Bioengineering: An Interface with Biology and Medicine
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Lecture – 19
Genetics-IV

Welcome to MOOC-NPTEL course on bioengineering, an interface with biology and medicine. Before I come to some of the interesting examples of how genetics and genetic testing has made huge contributions, let me first kind of take you from the last lecture where we started discussing about genetics and genetics rules.

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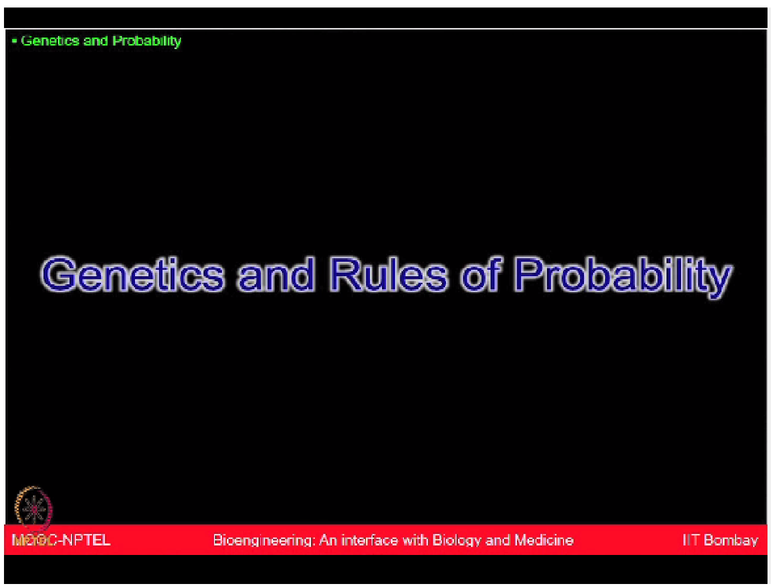

And we were talking about law of independent assortment where we discussed that how in dihybrid crosses, even when you are studying 2 different properties, those properties are getting segregated independently. And I has asked you to make some Punnett square and I am sure you are all trying to make those 16 boxes and trying to show that what could be the, gametes will look like but you must have realized that while it can be done, but it is not, you know, something which is very easy to do.

Just because, you know, you have to make too many gametes and you have to write lot of details for them. So, you know, all of you are having mathematics and you know, engineering background, why not use probability rules to find out what is the probability of each type of those gametes are. And genetics in many ways is like mathematics. It is just based on rational. If you just simply forget about, you know, in that red versus white or purple versus white, if you just forget those colour names or just do not think it is what object we are talking.

So you are talking about 2 properties. You are deriving the gene and alleles for those properties and then you are using some mathematical rules to see that how they can transmit from one to next generation. So a good way of thinking about dihybrid cross cell and multiple properties is to use probability rules. So that is what I will talk first. So let us just first think about rules of probability and I am sure for this audience.

I do not have to teach too much what probability is. You are measuring the things in the scale of either 0 or 1 and just imagine that, you know, from egg and sperm, you are deriving the gametes.

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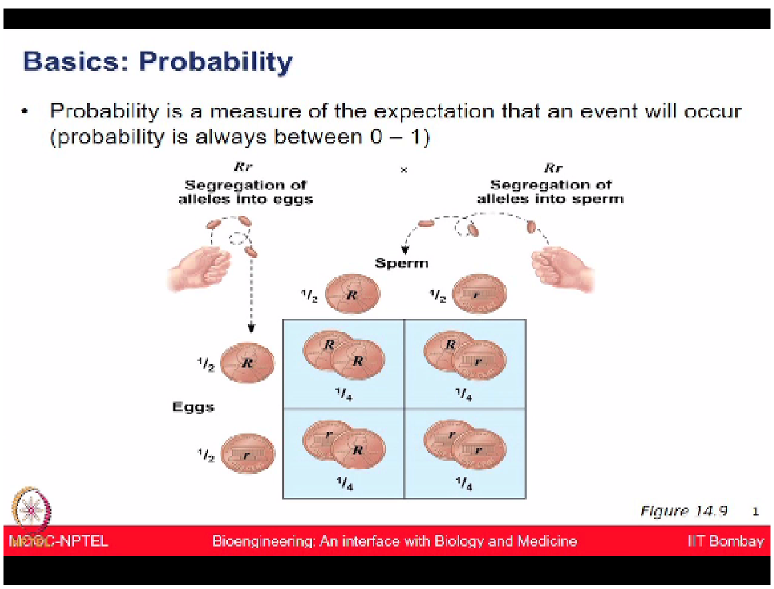

And those gametes, let us say if you have RR or you know Yy, those are segregating. So, you know, they are splitting into 50%, half and half. Now from those gametes if you see this case here, you have half R and half r from the sperm and from the eggs and now you are deriving those gametes. So you have 1/4 probability of RR, 1/4 probability of rr and half the probability of heterozygotes which is R and r.

So if you just think about all the crosses in this kind of probability bases, then I think many of the genetics problems which will be asked to you, will become much simpler. Of course, you can still cross check something with Punnett square but you will find probability rules much simpler way of deriving those.

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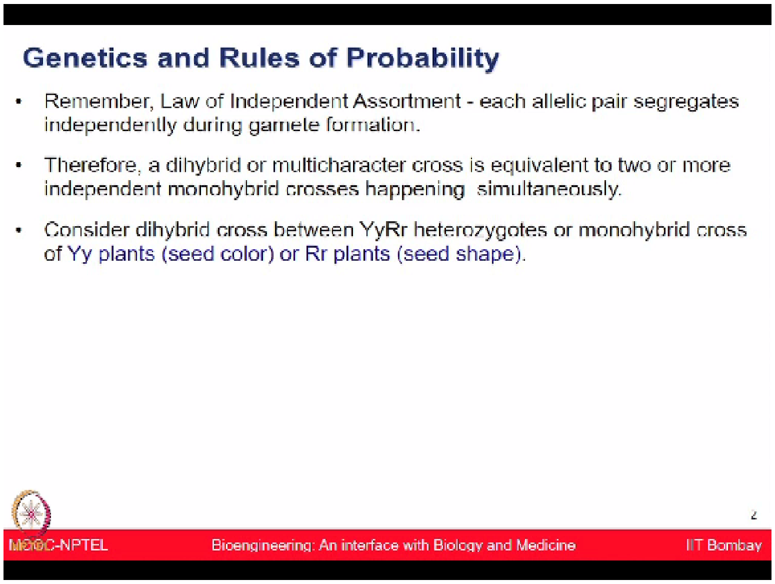

So in the law of independent assortment, we talked about that each of the gene for contrasting pair, those alleles segregate independently in the next generation. And then we have discussed that these are the dihybrids or even, you know, multihybrids, various characteristics which are there, they are passing from one to next generation but they are actually following their own independent route.

