Introduction to Evolutionary Dynamics
Prof. Supreeth Saini
Department of Chemical Engineering
Indian Institute of Technology, Bombay

Lecture – 02
History of the theory of Natural Selection – 2

Hi everyone. Welcome to the next lecture of the course and we will continue our discussion of the story of development of the theory of natural selection. So, we ended our last lecture by discussing two of the three characters that we wanted to Henry Bates and Alfred Russell Wallace. Today we will talk about Darwin and bring back Wallace and Bates into discussion towards the end of the lecture. Darwin was born in 18 or 9 he came from a rich family and at 22 he did not really know what to do in life, he was interested in natural life, and in 1832 he got a chance to go on a ship voyage on a ship called h m s beagle and the journey was supposed to last 2 years and go around the world collecting samples.

His job on the ship was as an amateur natural's naturalist and also to act as a dining made for the ship's captain Fitzroy. So, in 1832 Darwin goes on this ship called h m s beagle which starts from England and eventually makes its way across the Atlantic, and make stopovers along the eastern coast of South America. After going round South America the journey takes him to Australia southern tip of Africa back to the eastern coast of South America and back to England. This whole journey was supposed to last about 2 years. However, as luck would have it Darwin was sea sick and the whole journey lasted for about 5.

The there were major repercussions on Darwin along this journey and some of the most insightful observations that he made in to natural life and its implications on theory of evolution were made in the early phase of his journey. As the ship was crossing Atlantic so if you see here on the slide be the map that the h m s beagle took his shown here.

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It started from England and made its way past Argentina all the way down South America and from there Australia southern tip of Africa back to South America and back to England. That is a journey that Darwin took as the ship was crossing the Atlantic ocean Darwin again came from a rich family, he had a state of the art microscope along with him on the journey and as the ship is making its way to the Atlantic his use he is looking at this planktons under his microscope and these are present in their most resplendent beauty and colours; and Darwin asks himself that why are these organisms of such beautiful colours present in the middle of the sea, why did God make these species and place them here where there is no one to enjoy them and appreciate their beauty.

Because that was the prevalent view that God made species and they were immutable the next major influence came at a place called Bahia Blanca on the eastern coast of South America, where Darwin notices that the species which are present in that particular area and the fossil records which are present in that particular area, bear are marked resemblance except for the fact the fossils are of a much larger organism that the ones which are present in that area now. Why does the similarity between organisms that existed in that area in ancient time, why is there is the similarity between them and the present a organisms in that area we beveleded Darwin; and from there on when the ship made its journey across the south American continent and came to this group of islands

on the western coast of south America these Ecuadorian islands which are called Galapagos islands, which are the very famous ones which I am sure everybody is heard of is where Darwin made his most remarkable observations.

When Darwin went to these closely situated islands in Ecuador which are called Galapagos Islands, Darwin was very very sick. In fact, in one of his notebooks he writes that Galapagos islands are not very pretty and he writes that if there was a garden in hell this would what it would look like, but a curious thing happened a couple of curious things happened on the islands one was that the natives of the islands stole Darwin that just by looking at the turtle and the design on its back they could tell which of the islands had the turtle come from which means the turtle on each particular island had a slightly different pattern or a design back on its shell.

Darwin also noted that finches were present on every of every one of these islands, but each island had a finch which was slightly different than the others, the difference was perhaps in the colour on the chest the difference could be in the structure of the beak or a colour associated with right next to the eye, but each of these finches had with had these very slight this differences associated with them.

So, theory begins to take shape in Darwin's mind while he is on his journey that species are not immutable, but it is the interplay between the environment in which a specie is growing and the specie itself that species develop and the change over generations; and the things that these finches developed the these finches took the particular form based on the exact environment which is associated with one particular island. If two islands had slightly different environments the finches adapted themselves to best survive if those particular environments and hence that led to the changes which could be seen by everybody around then.

That was how Darwin started farming his theory of evolution. Of course, Darwin comes back in 1836 with the shape and he is still working on the theory associated with his view of evolution. But he is not very certain and the views are still taking shape his mind and he is careful not to make his views public. In fact, the one of the best representations of how the Darwin how this theory of natural selection was taking place in his mind can

be found from his notebooks page which he wrote in March 1837 and this is a very very iconic picture.

