SCIENCE MAGAZINE PODCAST –1 June 2007

Music

Intro

Interviewer —Stewart Wills
Greetings, and welcome to the *Science* Podcast for June 1, 2007. I'm Stewart Wills, the online editor of *Science* Magazine. Today: When the ancestors of humans learned to walk on two legs; how to teach science teachers; and how global warming might lead to global wetting. All this, plus our usual roundup of other stories from *Science* and its online daily news site, *Science*NOW. So stick around.

Music

Interviewer —Stewart Wills
Getting around on two legs is one of the fundamental things that make us human. Indeed, it has generally been assumed that habitual human bipedalism developed some time after the human lineage diverged from those of the chimps and other great apes, more than 4 million years ago. But what if human bipedalism traces to characteristics that developed much earlier? That is a question explored by British scientists Susannah Thorpe, Roger Holder, and Robin Crompton in a new report this week in *Science*. We are very pleased to have Dr. Crompton on the line to tell us more. Dr. Crompton, welcome to the *Science* Podcast.

Interviewee —Robin Crompton
Thank you.

Interviewer —Stewart Wills
Well, Dr. Crompton, could you tell us a bit about sort of the conventional wisdom regarding how human bipedalism developed?

Interviewee —Robin Crompton
Okay, for a long time now people have thought that our common ancestor with the chimpanzees and gorillas would have been an animal rather like a common chimpanzee -- in other words, an animal which walked around on all fours bearing its weight on its knuckles. And it was thought that we first became bipeds when the forests started to retreat and grasslands expanded, in other words, as we kind of moved out onto the Savannah.

Interviewer —Stewart Wills
And that all sounds pretty logical, I mean the idea is the knuckle walking evolved into human bipedalism after humans diverged from these earlier animals. What could be wrong with that?

Interviewee —Robin Crompton
Well, one thing that I have always been uncomfortable about is that most people in my field have always agreed that the way we can define the apes as a whole is related to adaptations which are related specifically to upright posture. Now, that suggests that the ancestor of all living apes was an animal which moved around in an upright posture, not in a horizontal posture. And so in order to have a knuckle-walking origin for human upright bipedalism, you have to go from upright posture down to horizontal posture and back to upright posture again, and that seems rather complicated. Secondarily, there isn't, I think most people have agreed, any good evidence at all for knuckle-walking adaptations in fossils of human ancestors. Thirdly, new fossils appear to show that evidence of some kind of bipedality at about five to eight million years ago. That's an age very similar to DNA sequencing dates for the genetic separation of the humans and chimpanzees. From about five million years onwards and specifically after 4.5 million years, we have the appearance of one human ancestor after another which has a combination of upper limbs apparently adapted for life in the trees and hind limbs adapted for bipedal walking. Now, these fossils, it appears more and more definitely these days, are found in predominately wooded environments -- woodland or forest or even closed forests. And it is not until about two million years ago that humans are thought to be associated with open or grassland savannah environment, and then it is not as Australopithecus anymore, it is actually our own genus Homo, and we are talking about animals which have proportions very, very similar to our own.

Interviewer —Stewart Wills
So, we are starting to see evidence emerging in the fossil record that just doesn't really square with this knuckle-walking-to-bipedal story for humans.

Interviewee —Robin Crompton
Right.

Interviewer —Stewart Wills
So, what approach did you and the rest of your team take to actually examine this problem?

Interviewee —Robin Crompton
So, our hypothesis was that we might be able to find some advantage to being bipedal in the trees. More and more scientists have started to wonder whether there could be an arboreal or tree-living origin for bipedality. So, we wanted to go and see whether -- what use being a bipedal could have in the trees. So, the animal we need to go and look at is the animal which is still living in the trees, of all the Great Ape types the most arboreal animal, that is the orangutan. So, Sue Thorpe spent about a year following orangutans in Sumatra dawn to dusk, recording the patterns they use, how many branches they use to support their body weights, diameter of the supports that we could see, how flexible that they would be.

Interviewer —Stewart Wills
And so from looking at these orangutans what did you actually find out?

Interviewee —Robin Crompton
Well, very surprisingly, we found that when they used bipedalism, which is about 7% of their locomotion, rather than that being on the firm, solid, ground-like support, it was actually on the very finer support at the periphery of the tree grounds, where they would be normally hunting for fruits or transferring from one tree to another straight across the canopy. It is actually quadripedalism which is associated with the biggest, largest horizontal boughs. And so, that's completely opposite what we expected. On top of that, whereas we know that all Great Apes do operate bipedally a little, all primates, including monkeys and apes, when they are moving on bending supports, flexible branches, tend to use more bent-limb postures for security. Orangutans are an exception to that. That is the other way around. When they are moving on these fine supports, they actually use more straight postures of the legs. The only other case that we can find which is similar to that is actually when humans are running or springy, indoor running tracks.