We have discussed this example of Yy and Rr, this particular heterozygote having 2 like 2 different type of monohybrid crosses when you are talking about 2 properties. The seed shape as well as the seed colour. So seed colour Yy and the Rr can be your seed shape. So irrespective of these RR or YY, I am sure you can use any nomenclature for these.

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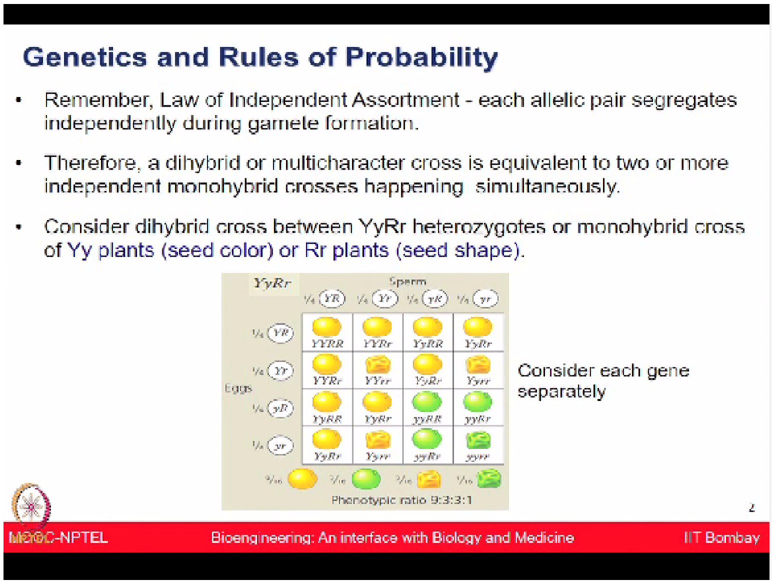

So this is what the results we have seen last time. This is what I had asked you to derive and based on this particular phenotypic ratio which is 9:3:3:1, we concluded that when Mendel was doing the experiment, he thought and hypothesized 2 possibilities whether the gametes could be, you know, assorting dependent way or independent way. If it was dependent way, then probably ratio have been 3:1 but just because in this time, he found 9:3:3:1, then it was conceded that they are assorting independently.

And you are asked to make these chart using the Punnett square. So now let us think about the same cross. And then let us see, can we use the probability rules and then those can be used to derive these gametes, right. So let us think about 2 monohybrid crosses. In all the genetics class, it will be good idea that all of you are active. You are having your notebooks and pen in the class. Even the simple thing which we do, you are doing it and sometime I will leave it half the way and I will ask you to complete. So please start making some crosses.

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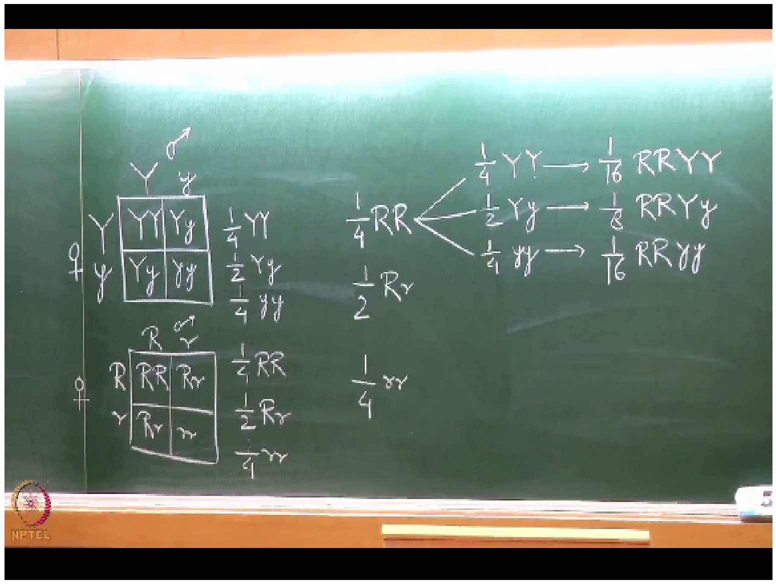

So let us take 2 properties, let us say seed shape and seed colour. So we are doing 2 separate monohybrid crosses for seed shape and seed colour. Very straightforward, I think we got these gametes which is half, 50% are in the heterozygotes and then we have 1/4th, 1/4th of the homozygous dominant or recessive. So now let us think about the, you know, how best we can use these numbers now for calculating the probabilities.

So all of you multiply the individual probabilities for RR and YY, say you can start deriving these gametes, what will be their probability. The first one 1/16. Alright, so what you can see now that, you know, if you would have done Punnett square, probably it was much more tedious for you to fill that Punnett square but now if you are looking at individual probabilities first and then you are multiplying those.

So now you can derive each of the gamete, what will be the genotypes and what is their probability in the F2 generation. So I think in this way if there are different properties are given to you for a dihybrid cross, then you can first try to derive their individual crosses and then use those calculations and probability values to derive the dihybrid cross probability.

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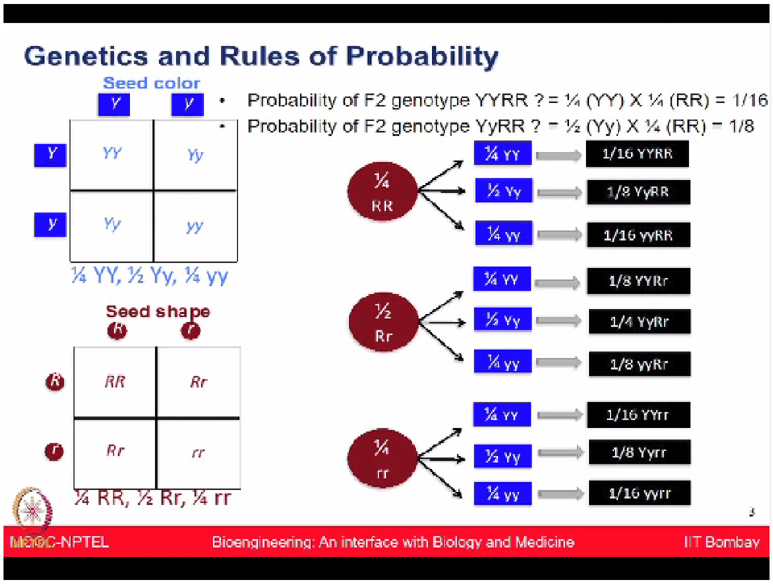

Now the questions which will be asked will be something like this. That what could be probability of the F2 genotype for a gamete which is YYRR. So to find out this one, you have to see these individual values and then you have to calculate and then you can tell that, you know, this is probably 1/16 probability you have for this particular genotype to appear. Same for the next question where it is 1/8 probability for Yy and RR.

