Science Magazine Podcast

Transcript, 26 August 2011

http://podcasts.aaas.org/science_podcast/SciencePodcast_110826.mp3

Music

Host – Stewart Wills
Greetings, and welcome to the *Science* Podcast for August 26th, 2011. I'm Stewart Wills.

Host – Kerry Klein
And I'm Kerry Klein. This week: analyzing the first samples from an asteroid, evidence of a new type of human in Siberia, and how the act of drawing can enhance scientific learning.

Host – Stewart Wills
Plus our usual wrap-up of some of the latest science news from our online daily news site.

Promo
Support for the *Science* Podcast is provided by AAAS: the American Association for the Advancement of Science. Advancing Science, Engineering, and Innovation throughout the World for the Benefit of All People. AAAS—the Science Society—at www.aaas.org.

Music ends

Host – Stewart Wills
In June 2010, after a sometimes harrowing seven years in space, the Japanese Aerospace Exploration Agency's Hayabusa spacecraft returned to earth, carrying precious cargo: more than 1500 dust particles from a near-earth asteroid called 25143 Itokawa. It's the first time asteroid samples have ever been returned to Earth for scrutiny in the lab. A special collection of papers published in this week's *Science* reports on the first detailed analysis of those samples. In one key finding, the samples finally establish that stony, or "S-type," asteroids like Itokawa are made of the same material as chondritic meteorites found on Earth. Scientists have long suspected such a tie -- but couldn't be sure, because the composition of asteroids previously could only be inferred from the spectra of their reflected light. A leader of the program and author on the Hayabusa papers, Tomoki Nakamura, spoke with me about the mission's findings and significance from his home in Sendai, Japan.

Interviewee - Tomoki Nakamura
The most important goal of the Hayabusa mission is to demonstrate that the asteroids are really primitive solar system bodies that record the early evolution of our solar system. And for this we need to show asteroidal material is identical to chondrite materials because we already knew that the chondrites are the most primitive material in our solar system.

Interviewer - Stewart Wills
Chondrites being the most common sort of meteorite that's found on the surface of the Earth.

Interviewee - Tomoki Nakamura
Yes, yes.

Interviewer - Stewart Wills
So you were trying to essentially make the tie between these chondrites – these meteorites on Earth that are thought to be sort of samples of the primitive solar system – and the asteroids out in space, these so called S-type asteroids. This mission, of course, is targeted to a specific asteroid, which was called I think 25143 Itokawa. Why was that asteroid chosen, in particular, for this mission?

Interviewee - Tomoki Nakamura
Yeah, there are a few reasons. The one reason is it is a near-Earth asteroid and relatively easy to reach, but not too easy. Also, another reason is that it is a S-type asteroid that is the most abundant meteorites in the inner asteroid belt. So Itokawa is a kind of representative asteroid.

Interviewer - Stewart Wills
A representative asteroid of one of these S-type, or stony-type, asteroids…

Interviewee - Tomoki Nakamura
Yes.

Interviewer - Stewart Wills
…which are also found in the asteroid belt.

Interviewee - Tomoki Nakamura
Yeah, right.

Interviewer - Stewart Wills
But this particular asteroid – if I'm understanding you correctly – was in a in a different orbit that took it closer to Earth and thus made the asteroid easy to reach?

Interviewee - Tomoki Nakamura
Yes, right. So, yeah, the most important reason is because it is the a near-Earth asteroid.

Interviewer - Stewart Wills
So the mission was launched back in mid 2003 and ultimately landed on the asteroid I think in November of 2005. But I guess there was a certain amount of suspense about whether the probe would actually be able to take samples. Could you talk a little bit about the sampling process when it did land on Itokawa?

Interviewee - Tomoki Nakamura
It's a kind of long story. But the sampling horn didn't worked as planned. The sampling horn like a nose of elephant touches down the surface asteroid to collect asteroid surface material. And the metallic projectile should have impacted the surface, but it cannot be fired with the program. Therefore, we didn't know the sample collection was successful or not.

Interviewer - Stewart Wills
So you didn't know whether the planned sampling strategy was actually working?

Interviewee - Tomoki Nakamura
No. Actually the sample horn just impacted on the asteroid surface, but the metallic projectile cannot be fired.