Interviewer —Stewart Wills
So, when these orangutans -- in the portion of their time when they were using bipedalism, they tended to use a form of bipedalism that was much more similar to human bipedalism than to bipedalism of other great apes.

Interviewee —Robin Crompton
That is absolutely correct, yeah.

Interviewer —Stewart Wills
So, if I am understanding this correctly, you are saying sort of that the raw material for human bipedalism had already developed millions of years before the ancestors of humans actually diverged from Great Apes. So, what happened after that? I mean, clearly we don't walk like any of these animals, orangutans, chimps or gorillas, now.

Interviewee —Robin Crompton
Right. To some extent this has to be speculation, because we cannot go back in time and verify it. But the environmentalist Jonathan Kingdon hypothesized that about in the late middle Miocene -- that is about 9 or 12 million years ago -- tropical forests in both east and central Africa began to experience a series of drying events and interspersed with events when the climate became more moist as a result of global cooling events. So, cyclically, the forest's canopy starts to break up and eventually reform. Now, that would mean that for an ape, which is a large-bodied animal, it is no longer possible to cross from one tree to another at canopy level. So then, the African apes which were living in this changing and breaking-up forest environment had to adopt a new strategy. We think that our own ancestors, the human ancestors, more or less abandoned the larger trees, abandoned the canopy, and started feeding primarily on the ground or on the smaller trees, and became more and more ground adapted -- and they actually *retained* the bipedal adaptation from the repertoire of the common ape ancestor. On the other hand, the ancestors of chimpanzees and independently gorillas took another element of the common ape repertoir -- that is, vertical climbing, which is when they climb up and down a vertical tree trunk with flexed legs and extended arms -- and developed that further,

which allowed them to access both the treetops of the canopy and the ground food resources. This requires, they became very specialized in the forelimb and hind limb anatomy.

Interviewer —Stewart Wills
So, the action as far as evolution was concerned was more in the chimps and gorillas than it was in the humans.

Interviewee —Robin Crompton
Absolutely. Knuckle walking, we think, is an innovation coming from developments of further specialization on vertical climbing, whereas human bipedalism is actually a retention of a posture of the common Great Ape repertoire.

Interviewer —Stewart Wills
Dr. Crompton thanks for being with us today.

Interviewee —Robin Crompton
Thank you.

Interviewer —Stewart Wills
Robin Crompton of the University of Liverpool is the co-author, with Susannah Thorpe and Roger Holder of the University of Birmingham, of a new study on the origins of human bipedalism. The paper appears in the June 1st issue of *Science*.

Music

Interviewer —Stewart Wills
Coming up in a moment, teaching science teachers.

Interviewer —Stewart Wills
Training the next generation of science and math teachers has emerged as a crucial national issue. In this week's News Focus section, *Science* deputy news editor Jeff Mervis looks at what a number of undergraduate institutions are doing to get science teacher training back on track. He is in the studio with us now to talk about it. Jeff thanks for dropping in.

Interviewee —Jeff Mervis
Glad to be here.

Interviewer —Stewart Wills
Jeff, before we dive into what these schools are doing, why is this such a big issue now?

Interviewee —Jeff Mervis
Well, that's a good question. The issue is the quality of instruction in the nation's public schools. And that grows out of concern that student test scores, both on their own and in comparison with an international group, are not as good as they should be. And one of the factors in that equation, of course, is the quality of teachers. So, setting aside the question of whether tests can actually measure what the students learn, people felt that we needed to improve the quality and the quantity of teachers. There is a shortage of well-trained teachers in the secondary schools, and a lot of the teachers haven't had the kind of course work in the specific subject matter that they need in order to do a good job in the classroom.

Interviewer —Stewart Wills
Okay, so you looked at three undergraduate institutions in particular that are kind of taking different approaches to addressing this problem. Can you just talk about some of the things those schools are doing?

Interviewee —Jeff Mervis
Sure. I should say first that it's a big change for research universities, which are generally aimed at taking the best students and preparing them for a future in the lab or as a professor. These schools have decided that it's just important for them to train future teachers and so they have tackled that issue in a lot of innovative ways. University of Texas began a program called 'UTeach' about 10 years ago, in which they tried to attract freshman majoring in all science areas into teaching by giving them a classroom experience as freshman, and then drawing them in through courses that have been redesigned by master teachers, so that they involve the science as well as the pedagogy. The University of Colorado at Boulder has taken a different approach, in which they give their students their first taste of teaching by teaching peers, in other words, other undergraduates, in introductory courses that they themselves have taken, and at the same time they learn pedagogical skills on how students learn. The third university that we visited, Brigham Young University in Utah, takes somewhat traditional approach, but mentors students very carefully and draws on their interest in service, which is a big part of this school.