So this is very straightforward way. I am sure now you are much more familiar and confident that the same type of things can be done using Punnett square as well as using probability rules.

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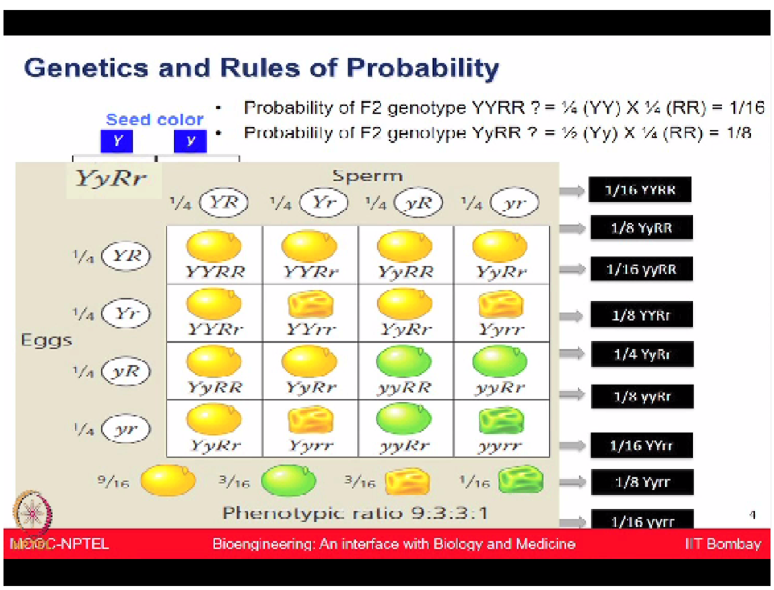

So now we can just simply compare the 2 which we have learnt. This is one which we have seen in the Punnett square and now these individual values which we have derived from the probability rules. And both of them are going to show the same ratio of law of independent assortment, 9:3:3:1. Now, you know, I think let us have some small simple questions for you. We talked about some albino child in the family.

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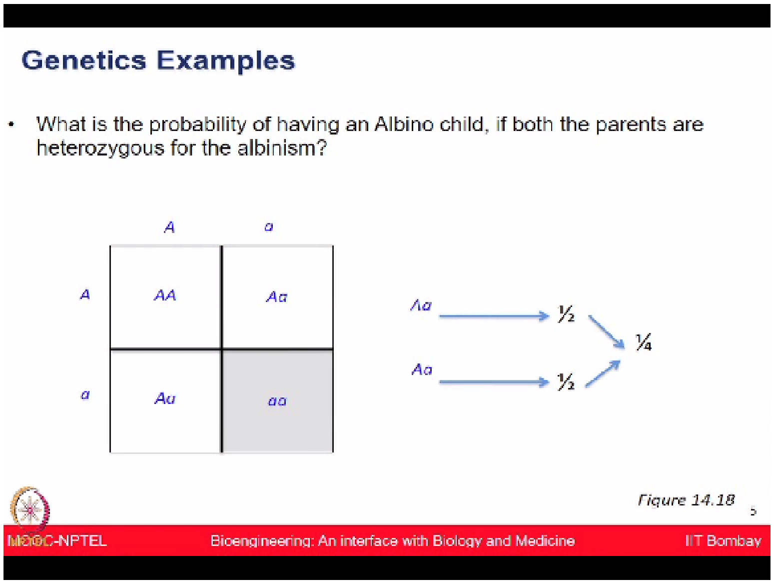

In this case if we have, both the parents are heterozygous for the albinism, what will be the probability of the child being albino? Straightforward. Let us think little bit in different terminology now.

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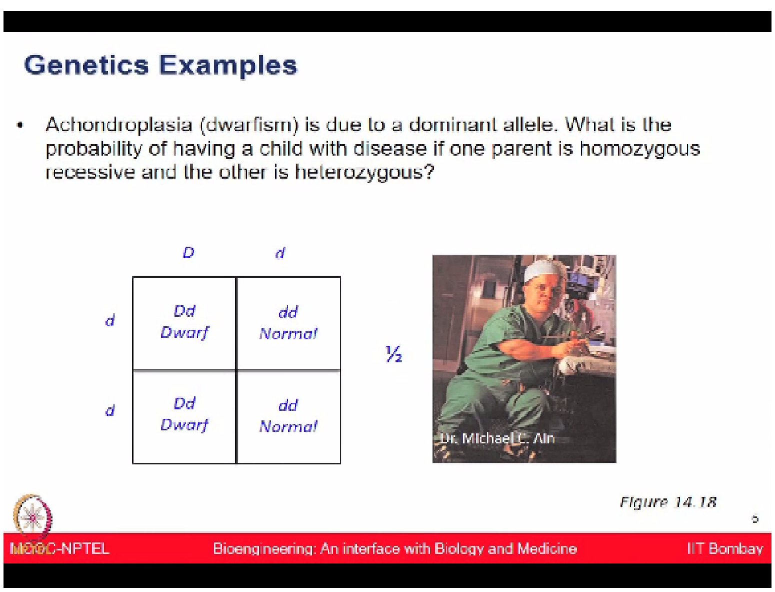

Another disease which is achondroplasia, a type of dwarfism. In that disease if one of the parent is homozygous recessive and other is heterozygous, please do that. And you can use any of the nomenclature for doing these particular type of crosses. **"Professor - student conversation starts"** Half. Right. **"Professor - student conversation ends."** Correct answer, half. So you have a half the child or progeny who will be dwarf and this is actually, you know, one of the cases doctor Mike Ain.

who was a scientist and he himself was suffering from this disorder of achondroplasia. So these disorders, you know, one would see many times in the human population and when you investigate that, you know, what could have been the cause, what could have been the, you know, family history. After looking at those analysis then you may realize that some of these things are actually already part of those pedigree and those particular genetic, inheritance of those families.