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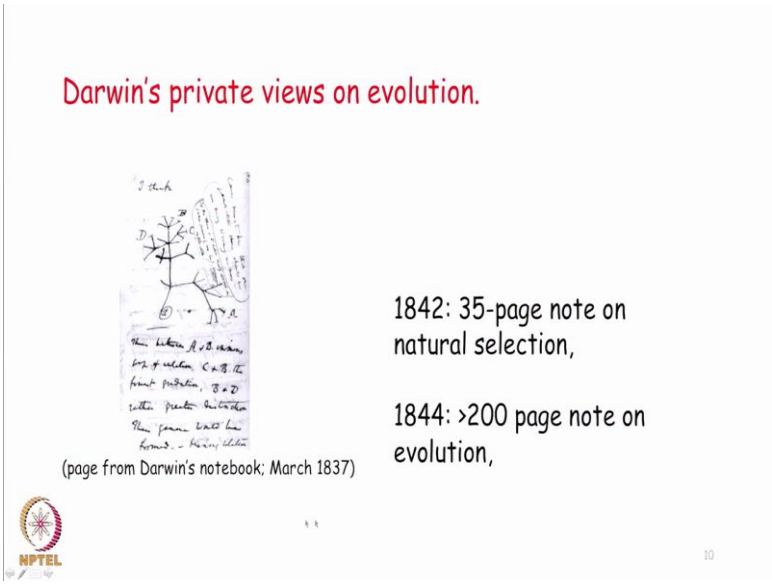

Where he says that species are not immutable species arise from other species this change takes place based on the environment that is posed to us particular specie, and hence origin of species can best be represented by this tree like structure where one node is one specie which gives rise to several other nodes which could which are other species and so on and so forth each node then further diversified into more nodes leading to leading rise to more species in the environment.

And it Darwin still is in an conjectural board because he puts this I think at the top left corner of his page. However, these are Darwin's private views he does not want to contradict the church at this point and hence he never makes his theory public except for a very few select group of friends. 1842 he has written 35 page note on natural selection which has grown to more than 200 pages by 1844, but still private.

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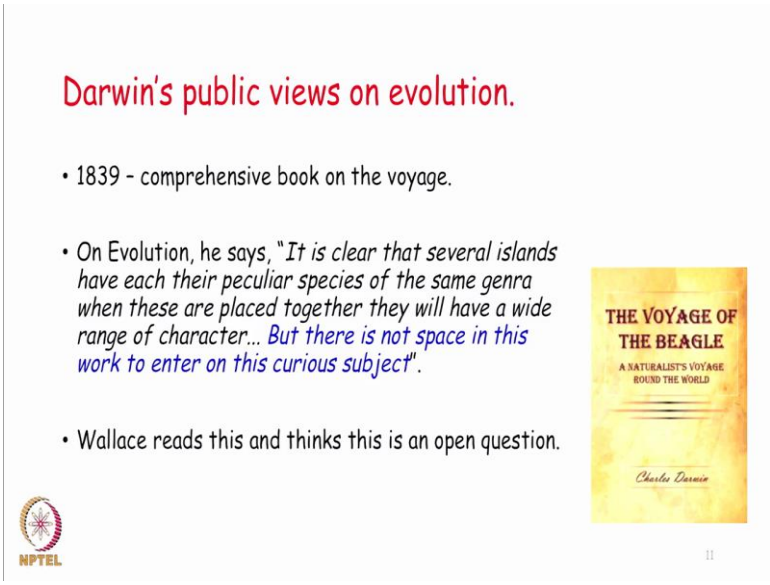

On the other hand if you look at Darwin's public views on evolution, he really does not go out and conjecture privately he thinks that it is a tree like structure which best explains rise of species and that is the question that he is most interested in like Wallace where do species come from, and he thinks species come from species in that tree like structure but publicly Darwin does not say that.