Interviewer —Stewart Wills
So, a variety of different approaches, ranging from mentoring to sort of peer training. How expensive are these programs to run?

Interviewee —Jeff Mervis

They vary depending on the program. University of Texas is the most expensive, and they have created an endowment, because they offer such inducements as tuition reimbursement for those first two courses, for example. They also pay the master teachers that mentor the students, because they want to be sure and get the best and they also want them to be committed. Brigham Young seems to do it on a shoestring, with the use of a couple of teachers who are just extremely committed and are very dedicated.

Interviewer —Stewart Wills
And that was the school that was really emphasizing mentoring in particular from above if you will.

Interviewee —Jeff Mervis
Right. And I should say University of Colorado has federal grants, which they have used, from the National Science Foundation and others who have long supported these kind of reforms in undergraduate teaching.

Interviewer —Stewart Wills
Well, sort of on a bigger scale I gather from your article that California has a real big ticket initiative going on this area as well.

Interviewee —Jeff Mervis
Yeah, California does, and of course as in many things, as California goes so goes the country. They have a large network of state universities, the California State system, that traditionally has trained teachers. And what they are trying to do in Cal State is upgrade that so that they attract not just the students that want to be teachers, but the students that want to be physicists and chemists, but also want to share their knowledge in the classroom. The University of California system, Berkeley, UCLA, and so on, are traditional research powerhouses, where once upon a time if you went into teaching you were seen as a failure. And they are trying to change that attitude.

Interviewer —Stewart Wills
Yeah, I mean, that was something that actually struck me -- that in some ways the biggest innovation we are talking about here is just these universities telling some of their most talented students, hey, it’s okay to want to be a science teacher.

Interviewee —Jeff Mervis
Right. For example, one student that we met at BYU had been at Carnegie Mellon, had done research in this summer, was an undergraduate at Cornell and other places. And she got the clear message from faculty as well as students that if you are really committed to learning science, you would follow me into the lab. And she said, well that’s maybe fine for you, but I am really excited about teaching kids and I want to do that, and she found that that wasn’t very popular message in some schools. But not at BYU.

Interviewer —Stewart Wills
Well, Jeff, an interesting story. Thanks for sharing it with us.

Interviewee —Jeff Mervis
Thank you.

Interviewer —Stewart Wills
Science Deputy News Editor Jeff Mervis writes about the efforts of several universities to boost training of science teachers in the June 1st issue of *Science*.

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Interviewer —Stewart Wills
Just around the corner: the wet side of global warming. Stay with us.

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Interviewer —Stewart Wills
One of the big unanswered questions about future climate change is how global warming will affect the water cycle, particularly the amount of rainfall. In a paper published online this week by *Science*, Frank Wentz of Remote Sensing Systems in Santa Rosa, California, along with three colleagues, casts new light on that question. The results of their inquiry could have big implications for assessing the possible human and environmental impacts of climate change. We are delighted to have Mr. Wentz on the line now to give us some details. Mr. Wentz thanks for joining us.

Interviewee —Frank Wentz
Thank you.

Interviewer —Stewart Wills
Well, first Mr. Wentz, in general, what do the climate models currently have to say about what global warming will mean for rainfall?

Interviewee —Frank Wentz
Well, first of all the climate models indicate that the total amount of water in the atmosphere will increase substantially with global warming, at a rate of about 7% for every Celsius degree of warming. This is due to the warmer air being able to hold more water as dictated by the Clausius-Clapeyron relationship. However, when it comes to rain, the climate models predicted much smaller increase of about 2% for every Celsius degree of warming.

Interviewer —Stewart Wills
So, in the simplest terms the models are saying that the atmosphere will be able to hold more water vapor because it's warmer, but the actual amount of water that evaporates and is returned as precipitation won't change much. So, what's wrong with this picture?