So I am sure now you are kind of familiar with this cross. I think I had seen 1 hand up a while ago for a question. I can now take your question. **"Professor - student conversation starts"** Alright. What does multihybrid cross mean? What does multicharacter cross mean? What that means? Many Rr, apart from that, is there something else? So he is just trying to clarify that what this multicharacter process means and you know, what this statement ideally, you know, how to simplify this? **"Professor - student conversation ends."**

So if we are looking at different properties, you know, if you think about classical Mendelian experiment, we were talking about 1 property at a time. Tall versus short, you know, flowers looks like purple versus white. So, you know, we were looking at 1 property, 1 characteristic at a time. Now if you look at multicharacteristics, different properties at the same time, those could be dihybrid if you are looking at 2 properties, could be trihybrid which can be 3 properties.

Now how those particular properties are getting inherited from one to next generation. So that is what the statement meant and then I showed you the 2 properties, we were doing the dihybrid cross in which way we can split this particular cross into 2 monohybrids and then we can derive the same values.

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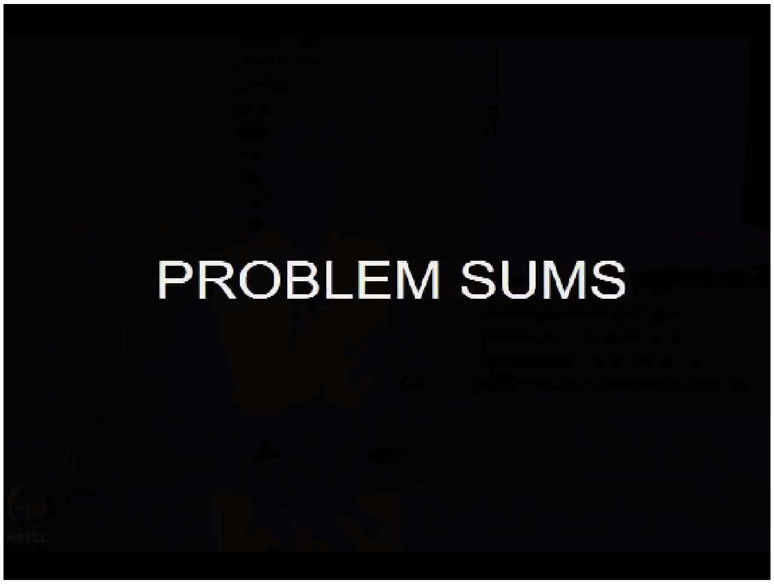

So now we will solve some genetics problems. Try solving these sums using the probability rule that we have just learnt. Of course, you can do using Punnett square as well. But do not use that because otherwise, it is going to take you longer time. And you will see that how easily and quickly you will be able to solve some very complicated genetics problem using these probability rules.

My TA will assist you but as I have mentioned earlier, please solve them yourself first before checking these solutions. So let us begin with the first question.

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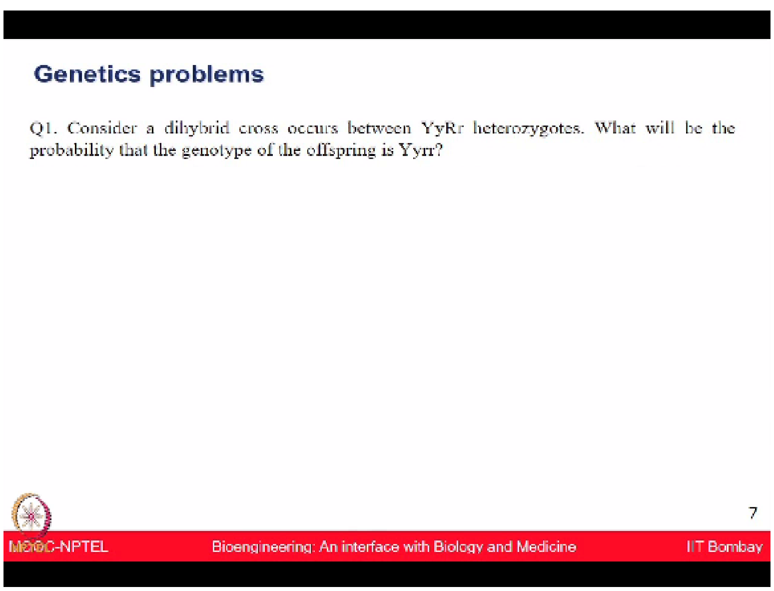

Consider a dihybrid cross occurs between YyRr heterozygotes. What will be the probability that the genotype of the offspring is Yyrr?

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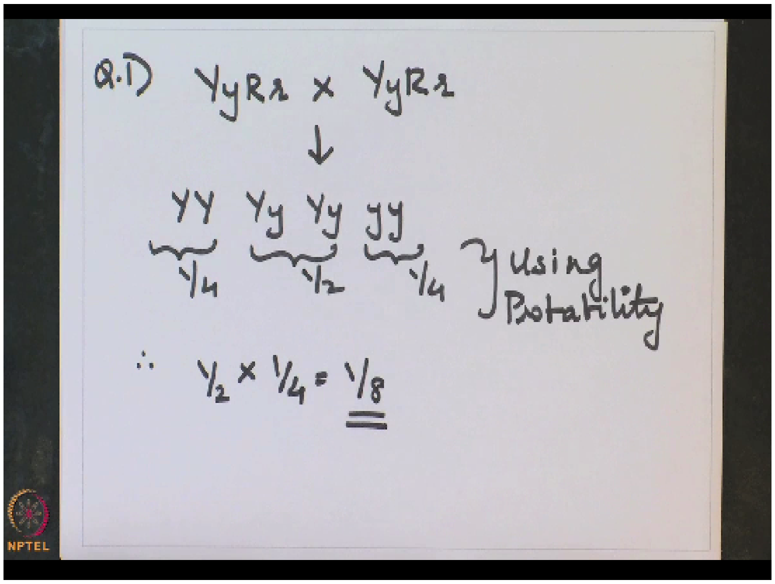

