The Origins of Us: Human Anatomy and Evolution Professor Alice Roberts

Title: Professor Alice Roberts – The Origins of Us: Human Anatomy and Evolution – 10th February 2012

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Speakers:

S1 - Professor Mark Pallen, Professor of Microbial Genomics

S2 - Professor Alice Roberts

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S1 Thank you all for coming to this Darwin Day event. This is actually a conference of three different events in effect, so this is the eighth Darwin Day even that we've had at the University of Birmingham., The Darwin Day initiative started in North America about ten or fifteen years ago as an idea of celebrating the life and legacy of Charles Darwin on his birthday, or close to his birthday. So Darwin's birthday is actually on Sunday but this was the closest working day that we could find. Over the course of the Darwin Day events we've had in Birmingham we've covered all sorts of things – the evolution of the human face, the evolution of genomes, the evolution of Biblical manuscripts, we've had the Darwin Correspondence Project come and present to us. We've covered a wide range of topics. On the back of all that exciting stuff going on we've made a new appointment and this is Professor Alice Roberts and I think she's going to feel a bit odd when I say that, she said she would, because this is a new appointment just this month and just a few days ago she started work here on the payroll at the University of Birmingham. I would now like to give the stage to Alice who's now going to give us a lecture to go with her series and her book called The Origins of Us. Over to you.

[applause]

S2 Thanks Mark.

[applause]

S2 Well I'm absolutely delighted to be talking here at Birmingham University and now this is my university too and I'm really really pleased about that and delighted to be part of such a fantastic institution. And thank you, Mark, for inviting me to talk today which he actually signed me up to do before I signed the piece of paper to say that I'd accepted the job! I'm going to talk about Origins of Us and I'm going to draw on the television series but if you didn't see it, it doesn't matter, we'll be extending out from what we talked about on the television series but it was a fantastic opportunity for me as a physical anthropologist to go to some places which I never thought I'd get to go to. That's one of the joys of doing a television series like this, but also to meet some fantastic experts in the field and to have time to really pick their brains, which again is an amazing opportunity and then to do that for a wider audience, so bringing the kind of latest cutting edge research in this area to the widest possible audience, which is great.

S2 We are an incredibly successful species. There is absolutely no doubt about that. We can be philosophical about the effects that we're having on the world around us but there's no doubt that we are a successful species. We have a population of something like 7 billion, we exist everywhere, we thrive everywhere, from the Tropics to the Arctic, but we're an African ape so how have we been able to do this? How have we been so successful? If we look at the other African apes, they don't live on all the continents of the world. They don't make beautiful art and architecture. They're not capable of the same things that we're capable of. How are we so special? Now I think the answers to that lie deep in our past, in our evolutionary history. I think if we go back in time we can get to a point where we were just another African ape. So we go back that far to the stage of the last common ancestor with our closest living relatives which are chimpanzees and this is, I was lucky enough to meet some chimpanzees in Uganda last year, both in the wild and also in a sanctuary as well where I could play with them, which was amazing, and you suddenly realise how close you are to these creatures. This is a four year old called Nipper and he lived up to his name. Chimpanzees are our closest living relatives and there are some similarities between us and there are some differences and superficially I think we notice some very obvious differences which make us feel as though we're very very different from them. They're covered in fur, they run around on all fours, they seem to be a world apart from us. I think we like to think of ourselves as not just being another animal but being something rather special, but we are just another animal.

S2 There's Nipper again and there's some enormous ape next to me there called Paul Jenkins. [laughing] One of the interesting things about asking this question, 'What is it that makes us human?' and taking this evolutionary approach to it is that we're going to find out things about ourselves but we're also going to understand more about our context. We're going to understand more about how we fit into the great Tree of Life on the planet. We're going to basically do the ultimate 'who do you think you are?' and trace your family tree back and back and back and understand where we fit. It's something which is incredibly intellectually satisfying I think, you know, we all ask that question 'who are we?' and we want to know more about it and this is taking it right back into the past.

