Bioengineering: An Interface with Biology and Medicine
Prof. Sanjeeva Srivastava
Department of Biosciences and Bioengineering
Indian Institute of Technology- Bombay

Lecture – 29
Evolution

One of the topic which we have to study, which is evolution, alright so, evolution is of course you know, a big interesting topic in itself, I do not think I can do justice to this whole topic.

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And the whole subject even in, in the time which is available to us but let us get a feel and the glimpse of the, the Darwin theory and origin of species.

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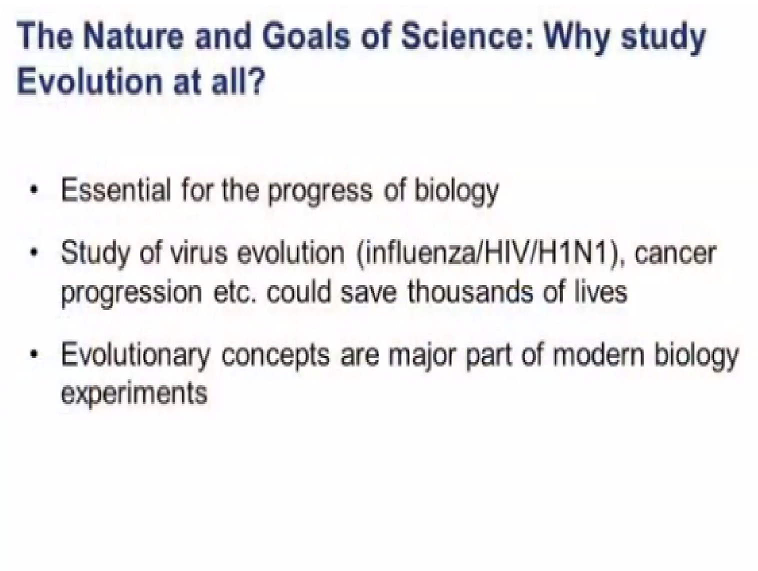

So, it is actually, essential for us to on one hand, know the latest technologies and tools and a study biology and know the latest technology, how it can influence biology, at the same time, lot of fundamental research happening at the developmental biology level or evolutionary biology actually, once in a while pays off for example, just imagine all of us sudden H1N1 strain came and we had no idea that you know this particular strain, how you know is getting in; affecting individuals.

People are all dyeing you know all over the world and little there was no information that how this virus came, lot of evolutionary biology they keep studying evolution of you know different organism including viruses and you know those evolutionary biologist were actually studying may be denote the trace of what happens to different family of H and N viruses and they realise that they actually, they do have a lot of gene recombination’s happening.

And they make different strains and as a result may be in a very short time people were able to decode that what can be sequence of these viruses and what can be their origin and then, what could be the possible ways of preventing that particular one, so this is how your basic understanding for the systems over the period can actually help you to really understand some concept.

So, H1N1 influenza, even HIV viruses, all of these are various examples in which way our studies of knowing these viruses over the period has really helped to save lot of lives, so evolutionary concept; they are the major part of the modern biology and biotechnology experiments.

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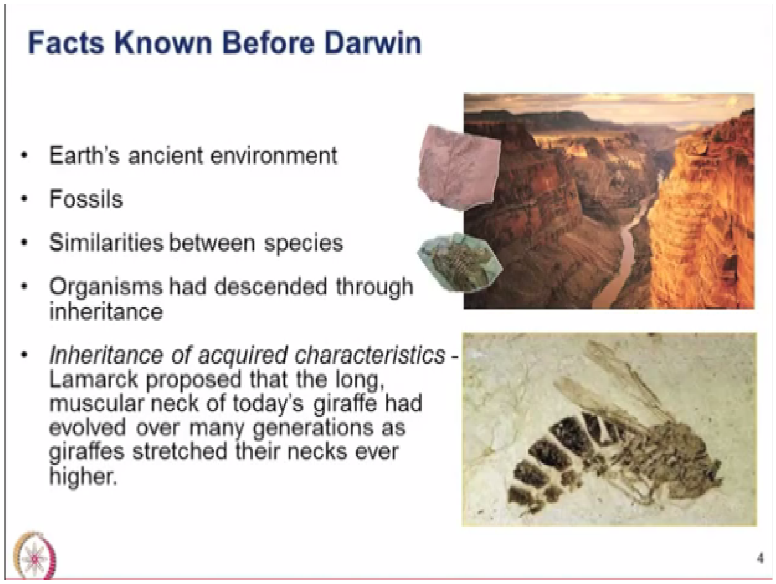

So, Darwin is of course you know, one of the authority in the field who has made his theory, origin of species, which we will talk in detail but before Darwin came and, and what he proposed the theory is, the thing which we are known that you know in the earth ancient atmosphere probably, there has been many changes happened over the period also, in the Jurassic era and that is where, lot of these dinosaurs and you know lot of these trees you know died and then became fossil forms.

And then, we have understanding that you know, many of these species having certain similarity some characteristics which are common. A scientist Lamarck mention that inheritance of acquired characteristics it means, over the period if certain giraffe, you know for his food habit, if it needs to climb up probably, you know it has a long neck because it needs to eat and that is the trees which are having very long overall branches and the leaves.

And as a result it has to really climb up and therefore, to evolve over the period for that kind of acquired characteristics which has resulted into the characteristics going into the inheritance.

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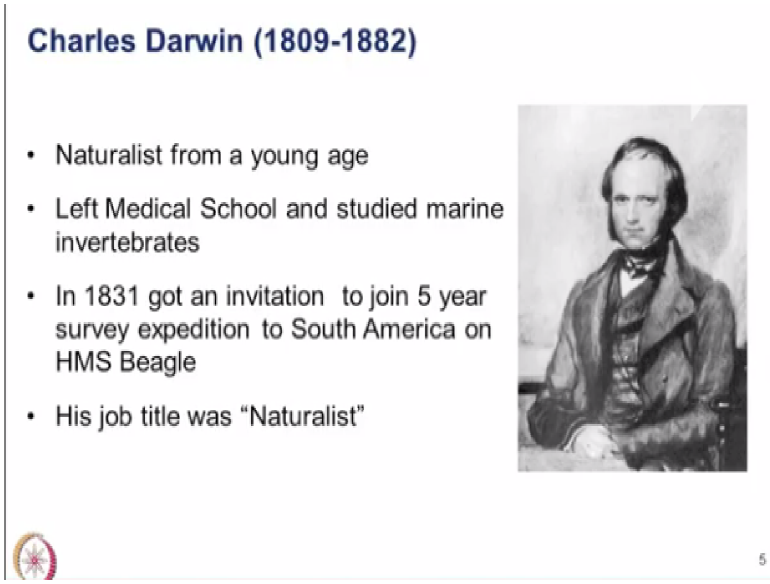

So that was the earlier understanding of our evolution and our you know for the systems but then Darwin came and he studied these things in a very different manner and he was kind of somebody who likes to observed the, the natural systems and he in fact, left his medical studies and focus mainly on the looking at different invertebrates, different; looking at different geological features of different organisms.

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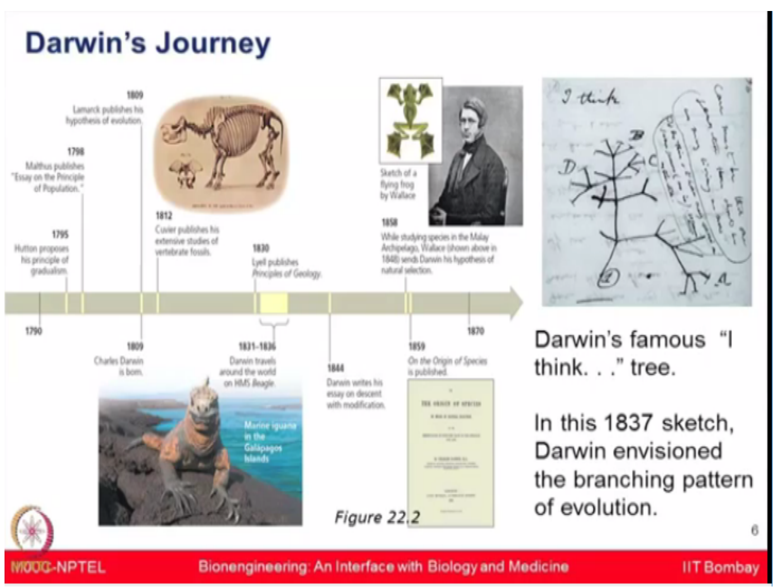

And then, fortunately he was offered to take a 5 years long sea trip to explore the sea expedition on a ship HMS Beagle and his job was actually to be a naturalist, who will observe all these creatures and these different organisms which are present in those environments, alright, his book was actually you know one of the most read more sold book, origin of species and if you look at just his journey, I think he is you know the voids that the sea trip has the tree made huge impact on his observations for the nature.

