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#371: Slippery descent: Untangling the complexity of our evolutionary history

VOICEOVER

This is Up Close, the research talk show from the University of Melbourne, Australia.

[Music]

ANDI HORVATH

Hi. I'm Dr Andi Horvath. Thanks for joining us. Today we get up close to our ancestral past, and the ongoing quest to trace the lineage of the modern human, Homo sapiens, and other close relatives. The evolutionary tree has sprouted countless branches and twigs from the animals that first started to walk upright to the many branches that resemble humans, like Neanderthals. For periods of history these species thrived, but some branches became extinct, adding to the complexity of our origins. Paleoanthropologists, with the help of fossils and molecular evidence and recent developments in genomic techniques, know a lot more than they did a generation ago, but a unified theory of the precise origins of Genus Homo remains elusive and a subject of ongoing debate.

So what are the clues to the history and geography of human origins and how do we determine if we're related to beings in the past that share some of our humanlike characteristics? To guide us up into the canopy of the Tree of Life we're joined by veteran paleoanthropologist Bernard Wood, who is the University Professor of Human Origins and the Director of the Center of Advanced Study of Human Paleobiology at George Washington University in the US. He is currently also a Miegunyah fellow at the University of Melbourne. Bernard, welcome.

BERNARD WOOD

Thank you very much.

ANDI HORVATH

Now, Bernard, since the discovery of fossils in Southern Africa a century ago, humans have become aware we're not the first humanlike life forms to traipse the earth, and these subsequent finds where fragments of when, where and perhaps clues to why some species thrived for a time. Give us a time machine tour of evolution. What are the pivotal points that we eventually get to that tell us ah, this might be the human path?

BERNARD WOOD

Well, the Tree of Life as far as we're concerned can go all the way back to the base of the tree, billions of years ago. But I think you're asking me what are the creatures that are alive today that are most closely related to us, and what's happened since we shared a common ancestor with those creatures. It turns out that the creatures that are most closely related to us are chimpanzees and bonobos, that used to be called pygmy chimpanzees, and we are more closely related to those two creatures than to any other great ape, which means that chimps and bonobos are more closely related to us than to any other great ape.

Now, that's probably extremely puzzling for chimps and bonobos because they are in zoos along with gorillas and orangs and apparently they are more closely related to the people that wander around zoos. So the starting point is that - so the common ancestor, hypothetical common ancestor - and the amount of genetic difference between us and chimps and bonobos, if you calibrate that in really clever ways, the estimate is that that common ancestor lived between six and eight or nine million years ago. So that's when our particular story starts. But as you suggested in the introduction, not all the creatures in the Tree of Life are necessarily ancestral to creatures that are alive today.

So when we look at the human branch of the Tree of Life, we need to consider that it might not just contain our direct ancestors, it might also contain close relatives. I had a father and a grandfather and a great grandfather and a great-great grandfather; my grandfather had nine brothers and sisters. Now, they are my close relatives but they aren't my ancestors. They are maybe necessary for somebody else's ancestry but they're not necessary for mine. So we think that in the small piece of the Tree of Life that leads to modern humans, there are also branches that lead to other things which did not make it to the present.

ANDI HORVATH

Now, many of us were taught in school about hominids, but I've heard the word hominin. So explain the difference; what's happened since I've been to school?

BERNARD WOOD

What's happened since you and I have been to school? A lot has happened since you and I have been to school. When I went to university and started to learn about these things, this genetic and molecular evidence and morphological evidence that modern humans are closer to common chimpanzees and bonobos than to any other primate, that was not conventional wisdom. Which meant that people still laboured under the misapprehension that humans were really very special, which meant that in order to recognise this specialness they were put into their own family, and the name of that family is the Hominidae, and all the apes were put into their own family, and that family was called the Pongidae.

So the informal way of talking about the Hominidae is hominid and the informal way of talking about the Pongidae is pongid. So we were hominids and the apes were pongids. Now we know that we are closer to a couple of those apes, we can't be so different so we have to have another label, and that label is now either a tribe, which is a lower level than a family in the Linnaean hierarchy, and that tribe is called the Hominini, so therefore we are hominins and not hominids. I apologise but that's just the way it is.