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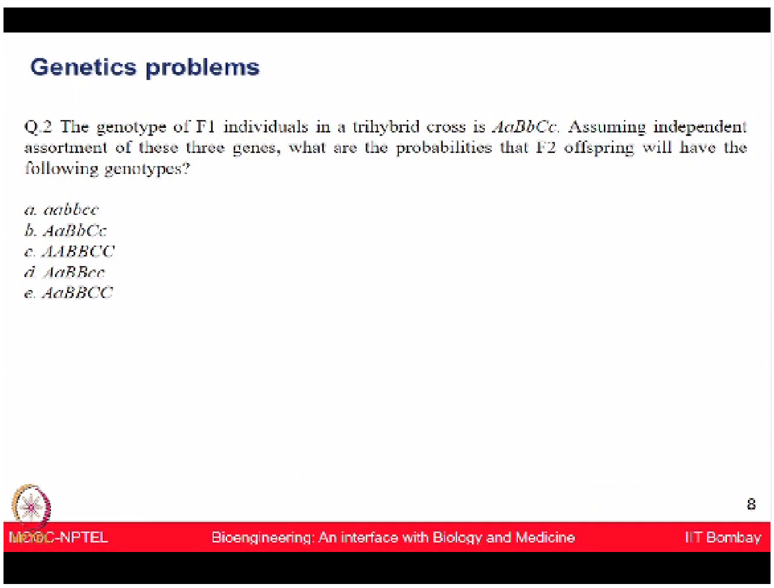

The genotype of F1 individuals in a trihybrid cross is AaBbCc. Assuming independent assortment of these genes, what are the probabilities that F2 offspring will have the following genotypes?

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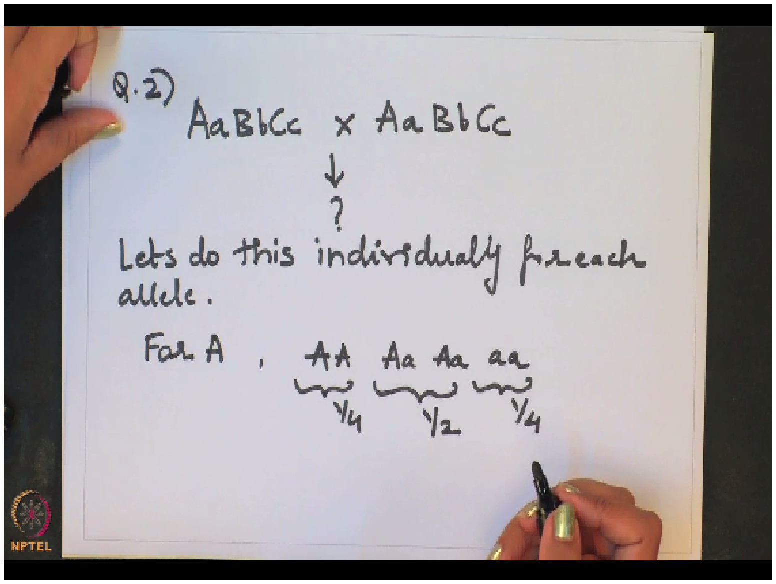

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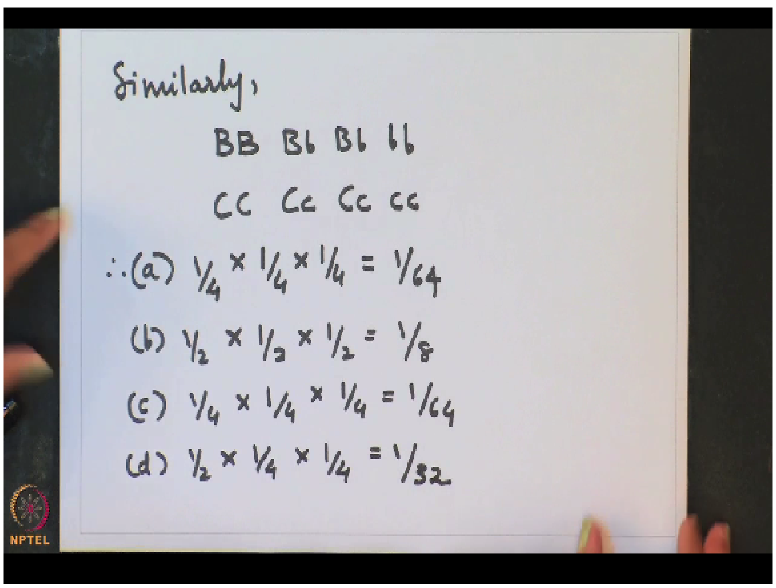

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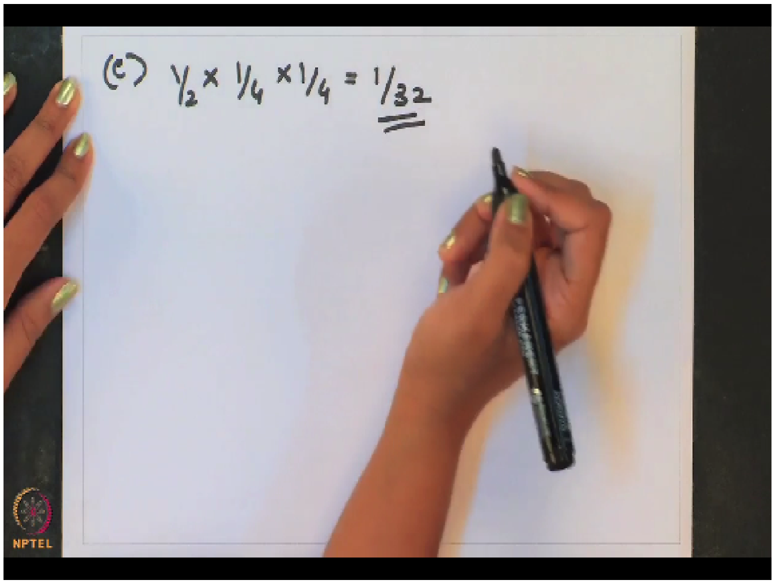