And then, kind of based on those observation, he was documenting which he was kind of you know, making from different islands while travelling and those has resulted into you know this particular book which is origin of species where he put there is lot of evidences that how life would have evolved all, this became one of the you know, most famous drawing which show the tree of life in which way it would have branched.

And he first time in vision that in which way branching pattern would have been used for the evolution to happen.

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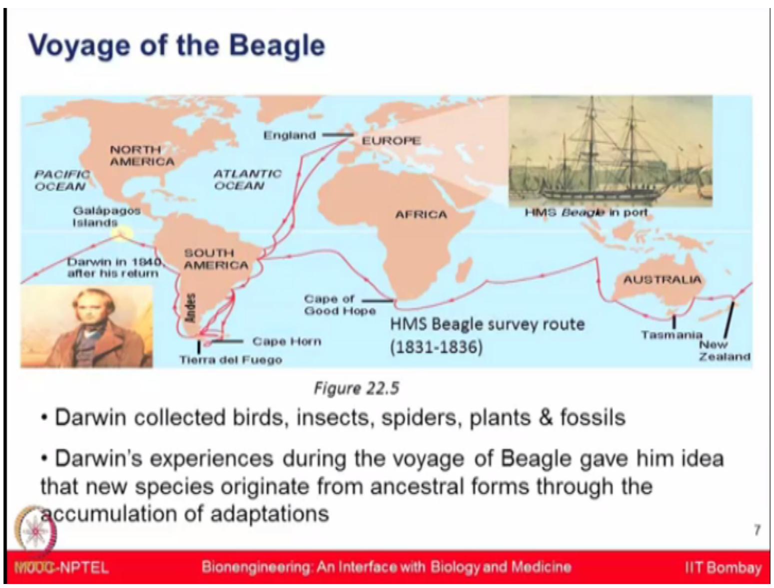

So, during his voyage of the Beagle, what is the; shown here in the map in which way he was travelling across different continents, Darwin collected various species of birds, insects, spider's plans etc. and then he was documenting those that you know in which environment they are more adapting, so what is actually leading them is a certain kind of a species to have much more inclination to grow in that environment as compared to other.

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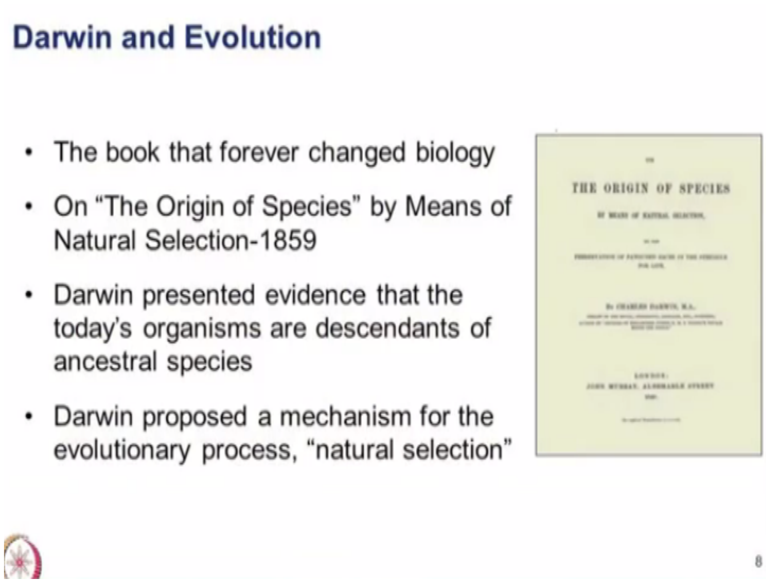

And looking at those, then he kind of wrote this book, origin of species in 1859, where he provided the evidences which is for the todays organisms, how they are descending from the ancestral species and he proposed that through a process of natural selection which is happening, so to reach out of these conclusions he had collected many of these organisms as I mentioned.

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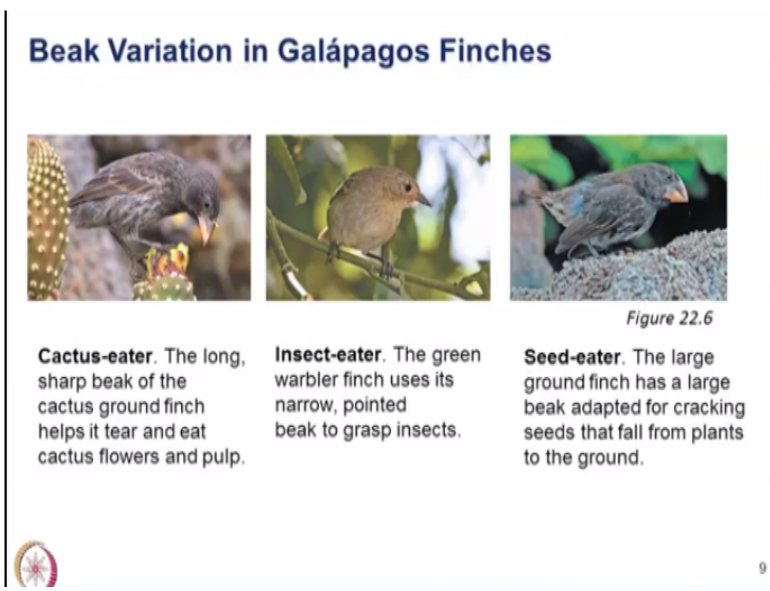

For example, he observed that in different Galapago island in different birds species are there and those birds, one of them let us say cactus eater, so this is actually attractive having different type of beak as compared to other bird which is insect eater or seed eater, so they are living in different islands and they have different beak behaviour and that is probably because their food habits required these kind of adaptation to happen, so and that is where they are more naturally found in those kind of environment.

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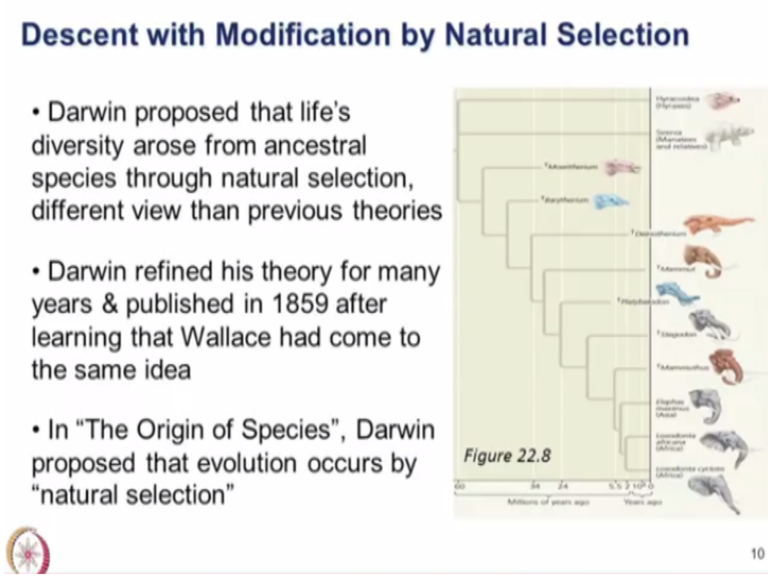

So, he made those observations very scientifically, he documented those and proposed that life diversity arose from these ancestral species by the process of natural selection which was different view than the previous Lamarckism and the other view (()) (06:36) thinking that how the acquired inheritance may happen and first time he actually, publishes his work only after he realised that another scientist Wallace who is also working in the similar theme.