ANDI HORVATH

Fair enough. So give us some insight into hominin fossils. You often liken them to old car parts that you find on a highway, like a bit of transmission there and there's a fender over there and a headlight over there.

BERNARD WOOD

Yeah. My particular introduction to this was to work on a collection of fossils which had been assembled by Richard Leakey and his colleagues, including me. I was given the task of trying to work out what all these skulls and teeth meant. I know you used the metaphor of car parts; let me try another metaphor. It's like being given a whole lot of jigsaw pieces except that you don't know how many jigsaws are represented in this piece. It's like your worst nightmare at home; the kids haven't put the jigsaws away in their own boxes and you have this collection of jigsaw pieces. So you don't know how many jigsaws are represented in this pile of pieces, you don't know in what proportion any jigsaws are represented in this pile of pieces. So one jigsaw may have three pieces; another jigsaw may have 43, and they're all roughly the same thickness, and nobody has been thoughtful enough to give you any sky or any edges or anything like that.

ANDI HORVATH

Oh, I see.

BERNARD WOOD

So you're basically having to work out how many animals are represented by the fossils. Luckily in my case there were some pieces that were so distinctive that they weren't confused with the majority of other jigsaw pieces. So that was good, but then there were a whole lot of pieces that looked roughly the same and it took me about 13 years to try and come up with some conclusion, most of which has stood the test of time; some of it hasn?t.

ANDI HORVATH

So tell us then, when you find a fragment of a bone and you start to look for clues as to what that lifeform is, like a tooth, how do you extrapolate what the lifeform is?

BERNARD WOOD

That's an interesting question, and it's dawned on me that the most productive way for me to think about these animals is that they're like model organisms in biology. It's just that we didn?t have any role in designing them, natural selection and genetic drift designed them, in inverted commas. My job is to find out as much about these model organisms as I can. You use whatever lines of evidence you can. So for example, if you have just a tooth you can look at the outer surface and you can see what it looks like, and we call that morphology. Now you can actually use CT techniques, the sort of imaging techniques that you might have if you go to hospital; we can now look at the internal structure of that tooth.

We can also, using methods from other sciences, we can use stable isotopes to work out what the photosynthetic pathway was of the vegetation that that animal was eating. You can also look at the microstructure of the enamel, which is the outer coating of your tooth. You can look at that and you can work out well, was the tooth built to be strong, was the tooth built to be durable, what was the tooth built to be? We want to reconstruct how many creatures there were, and once we've got a hypothesis about these fossils probably all belong to this creature, we then want to know the things you would want to know if you had discovered a new monkey in a forest in Thailand. You'd want to know how big they were, were the males larger than the females, what was their social organisation and what did they eat, where did they live, how did they move around the forest?

ANDI HORVATH

Sure.

BERNARD WOOD

So you want to know all those things; the only problem is that we don't have much evidence. So we have to keep restraining ourselves from over-interpreting the evidence that we have.

ANDI HORVATH

All right. So morphology can tell us some things but what doesn?t it tell us? You've said there's limitations to the interpretation?

BERNARD WOOD

The morphology - we used to think that morphology was a pretty good guide to the relationships among these early hominin species, and in general we thought well, the more alike they were the more closely related they were. We now know that sometimes animals, including early hominins, look alike not because they're closely related but because they're adapted in similar ways.

ANDI HORVATH

So shared morphology or shared shapes are not always shared evolution?

BERNARD WOOD

Well, they are shared evolution because adaptation is evolution, but they're not shared phylogeny. Phylogeny is the technical term for the shape of the tree and the branches and relationships within the tree. So morphology is not quite as good a guide to phylogeny as we had hoped it was, but that's one of the things that we're struggling with at the moment.

ANDI HORVATH

Okay. So if we went on a fossil hunt with you, where would we actually go? Are there hotspots for fossils, and where do we find them today?

BERNARD WOOD

Well, the fossils that I'm interested in are mainly the earlier phases of human evolution, which means Africa. If I had a fairy godfather and he said here's a million dollars, you can go and look for fossils anywhere you like, and the fairy godfather was also able to control the politics in the countries in Africa then I would probably go somewhere in West Africa that hasn?t been explored very much, like Niger or somewhere like that.