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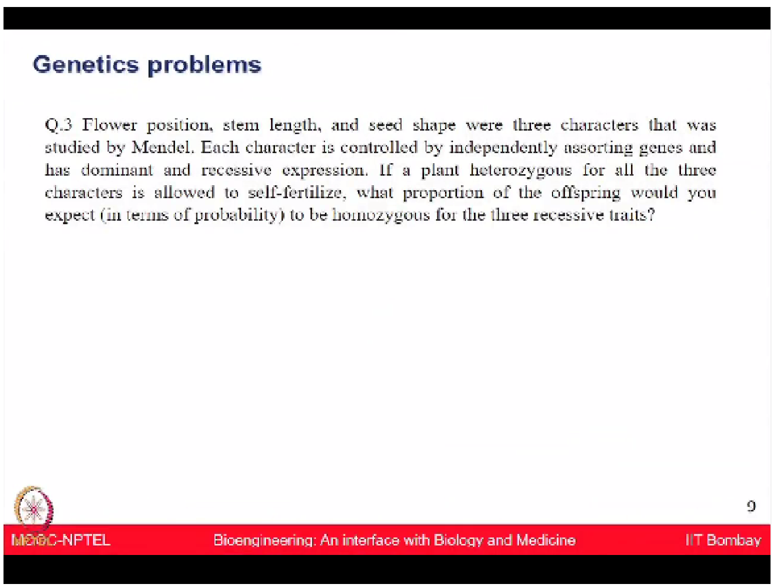

Flower position, stem length and seed shape were 3 characters that was studied by Mendel. Each character is controlled by independently assorting genes and has dominant and recessive expression. If a plant heterozygous for all the 3 characters is allowed to self-fertilize, what proportion of the offspring would you expect in terms of probability to be homozygous for the 3 recessive traits?

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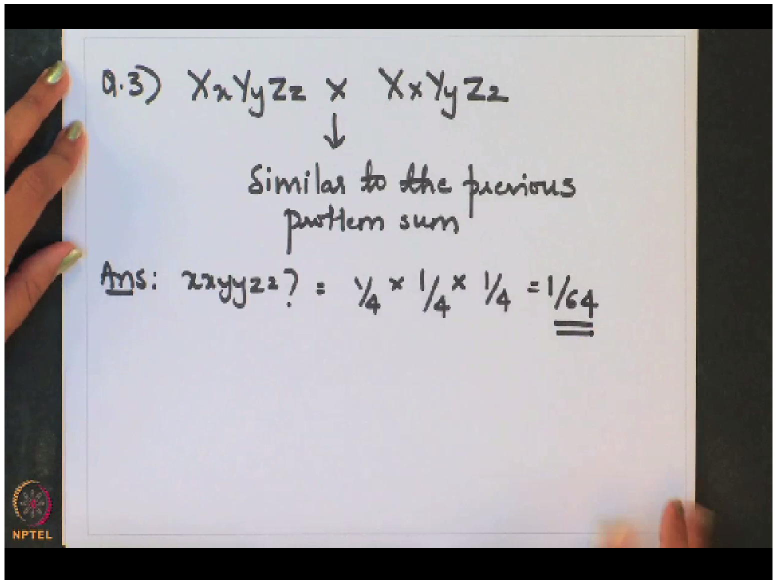

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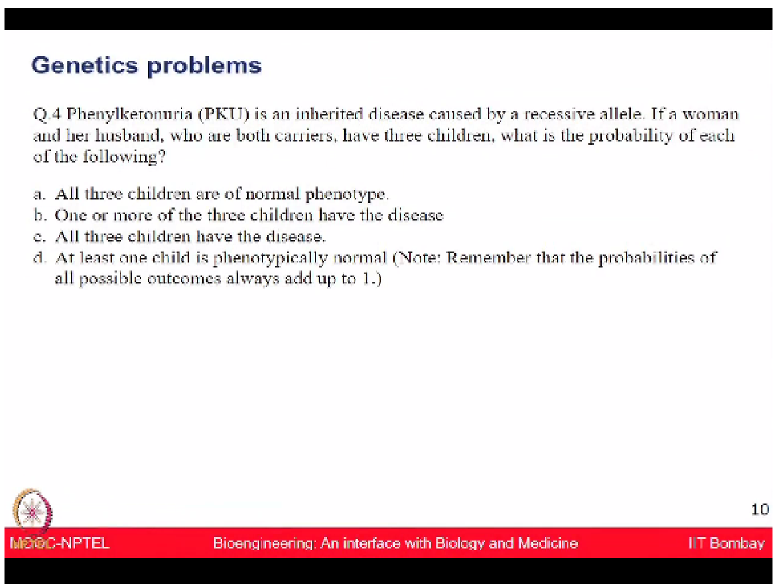

Phenylketonuria or PKU is an inherited disease caused by a recessive allele. If a woman and her husband, who are both carriers, have 3 children, what is the probability of each of the following? All 3 children are or normal phenotype. One or more of the 3 children have the disease. All 3 children have the disease. At least 1 child is phenotypically normal.

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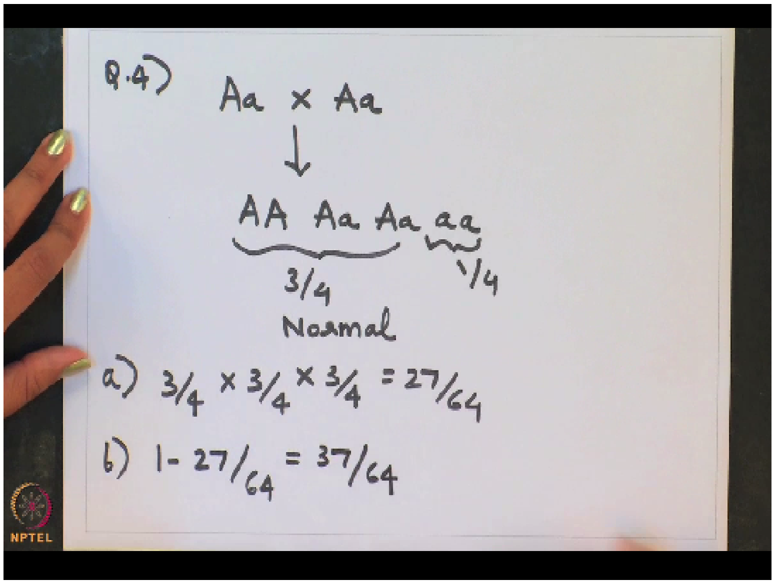