Interviewer - Stewart Wills
Oh, I see.

Interviewee - Tomoki Nakamura
Therefore, yeah, therefore we didn't know we obtained sample or not until the day of opening the sample capsule on the Earth.

Interviewer - Stewart Wills
Wow.

Interviewee - Tomoki Nakamura
So we have to wait five years.

Interviewer - Stewart Wills
Wow, that must have been a long five years.

Interviewee - Tomoki Nakamura
Yeah, a long five years, yeah. Actually we practiced the opening capsule and the separation of the particle from the capsule for two years.

Interviewer - Stewart Wills
To be sure that when you actually opened it, if there was material there, you would you would be sure to collect it.

Interviewee - Tomoki Nakamura
Yeah, right.

Interviewer - Stewart Wills
Okay, so let's talk about that. The probe came back to Earth in June of 2010. And these samples – which I gather were just these extremely tiny grains of dust, more than 1,500 of them, you successfully removed them – how did you establish that they actually were

from the asteroid? I mean I suppose we could imagine some sort of contamination, for example. How did you establish that they actually were from Itokawa?

Interviewee - Tomoki Nakamura
We found more than 1,500 particle, as you know. They are natural rocky particles. And the particles are made mainly of five minerals. Some are common on the Earth but others are not. So mineral combination is important because it reflects formation condition of the rock that contain minerals. And there are no terrestrial rocks that contain all the minerals together we found from Hayabusa capsule; therefore, we are convinced that the rock particle we found in the Hayabusa capsule are real asteroidal samples.

Interviewer - Stewart Wills
And let's talk a little bit about the core purpose of the mission, as you mentioned at the outset, which was to better establish the connection between S-type asteroids and stony meteorites, or ordinary chondrites, on Earth. And I suppose the S-type asteroids – if I understand it correctly – are defined remotely based on analyzing the spectra of their reflected light. And, so it was important to establish a connection between those and the actual, you know, meteorites that we have samples of on Earth. Can you tell us a little bit more about how that particular finding was reached – how you established that connection?

Interviewee - Tomoki Nakamura
Yes. The most important science derived from our finding is that asteroids are made of very primitive material for recording formation of our solar system; therefore, we demonstrated that asteroids preserves record of the early formation of planet like our Earth. And as for the relationship between S-type asteroid and ordinary chondrites, S-type asteroids are believed to be parental object of ordinary chondrites based on the spectroscopic observation of asteroid and meteorite, as you know. However, there is a problem. It has been well known for long time that reflectance spectra of S-type asteroids and ordinary chondrites do not match perfectly probably due to the effect of space weathering.

Interviewer - Stewart Wills
…of space weathering…

Interviewee - Tomoki Nakamura
Yeah.

Interviewer - Stewart Wills
I see.

Interviewee - Tomoki Nakamura
We've solved this problem and found that this mismatch is really due to space weathering.

Interviewer - Stewart Wills

So, in other words, there was this hypothesis that the S-type asteroids might be the parent bodies of ordinary chondrites, but since the match wasn't perfect you had to establish that space weathering was the reason for that, and you were able to do that by analyzing these samples?

Interviewee - Tomoki Nakamura
Yes, exactly, yes.

Interviewer - Stewart Wills
And so, that's obviously a great finding. What other findings came out of this mission that you think are particularly interesting?

Interviewee - Tomoki Nakamura
We published six papers together in the same *Science* issue, and all six papers show the results of analysis of asteroidal samples and show the origin of asteroid Itokawa and the evolution of surface material based on independent evidence. So they are very interesting, please take a look. Especially a finding reported by Dr. Noguchi's paper is very important because they uncover a detailed mechanism of space weathering taking place on the surface of asteroids.

Interviewer - Stewart Wills
So, in other words, we not only have been able to establish that the difference between the spectra of chondrites and S-type asteroids is due to space weathering, but we've learned a lot about the process of space weathering in these asteroids themselves.

Interviewee - Tomoki Nakamura
Right, right. So Noguchi's paper demonstrated that the mechanism of space weathering is somehow different from that taking place on the moon.

Interviewer - Stewart Wills
Well, I understand that there's a Hayabusa 2 mission on the drawing boards that will launch in a few years. Can you tell me something about that mission?