What you need to do is to go to places where the rock layers which preserve the landscape in which these early hominins were living; you need to go to places where those rock layers have been exposed by erosion. There may be wonderfully interesting fossils immediately outside of this building in that garden, but there is no exposure of the sediments in that garden, so if I want to find the fossils I would have to persuade somebody that I'm allowed to dig a hole. You can't go around Africa and dig holes everywhere, and so you go to places where nature has made a hole, like a rift valley, or you go to places where nature has exposed the contents of a cave that contains early hominins.

ANDI HORVATH

Do you find a lot of other animals as well? When you look for hominins, do you actually find other species?

BERNARD WOOD

You do, and in fact, hominins are pretty rare. So in the sites that I'm most intimately acquainted with, hominins are about as rare as carnivores like cheetahs. Those things are rare; if you go on a safari to East Africa, something like a cheetah, there aren't that many, they have quite a large range, they don't tolerate other animals in that range. So hominins are rare, which means that basically by the time you come to find hominins you have found lots of fossil pigs, lots of fossil antelopes, lots of elephant fossils and lots of other fossils. So hominins are really quite rare; monkeys are rare but a little more common than hominins.

ANDI HORVATH

Right.

BERNARD WOOD

We normally start by finding a fossil site where you find the fossils of other mammals and then there are some mammals, where experience has shown us that if you find those mammals then you're quite likely to find hominins.

ANDI HORVATH

Right. So you've got to sort through a lot of pigs and antelopes before you get - oh.

BERNARD WOOD

You've got to sort through a lot of pigs and antelopes.

ANDI HORVATH

Before you get to the hominins.

BERNARD WOOD

Before you get to what I consider to be the good bits, yeah.

ANDI HORVATH

Okay. And if I do find a fossil, how can modern genetic techniques add to our understanding of the fossil connections?

BERNARD WOOD

Well, you need to find a fossil which still preserves molecules, and those molecules can be things like amino acids, like the albumin that makes eggwhite white, hemoglobin, and the most interesting molecule of all is DNA. Now, the problem is that those molecules do not last that long, and the furthest back in the hominin fossil record that people have been able to extract, just small fragments of DNA is about 400,000 years. They have managed to recover quite a lot of DNA from quite a number of Neanderthals; they have managed to recover some DNA from some teeth in a cave called Denisova, and the teeth were initially believed to be Neanderthal teeth, which is why their DNA was being sequenced.

Then once they sequenced the DNA, much to their surprise - and this is a lab in Leipzig run by Svante Pääbo - much to their surprise they discovered that the DNA was not like all the other Neanderthals they had found, it was even more different than modern humans, and so these are known as the Denisovans. Here's a case where we know more about their DNA than we do about their morphology, because all we have are a few isolated teeth. The thing about DNA is it doesn?t really tell you much about morphology.

ANDI HORVATH

It doesn?t really tell you about the environment they lived in.

BERNARD WOOD

It doesn?t really tell you much about the environment; it tells you about relationships, which is why it's important.

ANDI HORVATH

I'm Andi Horvath, and you're listening to Up Close. In this episode, we're talking about the evolution of humans and our close relatives with author and paleoanthropologist Professor Bernard Wood. Now, Bernard, we've heard about the out-of-Africa thesis.

BERNARD WOOD

Right.

ANDI HORVATH

This was first I think coined by Darwin. Now, what is it and does it still stand today?

BERNARD WOOD

Well, Darwin's logic - and you have to understand that this was a British take on things. If you went to Germany and talked to somebody like Ernst Haeckel, he would have had a different take on things. But the British take on things was that of the apes, when Darwin was writing The Origin of the Species and The Descent of Man, especially the latter, what little was known about the morphology of the apes suggested that the African apes were more similar to modern humans than the Asian apes. Darwin's logic was that in that case, if you wanted to find the early ancestors of modern humans you should go to Africa to look. The Germans, they took the view that the orangutans were closer to modern humans, so they took the view that if you wanted to find the ancestors of modern humans you should go to Southeast Asia, which is exactly what some of them did and that's how they discovered the remains of Homo erectus. So the result was terrific; the reason we now know to be wrong.