In his most comprehensive work that summarises the journey on the beagle which is called the voyage of the beagle, on the topic of evolution Darwin does not spend any time he says it is clear talking of the finches on Galapagos islands, he says that it is clear that several islands have each their peculiar species of the same genre when these are placed together they will have a wide range of character, but there is no space in this work to enter on this curious subject of course. So, Darwin is side stepping the issue the question associated with evolution, this book was published 3 years after his journey in 1839 and Wallace might have read this book and thought to himself that evolution of species is an open question, and was that open question that drove him to Amazon in the 1840s and spend 4 years there collecting samples along with Henry Bates.

So 1852 is when Wallace survives the see fire and makes it back to England, but in 1853 he is ready to go back to sea again and before he goes back he still interested in the

question of, where do species come from? And this time he goes he chooses to go to the Malay Archipelago which is the present emulation islands in southeast Asia and before he heads over he goes and meets Darwin who is the best known naturalist in England at that time, and asks him if he would be interested in following Wallace's work and giving him advise as he goes there to try on it on his quest of answering where do species come from.

Of course, he does not know that domain already has a possible answer to that question and Darwin does not confide in Wallace and tell him that he is arrived at the question, but Darwin tells him that he is very would be very interested in following Wallace's work as he goes to the Malay Archipelago and collect samples.

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So, the next figures summarises Wallace's journey Darwin is still in England where as Wallace has gone Malay Archipelago which is between Australia and the Asian land mass lands there in 1854 and of the on the bunch of these islands he makes about a hundred crossings travels thousands of miles and collects hundreds of thousands of specimens over next 8 years. But the peculiar thing that Wallace notes on this journey of Malay Archipelago is the following; that along the islands he could clearly draw a line between the island, where on all the islands belonging which belonging close to

Australia they were the animals that existed were marsupials like Kangaroos you carry their young ones in a pouch.

Whereas, on all the islands that were towards Asian land mass as compared to the Australia the marsupials did not exist and you had more monkey like animals present there. In addition just like Darwin as he moved from one island to another, Wallace noticed that the design on the butterfly wings had a very peculiar fashion and that was associated with which island did the butterfly came from.

And just as Darwin has formulated his idea of theory of evolution by from is journeys and lessons from Galapagos Islands, this experience on the Malay Archipelago shaped the theory of evolution in Wallace's mind. Both Darwin and Wallace were also influenced by a economist called Thomas Malthus; Thomas Malthus in 1798 as you can see here has written an essay which was called an essay on the principle of population.

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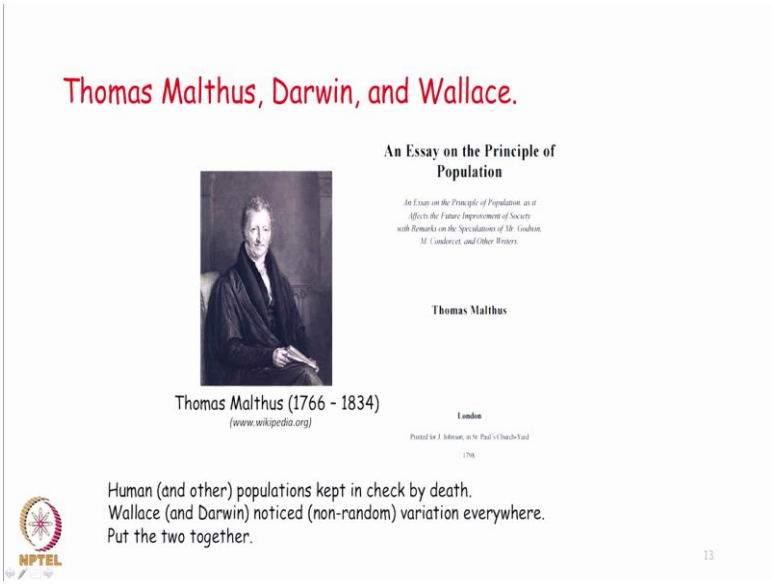

And Malthus who was an economist his argument was that human and other populations are kept in check by death happening; overcrowding of an environment does not happen because death takes over resources become limitation. But what Darwin and Wallace had both notice was that there is variation that exists in nature everywhere, and this variation

is non-random in the sense that only those variations which are best adapted to an environment survive and others perish.

But Malthus saying that competition for resources which would lead to death keeps populations in check; and Darwin and Wallace both independently put that two ideas together leading them to theory of natural selection, and in 1855 Alfred Russell Wallace wrote this essay which is called on the law which has regulated.