S2 Darwin, and speaking on his birthday today, I have to mention the great man, Darwin thought that we were probably very closely related to African apes and he thought that through observation of the African apes of gorillas and chimpanzees. So this is a direct quote from the Descent of Man, 'in each great region of the world the living animals are closely related to the extinct species of the same region. It's therefore probable that Africa was formerly inhabited by extinct apes, closely allied to the gorilla and the chimpanzee and as these two species are now man's nearest allies, it's somewhat more probable that our early progenesis lived on the African continent than elsewhere'. Now this now sounds, you know, you think well yeah, that sounds reasonable. Of course it does. But he's very carefully looking at gorillas and chimpanzees and deciding that they're closer to us than orangutans for instance in Asia and he's also saying this in a complete absence of any hominine fossils. There are no fossils of human ancestors at the point in time when Charles Darwin makes this very prescient statement and of course, he was right, as he was about many things. So we now have many, many fossils but we also have other ways of knowing that we're very close to African apes and that we are indeed an African ape ourselves. I think that when you get up close and personal with African apes you realise that, you look into their eyes, you see something looking back at you that's perhaps a little bit more, well, or less other than other animals and I love this picture of a mother gorilla and a baby gorilla and it's just, being a recent mother myself – or recent-ish – this really kind of strikes a chord with me. Of course there are other ways, less kind of perhaps sentimental ways of assessing that difference. We can look at our genetic codes and we if look at the non-coding regions of our DNA we find that actually we are incredibly close to chimpanzees. There's just about a 1.2 or 1.3% difference between us and chimpanzees and remarkably, and this is something that we really didn't know until the genetics came along, we are closer to chimpanzees than either of us is to gorillas. [0:07:55] think because again, if we just look at the superficial differences between the two of us, well, chimps and gorillas are hairy, chimps and gorillas both knuckle-walk on the ground. Perhaps we'd think that they're more closely related, they're kind of twin species and we're something off on a limb. Or perhaps each of us is equally related. Not at all and this is why people like Jarrad Diamond have said 'well actually, we're the third chimpanzee'. You've got common chimps, you've got Bonobos and you've got us. Maybe we're not Homo Sapiens at all, maybe we're Pan Sapiens. Perhaps an alien coming in and visiting earth with a bit more of an objective view than we have might say that and might get us to completely re-write our classification systems. We like to think of ourselves as being special so let's stick with Homo Sapiens for now but keep this difference in mind, this very small difference.

S2 If you look at a chimp and human skeleton and you look at the entire skeleton, they're very obviously different for different species but actually, when you start looking at individual bones, there are areas where that difference disappears and I've always said – I never tried it when I was at Bristol because I thought it might be a little bit too naughty; who knows, maybe I'll try it at Birmingham – I always said I could put a chimpanzee humorous, a chimpanzee upper arm bone in a medical student's spot exam, their anatomy exams, and they wouldn't notice that it wasn't human. And that's not really saying anything about medical students in the UK, that's really saying something about how similar chimpanzee humouri are to human humouri. OK, that's just one bone and I'll probably [0:09:28] a similar one. When we start to look at the rest of the skeleton we can see that there are quite significant differences between us and chimpanzees. There's something going on in terms of limb proportions. Chimps have got very long arms and short legs. It's kind of the other way in us; although we have retained quite long arms for a mammal, we've got ridiculously long legs. Things are going on in the pelvis. Look at that pelvis there, it has very long thin iliac blades and these have got squashed down in us. So there's all these kind of, it's almost like you've taken the chimpanzee skeleton and morphed it. But of course that's not right because chimpanzees aren't an ancestor. Chimpanzees are a cousin so we still don't know where we've come from, we still don't know how much morphing has gone on. Maybe the last common ancestor looked like us and it's chimpanzees that have changed. Think about that for instance. I think we have these images in our heads which are put in there by popular imagery. We'll all have seen that picture, which I couldn't get cleared for copyright, of the ascent of man, so that kind of linear idea of starting off something – I'm going to have to act it out because I haven't got the picture – starting off something like a chimpanzee here and then you're gradually un-hunching and becoming more and more human and then in the funny versions of it you end up hunched up over a computer or something at the other end. But I think we end up with this kind of popular misconception that we've evolved from chimpanzees. That can't be right. Chimpanzees are modern animals, just as we are. So we've both evolved from a common ancestor and one of the really interesting areas of research at the moment is looking at what that common ancestor looks like and perhaps even those of us who are undertaking research in this area have had this kind of idea put into our heads that we find it actually quite difficult to get away from the idea that the last common ancestor must have been very chimpanzee-like and we've evolved away from that and I'll explain what I mean by looking at some anatomy in a minute.

