Course Name: I Think Biology

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Week:7

Lecture:38

W7L38_Human Evolution

Hello, good morning. Today we are going to be learning about human evolution as part of the NPTEL course series. My name is Divya, I am a faculty at Azim Premji University. So today, we are going to talk about where did we come from, what are the timelines of our species evolution, who are our closest relatives and how do we really differ from them and how do actually scientists find all these evidence? But before going into our own timelines and our own species evolution, let us look at the life on earth, the timeline for life on earth.

As we know, earth itself is around 4.5 billion years old, but the life on earth is around 3.7 billion years ago. If you see prokaryotes here, as depicted in this picture, the single cell organisms evolved 3.7 billion, around 3.7 billion years back. So, it is quite old, but and if you look at various organisms have evolved at various time points. But when you come to humans, humans are very, very, very recent.

Humans, when I say humans, these are Homo sapiens and they are around 0.2 million years or 0.0002 billion years back or in other words, what we are familiar is around 2 lakh years ago. So, human origins is very, very recent in the history of, you know, life on earth. Now, let us look at how are we related to other, you know, great apes and other Homo species as well.

So, this is a evolutionary tree, a broad phylogenetic tree, which depicts the relationship between human beings and other great apes. So, you have Orangutans, which is a genus pongo, Gorilla, genus gorilla and under the genus Pan, you have chimpanzees and bonobos. So, as the tree depicts, we bifurcated or we evolved or we diverged from chimpanzees and bonobos 5 to 7 million years back and they have been, since then they have been independently evolving.

So, our closest relatives, we can say as per the latest evidence is chimpanzees and we have been evolving away or separate independently around 7 million years ago. Now, let us look at just Homo and other close relatives. So, we are not, we are moving away from gorilla, orangutan and chimpanzees and bonobos, we are just looking at, you know, Homo and other species in the Hominin group.

So, as I told, we diverged from chimpanzees around 7 million years ago.

So, our homo genus is around 2 million years, it is different species in the Homo group or the homo genus evolved around 2 million years till the present. So, Homo sapiens, if you look at it, it is a very, very recent origin. But there are several other species in the Homo genus and we will come to that in a bit. But you will also notice in the other Hominins are Austerlopithecus and then Ardipithecus and then there is this genus called as Sahelanthropus that actually is the oldest fossil known which is basically it is different from chimpanzees, it diverged from chimpanzees and this Sahelopithecus had a common ancestor 7 million years ago. So, this is the timeline of various Hominin species which we know currently.

Of course, you have to keep in mind that when I say 7 million years or 2 million years back, these are all based on fossil records and the timeline is based on a comparative, you know, you find a fossil and you date it and then you compare it with the available fossil and also with the DNA evidence. So, the exact timeline keeps, it is a little fuzzy because it is based on, it is a relative comparison. So, as in when scientists keep finding new and new fossils, we will add more species into these groups and also timeline keeps shifting a bit.

Okay, so now let us look at what are the characteristics of humans. So, this is between early humans to modern humans. So, the timeline is 1.8 million years ago to current. There are three characteristics. Humans have bipedality that means that they can walk on two legs. They have learned to use various tools with their hands and they have large brain.

So, now we are going to look at what are the different groups which have all these three characters and what are the costs and benefits of these traits. So, when I say these traits, bipedality, tool use and large brains are all traits which modern humans have and there are definitely benefits to it, but there are also costs to it.

Okay, so this is another way of representing our evolutionary tree. So, again we are going as back as 7 million years ago and you see Australopithecus, Ardipithecus and this is the Homo group, right and this is the Homo sapiens, this is where we are, a very, very recent origin.

Okay, so if we look at, you know, bipedality, that came about, so if you look at this particular panel here, you can see this is a comparison between chimpanzee and other different various Hominin groups.

So, chimpanzees were quadrupedal, so they walked, they walk on four legs whereas Ardipithecus is bipedal, walking on two legs. Gray-shade is kind of somewhat bipedal, bipedal kind of a thing and Australopithecus, Homo erectus and humans Homo sapiens are definitely bipedal. Okay, how do we know this? We know this by skeletal evidences and various other things which will come, we will talk in a bit.