Interviewee —Frank Wentz
Nothing is necessarily wrong with that picture; however, it does require a decrease in global circulation -- that is to say, the winds would have to decrease along with global warming. A rather crude example would be like a conveyor belt, a vertical conveyor belt, where evaporation is putting parcels of water onto the conveyor belt and they are being conveyed upwards, and at the top of the conveyor belt, think of them falling off the end as precipitation. Now, both the models and the observations indicate that with global warming there will definitely be more boxes, more parcels of water, on the conveyor belt. And if the conveyor belt doesn't slow down, then you are going to have more parcels falling off the end. But what the models are predicting is that this conveyor belt, that is, the global circulation, is going to slow down. So, that's the way in which they can **a)** Predict substantial increase in water, but **b)** predict that the rain and evaporation itself will really not increase very much.

Interviewer —Stewart Wills
So, this sounds like a bit of a paradox. How did you and your team investigate this?

Interviewee —Frank Wentz
Well, we looked at satellite retrieval of a number of different parameters that included rainfall, evaporation, wind speed, and the total water in the atmosphere. And we looked at it for the last 20 years. We would have loved to go back further, but the satellite data began in 1987. And as a check on our analysis, what we did is we compared monthly global precipitation with monthly global evaporation. Now, when you average over the entire planet for a month, evaporation must equal precipitation, that is to say, what goes up must come down. And there is a small storage term that comes into play, but it's really negligible in size.

Interviewer —Stewart Wills
And so, you did this kind of bookkeeping exercise, I guess you could call it. What were the results of that?

Interviewee —Frank Wentz
Well, first of all we found that the evaporation and the precipitation time series were very similar, which we had hoped to have find, and they should be exactly the same, and the fact that the actual satellite observation showed that they agreed so well, that gave us more confidence in results. And both of them, evaporation and precipitation, showed an increase of about 1.3% per decade. And we can also measure total water in the atmosphere, and that also increased about the same amount. Now, during this 20-year period, the Earth warmed about 4/10th of a degree Celsius. So if you go through the math, what you get is that the change in evaporation, and the change in precipitation, and the change in total water all increase by about 6.5% per degree of warming. And that rate

is about three times what the models are predicting. And we also, we didn't see any decrease in the circulation. We saw no decrease in global winds during the last 20 years. In fact, what we saw was a small increase. But let me add that our analysis only covers a 20-year period, and it's rather short to base any definite conclusions about a process as complicated as this one. However, the results are suggestive, and considering the implications, I think that it would be prudent for the modeling community to look carefully at the results -- and also feed them back into their models, and how they construct their models, particularly when it comes to radiative forcing.

Interviewer —Stewart Wills
Well, let's talk about -- I mean, you mentioned the implications of this, let's talk about some of those implications. I mean, granted as you say there may be some open questions here. But you know, it seems like if this analysis is correct, and if indeed the amount of evaporation and rainfall that we might see in a warming world is maybe three times as large as the models are telling us, that has some pretty big implications for the future we can expect. Can you talk a little bit about that?

Interviewee —Frank Wentz
Yes, some. Implications are always difficult, but if the rain continues to increase at the rate that we have seen it in the last 20 years -- and that is a big if -- and global warming continues at the rate of about 0.2 Celsius per decade, and that's a typical rate that most people seem to agree with -- both the models and the observations suggest that 0.2 Celsius per decade maybe some more -- then, our results are indicating that at the end of this century, the rain would have increased by 13%. Now, that's a very substantial increase, and of course it begs the question: where will this additional rain fall? And that is the 64 dollar question. Some of the climate models predict that the wet areas on the planet will get wetter and the dry areas will become drier, and that's clearly not a very attractive scenario. What we saw a hint this in our satellite data, were the rainfall in western Pacific -- and that's an area of very heavy rain -- that area showed the largest increase of all regions during the last 20 years. However, given the discrepancy we are now observing between the observations and climate models, I have some doubts as to this wet-getting-wetter, dry-getting-drier prediction of the models. With respect to severe weather events like hurricane, I am really not sure what the implications are, but with this much more rain worldwide, it certainly could pose one of the more serious risks associated with climate change.

Interviewer —Stewart Wills
Well, Mr. Wentz congratulations on this work, and thanks for filling us in on it.

Interviewee —Frank Wentz
You are welcome.

Interviewer —Stewart Wills
Frank Wentz is the lead author, with three colleagues, of "Will Global Warming Bring More Rain," a report published online this week by *Science*.

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Interviewer —Stewart Wills
Finally today, Erik Stokstad, the Managing Editor of *Science*'s free daily news site, *Science*NOW, is in the studio with Tunisia Riley of AAAS for our usual roundup of other recent stories.

Interviewer — Tunisia Riley
Hi Erik, welcome back. What do we got for us today?

Interviewee —Erik Stokstad
We are going to talk about a type of retardation called Fragile X syndrome, go into quantum computing for just a little bit, and then relax with some dinosaur tracks.