S2 Some of the big differences between us and chimpanzees are in the shape of our spines. We have this really beautiful shape in our spines, a double S shape and this relates to the fact that we have stood up on two legs. Most of the really big differences in our skeletons are relating to this. They're relating to the fact that we are bipedal. That's not to say chimpanzees aren't bipedal, ever, they're actually bipedal quite a lot of the time. Perhaps I should say that we're habitually bipedal. It's our locomotion of choice. If we're asked to move from A to B what we tend to do is stand up and walk there or run there. If you ask a chimpanzee to do the same thing, inevitably they'll drop down onto their hands and knuckle walk across the floor. But they can stand on two legs as well. So when did this standing on two legs happen? When did this first start to appear? When did we see that happening in our skeleton? Well, actually this very early fossil lacks a spine so we can't look at that spine and go 'oh well, it's got the lovely S shape that chimpanzees don't have but that we do have'. This is a fossil called [Tumi or ….- 0:12:36] and was discovered in Chad in 2002 and it is just a skull, so then perhaps you're left thinking how on earth can you tell from just a skull that this ape stood up and walked around on two legs? Well I'm quite persuaded by this actually because it has to do with the position of the large hole underneath the skull where your spinal cord comes out. We don't like to call things by an easily accessible name in anatomy so we're not going to call it 'the large hole', we'll call it [Framen Magnum - 0:13:13], which means large hole – a bit of Latin and Greek does help with anatomy because it's all translated. So, what's interesting about [Tumi] is that his [Framen Magnum], instead of being positioned right on the back of his skull here, like a chimpanzee's [Framen Magnum] is, then leading off into the spinal canal of the vertebral column like this at an angle which puts its head in the right position for walking along on all fours, what we're seeing instead is that the [Framen Magnum] is down here. So in fact this looks like it's the skull of something which has a skull balanced on an erect spine. So he looks as though he probably was much more upright than a chimpanzee. [Tumi] is also really interesting because [0:14:05] the evidence for being bipedal, standing on two legs, weight bearing on two legs, pushing it back to almost the time of the split genetically from chimpanzees. So this fossil dates to 6 to 7 million years ago. Well, we've got an estimate of the divergence from chimpanzees of somewhere between 5 and 8 million years ago, so he's pretty much at the split. To be very controversial, I suppose we could say do we know if [Tumi] is really a hominine ancestor after all? Could he be a chimp ancestor? That's an interesting suggestion. Another thing about [Tumi] is that I think he dispels another myth, another kind of common image that we have in our minds about human ancestors dropping down out of the trees and walking out across the Savannah and that's how, you know, it seems like such a nice just-so story doesn't it? You're climbing around in the trees and then you drop down and you start walking on two legs. There's a couple of things which don't quite ring true about that. One of them is that when chimpanzees drop out of the trees, they don't walk on two legs. There's nothing necessary about walking on two legs if you're going to walk along the ground. Not many animals do it. Think about it, there's very few animals that walk around on two legs. It's a stupid thing to do. You're much more stable on four. And if you haven't got, if you're going to do two legs, it helps to have a tail to balance on like a kangaroo. So it's a very odd thing to do first of all.

S2 The other thing is that actually it wasn't as though there was this big grassland environment for [Tumi] to walk out into. He didn't walk out into a Savannah environment. He was still living in quite a wooded environment. This is what he might have looked like. This is one of the reconstructions from a Dorling Kindersley's book on human evolution which I was involved with which was published in autumn last year and I was absolutely over the moon to have the Kennis brothers working on it. The Kennis brothers are a fantastically creative pair of Dutch brothers who are paleo artists, they bring ancient beasts to life and amongst the animals they bring to life are ancient human ancestors. So they're basically making reconstructions based on casts of the original fossil material and then talking to the scientists, trying to get an idea of the best possible way of reconstructing these ancient hominines. So this is what [Tumi] might have looked like. And he did not walk in a Savannah environment.