Okay, so of course, chimpanzees are frequently arboreal, though they do walk on the ground. Ardipithecus are also frequently arboreal. Australopithecus can do little bit of both, both arboreal as well as terrestrial and Homo erectus and Homo sapiens are definitely very rarely arboreal, right. There are characteristic difference between shape and size of the teeth as well. Chimpanzees have a large canine teeth which is very useful for cutting, you know, the kind of food the chimpanzee eats whereas you can see that as we kind of progress from Ardipithecus to Homo sapiens, the canine teeth size has reduced and also you can see the brain size has continuously increased as we move from chimpanzee to Homo sapiens.

So, now we are going to look at specifically about bipedality. So, having walking erect basically, walking straight on two legs had many changes to our anatomy and physiology. So, there were changes in the foot, so instead of having digits come out like this, digits are all aligned in the same way, our toe digits, right and there are changes in the hip, changes in knee, leg and as well as spines. These are all various changes as you can see in these, broadly see in these skeletal forms.

But what are the benefits of walking upright? Let us think about it, take a few seconds and think about it. Definitely, you can see at a more, you know, broader range, you can see far and wide. Walking upright also releases your hands, you do not need four limbs to walk, right. So, it kind of releases your hand to hold other things, you can hold babies, you can hold, you know, tools, so on and so forth, right. And it is also easier to pick up food from higher areas such as trees. You can scan the landscape better, you can also basically, you can intimidate or you can appear larger, so it enabled early humans to appear larger than themselves. So, these are the benefits.

What might be some of the costs of, you know, walking upright? Definitely, lower back pain is one of the costs of walking upright. There are a lot of slip disks which are common in humans, so that is also a cost of walking upright. Arthritis of hips and knees and also collapsed foot arches, these are all various costs which we commonly see in modern humans. These are costs of walking upright, okay.

So, now let us look at some of the early groups, our relatives who had this bipedal nature. So, Ardipithecus as we were talking earlier, this is a fossil which is found in Ethiopia, which is around 4.4 million years ago. So, this Ardipithecus walked both upright as well as it was arboreal. It had canines similar to humans rather than chimps, so the smaller canines and pelvis similar to humans as well as chimps and but it had a small brain compared to brain size of human beings, current modern humans and this species did not use tool, okay.

How do we know all these things? Because when we are looking at fossil evidence, when we are finding these, there were no other elements such as tool use, we will come to it, but people have not found any evidence of tool use so far.

Lucy is a very, very well known Australopithecus species and we people have found this that it was found in Ethiopia again in Africa and it dates back to 3.75 million years ago. It was bipedal,

small bipedal with a small brain and again no tool use. Actually, this is the skeletal remains of Lucy, what was found and this is a cast of, cast made kind of based on these skeletal remains and this is in one of the museum exhibits. So, this is what how scientists have recreated, you know the Australopithecus specimens, okay. So, again the fact that thing that I am trying to reiterate is what are the genus or what genera had bipedal and big brains and tool use and what are the other genera which did not have. So, Ardipithecus and Australopithecus were bipedal, but they did not have tool use and they did not have larger brain.

Let us look at benefits of large brain. Benefits of course, large brain means higher processing power, right. It is like having big computer processing unit, right. So, you can process very fast, you can store memory and you can also recall, right. So, store more information, collect and process information fast, within seconds and also solve problems.

You can abstract different concepts, you can imagine stuff, brain also allows you to be more creative etc, but there are definitely costs to having big brains. The costs are energy consumption. So, it is around brain size is around 2% basically of our body weight, but it consumes 20% of body's oxygen supply. It is a huge amount, right. So, in order to have this big brain capacity, you need to give it a lot of oxygen and it consumes 20% of our blood flow and the other cost is of having large brain is you have large heads and it makes difficult childbirth, right.

So, these are some of the costs. Now, let us look at how did brain volume, size change over time and there is a correlation definitely. Remember that it is just a correlation, but not causation as such. But there is a relationship between climate change, how the climate is changing and also how the brain volume has changed.