Interviewee - Tomoki Nakamura
Yes, Hayabusa 2 will be launched in 2014, so three years to go. The next time we aim to go to C-type asteroid and bring samples back home. And I hope next time much more samples. And the C-type asteroids are enriched in water and organic material, and we hope to obtain crucial information on the origin of water and life on the Earth.

Interviewer - Stewart Wills
Tomoki Nakamura, thanks very much.

Interviewee - Tomoki Nakamura
Thank you.

Host – Stewart Wills

Tomoki Nakamura is lead author of a new paper on the link between S-type asteroids and stony chondritic meteorites, established through samples from the Hayabusa space mission. You can find the full package of papers on the mission at www.sciencemag.org/hottopics/hayabusa2011.

Music

Host – Kerry Klein

In a News Focus article this week, Ann Gibbons writes about the surprising discovery of a new type of human in a cave in remote Siberia, and the implications of this discovery on conventional views of human evolution. She had the opportunity to visit the cave earlier this summer and she spoke with me about it from her office in Pittsburgh.

Interviewee - Ann Gibbons

This all started last year when a team from the Max Planck in Germany got DNA from the pinky finger bone of a girl who lived in Siberia in a cave called Denisova Cave about 30,000 to 50,000 years ago. And, when this group led by Svante Pääbo at the Max Planck got the DNA, they thought, "Oh, we're going to hopefully get DNA from a Neandertal – which is a kind of human that lived 30,000, 50,000 years in Europe – or maybe an early modern human like the people that do the cave art in Europe." So they went and got some DNA from the bone. And then, when the results came out in the lab that she was not a Neandertal nor was she a modern human, Svante Pääbo didn't believe it. He didn't believe his postdoc. And they went back, and when they sequenced the entire genome, it turned out she comes from a kind of people – archaic people that were alive in Asia 30 to 50,000 years ago – that are more like Neandertals than us, but they're separate, they're a separate population. And here's the mystery – they only have three fossils of Denisovans. So they are in this strange position. It's really a 21st century problem of having a genome in search of a fossil record. So all these researchers came together near the cave in this beautiful country in the Altai Mountains in Siberia to talk about what do we know about people that lived here 30,000 years ago, and who were the Denisovans, what do we know about them?

Interviewer - Kerry Klein

So let's set the scene here a little bit. This Denisova Cave is in Siberia. Can you just tell me a little bit about the setting and what the cave itself looks like?

Interviewee - Ann Gibbons

Absolutely. The cave is in the Altai Mountains, which are southern Siberia. So people think of Siberia they think of a really frigid area. Well, in the summer, it's not frigid; it's beautiful. It's rolling hills with, you know, wildflowers, bee balm, and wild mint and Queen Anne's lace all blooming in these beautiful birch forests. So it's really stunning countryside but very remote. This is 350 kilometers north of where Kazakhstan, Mongolia, and Russia meet. And there's a lot of caves in this area because of the kind of rock in the region. And you walk up a hill and there's this big, big opening, and you go in and it's like a huge gallery. There are three rooms to it. And what's remarkable about this cave is it's got a fantastic view of the river and the valley below. So anybody who would have lived in this cave would have seen other kinds of people going by, and they would have seen what kind of game they could hunt. It would have been a really great vantage point. And we know that humans have been living in this cave off and on in the region for 300,000 years and in the cave for about quite a long time, as well. And it turns out in this cave it wasn't just Denisovans – there's also evidence that Neandertals were there and that modern humans were also in the cave.

Interviewer - Kerry Klein
So before scientists went to this cave about a year ago and found these fossils, did they suspect that all of these humans lived there beforehand? Or what led them to this cave in the first place?