S2 Another fossil which has kind of challenged that kind of long-held idea about bipedalism evolving as human ancestors dropped out of the trees and walked on the ground, is this chap, and you might have heard of him, he's called Ardipithecus or Ardi and these fossils date to 4.4 million years ago and they seem to show something quite interesting. They seem to show a mixture of adaptations to walking on the ground but also some adaptations that look as though they're doing quite a bit of walking in trees, which seems like a slightly strange thing to do perhaps but it does seem that what we've got here is a creature which basically moved around in trees with an upright body so weight bearing on his feet and so then that becomes perhaps a precursor for weight bearing on your feet on the ground. Perhaps what he's doing in the trees is walking, effectively walking along branches and stabilising himself with his hands. What's really interesting about this is that there are modern apes that do quite a bit of that and the most bipedal modern ape is also the most tree-living, the most arboreal. It's the orangutan. So now we're going away from the African apes and looking at something which might perhaps be a better model for what our ancestors looked like than the living African apes. Perhaps our ancestors were a little bit more like Orangutans in some way. Perhaps they were more bipedal but not on the ground, bipedal in the trees. And this is based on research which has been carried out here at Birmingham University. Although I say it's been carried out here at Birmingham University, we don't have many Orangutans here so students and researchers are going out to Borneo and looking at orangs in the field and looking really carefully at how they move around and why they do it because I think something that springs to mind immediately is why should this ape be moving like that in the trees? Why isn't an orangutan dropping onto all fours and moving along branches on all fours? Why are they kind of standing and walking in trees? What might be useful about that? There must be something that's useful evolutionarily for that behaviour to be there and it seems to be [0:19:09] first of all it's a difficult for a large bodied ape to balance on the top of a branch. It's actually much easier to stand on it and use your hands to balance. Also you can get right out to the edges of trees and reach out for fruit on the thinnest branches by doing this. So it's quite a useful way of edging right out to the edge o a tree and getting at that precious fruit. It also means that actually you can get from one tree to the next tree without dropping onto the ground and again, if you're a large bodied ape that's quite an important thing to be able to do. If you're going to spend most of your time in the trees and that's where you're getting your food, then not dropping onto the ground is great. It means that you are removing yourself from a risk of predators. As soon as you drop onto the ground then you could be eaten by something. It's also, you're using less energy. If you can basically walk from one tree into the next rather than climb down the tree, walk across the ground, climb up the next one, that uses a lot more energy. So maybe that's why our ancestors were doing this and as I say, from Ardi it looks as though this may be the origins of our walking on the ground. I think it does make us wonder whether actually some of the differences that we see are differences that have appeared in chimpanzees and have been conserved in us. So maybe actually we're getting a very weird view of ourselves by comparing ourselves with gorillas and chimps and going 'OK, when did we become different?'. Maybe that's not the question. Maybe we're looking at a last common ancestor which means that actually we've been quite conservative, we've carried on doing the walking on two legs thing, even if we've moved that onto the ground, and it's the other two which have evolved in a different way and become knuckle-walkers. And actually when we look at the form of knuckle-walking in gorillas and chimps, it looks as though it's different. It's anatomically, it's functionally different, so perhaps they did independently evolve that way of walking around.

S2 As we look at more fossils and we've got a lot of fossils now of ancient hominines we see more clues to becoming perhaps more and more adapted to moving around on two legs and moving around on two legs on the floor. This is a really famous fossil. This is Lucy. So Lucy is an australopithecine dating to around 3 million years ago and she's got some adaptations in her skeleton which make us think that she's really kind of acquiring more adaptations to walking around on two legs. Her pelvis now looks much more human. I know it still doesn't look quite human, it still looks weird compared with a human pelvis, but it doesn't have that great big long iliac blade that we saw in the chimpanzee for instance. Her legs have got a very definite angled femur, so this thigh bone here is angled in towards the knee and there are some really beautiful fossils of just the knees of australopithecines which show us that their knees are angled in and your knees are angled in, everybody's knees are angled. Everybody has a little bit of knock-knees about them and it's all about bringing in your, it's having hips at the side and then bringing in your knees so they're underneath your centre of gravity and so then you have to have a little bit of an angle there and Lucy has got that. She's still got some what look like adaptations to moving around in the trees in terms of the proportions of her limbs so she hasn't got terribly long legs and she's got quite long arms but actually a recently discovered skeleton which is called The Big Man, [Kadanamoo], another australopithecine, has got longer legs so perhaps we're getting a slightly different or a slightly strange idea of what these australopithecines looked like and indeed, perhaps there was quite a lot of difference between the males and the females. Unfortunately [Kadanamoo] doesn't have a skull so a few researchers say well we can't be sure that he's the same species but I think most researchers are happy that he is.