And he is convinced with Darwin's idea because Darwin's idea were first time going to you know make your changes in the previously known theories, so first time he propose that evolution could occur by the natural selection process, so the natural selection is essentially a process where individuals having certain heritable traits as I showed you in those Galapago island, these birds having specific features, different type of peaks.

And those were actually required for their food habits in which way they can survive and those traits could be actually heritable now for their survival and further it is actually being carried in the next generation after a production and therefore, these traits are being inherited.

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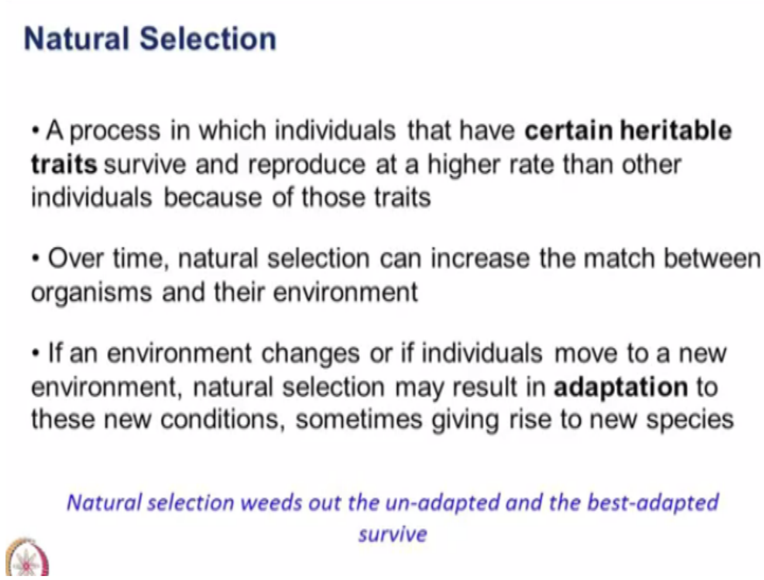

So, over the time, the natural selection can increase a good match between the organism and in which environment they want to live and survive, if the environment changes or the individuals move to a new environment probably, adaptation has to happens, so natural selection may result into the adaptation to the new condition and sometime that may result into the new species formation.

So, these are the kind of his theory, which ideally said if you are able to adapt and move to the new situation, new environment then that is a natural selection, you are able to adapt to the right condition, if you cannot then you will be wiped out, you will leave out from that particular population and that that is where the natural solution is going to favour, those who are having superior ability of adaptation.

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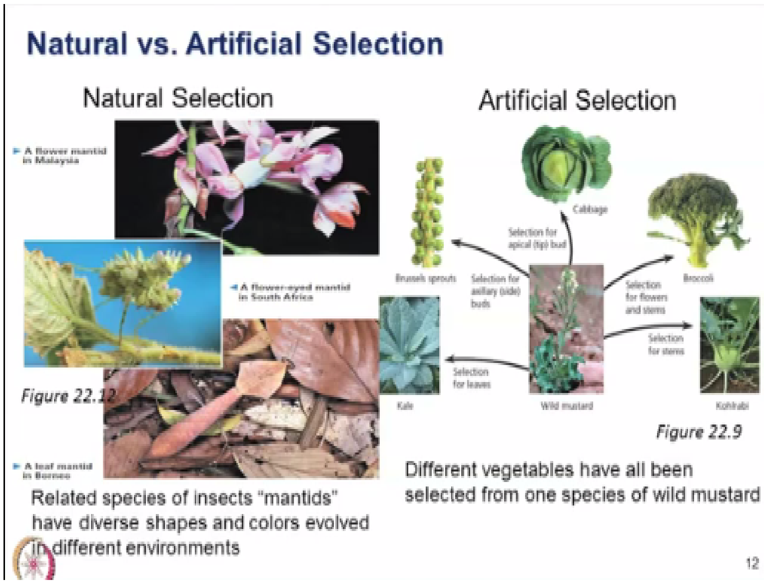

Just showing you here a couple of examples, one for natural selection versus artificial selection, so natural selection here you know, different type of environment you can see for the related species of insects which are living there but they can change the colours as per their environment and the shape in fact and these are the natural selection whereas, if you look at here, the cabbage and various type of broccoli etc. derived, they are from the wild mustard.

But we are you know, for our food habits for our you know food requirements, we grow them in different environments and different type of vegetables have been produced which could be the example of artificial selection, this is natural selection for the environment where one like to adapt for that survival, this is artificially selected just for our requirements for the food and other practices.

There are scientists who have been studying the gene behaviour and their overall impact to the population and looked at the things in much more numerical ways.

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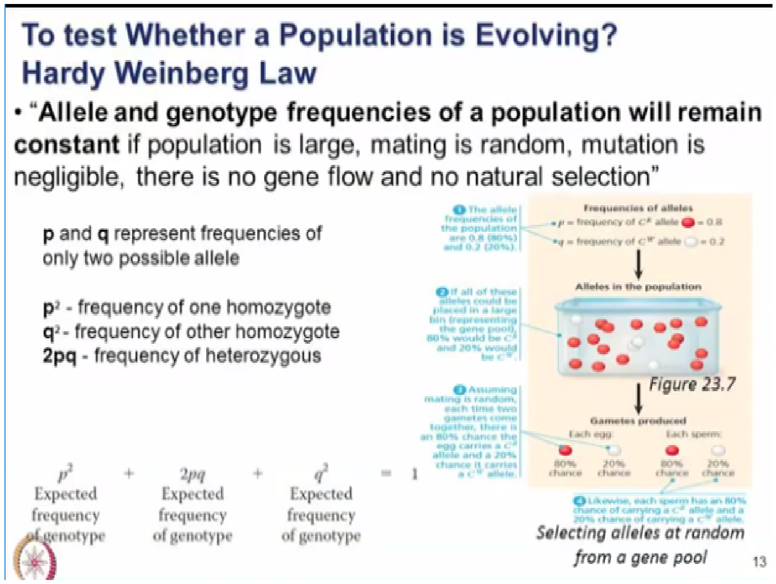

And these are, are known as Hardy Weinberg law, so an allele and the genotype frequencies of a overall population will remain constant, so leaving Hardy Weinberg law is applicable if population is large, mating is random, there is no mutation assumed, there is no gene flow and no natural selections, so things are very static, now going back to your original example of you know red versus white genes for that flower characteristic.

In this way the p and q represent frequencies of 2 possible alleles for the red gene and the white gene here, let us assume this one is 0.8 and this one is 0.2, so the Hardy Weinberg laws says p square + 2pq + q square is going to be 1 for all of these genes in the random population.

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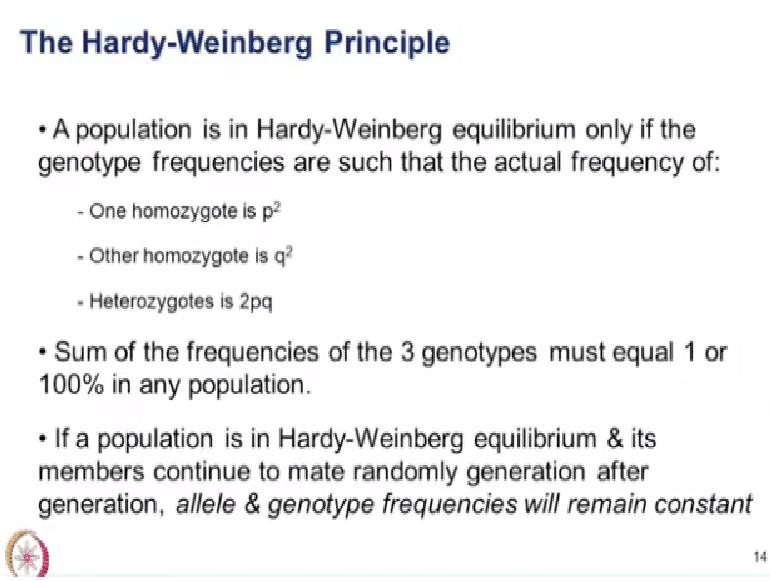

So, if you have 1 homozygotes genes, which is p square, another one is q square and heterozygote is 2pq, so you can actually calculate overall gene frequencies and the some of the frequencies of 3 genotypes has to be = 1, so if a population is in the Hardy Weinberg equilibrium and all the members actually mate randomly, so then you will have the gene, genotype frequencies that will remain consistent in the population.