Interviewee - Ann Gibbons
No, most researchers would not think that. The whole story of modern human origins is really the last couple of hundred thousand years people have focused on Africa, where modern humans came from; the Middle East, where we moved through and maybe encountered Neandertals; and Europe, where both Neandertals and moderns were. So the Altai, Siberia is way off the beaten path. I think, you know, Asia has been a mysterious spot where people didn't really know what happened – it's been a bit of a black box – but having said that, that's the view from the west. Russian archeologists have been working there since the 30s citing lots of evidence of different kinds of humans in the region – early *Homo erectus*, which was a direct ancestor of ours; and they knew Neandertals had been there too. So it was interesting, but it was a bit of a backwater. It really took the geneticists coming into the picture in the last decade – with big breakthroughs in techniques to sequence ancient DNA – to create this opportunity and to put a focus on the Altai in Asia. Because what happened in this case is Svante Pääbo, was looking for Neandertal DNA from all over the Old World, Asia, and Europe, and he sequenced the entire genome of Neandertals first, and that was published in *Science* last year. And so, that led to testing the DNA on other fossils, and that was how they discovered this new kind of human. So that has suddenly really put a big spotlight on Asia.

Interviewer - Kerry Klein
Now, you mentioned a pinky finger. What other fossil evidence was there for this new type of human?

Interviewee - Ann Gibbons
Well, it's really scrappy. There's not much. It's a little piece of a tiny knucklebone in a girl's pinky finger, and they know it's a girl because the growth plates were not fused. They also found two molars. And the molars are really big – they don't look like molars from a Neandertal or a modern human. And, in fact, Bence Viola – who's one of the anthropologists – at first thought it was the molar of a cave bear because it was so big. So they've got a really scanty fossil record. The irony is of the course that the DNA is so well preserved in that finger that the quality of this complete genome for the Denisovan girl is better than the complete genome for Neandertals – and they've sampled at least seven or either Neandertals to create that genome. Oh, the other thing that they've found is that Denisovans in just three fossils have more genetic complexity than all the

Neandertals. Neandertals have very little genetic diversity. So now that they have a genome from Denisovans they can see, did our ancestors interbreed with them? And the only people that still carry it are people in Asia, specifically Melanesians and Papua New Guineans – the islands out there near New Guinea and Indonesia – and also Australian Aborigines. So, they know that in the old days when the Denisovans were alive that their range was all over Asia, was much broader. But Asians do carry some Denisovan DNA, and all Europeans and Asians also carry some Neandertal DNA. So we know that our ancestors, modern humans, as they came out of Africa encountered Neandertals and interbred with them, and then they encountered Denisovans and interbred with them. So this is a complex story that is involving population geneticists trying to figure out the best scenarios, you know, how much interbreeding was there? It involves the fossil hunters who are trying to find the fossils – these are paleontologists, archeologists, and paleoanthropologists. And it involves the other people who try to date the sites where these came from – the geologists.

Interviewer - Kerry Klein
Anthropologists and paleoscientists kind of agree on the path of human evolution in the last few, you know, hundreds of thousands of years. How does the appearance of these Denisovans play into that? Do all scientists agree with this? Are they happy about it?

Interviewee - Ann Gibbons
I think it's very interesting because we've had two leading models that were sort of almost two extreme versions of what it turns out may have actually happened. So modern humans, archaic *Homo sapiens*, arose in Africa – the first fossils are about 180,000 years old from Ethiopia. When a group came out of Africa, we know that they encountered archaic people that were already living around the Old World in Asia and Europe. These archaic people were descendants of *Homo erectus*, which also gave rise to modern humans in Africa. When they encountered them, one view was, the out of Africa replacement model, is that modern humans completely replaced these archaic people and didn't interbreed with them. So it was a complete different species, Neandertals, and we just wiped them out completely, you know, whether it was disease, whether it was warfare, that's been one of the big questions. The alternate view, which has become more the minority view in the last decade, or last 20 years even, was regional continuity, also known as multiregional evolution. The idea there was that yes, some modern humans came out of Africa, but as they encountered archaic people all over the world, they interbred. And they interbred enough that modern humans arose in several different places – different populations with different regional traits. The early versions of that model assumed that there was a lot of interbreeding. So what we see now with the Neandertal DNA and the Denisovan DNA, the best model that fits the data, according to the population geneticists who are working on this data, is this is a low level of interbreeding. When our ancestors first came out of Africa – maybe in the Middle East, somewhere before they spread all over Europe and Asia – they interbred with Neandertals. Small amount of interbreeding because, you know, something like 2 to 5% of our DNA – if you're European or Asian – comes from Neandertals. Then, a group that headed on into Asia encountered the Denisovans because Melanesians and Australian Aborigines, in addition to having the Neandertal DNA, also have a little bit more of the

Denisovan DNA, up to maybe 7%, 10% of their DNA is a mix of these two archaic people. So this is not wholesale, you know, wife swapping, if you know what I mean. They're emphasizing that this is leaky replacement – that modern humans really did replace the archaic people, but there was some interbreeding, there was some exchange of genes.