Interviewer — Tunisia Riley
Sounds like a great mixed bag of information (*laughs*). Let's start with Fragile X syndrome. First of all, just what is this?

Interviewee —Erik Stokstad
It's the most common kind of retardation that's inherited in boys. It's quite common overall -- perhaps 1 in 4000 people have some degree of it. There is a range of symptoms, from learning disabilities to total retardation and associated symptoms like anxiety and autistic behaviors. About 15 years ago, scientists discovered the gene, the single gene mutation, that causes this syndrome. What happened now is a group mutated that gene in mice and then did an experiment to see if they could relieve some of the symptoms. So, what they did was they took this mice and then they figured out what was going wrong in its brain, and that was that the cells were not able to encode memories through a process called long-term potentiation. The next step was to take similar mice and put them in a cage with lots of little mice toys in a stimulating environment. After two months, they looked at the brains of those mice, and they found out that the neurons in their brains were much more able to encode memories.

Interviewer — Tunisia Riley
Is this going to help find a treatment for the disorder?

Interviewee —Erik Stokstad
That's what the researchers hope. But it's a fairly obvious thing to do, and as another scientist pointed out, it's more than likely that a lot of concerned parents have been trying things like this, and there really has been no great treatment for Fragile X syndrome.

Interviewer — Tunisia Riley
Okay, let's switch to a story about qubits. It sounds like the treat I used to feed my dog when I was a kid. What you got for us there Eric?

Interviewee —Erik Stokstad

Well, maybe a treat for Schrödinger's cat, I don't know (*laughs*). This is one small step on the long road to quantum computing. The idea with quantum computing of course is that we could eventually have vastly more powerful computers. What they have done here is to make an advance with the control of electrons. Computers encode information in 1s and 0s and right now we have 10,000 or so electrons represent every 1 and 0. The advance here is that they can control the release of electrons and there you can just sort of tickle the electricity and out will pop an electron, a single electron, and it will stay inside what's called a two-dimensional electronic gas. And there it can act as a quantum bit.

Interviewer — Tunisia Riley
So, does this mean we are getting close to quantum computing?

Interviewee —Erik Stokstad
It's a long way's away. First thing that probably needs to happen is that we need to speed up the electronic detectors. So you can send out these single electrons every nanosecond or so, but we will have to speed up the response rate of the detectors by an order of magnitude or so to be able to detect them. So, there is still a long way to go. You can hold on to your laptop for a while.

Interviewer — Tunisia Riley
Last, but certainly not least, a new wrinkle on dinosaur footprints. You got to explain this one.

Interviewee —Erik Stokstad
Alright, well if you had a hard time shutting me up on the quantum computers wait till we go here (*laughs*). What is cool about the footprints is that these are fossilized behavior. So, when you find these trackways, you can tell something about how the animal was actually moving in the real world. There has been a fair amount of debate about dinosaur trackways in the past that were thought to be under water. So, the question is, were they in the water? Where they swimming? What were they doing? What's really cool about these trackways is they are long and they have ripple marks on them. So, it's clearly water, you got these three little scratch marks from the claws so that they know it was a kind that belonged to a kind of dinosaur called a therapod. So, since we only have the claw marks and not kind of the heel print, it's fairly logical inference that's something was supporting the weight of the animal's body. That's probably water. So, what we have got is an animal maybe not swimming because it's touching the bottom, but it's going through water. What's also neat is they can tell was swimming against the current. So it clearly had its eye on something and wanted to get somewhere.

Interviewer — Tunisia Riley
So, what does this tell us about dinosaur behavior?

Interviewee —Erik Stokstad
Well, it reinforces the idea that they were very capable predators. You know it's kind of hard to imagine a big, carnivorous dinosaur running up to the water and then saying 'Oops! I am not going to get my feet wet'. (*laughs*)

Interviewer — Tunisia Riley
Well Erik, as usual a great mix of stories. Thanks so much for dropping by.

Interviewee —Erik Stokstad
Happy to any time.

Interviewer — Tunisia Riley
Erik Stokstad is the Managing Editor of *Science*NOW, the free online daily news service of *Science*. You can catch up with these and other stories on the site at sciencenow.sciencemag.org.

Interviewer — Stewart Wills
And that wraps up the June 1, 2007, *Science* Podcast. The show is a production of *Science* Magazine and of AAAS, the Science Society, with additional financial support from the Golden Fund. The content is provided by the news and editorial staff of *Science*, and Jeffrey Cook composed the music for the show. I'm Stewart Wills, the online editor of *Science*. On behalf of the journal and its publisher, the American Association for the Advancement of Science, thanks for joining us.