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The introduction of new species and in this he writes that every species has come into existence coincident both in space and time with a pre existing closely allied species. Again he is arguing the same thing which Darwin saw in South America that species just do not crop up anywhere species arise in areas where similar looking specie species already exist. And independently from Darwin and remember the note that Darwin had in his notebook from 1837, in 1855 Wallace now writes that- "the best mode of representing the natural arrangement of species is a branching tree"!

Which is just a fascinating example of how two minds working so far away in space and time converge to the same idea on a specie on the theory as important as evolution. Of course, when Darwin when Wallace published this in 1855 his ideas wont well received

and he was sent that he was financed and sent there to collect specimens and sent back to Europe and people back in England were basically told him that you just keep collecting samples and keep sending them back to us.

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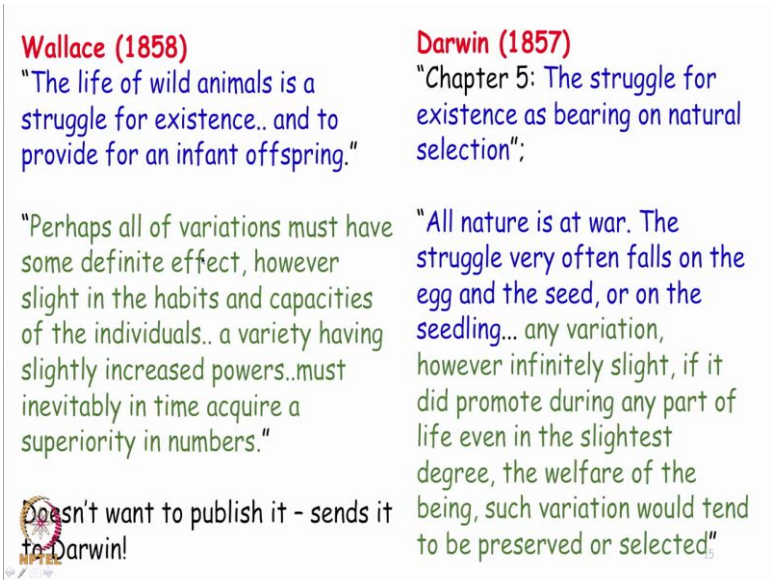

So, exasperated Wallace writes his notes, but this time before seeking publication he sent his ideas across to Darwin, and in his notes are these following lines which are perhaps worth reading. It says the life of wild animals is a struggle for existence and to provide an infant offspring that is the struggle that all life forms are going through. "Perhaps all will all variations must have some definite effect, however, slight in the habitats and capacities of the individuals; a variety having slightly increased powers, must inevitably in time acquire a superiority in numbers." So, what he is that there are variations and each variant is slightly differently adapted to survive and flourish in that environment and in such a setting the individual which is most suitably adapted to survive and flourish will take over the entire population and eliminate the others.

That is the nature of the note that he sends to Darwin and before we go ahead it is perhaps best to compare these words of Wallace with something that Darwin had himself written. In chapter five of the draft of origin of species, Darwin writes the struggle for existence as bearing on natural selection all nature is at war the struggle very often falls

on the egg and the seed or on the seedling just survival of the offspring which is what Wallace is talking about here. Any variation however, infinitely slight which is against something that Wallace is talking about having slightly increased powers, if it did promote during any part of life even in the slightest degree the welfare of the being such variation would tend to be preserved are selected.

Again almost identical ideas obtained around written around the same time, but developed for away in space and time. Wallace sends his note to Darwin and says that this is how I think species evolved what and Darwin who is had this theory in mind since the late 1930s reads that in 1815 the 1850s and realises that this independently the same thought independently has also been arrived at by Alfred Wallace, and he has not shared his theory with so many people.

So, what it does is he shares the note that Wallace sends him with a couple of his friends who had already known that domain had arrived at this theory way back in time and asks them what to do. And the friends then suggest that Wallace and Darwin be given equal credit for this for this discovery and their papers be read jointly in conference proceedings around that time. And those friends if we look at this slide here this are an interesting slight from this summarises a letter from Charles Lyell who was a geologist and Joseph Hooker who was a botanist.