Interviewer - Kerry Klein
So what are the next steps in this field?

Interviewee - Ann Gibbons
So there's several different directions the research is going in. On the one hand, the archeologists in Russia, led by Derevianko and Mikhail Shunkov, are looking in all the caves for more fossils of not only Denisovans but modern humans and Neandertals. They're also trying to redate Denisova Cave because right now the dates are vague – somewhere between 30,000 and 50. So one of the big questions there is, "Were they in the cave at the same time? Were they in the cave sequentially?" You know, everybody wants to work out those dates to answer that question. Another line of research is archeologists and anthropologists all over Asia, researchers working in China, working in Mongolia, working in Kazakhstan and Eastern Europe. They're at the meetings because they are going back and looking at the fossils they already have and their collections and looking for new fossils to see if they can find evidence of the Denisovans, that there is this third kind of human. The third area is, of course, the genetics and there's two questions going on there just to sort of oversimplify this. One is refining the population genetics models to really get a good sense, as well as we can, what this migration looked like – how many individuals were coming out of Africa, you know, how much interbreeding was there really. And then, there are groups that are searching that DNA. In fact, we have a paper in the current issue of *Science* where Peter Parham's group at Stanford took a look at the Denisovan DNA that was in Asians and Melanesians, and they propose that there's a DNA lineage that's actually found in Asians today – and particularly at the highest levels in Iraq – that is a variant or a type of an immune gene that they think we inherited from Denisovans. Meanwhile, other groups, including Svante Pääbo in Germany, are looking at the Neandertal genome and asking the same question, "What did our ancestors inherit from Neandertals?" And finally, the other big question is, "Why did we survive and they didn't?" And that's part of this research, as well – can we learn anything from the DNA and the fossils that will tell us that?

Interviewer - Kerry Klein
I find it quite symbolic that basically this discovery may represent a crossroads, a regional continuity, and it's bringing together so many countries now…

Interviewee - Ann Gibbons
Yes.

Interviewer - Kerry Klein
…to unite in this research.

Interviewee - Ann Gibbons
It was really evident in the meeting when – it was an international meeting with about 24 people, and it was great because we had people from all different disciplines together and from different nations asking the same questions but from different perspectives. And that's pretty exciting. This is going to be an area of research, and the fossils coming will keep people busy for many, many years, probably decades.

Interviewer - Kerry Klein
Ann Gibbons, thank you so much.

Interviewee - Ann Gibbons
You're welcome, thank you.

Host – Kerry Klein
Ann Gibbons writes about evidence for a new species of human in a News Focus this article week. The new paper that she mentioned, on the shaping of the immune system in archaic humans, including Denisovans, is published online today at www.sciencexpress.org .

Music

Host – Stewart Wills
How can we improve scientific education? Shaaron Ainsworth, a psychologist at the University of Nottingham, thinks she has one answer: get students to draw more. In an Education Forum article in this week's *Science*, Ainsworth, along with colleagues Vaughan Prain and Russell Tytler, argue that making drawing a key element of scientific education -- on a par with reading, writing, and discussion -- can deepen student engagement, reasoning skills, and the ability to grasp complex ideas. Ainsworth talked with me about it while on holiday in the Dominican Republic.

Interviewee - Shaaron Ainsworth
I think we're all familiar with the ways that reading, writing, and talking support learning in science. And we're not trying to argue in this paper to stop reading, writing, or talking, we're just arguing that drawing isn't solely for the art classroom but also has a very important role to play in the science classroom as well. If we look at our scientific visualizations, for example, you know, if you look at the front cover of *Science*, we see they're getting more and more and more impressive. But we just want to argue that learners can pick up a pen and sketch and that can be just as important.

Interviewer - Stewart Wills
You make a good point. We're at a point where visualizations of scientific data are just becoming extremely sophisticated. But you're talking about something much more elemental in this paper, which is using drawing, I guess, as a learning aid in science. What are some of the specific rationales that you argue for here for emphasizing drawing in science education?