S2 So when did long legs appear then, because one of the things we noticed about the differences between ours and chimps skeletons is that we've got long legs and if we go back in time, what we're seeing is ancestors with short legs. Well long legs really stride out onto the scene with this chap and I think this is probably my favourite hominine fossil. He's a really beautifully preserved skeleton and I've lain him out here. This was while we were filming Origins of Us in Kenya. He's called Nariokotome Boy. I don't think he was called that when he was alive. He died by the shores of a lake which is in a region which is now by the Nariokotome River in Kenya. It's also nice going to these places and meeting locals so I know that it is Nariokotome and not as I used to say 'Nariokotome'. When we filmed this we filmed it with a little 5D camera, a little Canon 5D camera positioned above it. It's a fantastic camera, the 5D, it stakes HD video. I don't think Canon realised it was going to be so popular as a film camera when they produced it, but we filmed it looking down on the skeleton and I laid the skeleton out. What you couldn't see in the shots in the series was the tent, the safari tent in the background where we disappear off and have cups of tea from time to time because that would make it look far too easy. And the interesting thing about Nariokotome Boy is partly his long legs but also there's lots of other aspects of his skeleton which you can't really explain as adaptations to walking. You look at his skeleton and there are things about it – the long legs perhaps you could explain as an adaptation to walking, getting a nice pendulum effect going, but there are other things including a strong neucal ligament at the back of the skull leading down onto the neck vertebrae, the cervical vertebra. A long and flexible waist, we haven't really seen that before. Drop down shoulders. Her shoulders are sitting nice and low now rather than being up high and ready for moving in the trees. Her shoulders have dropped down. And he also seems to have well-developed springs in his legs in the form of tendons. We've got a very thick Achilles tendon compared with other apes and it seems that this is developed by the time we get to Nariokotome Boy. So this is the cover of Nature, based on the paper by Lieberman and Bramble who put forward a very coherent argument that these adaptations in Nariokotome Boy's skeleton are not about walking at all, they're about running, and it was amazing because I think we'd always thought about human evolution as being all about walking and suddenly there is this new form of locomotion that obviously we know about, we know we can do it, but from Dan's very careful analysis of the anatomy of living humans and of Nariokotome Boy and also of biomechanics, so he was running humans on treadmills, he was looking at which muscles are being used, he was able to say 'look, there's a whole suite of anatomical adaptations here that we can't explain just through walking. It seems that running was a really, really important thing for this young man'. And when I say young man, he's a strange young man. If I were to look at this skeleton in my lab and analyse him as a modern human I'd say he was a young teenager. He's about 5ft1 and I'd be slightly worried about the way that his bones are developing and his teeth are developing because there seems to be a disparity between the age I'd get looking at his teeth and the age I'd get looking at his bones. And actually, if you look at him really carefully and you say right, let's – we can't just use modern humans as a way of ageing him, we have to look at other primates as well. Let's look at chimpanzees and let's look at how they develop. He doesn't seem to be developing like chimpanzees either so he seems to have his own programme of development. Perhaps that's not surprising, you know, he is another species, he's Homo Agasta, or African Home Erectus. But the best guess I think so far is that this is a boy who's 8, which is really quite shocking. A 5ft1 8 year old! So he was achieving maturity much earlier than we do and there's a big debate about whether or not there was an adolescence at this point. Chimpanzees don't really have an adolescent growth spurt in the same way that we do and it seems that Nariokotome Boy might not have had an adolescence as well.