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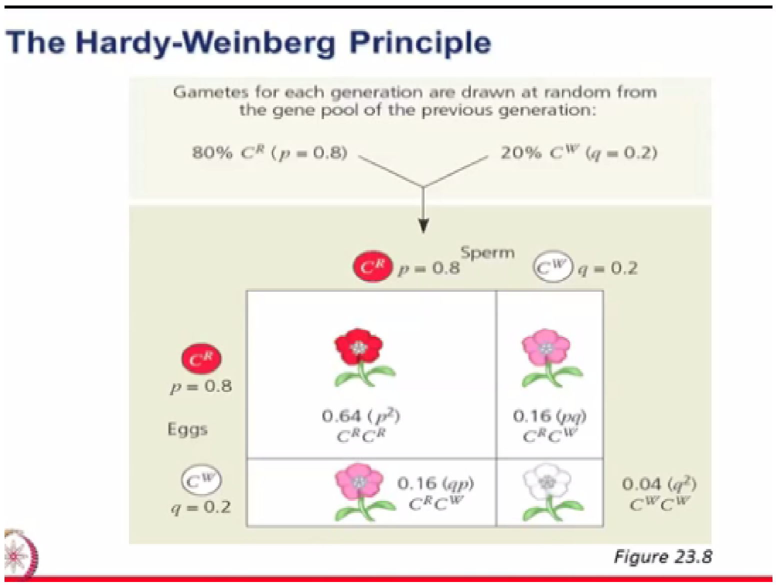

Coming back to this particular example please do try this yourself, just imagine if the allele or the frequency here is 0.8 for the red and 0.2 for the white, if you do this cross here again, the punnet square, you can see that you know, the p square is going to be 0.64, q square going to be 0.04 and you have the pq which will be 0.32.

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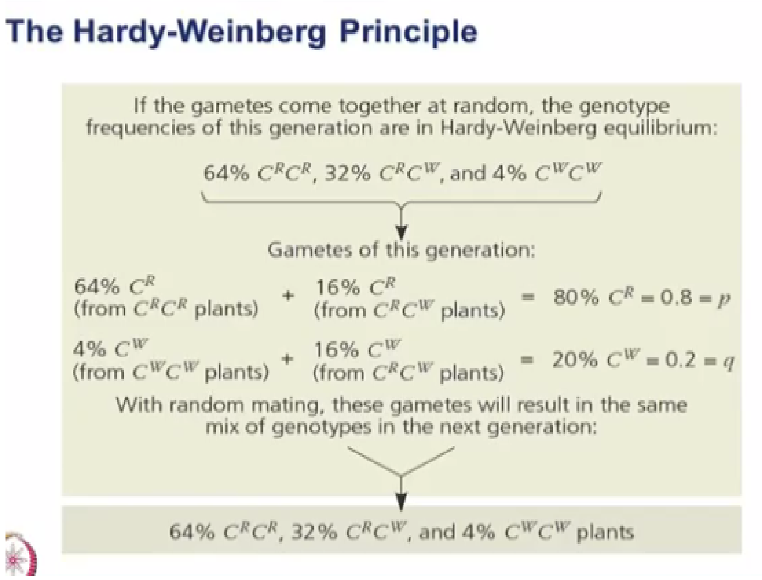

So, this is something exactly what I have mentioned in my next slide which you can actually, calculate and you can see that overall it will be 1 and like that if you have been given certain you know, the frequencies or certain type of allele behaviour, you can look at in the Hardy Weinberg equilibrium, how you can calculate those genotypes.

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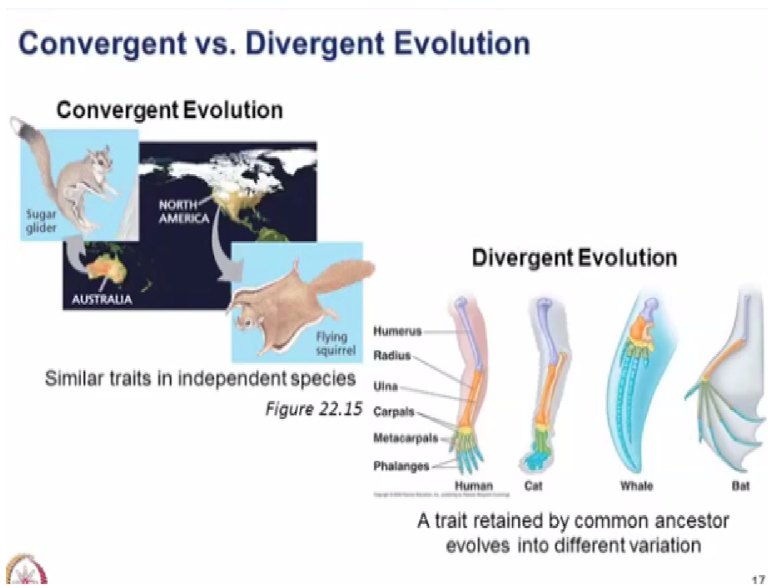

Another terminology which is relevant here in the context of evolution is convergent versus diverted evolution, so convergent evolution is when we have similar traits but they are found in the independent species growing in independent environments for example, here you can see in Australia versus North America, these squirrels and the gliders, they are having similar traits now, divergent evolution is that there are certain traits which are common across different species.

But they evolve into different type of properties, so if you look at anatomically, all of these whether some human hand or cat or whale or bat, they look very similar in their anatomical way but they have been adapted to do different activities and therefore, something can be used for flying or for you know, swimming or for you know various activity which we do or even climbing up in the cat space, so these are the divergent evolution examples.

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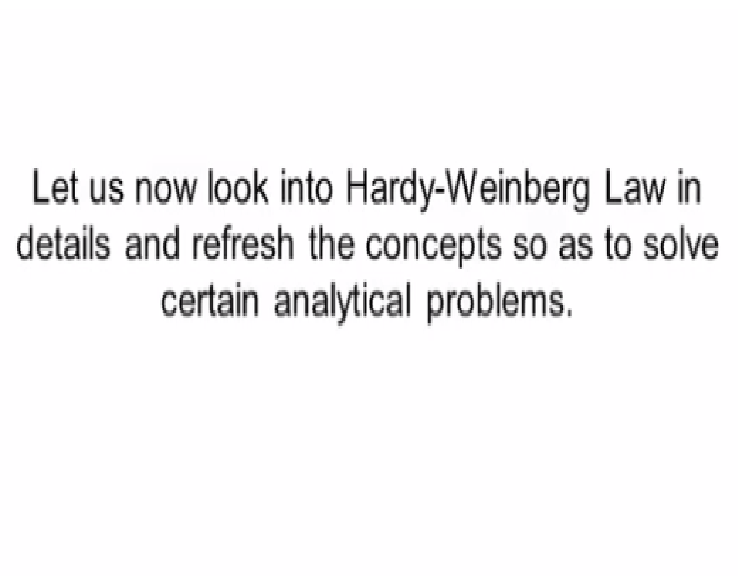

Let us now look into hardy Weinberg law in some more detail, refresh the concept, so as you can solve some analytical problems.

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Learning evolution at the genetics level; Hardy Weinberg; law population genetics law.