ANDI HORVATH

Is it likely that human evolution was going on in two places at the same time, both in Africa and in Asia? Or are you alluding to the fact that we came out Africa a number of times? Or did we come out of Africa at all?

BERNARD WOOD

Well, the evidence we have since Darwin has all confirmed his hunch that modern humans are more closely related to the chimps, bonobos and gorillas than they are to orangutans. There are few people in the world who still hang onto that hypothesis, but it's wrong. As much as you can say about anything in biology, it's wrong. The other thing that underpins this is that the earlier phases of human evolution, the fossil evidence is confined to Africa. We only start seeing fossil evidence of early hominins outside of Africa around two million years. That doesn?t mean that hominins had not left Africa before two million years, and frankly, leaving Africa for these hominins, this is a construct that we put on them. They wouldn't have known where the hell they are. They [weren't saying] wow, we've left Africa; wow, this is another step in the ladder. So there have been several out-of-Africas because early hominins left Africa, then we think creatures like Homo heidelbergensis, which are a little more advanced, left Africa.

ANDI HORVATH

But some stayed behind.

BERNARD WOOD

But some stayed behind. They didn?t all leave, but some left. We now know that modern humans in the rest of the world all come from Africa, so the modern humans in the rest of the world did not evolve in situ in Java or in China or in India or wherever. We now know that distinctive parts of the genome of modern humans, no matter where they are in the world, can be traced back to Africa. So this most recent out-of-Africa is probably around 60,000, 70,000 years ago.

ANDI HORVATH

And how many humans are we talking about from 70,000 years ago?

BERNARD WOOD

That's an interesting question. There was a paper a few years ago where they collected mitochondrial DNA, I think from a group of chimpanzees in West Africa. At the time this paper was written, mitochondrial DNA was most of what we knew about

modern humans. They discovered that there was more genetic variation in this small group of chimpanzees in West Africa than there was in the whole of their sample of modern humans. That's counter-intuitive because if we have a common ancestor with common chimpanzees and bonobos, and if a genetic variation just accumulates as a function of time, we should both have the same amount of genetic variation. And so very clever people looked at the genome of modern humans and they calculated that modern humans and not chimpanzees have been through what's called a genetic bottleneck.

In other words, for some reason to do with climate or disease or some natural disaster, modern humans in Africa have been shrunk to a really small population, and they estimate - and there may be more up-to-date estimates, but the one I remember is that the effective population size was in the order of 10,000 individuals. So basically the message is that we nearly didn?t make it.

ANDI HORVATH

Wow.

BERNARD WOOD

And then from those 10,000 individuals, they did make it, but because they were contracted down from probably many hundreds of thousands, the genetic variation that they took with them for the subsequent 60,000 years was very narrow because it was just a genetic variation that could be captured by that small population, and that's where all modern humans come from. So the chimp next door to another chimp in a tree is more likely to be genetically different than you are from somebody who lives in Greenland.

ANDI HORVATH

Now, I want to talk more about the presence of multiple evolutionary branches and that were going on perhaps at any one time, which makes it a little bit difficult to identify our direct modern human ancestors, and I want to look at some of these groups. Now, one of your favourites Bernard I know is boisei. Tell us about that; why are they close relatives of us and why are they of such interest to you?

BERNARD WOOD

Well, we put them in the close relative category and not in the ancestor category because they're so weird. In order to get from Paranthropus boisei to modern humans, it's like getting to a motor car from a railway train. It would require so much evolutionary change that it's just racingly unlikely. But these creatures lived for about

a million years in East Africa from about 2.3 million years but probably before, to about 1.4, 1.3 million years but probably after. They were perfectly successful, but they weren?t our ancestors. They lived alongside and in the same lake basin, in the Omo-Turkana Basin in Northern Kenya. They are found alongside creatures that are probably more likely to be our ancestors. But you have to remember that the sites in the East African rift valley and in the cave sites in southern Africa it's unlikely that they sample everything we can possibly know about human evolution.

ANDI HORVATH

How long were they around for?