So, let us look at the climate fluctuation first. So, this is colder and warmer climate. What is shown here is how climate has been fluctuating over millions of years ago and around 1 million years, is where climate, greatest climate fluctuation happened according to this graph and if you see the brain case volume basically measured in cc, it has gone up significantly more in this particular time period. So, there is a relationship between how climate is fluctuating and how brain size or brain volume has been increasing. So, what can you kind of infer from this? One idea is that, fluctuating climate also needs more, puts more demand on the species which are existing to adjust to that fluctuation climate and an idea is that if you have larger brains that equip you, equips you to evolve or adapt to the changing environment, okay.

So, let us now look at tool use. A lot of animals use tool. This is an example of chimpanzee using a little stick here. Basically, it is kind of using the stick as a tool to excavate termites from this termite hill. So, it lowers the stick and termites kind of hold on to the stick and then it takes out the stick and it is eating that termite. So, that is one, you know, one way of using a tool.

So, tool use has been reported in other animals as well as, you know, something like crows and stuff like that. But tool use in early humans that is around 2 million years ago has been very diverse and complex. So, these are all the examples of tools, various tools made up of stone and also some in later years made up of wood and metal. It gives you an example of various uses of those tools. Some are sharp, some are kind of heavy. So, it was used for various purposes.

So, tool use in humans are, early humans are way more complicated than tool use in other animals, right. So, now we are going to go a little bit more detail into the homo genus itself. There are various species which has been found in the homo genus.

So, Homo habilis is around 2.5 million years ago. There is Homo erectus, Homo heidelbergensis, Homo florensis, of course, Homo sapiens are around 0.3 million years, so and to present. So, this is our group. The things which I have highlighted in yellow are what we will be talking in detail in the coming few slides.

So, Homo Neanderthalensis were basically present in Eurasia around 0.4 to 0.04 million years ago, right. So, these are all very, very recent species which we are talking about.

So, 0.04 million years is 40,000 years ago, they coexisted or they lived in the same areas as Homo sapiens. So, did Denisovans, in actually in different parts of Asia. So, the question is we have found different different species in the various species in the Homo group, right. So, how is it that currently only Homo sapiens survived? We are the only species in the Homo group which who have survived, right. Though we have lot of, we have uncovered lot of fossils and we know from fossil records and also DNA by looking at its DNA, looking at its genomes, we know that they lived in various parts of the world as early as you know as early as 40,000 years back.

So, how come only we survived? That is a difficult question to answer because there could be various factors, there could be climate change, there could be chance event because of which Homo sapiens prevailed and people are still debating about this. But it is important to know that there were other species as well in Homo genus.

So, now let us look at Homo neanderthalensis. Again, so please do not think that okay, this was the exact picture taken about Homo neanderthalensis. This is a recreation of a Homo neanderthal based on fossil evidence, based on you know the size and what have you know also looking at genes, people have actually recreated this kind of a picture.

So, Homo neanderthals existed around 40,000 years ago in Eurasia and they had various characteristics. They had broad nose, wide nose basically, broad forehead and wide nose to kind of probably people think, scientists think that to kind of overcome the humid air, to take in and kind of deal with the humid air. So, there have been various hypothesis like this. They were big brain, they were very sophisticated at using tools, they were very good hunters and there is

evidence that humans and neanderthals may have intebred. They lived together in different parts of the world including Eurasia 40,000 years ago and they are very likely that they have interbred and what, how do people know that, because if you look at our genome and of course, neanderthal genome has also been sequenced, It has been decoded.

In fact, Svante Paboo has been awarded Nobel Prize recently because of his work in paleoanthropology. So, because of the genomes of neanderthals and our own genome, we know that we have , you know anywhere close to 1 to 3 percent of our genome is either neanderthal genes and or Denisovan genes.

So, we have inherited both good as well as bad genes from neanderthals. So, let us look at what are the things which neanderthals have influenced in our own traits. So, there are various skin lesions which we have and which people, which scientists have attributed the genes which are responsible for these skin lesions come from neanderthals.