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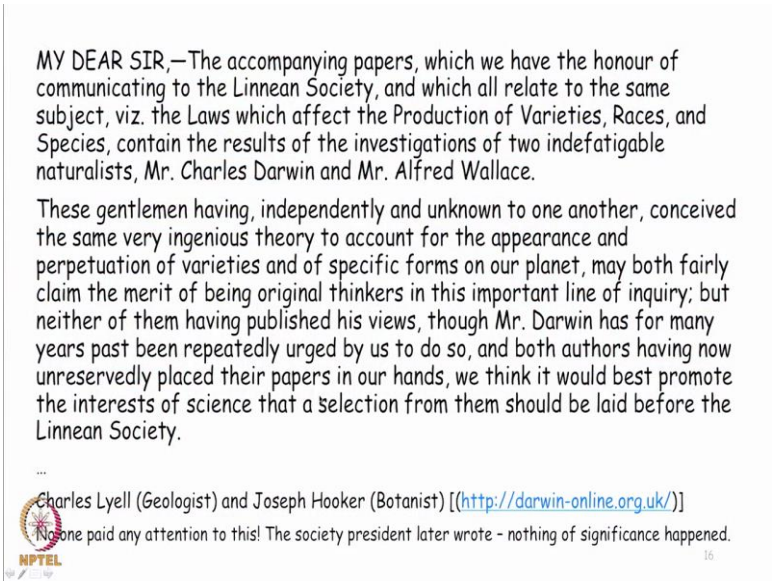

And this is the letter that they write to the president of the Linnean Society where they are proposing that the work from Darwin and Wallace has been independently arrived at by both these people and that their work should be admitted as independent contributions.

And it is worth reading the first paragraph which says the accompanying papers which we have the honour of communicating to the Linnean Society and which all relate to the same subject which we the laws which affect the production of varieties races and species, contain the results of investigations of two indefatigable naturalist mister Charles Darwin and mister Alfred Wallace. These gentleman having independently and unknown to one another conceive the very same ingenious theory to account for the appearance and perpetuation of varieties and of specific forms on our planet; may both fairly claim the merit of original thinkers in this important line of enquiry.

Lyell and hooker go on to speculate they go on to request that neither of them have communicated they had other ideas publicly and it would only be fair if their works at read on the on the meeting of an annual Linnean Society. The reading does take place neither of neither Darwin nor Wallace could attend that meeting Wallace was of course, away in the Malay Archipelago and Darwin was grieving the death of his child which

had only happened a few days back.

The works were read but did not really, cause a stir and the society the president in his notes for the meeting later wrote that nothing of significance was reported in this year's Linnean Society. So, this is how the theory of evolution progress of course, the following year the year after the reading Darwin quickly comprise together with his book origin of species published in 1859 and that is a book that is been in print ever since. The book also makes Darwin an enemy of the church and he faces ridicule form for many from many quarters about proposing a theory of evolution which does not invoke God.

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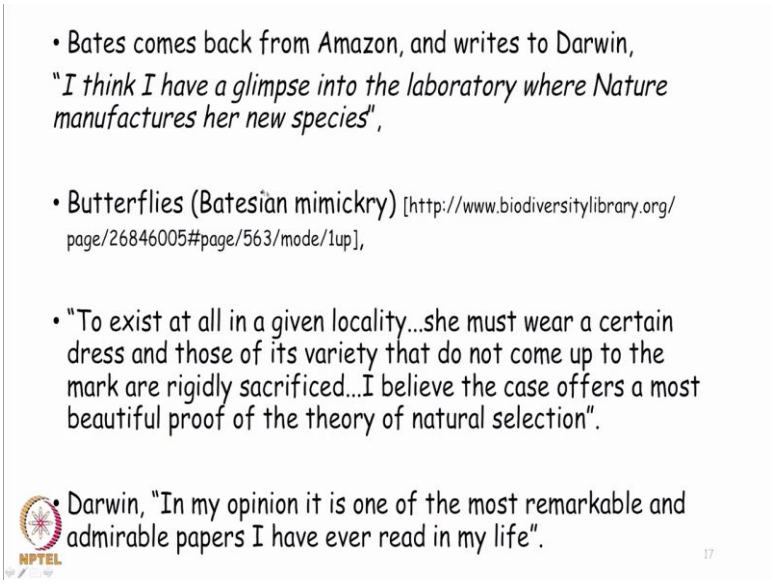