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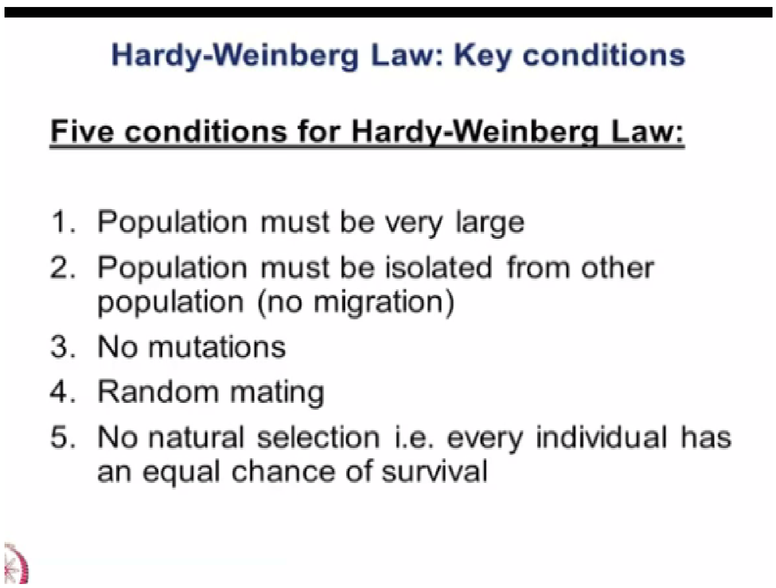

What is the key conditions for Hardy Weinberg law, let us review these 5 conditions for Hardy Weinberg law, first; population must be very large, second; population must be isolated from other population, so there is no migration, third; there is no mutation, fourth; random mating, fifth; no natural selection it means, every individual has an equal chance of survival.

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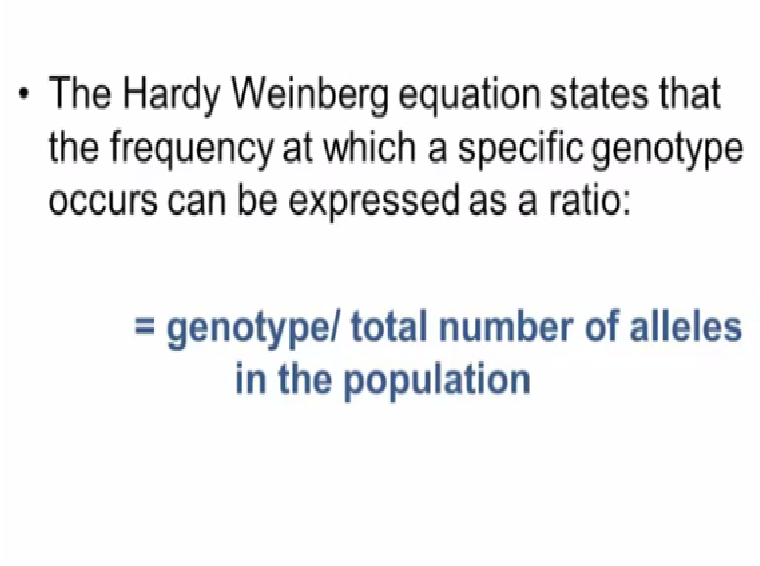

The Hardy Weinberg equation states that the frequency at which a specific genotype codes occurs can be expressed as a ratio, genotype divided by total number of alleles in the population.

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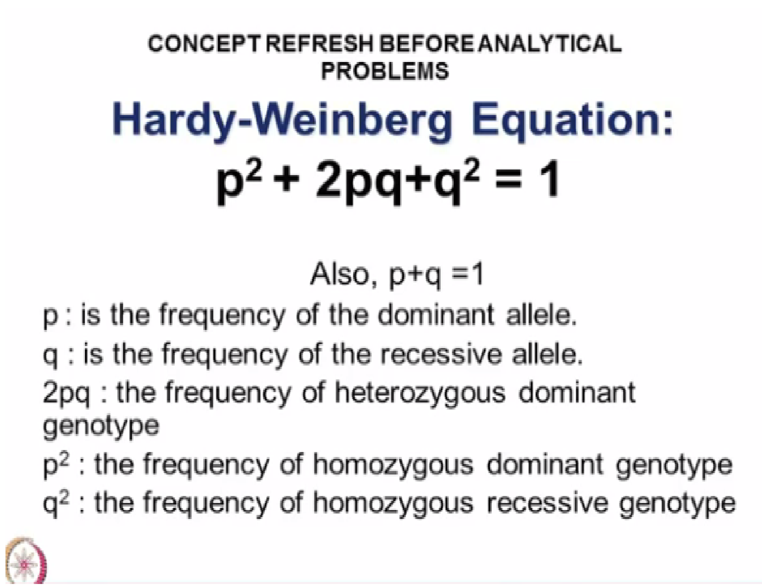

Let us review this concept before performing analytical problems, Hardy Weinberg equation; p square + 2pq + q square = 1, also p + q = 1, where p is the frequency of dominant allele, q is the frequency of recessive allele, 2pq is the frequency of heterozygous dominant genotype, p square is the frequency of homozygous dominant genotype, q square is the frequency of homozygous recessive genotype.

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Let us now solve some analytical problems based on The Hardy Weinberg Law

Let us now solve some problems based on the Hardy Weinberg law, you should try yourself first but a TA will also guide you to show the solution, so let us start now.

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Question 1: There is a herd of Zebras in the Masaimara region of Africa. Assuming that this population is following the Hardy-Weinberg equilibrium.49% of the Zebras are homozygous dominant for a trait (XX) the gene for which is present as 2 different allele. What percentage is homozygous recessive?

A. 50%
B. 60%
C. 5%
D. 9%

There is a herd of zebras in the Masaimara region of Africa, assuming that this population is following the Hardy Weinberg equilibrium, 49% of the zebras are homozygous dominant for a trait XX, the gene for which is present as 2 different alleles, what percentage will be homozygous recessive? 50%, 60%, 5% or 9%.

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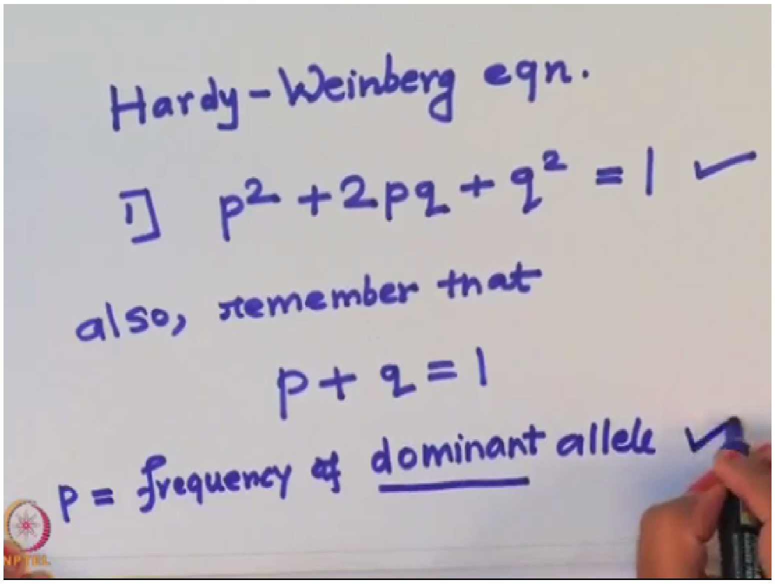

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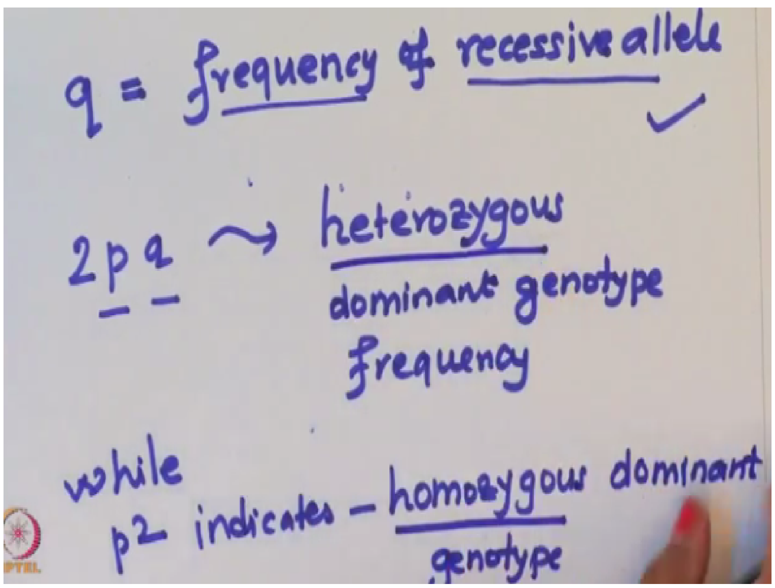