There is urinary tract disorder, then there are addiction to tobacco and depression and the genes involved for this is also probably have come from neanderthals. It is not that we have got lot of bad traits from neanderthals. We also have a strong immune system because of them. People who have severe COVID who are more prone to basically COVID also have certain genes which might be from neanderthals. So, also you should remember that it is not that you know we have only inherited bad genes.

We should keep in mind when did these traits were evolving and perhaps it was very, it was not so bad at that time period, right. So, for example, you know there is more blood coagulation, enhanced blood coagulation, but perhaps that was very good long time back because maybe because of the cuts and accidents that people had, neanderthals had. So, that kind of facilitated, increased blood coagulation and probably the trait was beneficial for them and that was retained. But now it could be maladaptive because you know it causes other complications. So, a trait might be maladaptive now, but it could be very useful or beneficial in the early you know, when the 40,000 years ago much earlier when the climate and lifestyles were very different.

So, that is important to keep in mind. Now, let us look at Denisovans. Denisovans lived around 30,000 to 40,000 years ago in parts of Siberia and Asia. Very, very few fossil remains have been found that does not mean that there are no fossils, but people are still working on it. This is a most recent discovery and I have written something here known as which states that Tibetans may have acquired genes from Denisovans which make them conducive for living in high altitude.

What I mean is that you know there is something known as high altitude sickness, right. So, we say for example, when we go near, when people climb Himalayas or when people go into high altitude you cannot breathe so well, because of low oxygen in the atmosphere, right. But Tibetans they do not have much of an issue dealing with high altitude problems because their

heamoglobin is well adapted to that particular environment. In fact, the regulation of this particular, how hemoglobin carries oxygen and how it utilizes, how the body utilizes oxygen is an adaptation which Tibetans have acquired from probably, perhaps from Denisovans. So, this again I should not say Tibetans have acquired from Denisovans. What I mean to say is that early humans like Denisovans and modern Homo sapiens present in that area, interbred and Homo sapiens acquired certain genes from Denisovans which make them kind of better adapted to living in high altitude and the same gene what you see is also present in Tibetans.

So, this is an example of how humans are still evolving and how we have acquired genes from other you know other species very, very close relatives of ours, which you can see in the present day humans. So, I just wanted you to kind of appreciate all the timelines we have talked about now when compared to the modern like our own timelines. Anything which is more than a lakh it is kind of difficult to appreciate, right. So, what we are talking about is human origin is very, very recent. You know, few lakhs of years human beings and when you compare to that agriculture or domestication of plants and animals is only around 10 to 12,000 years ago.

Civilizations is the oldest civilization, the Indus valley civilization is only around 9,000 years ago. So, that is the timeline we are talking about.

To summarize, we will go into summary, but I just wanted to show you some pictures about how do scientists find these evidence. These are anthropologists and paleoanthropologists and archaeologists who work very, very it is a very painstaking work. So, you see that it involves a lot of people and carefully they kind of they have to dig a little bit of the excavate earth and slowly brush upon brush. They use like small things like small brushes and forceps and stuff like that to kind of see whether what is a fossil and what is it could be just a stone, right.

So, this is an excavation site and based on that you of course, you discover various fossils and these are all casts. Some of them could be originals or some of them are casts of these fossils and together with fossil records and now with advanced technology, various ways to kind of sequence DNA from these fossils, both these have helped scientists to find, you know evidence of how are we related to other species.

So, to summarize, chimpanzees are our closest relatives. We differentiated from them around 7 million years ago. We are most closely related to Neanderthals and Denisovans and there is evidence that modern humans interbred with these groups and by looking at fossil records and whole genome sequencing of these, some parts of these fossils, we can estimate rough timelines of these events. So, you have to keep timelines with the, take timelines with a pinch of salt because new and new fossils are being discovered at a rapid rate and you know before we basically end this episode, there might be few other new fossils, you never know and when you think about the timeline, humans, human beings are itself, are very, very new and things like domestications are as new as 10,000 years back. With that, I would like to thank you and we will see you next time.