactivity compared to DNA. So ultimately these unstable molecules are replaced by the more stable genetic molecules. During this stage of evolution the DNA molecule emerged they have replaced RNA's role in the cell as both genetic material and structural component. The unstable and degraded nature of RNA has led to the development of double standard DNA genetic material that is both chemically and structurally more stable. So according to the hypothesis it is found that the RNA is actually being the preferred material for genetic material in the primitive cell okay.

So during the evolution what the cell has found that RNA is good in terms of genetic material because it reduces the steps right. You do not have to go for the transcription you can directly use that particular information to produce the protein. But on the other hand it is unstable so what they have done is they have converted the RNA into a double standard DNA and that is how you are actually bringing the more stability and chemically as well as structural stability into the structure. However RNA is not being completely eliminated they still serve as a genetic material in some systems like the viruses and they catalyze few essential biochemical reaction into the cell. Also the complex machinery of protein synthesis from DNA is still profiting through RNA okay.

So RNA is very important in terms of relaying the information from the DNA and that is why it is not been excluded from the complete picture of the protein synthesis. Still the protein is been synthesized from the RNA cell. So even if you see that the DNA actually stored the information it is RNA who actually you know dictate the production of the protein and that is how RNA is actually responsible for the particular type of phenotype. So RNA is present as a genetic material in some of the viruses right. So virus consist of two parts nucleic acid and the protein coat sometimes with additional envelopes.

So virus contains only one type of nucleic acid either the DNA or the RNA. These have RNA are called riboviruses they vary in the structure of their nucleic acid also the plant viruses are RNA viruses either single standard or the double standard. So you can have the animal viruses you can have plant viruses you can have single standard RNA viruses you can have double standard RNA viruses and in even in the plant viruses also you can have the single standard viruses like the TMB or you can have double standard viruses like the orayas viruses. Then we have the evidence in favor of RNA as a genetic material. So first evidence that RNA is also has a capacity to carry the genetic information came from the experiment which is conducted on the tobacco mosaic or TMB viruses. So Cricker and Schumann demonstrated in 1956 that the tobacco plant can contract mosaic disease when exposed directly to pure RNA from TMB.

RNA treatment render the pure RNA incapable of inducing the TMB lesions. Then Franklin, Pernhart and Singer demonstrated in 1957 that the progeny viruses from the TMB infection with viruses have RNA from one strain and protein from another strain were invariably of kind determined by the RNA not the protein. So this is what exactly they have done they have taken a TMB virus and what they have done is they have removed the capsid protein so they have removed fragmented that into a protein and RNA and then they degraded the RNA with the help of the RNA. So these are the four components so when they take the TMB virus and if they infect the new cells new leaf they could found that the infection is happening. When they remove the capsid okay

when they remove the cap a capsid part right so still it is actually having the RNA right and if you remove the cap capsid part or it is so if they remove the fragmented fractionated that into a capsid and the pro and RNA when they taken the capsid protein and infected that to the protein there is no infection so there is no infection right no infection. But they have take the RNA and if that infected into the protein and into the leaf what they found is there is a infection.

So basically the genetic information what was present into the RNA is good enough to produce the virus and that is how it actually causes the disease. Then they degraded the RNA with the help of the enzyme RNAs so there is no RNA right. They could found that there is no infection so there is no infection in this case also. So Grigor and Schumann correctly concluded that the viral genome of TMB is composed of RNA so if there is no RNA then there will be no infection. And then Franklin, Godhart and Singel uses the type A and type B TMB virus in this investigation the RNAs were then isolated RNA for the protein porting and then in order to create hybrid viruses Singel concluded the RNA of the strain with the protein of the another.

So the phenotypically and genotypically identical progeny virus was similar to the parental type from which the RNA had been recovered after rubbing the hybridization or reconstituted viruses on to the living one. So these people what they have done is they have excluded the RNA of they have isolated the RNA of the from the two different types of TMB viruses like TMB A and TMB B and when they mix them together what they could found that they are actually having the you know the hybrid viruses what is being produced. So in conclusion so Franklin, Godhart therefore come to the conclusion that both the DNA and RNA can carry the kinetic information as a result of all these investigations. His research established that the genetic material for TMB is stored in RNA rather than protein and however the DNA may always serve as a genetic material but DNA RNA is typically non-genetic RNA only serve as a genetic material in few instances when DNA is not present. So in summary what we have discussed we had discussed that the gene carries the data for the phenotypic expression and these genes are being called as a factor in the case of Mendel and the chromosome have the gene on them they are made up of the 60% protein and 40% DNA and stable genetic material that can replicate store information for expression and undergo the mutation is required and experiments by the Griffith every Hershey and Chase have reduced results that directly supports the DNA as a genetic material there are also some circumstantial arguments in favor of the DNA as a genetic material.

So experiment on TMB by the Grigor and Schumann demonstrated in 1956 that the it is the RNA which is actually carrying the information from one generation to another generation and that's how wherever you have the RNA it is actually going to be

responsible for generation of or causing the disease. Even when they have mixed the two different types of viruses what they found is that they are actually generating the hybrid viruses and the protein has no role in carrying the information from one generation to another generation. So by doing all these experiments it is concluded that the RNA is not being preferred as the genetic material until the DNA is present but if the DNA is absent the RNA is also being taken up as a substitute for carrying the genetic information from one generation to another generations or I will say that RNA is being preferred by the primitive organisms or such as viruses and whereas DNA is because DNA is more evolved so DNA is then taken up by the higher organisms and that's why very classific very categorically you can see that RNA is one of most referred genome in the case of the viruses whereas DNA is more preferred in the case of higher animals. So with this brief discussion about the genetic material we would like to conclude our lecture here in our subsequent lecture we are going to discuss some more properties of the genetic material and how it actually has a role in synthesizing the protein and we also going to discuss about the central dogma of molecular biology. So with this I would like to conclude my lecture. Thank you. .