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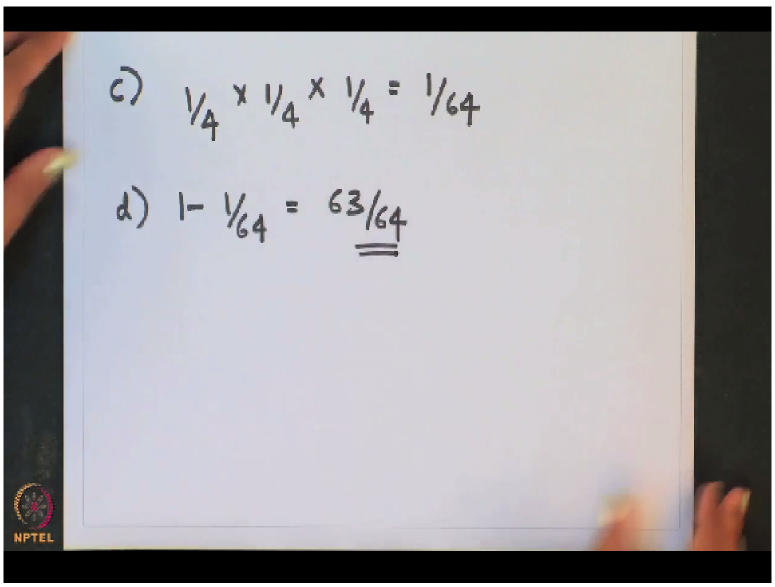

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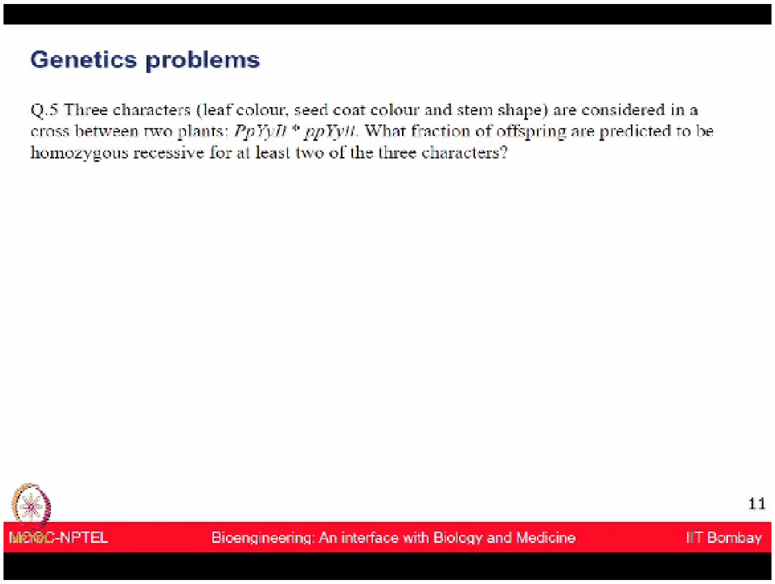

Three characters, leaf colour, seed coat colour and stem shape, are considered in a cross between 2 plants PpYyIi cross with ppYyii. What fraction of offspring are predicted to be homozygous recessive for at least 2 of the 3 characters?

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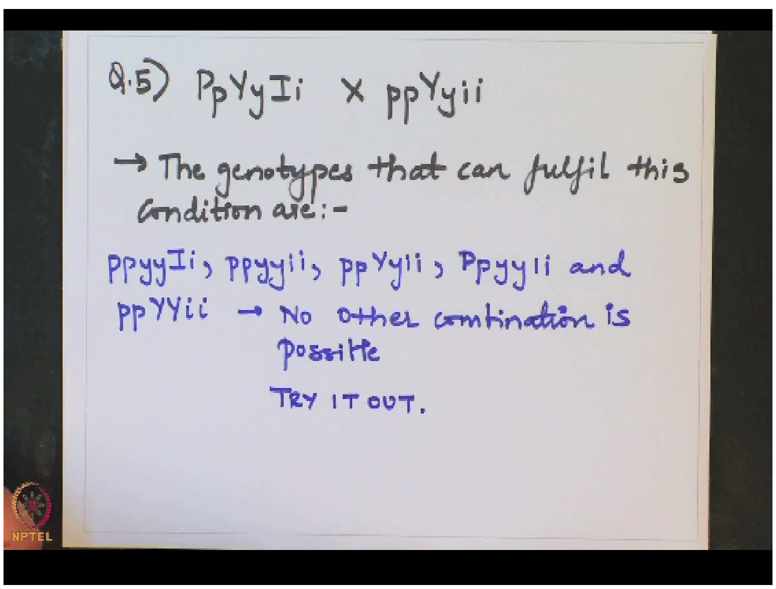

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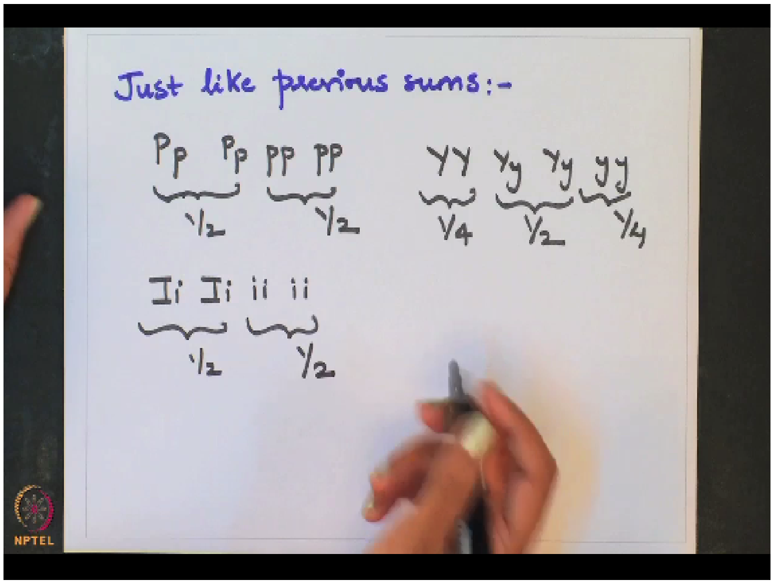