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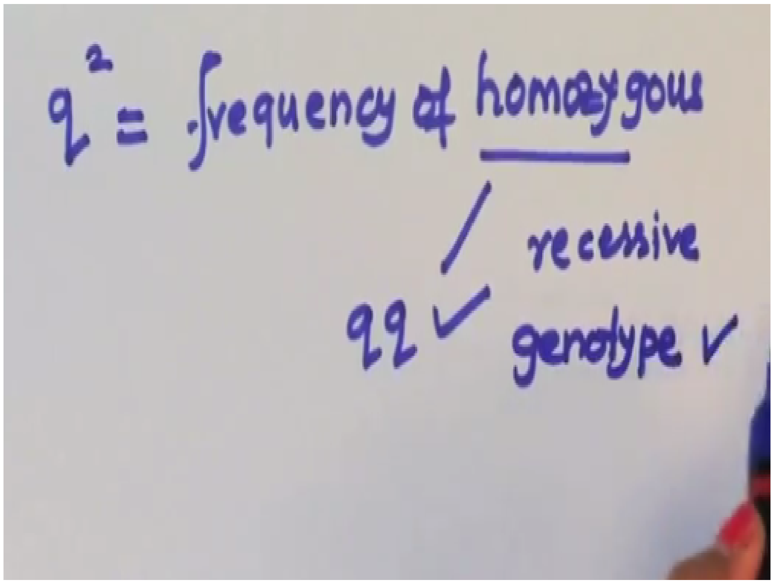

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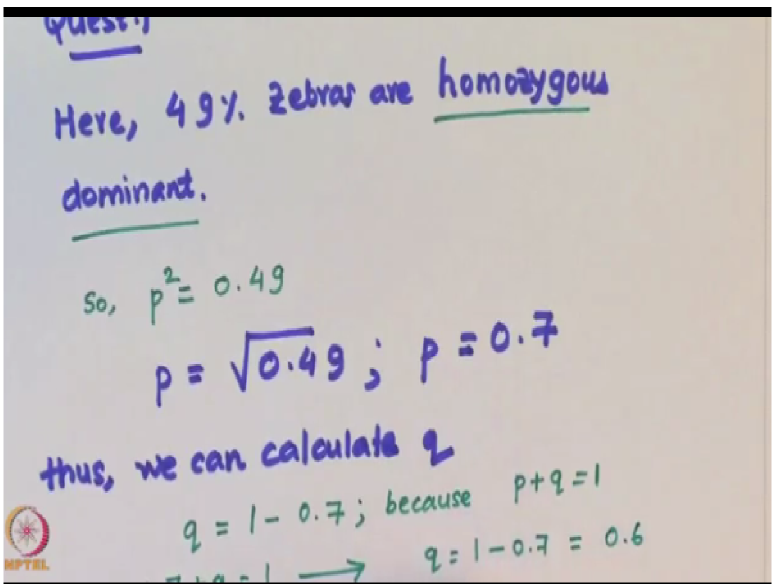

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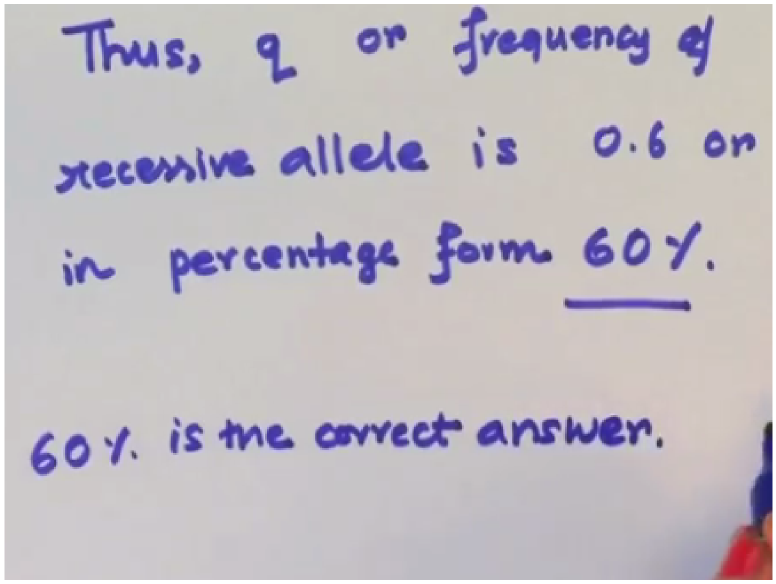

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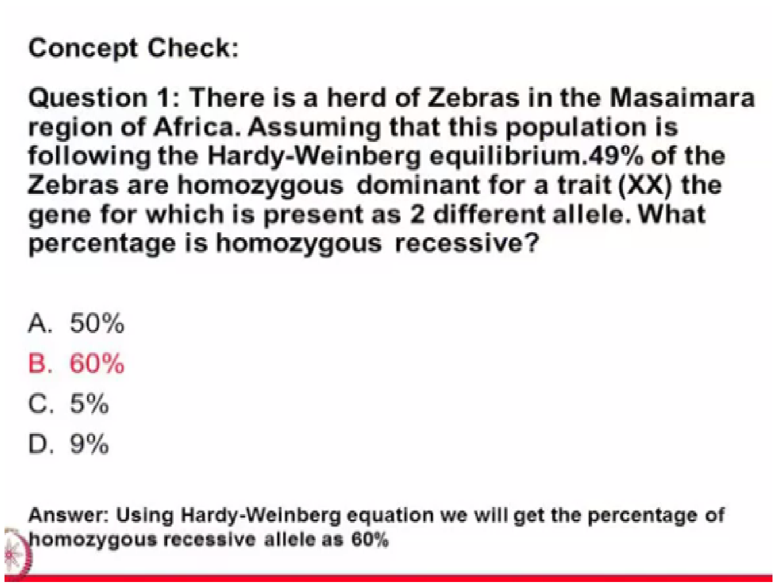

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Question 2: In a city the population that do not have freckles equals to 60%.Freckles are dominant traits and this indicates that 60% of the population is homozygous recessive-then what is the percentage of recessive allele in the population?

A. 100%
B. 60%
C. 20%
D. 35%

In a city, the population that do not have freckles equal to 60%, freckles are dominant traits and this indicates that 60% of the population is homozygous recessive, then what is the percentage of recessive allele in the population? 100%, 60%, 20% or 35%.