S2 Anyway, he is adapted to running. Look at his lovely long legs. I think if you saw him walking around, you wouldn't really bat an eyelid unless you were to get a really close look at his face. He's got a bit of a small head, his brain size is only about 750ml whereas most of us in here are getting up for one and a half litres, you know, we've got brain sizes almost twice the size of him. So you might think his head looks a bit small. Say he's wearing a hat or something! His face looks a bit weird as well, his teeth are a bit big but if you saw him in the distance walking along, I think he would have looked like a modern human walking along in the distance. He's basically got our limb proportions and it's quite amazing when you just look at that skeleton as a whole and suddenly you're looking at something which is very different from those australopithecines, very different from those kind of short-legged, long-armed creatures. This is a boy who, as the cover of Nature said, was born to run. So this young man then was running out across the Savannah. There is Savannah now. The Savannah has expanded in Eastern Africa. We know that. We know that from all sorts of paleo-climate investigations, environmental sampling. We also know it from the other animals that were around at the time. We've got a big explosion in grazing animals so we're suddenly getting all those antelopes that we're kind of familiar with in the landscape of Africa appearing and expanding. And Nariokotome Boy is amongst this group of animals that is exploiting these new grasslands, so he's running onto the grasslands. What is he doing? It must be really important for him to be able to run onto those grasslands. Now this is another very powerful concept which has [0:29:47] popular in the scientific imagination for decades, the idea of Man the Hunter. Presumably this is what Nariokotome Boy was doing, running onto the Savannah. He was running down animals, probably throwing some stone tools at them because he had some stone tools by that point and when we look at hunter gatherers today, of course hunting is an important part of what they do hence the name 'hunter gatherers'. So this idea that hunting is there at the kind of origin of our genus, homo, has been a very very powerful idea. But when you look for the evidence of it, there's very little evidence there. We have some stone cutting tools by this point but we can't really tell what they were used for. They could have been used for cutting anything. We can look at the scratches on them and people are starting to do that now but we're actually finding that it's very difficult to tell apart the scratches made by cutting something fibrous, so a kind of fibrous plant material, versus cutting meat. So hopefully there will be some new techniques at some point that we can use to say whether or not these things were used for cutting meat. We can look at isotope analysis and I think that that's giving us an idea that in fact there is some more meat in the diet but nevertheless, I don't think it's as important a transition as we've always thought it was. You know, there's always been this idea that meat eating comes along and that's what makes us human and I think there are some really interesting ideas about what else is going on at this time as well because other things are changing. So if we look at teeth for instance – I just mentioned about the stone tools – we get into the same problem with the teeth because if you're trying to look at, you can look at the micro-ware scratches on teeth so you can make a cast of the teeth, stick them under the microscope and analyse the tiny scratches on the surface of the teeth which basically record what you've eaten for the last couple of weeks and Peter Ungi in the States has been doing this with a whole array of hominine teeth and coming up with some quite surprising findings, one of which is that another set of hominines, the robust australopithecines, these massive jawed nutcracker men, probably weren't eating that many nuts and hard things, they seem to have been eating grass – or meat. And here again is the problem that meat and grass are going to leave a very very similar imprint on the teeth. What we do find looking at homos, so homo agasta here, Nariokotome Boy again, what we do find looking at his teeth is that actually what seems to be happening with these early homo species is that they are eating a wider variety of things. So we're getting some scratches, some pits, some kind of different patterns on the teeth. So there seems to be an expansion in the variety of diets, even if we can't put our finger on what exactly it is. Perhaps meat is a component there, perhaps they're also eating a variety of different plant foods. This is Nianza who's a Hadza hunter that I met last year in Tanzania. Now while he's out hunting, it's quite interesting when you meet hunter gatherer men actually and talk to them about how often they bring in big game and I think that anthropologists were slightly waylaid by hunters telling them that they bring home massive antelopes all the time and it's a little bit like asking somebody who's into fishing, you know, 'what have you caught?', 'well, it was that big'. It's a little bit like that because then when you talk to the women they go 'yeah, well, mostly it's rabbits' and you get a slightly different idea. So think that interviews with hunter gatherers have given us some misconceptions about the importance of big game hunting actually in human evolution as well. While Nianza – this is not to say that we can't get any insights, I mean these people are modern people, you know, we're not looking through a window into the past, they're modern people but perhaps they can give us some insights into how our ancestors lived. They certainly would have lived as hunter gatherers so we can perhaps get some ideas about the reality of that life from looking at people like Nianza and his family. Now while he's off hunting, what we find is that the women of the group, of the village, are off collecting food and actually what you find – and I was very pleased about this – was that if you add up the calories brought back by the men and the calories brought back by the women, guess who brings back the most? And the women know where to look. The men are off doing slightly risky things or hunting things which are not necessarily going to lead to a successful kill. The women are always successful. They will be relying on things like berries and fruits a lot of the time, but actually they always have something they can fall back on because even if there aren't any fruits and berries to find, there are always going to be things underground and this is an emerging idea that actually one of the really important foods to hunter gatherers and presumably one of the really important foods to our ancestors and really if we think about it carefully, they're quite important to us today as well, are tubers. So we're not talking, it's not the theory of then Man the Hunter, it's the theory of Woman the Tuber Gatherer! I mean just think about the staples that we have today. Forget about all the cereals because we're not going to domesticate cereals for tens of thousands of years, but think about other staple foods and potatoes form a really important part of our diet. So a good source of energy, they're a good reliable source of food and tubers, underground storage organs, were probably an important source of food for our ancestors going back a very long time ago.