In the meantime 1857 is when Bates Henry Bates who had gone together to the amazon along with Alfred Wallace in 1848 comes back and writes to Darwin, I think I have a glimpse into the laboratory where nature manufacturers her new species. So, what he is suggesting to Darwin is there at I have an example for you where natural selection you theory of natural selection or the survival of the fittest can be seem to work and Darwin is thrilled at the news because he is being attacked and what he really needs is an example of where this theory is seen evident in playing out it is playing itself out in nature. And the example that Bates is talking about is one of Bates what is commonly known as Bates mimicry.

And what Bates had has noticed is the fact he had noticed in amazon is a fact that some butterflies were poisonous. So, the predators would not touch these butterflies and of course, these butterflies because they were not being eaten up by predators their numbers grow. But some of the what happened as a result was some of the species which were non poisonous some of the non-poisonous species of butterflies also acquired characteristics, also evolved to look physically similar to the ones which were poisonous in nature. Hoping that the predator would look at them consider them as poisonous species and not pray up and not eat them up and hence this is referred to as beats in mimicry and was considered an example of natural selection playing into actions, where are random variation where one of the non poisonous butterfly species acquired a mutation to look somewhat similar to the poisonous species of butterflies and hence thrived a number because predators could not touch it now.

So, and then it goes on to say to exist at all in a given locality she must wear a certain dress and those of its variety that do not come up to the mark are rigidly sacrificed. I believe the case offers a most beautiful proof of the theory of natural selection Bates summarises. Darwin reads the work and says that in my opinion its one of the most remarkable and admirable papers that I have ever read in my life. So, that is sort of brings to the closure of the story of these three men which led to the development of theory of natural selection.

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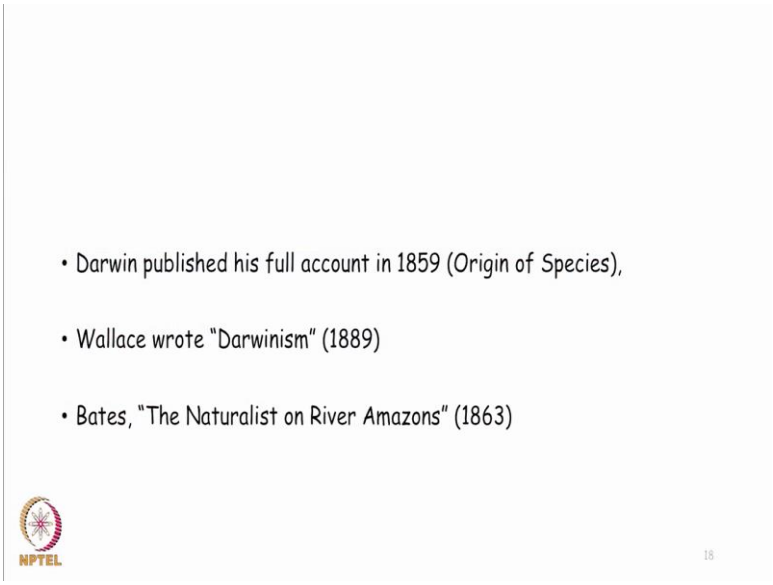

We will look at the slide this summarises the three most famous work with by these people, Darwin published tens of books in his life he eventually passed away in 1882, but he is of course, most well known for his 1859 the origin of species. Alfred Wallace only wrote one book in his life 1889 which he called Darwinism.

This was seven years after Darwin had died and of course, when the proposal was put forward by hooker and Lyell that a joint reading be done and both the both authors Wallace and Darwin be given equal to credit for natural selection there was no animosity and both were very generous in sharing credit with each other. Wallace always acknowledged that Darwin had arrived at the answer independently and way ahead of when Wallace eventually did; and Bates is most well known for his book the naturalist on river amazons which he published a few years after his return from the amazon.