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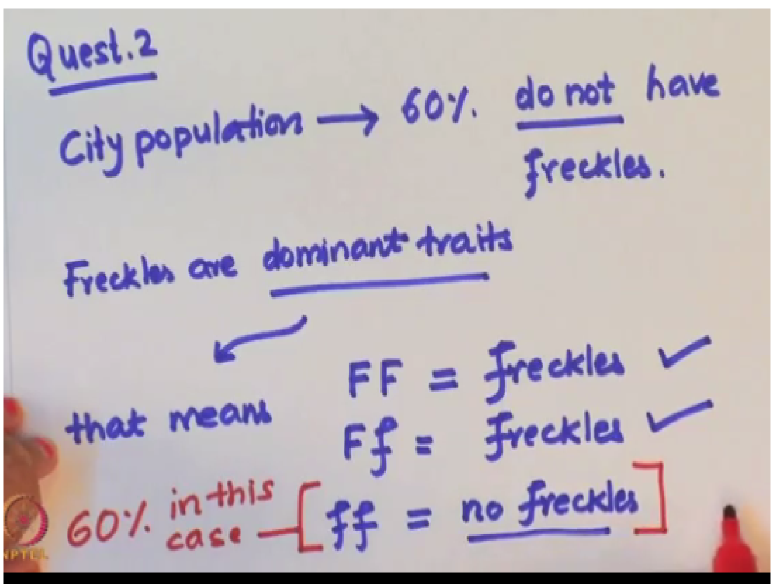

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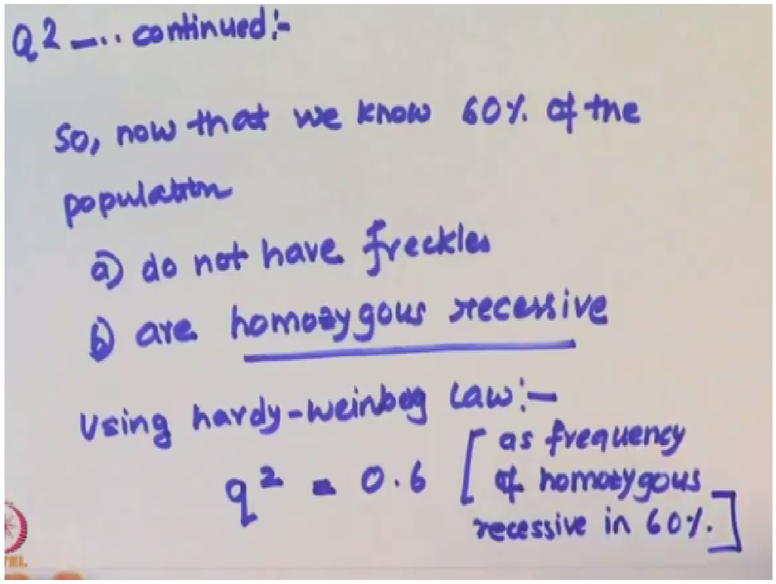

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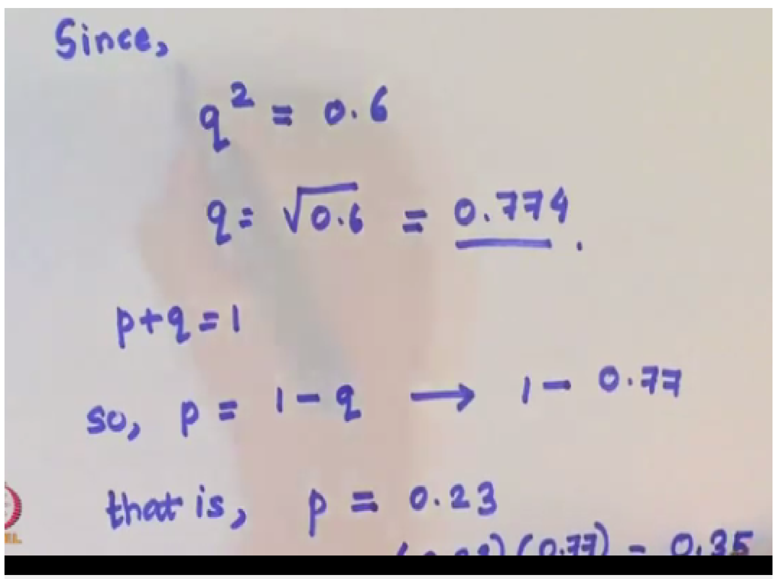

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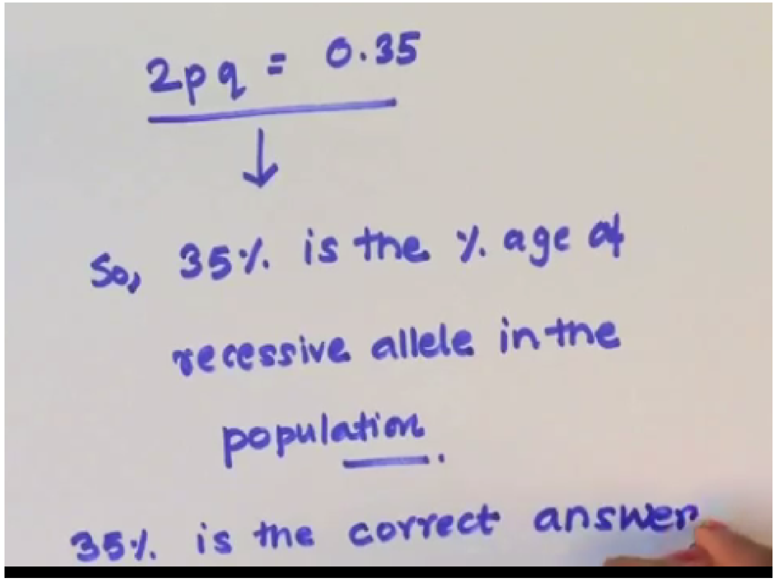

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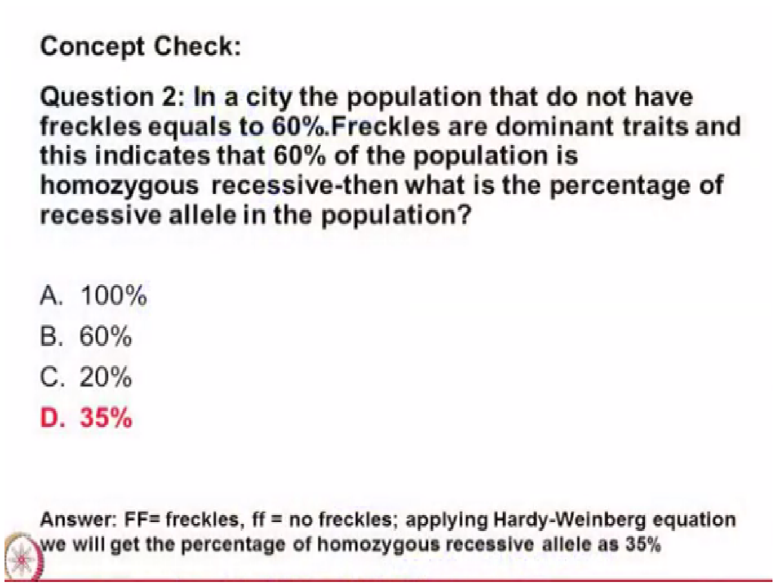

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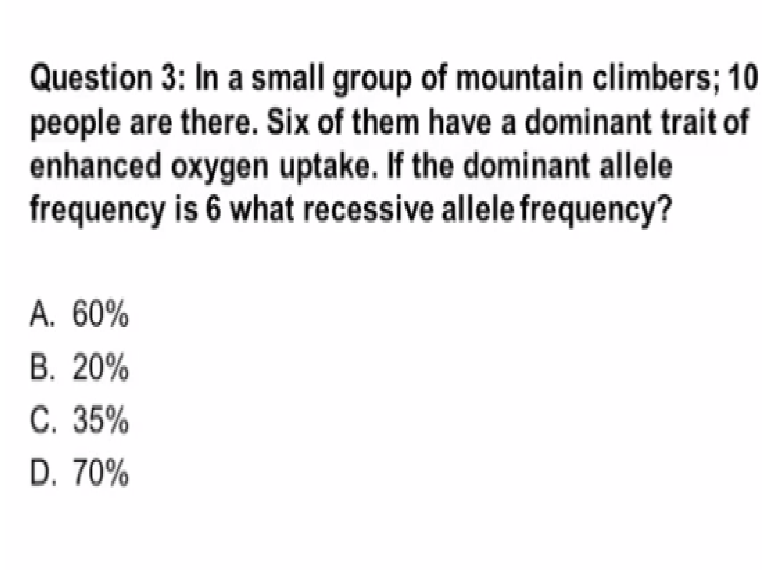

In a small group of mountain climbers; 10 people are there, 6 of them have a dominant trait of enhanced oxygen uptake, if the dominant allele frequency is 6, what recessive allele frequency respected? 60%, 20%, 35% or 70%.