S2 Going out with the women, I was quite surprised at some of the tubers that we're finding actually. I just expected them to look like potatoes I suppose, or sweet potatoes at least, and a lot of them were just slightly expanded roots. So this is one here, I think it's called [Equa - 0:36:21], and it has a kind of – that's a chunk of it there – so it kind of just looks like a tree branch, it's kind of a very thick root and you peel off the outside cortex with your teeth and then you can chew this bit and you don't swallow it because it's really really fibrous. It's actually delicious, it tasted a little bit like chestnuts. I really liked it and it was even nicer [0:36:50].

S2 And that brings me onto the issue of the incredible shrinking teeth. So one of the big things that we see happening in human evolution and one of the things that we really need to explain is why are teeth getting smaller over time? So we can look at all those other aspects of our skeleton and relate them to walking in the trees, walking on the ground, running on the ground, but other things are going on in our heads – we'll come to the most obvious one last – but our teeth are getting smaller. We have incredible shrinking teeth and a very very good idea about how this might have happened, I think, is something else that our ancestors did at some point. It's really difficult to know when human ancestors controlled fire. Imagine trying to find archeologically the traces of a campfire that somebody's made. It's a really difficult thing to do. The most likely thing is that that's going to get blown away and there won't be any traces of it left at all. It's also very difficult to discern the difference between fires that have been made and carefully controlled and wild fires. You might just be looking at a lightning strike or something. So it's actually very difficult. The most, we've got compelling evidence for a controlled fire by about half a million years ago but Richard Wrangham is a researcher who thinks that actually there's pretty good evidence going back as far as Nariokotome Boy and I think pretty much as soon as you've got fire, which is going to be useful to you in lots of ways, obviously keeping you warm at night, as a way of defending yourselves against predators, it's not going to be long until somebody sticks a bit of food in it and goes 'well that tastes nice'. And cooking is more than just making food taste nice. Cooking does something really important for us. Cooking means that we get a lot more energy from our diet than we would do otherwise so Richard Wrangham's idea is that cooking provides us with almost the same kind of boost as people used to put forward for the Man the Hunter idea that meat would be the kind of thing which gave us a lot more energy. He's saying actually, maybe we should be looking at cooking. This could be much more important in terms of providing early human families with lots of energy from their diet. It means that you can move some of the work of digestion out of the body. So effectively semi—digesting your food outside your body and then eating it so it means you're spending less energy on digesting it. You can do other things, you can do pounding of food, that does a similar sort of thing. You're obviously digesting the food by pounding it but actually cooking is a really efficient way of maximising the energy that you get from your food. I think it's a great theory. So now instead of the idea of Man the Hunter going off and catching meat, he's there but perhaps he's only bringing back the occasional rabbit. What we've got are women bringing in tubers and this idea of cooking. It seems so unlikely in a way but this idea of cooking being quite an important part of our evolutionary heritage. And all this extra energy that cooking is giving us will presumably mean that we could support bigger families and all of that sort of thing but perhaps it also gives us the energy to help a bit of us grow because the other big thing that's happening is an expanding brain.

S2 Now, Nariokotome Boy's brain is quite big when we look at earlier hominines, earlier human ancestors. At 750mls it's almost twice the size of an australopithecine brain which is about the same size as a chimp brain. But having said that, his body is much bigger so if we scale his brain to the size of his body there's not really that much growth in brain size because you'd expect an animal's brain to get bigger as their body size increases. The really big expansion comes in fact after Nariokotome Boy. By the time we get to homo hiedelbergensi, so we're looking at about 800,000 years ago, that's when we see this really massive expansion in brain size, so maybe that's when we became masterchefs. Who knows?