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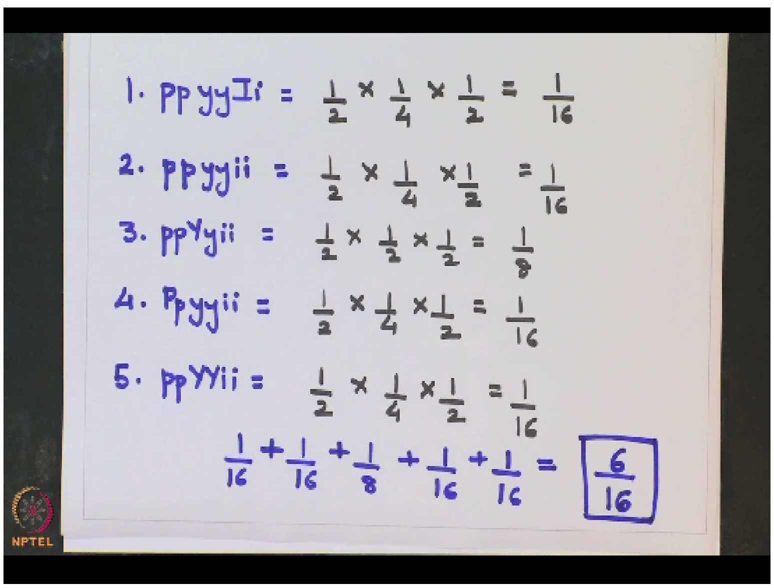

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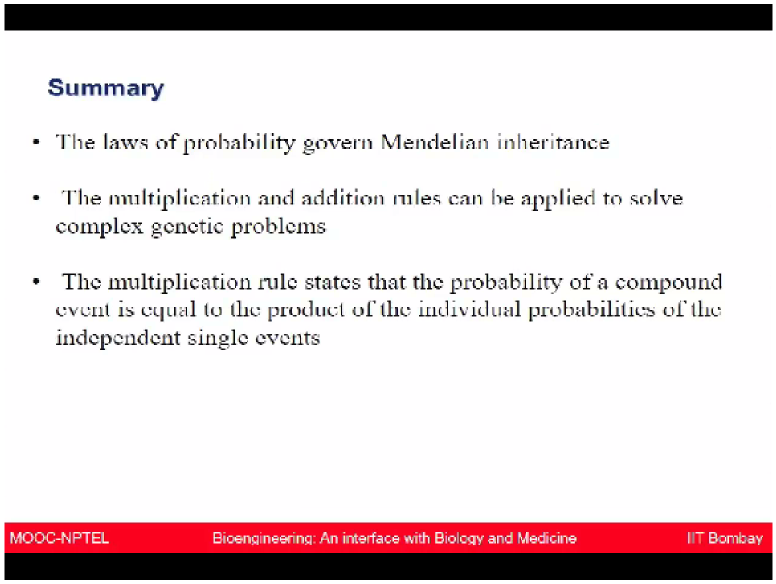

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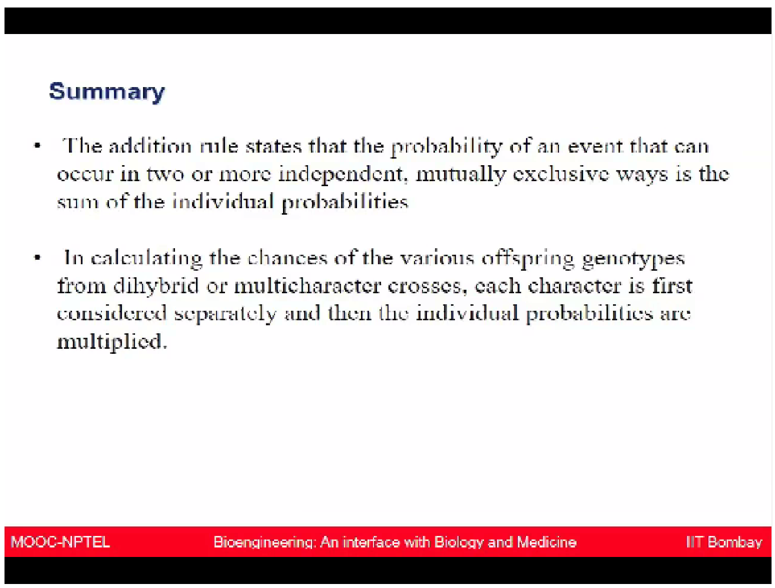

In the last few lectures, you have studied the 2 main Mendelian laws. Law of segregation and law of independent assortment.

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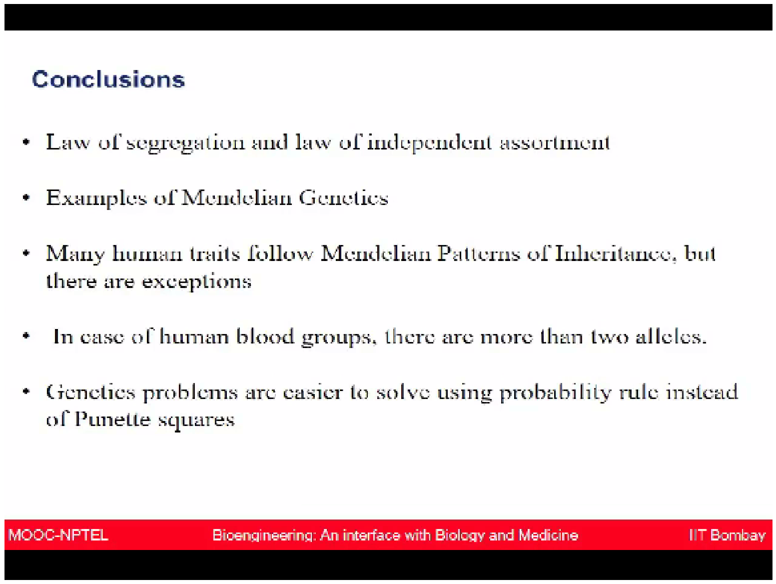

We have discussed some very interesting examples of Mendelian genetics. You have also seen that how many human traits follow Mendelian patterns of inheritance. But you have also seen that how many traits do not follow the Mendelian pattern of inheritance. For example, in case of human blood groups, there are more than 2 alleles.

The blood groups are not just A or B, they can also be co-dominant that is A and B or else they can be neither A nor B, that is O blood group. We have also solved many genetics problems together. You might have realized how easy it is to solve the problems using probability rules rather than drawing the Punnett squares. That is all for the day. Thank you and see you in the next class. Thank you.

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References

- Campbell Biology - Reece, Urry, Cain, Wasserman, Minorsky, Jackson 10th Edition, Pearson

- Sums taken/modified from Campbell Biology - Reece, Urry, Cain, Wasserman, Minorsky, Jackson 10th Edition, Pearson