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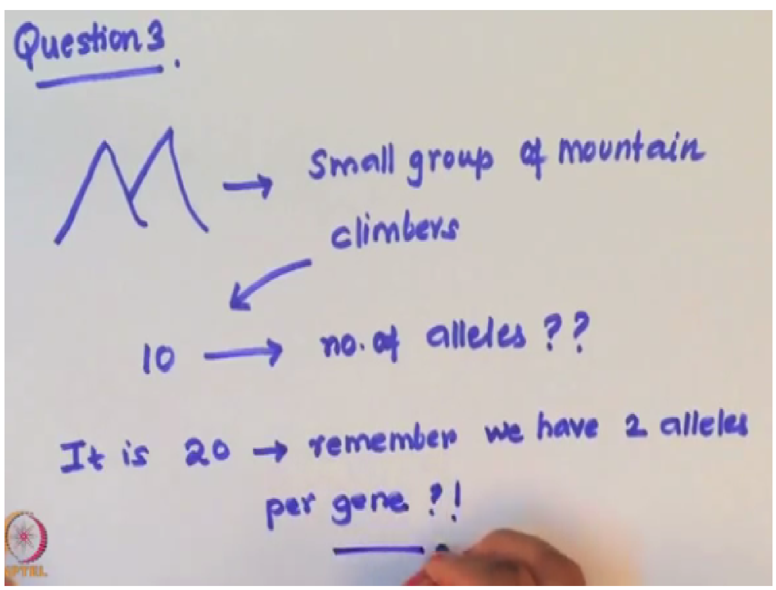

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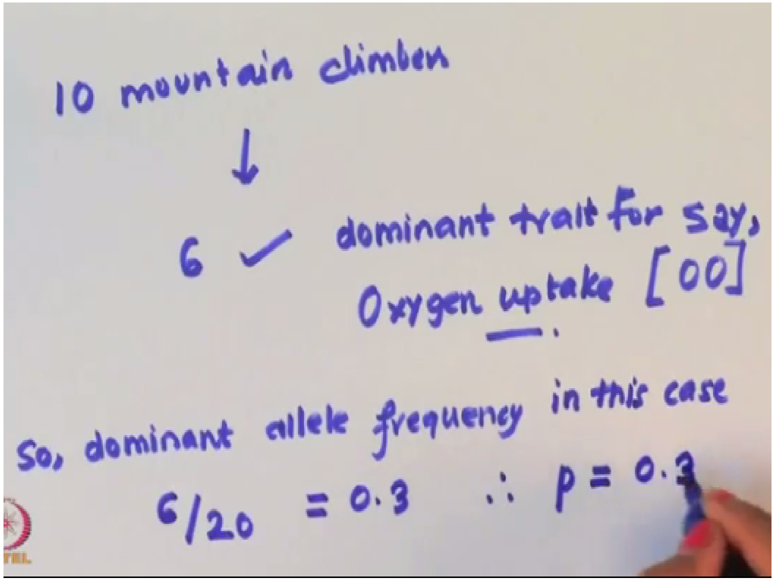

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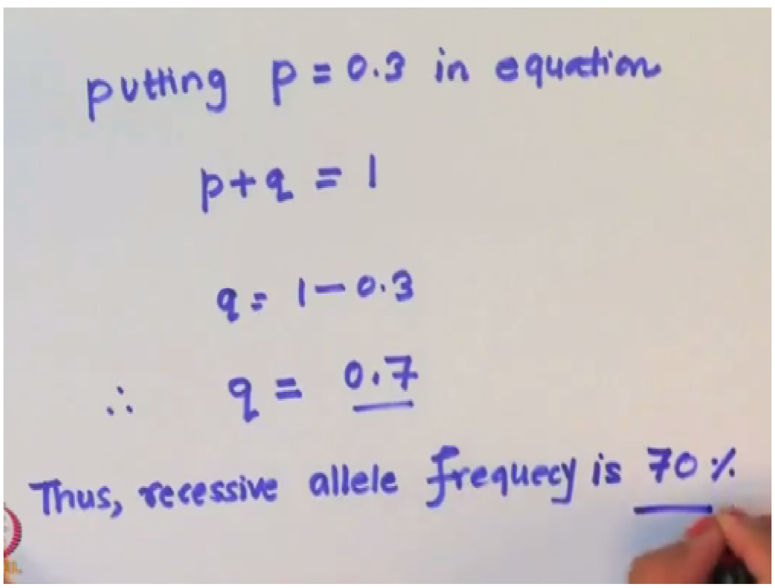

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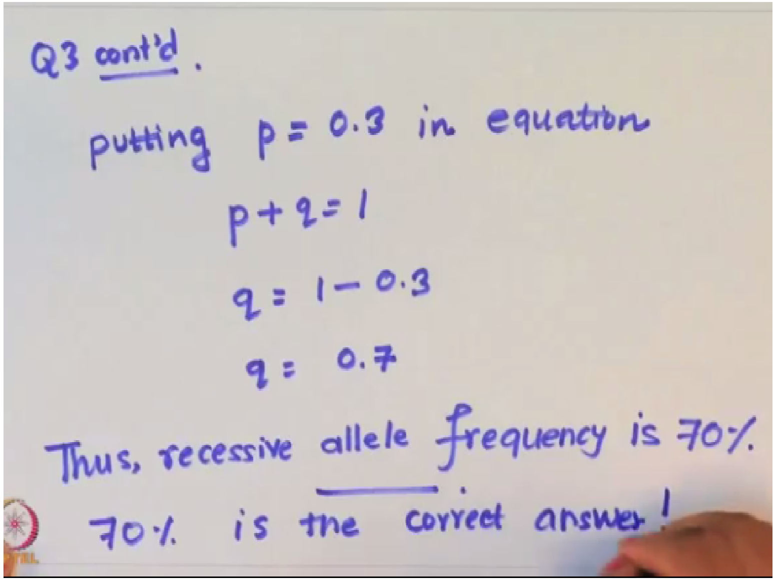

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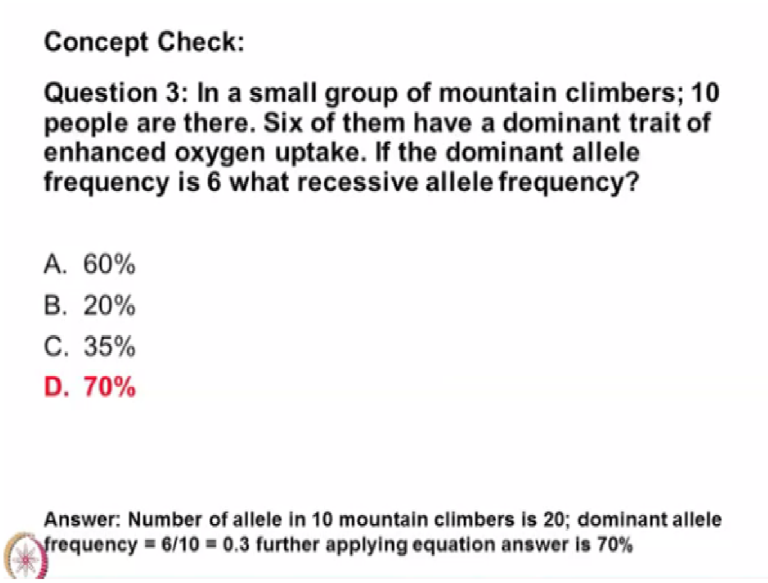

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Conclusion:

- You can integrate concepts of evolution into mathematical models and predict genetic frequencies of population
- You will now appreciate that how life began as a single cell and manifested into such diverse forms.
- Integration of key mathematical aspects you can predict traits and inheritance patters

So, in this way, you can even integrate the concepts of biology like evolution into mathematical models and predict the genetic frequencies of a population. Learning key concepts of evolution on one hand will make you appreciate the fact that life began as the single cell but manifested into such diversity additionally, by integrating key mathematical aspects, you may be able to predict traits and inheritance patterns.

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References

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