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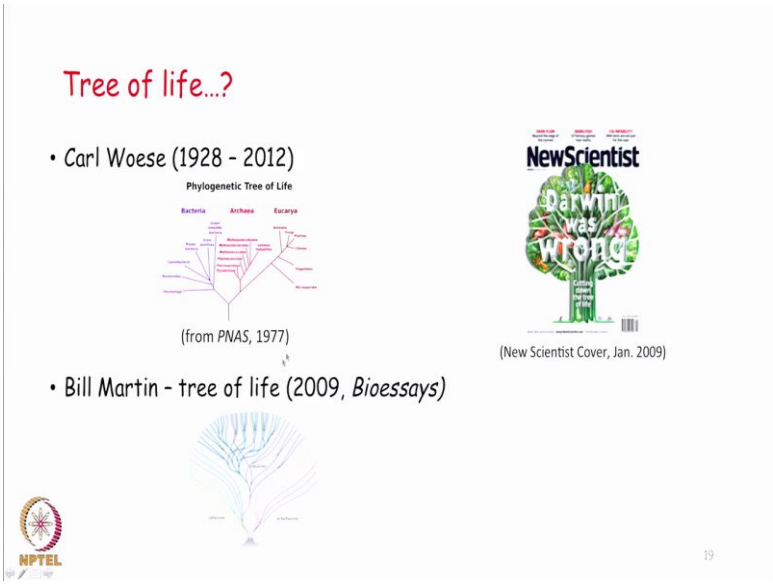

So, that that brings us to a more recent question of what does the tree of life look like which both Darwin and Wallace referred to. In this first slide is a picture taken from Carl Woese's life which represents the tree of life like this the text is too small to read, but essentially what is showing is that on the left here are the all the species which are bacteria in the centre is archaea and on the right or all the eukaryotes. So, this is all complex life and Carl Woese is famous for his discovery that there are actually three divisions of life and not two as previously thought.

So, this was more contemporary; however, this is a cover slide that I took from the new scientist cover from 2009 where it says Darwin was wrong and why the magazine implies that Darwin was wrong is because when we anticipate DNA changes taking place sequence changes taking place, we anticipate that the changes take place from one generation to the next generation as it passes from one generation to next some mutations some form of changes would take place and then changes would happen.

However this was the time when it was being discovered that among bacteria, a lot of DNA exchange takes place not from one generation to another, but in two, but between two existing bacteria also. This form of DNA exchange is not vertical in nature in the sense that it is not from one generation handed over to the next generation, but is

horizontal in nature in the sense that it is between DNA exchange between one existing individual of a species and another. So, this is horizontal gene transfer which led to the new scientist proposing that Darwin was wrong.

More recently; however, the tree of life has taken another shape and this is a picture that is taken from 2009 article written by bill martin attorney of, where again this is too small to read, but this is all bacteria this is all archaea and somehow somewhere down the line as we saw about around about two billion years back or so, and archaea and archaea and a bacterial cell combined and archaea cell engulf the bacterial cell that bacterial cell then the bacteria then shed most of its DNA eventually became a mitochondria, and this mitochondria powered this new cell and which and out of that arose all cellular complexity. So, the new tree of life has now the three divisions of life archaea bacteria both coming together to form the first eukaryotic cell and that eukaryotic cell developing into multicellularity and all complex life as we see it today.

Of course Darwin and Wallace and Bates or anybody at that time did not know they understood that is there, but changes taking place from species to species from generation to generation in a species and as you move forward in time specie adapted to its environment, but the mode of change the mechanism by which this change happened was unknown to them. Because the first evidence that came towards that and came from Gregor Mendel in 1865 where he famously work with his pea plants and published data which suggested that there was a certain mechanistic details certain mathematics associated with how this information is passed on.

Mendel's work up after publication remained largely unknown or unnoticed one of the reasons was that it involved a lot of math, until it was it until it was rediscovered in 18 in 900 by 3 people independently and that sort of set into motion quantitative and statistical development of biological and evolutionary processes. So, what I have what I hope to have talked about in these two lectures is given you some historical perspective about where did theory of natural selection and where did start of association of statistics and mathematics with biology came into being.

Next lecture on words which start with the first subject associated with our course which

is development of equations for the three basic pillars of evolution reproduction selection and mutation.

Thank you.