BERNARD WOOD

They were around for a million years, which is about the average length of a mammalian species. When you think that modern humans have been around probably for 200,000 or 300,000 years they have 700,000 years on us.

ANDI HORVATH

Right. I wonder if we'll make it?

BERNARD WOOD

Well, your guess is as good as mine.

ANDI HORVATH

Now, tell me about Homo habilis as well. They're also an interesting fossil that's got the whole paleobiology world talking.

BERNARD WOOD

Yeah, it's an interesting story, because the Leakeys had been working at Olduvai Gorge for a long time, been working for 25 more years at Olduvai Gorge. They'd found stone tools which must have been made by hominins. That was their logic and it's perfectly reasonable logic. They found evidence of Paranthropus boisei first, but this is a strange creature with a big, flat, wide face, huge chewing teeth, males have crests on the top of their skulls, so they're really weird. But the Leakeys thought hell, these must have made the stone tools. Then about a year or so later they started to find evidence of a creature which they subsequently called Homo habilis, that was

more like us. In other words, it has a dentition that was more like ours, it had a slightly larger brain, and so poor old Paranthropus boisei, who was given credit for making the stone tools, suddenly got it taken away and the stone tool manufacturer was passed over to Homo habilis because habilis means handy, that's why it was called Homo habilis.

ANDI HORVATH

Now, those two didn?t interbreed, did they?

BERNARD WOOD

Well, they may have interbred in the same way that modern humans and Neanderthals probably interbred and the same way that species of gorillas still probably interbreed for a time after their speciation. But even if they did interbreed, it didn?t prevent them being morphologically distinctive.

ANDI HORVATH

But they did actually use the environment in different ways. Did they eat different things?

BERNARD WOOD

They almost certainly ate different foods. It's likely, there is some evidence that Paranthropus boisei preferred the parts of the environment that were closer to sources of fresh water.

ANDI HORVATH

So what led to the demise of these early hominins?

BERNARD WOOD

Well, we don't know, but if you look at mammalian evolution you can either go around trying to find reasons for the extinction of every extinct mammalian taxon, but it's just happenstance. You're adapted for a particular environment, the environment changes because there are long-term cycles of climate change, other animals evolve and they get smarter at taking - so for example, even though apes are more closely related to us than monkeys, way back, more than 10 million years ago, there were more fossil apes than fossil monkeys. But eventually fossil monkeys outcompeted

fossil apes because we believe the fossil monkeys developed the means to consume fruit that was unripe, and the apes, when they eat fruit it has to be ripe fruit. So basically, the monkeys stole the fruit and ate the fruit before it could ripen and the apes could get at it. That's an example where it's not the question of you not doing anything right, it's a question of some other animal comes along and does something and gets in your way.

ANDI HORVATH

I'm Andi Horvath, and our guest today on Up Close is paleoanthropologist Professor Bernard Wood. We're talking about the disjointed ancestral lineage that maketh the modern human. So Bernard, can we actually speculate on how many species of hominins were alive at the same time in the same period of history?

BERNARD WOOD

We don't need to speculate about the number of hominin species alive today; it's one. But today is an accident of history. If today happened to be 100,000 years ago, which in terms of a six or eight-million-year history is within the margin of error, 100,000 years ago there would have been modern humans, there would have been Neanderthals, there would have been Homo floresiensis, there would have been the Denisovans. There were probably some late-surviving Homo erectus, and the molecular biologists suggest that there is another ghost lineage that we don't know what it looks like. So basically just because we're on our [ownio] today, it doesn?t mean that that was inevitable. Certainly, not that long ago, 150,000 or 200,000 years ago, the world was a lot more crowded in relation to hominins.

Why is there only one today? Neanderthals are an interesting organism because they seem to have been adapted, although not probably as clearly as a lot of people try to maintain, but they seem to be adapted to live in cold climates. But they were expensive to run; they had a lot of muscle, and somebody has estimated that to keep a Neanderthal going you had to find about 500 or 750 more calories a day than to keep the average modern human going. So in times when there wasn?t much food available, then Neanderthals would have not been advantaged, and modern humans would have been advantaged.