S2 This is a slightly distorted argument or idea that I've been presenting, the idea that you could get more energy out of something and therefore you're going to grow a bit of your body. That's now how evolution works. OK, we've got to have the energy in our diets or through cooking to release a bit more energy in order to be able to support this very energy hungry organ, the brain, but one thing doesn't lead to another. There has to be an evolutionary reason for growing that brain big. There has to be a reason for the brain getting so big. Because it's a very demanding organ it wouldn't have grown bigger unless there was a really important advantage to us in having big brains and that has been something which has taxed paleoanthropologists for decades and decades and I think still taxes everyone in the field. How and why have we developed these enormous brains? And you can come up with lots of ideas about it. You can say that oh well, perhaps it's about cooperative hunting, going back to the old Man the Hunter thing. Something about hunting, it must be in there. Well lions are cooperative hunters and dogs are cooperative hunters, they don't have massive brains so that seems, frankly, quite unlikely. There are other ideas about a kind of feedback between beginning to make tools and then having to learn to make those tools and that kind of demand that that might place on your brain and maybe you need a bigger brain in order to be able to create that kind of culture, to create that technology and that's a very good idea I think and we can test that. But another thing is actually about our societies and the way we interact with each other and there's been some quite interesting research looking at the size of primate groups and actually other animal groups and also the complexity of those groups as well and there seems to be a very definite link between the size of group, the complexity of group and brain size. And we have big social groups and we have incredibly complex social networks so maybe this is what is driving that massive brain size. We're very good at keeping track of people in our social groups as well and working out what they're doing and what their intents are and we can see some of that in chimpanzee societies when you look at how they interact with each other politically. But I think we do it even more. We do that whole thing of, we do some really complex things in everyday life of kind of working out what people are thinking, so going 'I think you think something about her and she thinks something about him and he thinks that about you' and you can keep track of it through several people and there's an idea that Shakespeare is so successful because actually his plays are based on so much complexity and people knowing things about other people and we love that, you know, we thrive on it. Maybe that's what has fuelled the expansion of our big brains. And when our big brains come together in these big groups there's a lot more going on than just politics. We're able to bring ideas together, we're able to express abstract ideas from deep in the recesses of our minds and share them with each other and build on them and create culture and we see a really interesting thing happening when population groups get dense enough throughout evolutionally history and archaeological time. We seem to have an effect when a population gets to a certain size and density that you get explosions of culture, explosions of ideas and there's a group in London which have been looking at that – Mark Thomas, not the comedian, the researcher – and that's a really exciting idea because up until this point in time – no, not up until this point in time, up until the invention of writing, it's depended on one person speaking to another to share ideas. When we get writing we can spread it more widely. When you get the printing press you can spread it even more widely. Now we've got the internet and the potential for ideas to grow and to feed on each other I think is just huge at the moment. So we're kind of at the very beginning of something incredibly exciting, something that we couldn't have foreseen going back into the evolutionary past as well.

S2 These are some children learning from each other and they taught me some clapping games as well. The importance of learning from each other and sharing ideas probably underlies the length of our lives as well. We have very long lives and particularly women, we live beyond our reproductive years and that's a very strange thing to do. It's very odd for an animal to finish reproducing and then live for decades beyond that. What is that about? What could be the evolutionary function of living beyond the end of your reproductive years? You should either carry on reproducing until you're dead or you should die at the same time as the menopause but there's something going on which means that elderly people are valuable. Elderly people, evolution is keeping people alive and that probably is down to sharing ideas and the fact that these older people in a population represent a repository of knowledge that the rest of the group can draw on. So all sorts of things are shaped by our evolutionary journey. We've seen our teeth being shaped by it, our brains being shaped by it, the shape of our bodies, the way we move and even the length of our lives as well. And hopefully at the end we've gained some deeper understanding of who we are as humans whilst at the same time acknowledging that we are animals and we are just another African ape.

S2 I'd like to introduce you to some of these ancestors as recreated by the wonderful Kennis brothers and we'll just go through time and meet some of our family on the way. Here are the Kennis brothers in their studio working away and building up the anatomical layers on a cast of a skull. This is a Neanderthal they're just doing there. So let's go back 7 million years ago, you've seen this character already, this is Tumi, homo hiedelbergensis from Chad and then we've got Australopithecus Africanus. This is a 2 year old. I love their reconstructions. So many of these reconstructions of ancient human ancestors are expressionless but here we're actually seeing a person, we're seeing a little 2 year old going 'ooh' and this is the town baby. And then we've got Australopithecus afarensis. This fossil from a group of fossils which has been called the First Family and then we've got homo habilis and homo agasta and homo erectus, this wonderful reconstruction of an East Asian ancient human. Homo [Antises - 0:48:44] of about 800,000 years ago and Neanderthal, the old man of [Lasha Pelu San - 0:48:52]. You could just imagine him speaking to you. I'm not sure what he would say or how we would say it. Another homo sapien and a homo sapien lady from Israel who probably dates to about 100,000 years ago. By this time we're pretty much us.

S2 Thank you very much for coming along this afternoon. I must say thank you to everybody who worked on the series. All of the people on the production side of things but also all of our fantastic contributors, experts in the field and also people, people that we met like the Hadza and also thank you to Dorling Kindersley for letting me use all the images from the book and to Adrie and Alfons Kennis who bring us face to face with our ancestors.

[applause]

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