So I think there are various reasons Homo floresiensis was probably overwhelmed when modern humans got to Flores. So there are various reasons that you can come up with post hoc explanations of why modern humans are the only creatures alive today, but we estimate that from four million years until relatively recently there has always been more than one hominin on the planet, and for many time periods there were three, four or five sorts of hominins, and that makes us just like pigs or just like antelopes.

ANDI HORVATH

Got it. Tell us about the value of studying the Tree of Life from the bottom up, which is what we've kind of been doing. What about the top-down approach?

BERNARD WOOD

Well, you can look at modern human variation as expressed in DNA and in other things, and you can try and come to an estimate about okay, this is how variable we are, how long would it have taken for that amount of variation to have evolved, and we're not the same across the world, and so you can reconstruct some recent human evolution from those data, but if I gave you the most complete modern human genome in the world, you couldn't tell me at the moment what that person looked like. You might be able to tell me its eye colour or its hair or something like that, but you couldn't tell me whether they were smart or not smart, whether they could run 100 yards quickly or slowly. So the genome is very helpful for some things and may ultimately be helpful for other things, but we know things like stature, even pretty simple things, they are under the control of lots of genes. So it's really difficult for us to reconstruct a whole animal from a genome.

ANDI HORVATH

Does that mean the controversy regarding the lineage of modern humans is going to remain a controversy forever?

BERNARD WOOD

Well, if you want certainty you should probably go into the hard sciences like physics or chemistry where you can say things. In biology, certainty is in pretty short supply. If you're trying to reconstruct evolutionary history, it's even in shorter supply. My view is that we are gradually going to become less ignorant rather than that we will eventually know. Some of my colleagues give the impression that they are in communication with God and She in Her infinite wisdom has imparted this information, but She hasn?t chosen to impart it to me. So I think we will get a better idea, but it's still always going to be these hypotheses, this one is slightly more probable than this one, this one is slightly less probable than that one. It's always going to be choosing a hypothesis which is most consistent with the data, not necessarily the hypothesis.

ANDI HORVATH

Where to from here in paleoanthropology? Do you think technological advances

might tip these debates?

BERNARD WOOD

Yes, I think so. Obviously more fossils help, but you need to be smarter about interrogating those fossils. I'm an interrogator of evidence; my job is to interrogate the fossil evidence that other people accumulate. My sense is that the fossil sites in East Africa and those in Southern Africa and those in Chad, they probably occupy about three per cent of the land surface of Africa. So it's probably likely that if you go to places in Africa that there must be other places where it's possible to recover fossils, and so that's probably going to help. But just being smarter about using morphology and capturing morphology in ever-increasing detail, that will also help.

ANDI HORVATH

The question of where did we come from and are we alone are questions that have captured humans and culture for aeons. But, why does knowing our origins matter? What use is it?

BERNARD WOOD

Well, it's of some practical use because there are diseases of modern humans that it would be interesting to know what the genetic basis of those diseases was and what stage in our evolutionary history those diseases might have started to impact us. You can make a case that it has some utility from that point of view. Really I think a stronger case is that it would benefit us all to have a healthier dose of humility, and the more you know about where you come from, the more you know about the fact that we nearly didn?t make it 60,000 years ago, and the more about the fact that we share such a lot with chimpanzees and bonobos and gorillas and orangs and we are really busy trying to drive them to extinction. There are lots of reasons why having a much better understanding about our place in nature should make us better people.

ANDI HORVATH

Lovely. It's somewhat reassuring that hominins in the wild were able to survive hundreds and thousands of years. Let's hope modern human can equal that. Bernard Wood, thank you so much for being our guest on Up Close today.

BERNARD WOOD

It was my pleasure.

ANDI HORVATH

We've been speaking with paleoanthropologist Professor Bernard Wood from George Washington University in the US on the understanding of humanity's evolution and on who we think we are. You'll find details of Bernard's publications on the Up Close website, together with a full transcript of this and all our other programs. Up Close is a production of the University of Melbourne, Australia. This episode was recorded on 1 June 2016. Producer was Eric van Bemmel, audio engineering by Gavin Nebauer. I'm Andi Horvath. Cheers.

[Music]

VOICEOVER

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