Interviewee - Shaaron Ainsworth
Well, drawing can help learning for many reasons. If we just look developmentally at young children's development, we know that children find drawing very motivating and very engaging, and compared to adults they tend to be much less worried about how pretty their drawings are. So in the science classroom, one thing teachers can do is just ask learners to draw their understanding, and then students and teachers tend to report being much more motivated and much more engaged in science as a result. But beyond sort of a general impact on motivation and engagement, we know there are distinct attributes of creating your own visual representations that can help learning. The one thing we know is that scientists tend to draw themselves. So the professional practices of many scientists in many different disciplines is drawing, and if we look in the history of science, for example, if we look at the work of somebody like Maxwell or Faraday, we know they drew as part of their inventing process. So if we want children to become scientists, then we might want them to practice the skills that scientists have. And, when students' draw graphical representations, visual representations for themselves, they tend to understand how these work better than when they just interpret the representations of others. I could also say that learners and scientists draw to support their reasoning. So compared to text, graphical representations tend to be much more explicit and much more specific in what you are forced to represent. Many people have heard the phrase "a picture is worth a thousand words", which exploits our notion of the fact that our visual system is very adapted to getting information from graphical representations. And so, doing that – as you draw, as you look through a microscope or reason about evaporation or pollination – is also really helpful.

Interviewer - Stewart Wills
So that's all sort of on the side of using drawing individually to understand and reason better. You also refer to drawing as sort of a learning strategy in your paper?

Interviewee - Shaaron Ainsworth
Yes, so you can actually teach drawing as a very explicit learning strategy. If you ask learners to read a text and ask them to explain it out loud as they go along, they tend to learn much more than if they just read it. And actually drawing can work in a very, very similar way. So, if you read, then draw what you think you've understood from the text, and then inspect your drawing, rethink it, reread it, you tend to get a better understanding; you might see that there were gaps in the material; you might generate new inferences about what you've come to understand; you might prompt further constructive strategies. So drawing can be sort of explicitly taught in that way, as well.

Interviewer - Stewart Wills
And also, drawing to communicate is another rationale that you state here.

Interviewee - Shaaron Ainsworth
Yes. So drawing can be a great way to support communication with others. Imagine a learner's drawing for a teacher, and then the teacher can talk to the learner about what they've drawn, they can discuss it. And because you're really forced to be very explicit again, there's kind of no place to hide your lack of understanding. So this gives teachers

a real insight into the processes of the student reasoning. And of course, it needn't just be with teachers. There's some nice work showing that students can talk to each other about their drawing. They can critique each others' drawings, they can work out whether they're clear, coherent, whether the content's right, and that can be a really supportive way of helping understanding, too.

Interviewer - Stewart Wills
Can you give an example of a study or a program that has been especially sort of useful in pointing out some of these advantages of drawing as a learning aid?

Interviewee - Shaaron Ainsworth
Yeah. So I mean it's certainly true to say that there's an awful lot of guidance in the literature for the benefits of drawing, and there was some work in the 1970s. But for some reason, drawing was sort of ignored for 20 or 30 years. More recently, we've become interested in it again. So if I would, say, look at the work of somebody like Peggy van Meter or Janice Gobert, what they might do is ask learners to read a text or compare them to learners' reading a text and seeing a diagram of the text, or learners reading a text and writing a summary, with finally learners reading a text and then constructing their own drawing. And what you typically find from those experimental studies is that drawing is at least as beneficial as, you know, seeing the text and writing summaries or seeing a picture, as well. But it's often even more helpful. So particularly when you're looking at tests that really probe learners' deep understanding of the domain, then drawing can be helpful.

Interviewer - Stewart Wills
Well, as someone who's rather artistically challenged, myself, I was heartened to see in your article that what we're talking about here doesn't really seem to be about quality or artistic skill in rendering or representing something but but sort of whatever seems to make sense to the learner. In fact, I thought some of the things that were shown as examples online were pretty interesting in terms of the approaches that were taken.

Interviewee - Shaaron Ainsworth
We often say in psychology that you do research in the thing you're not good at, and I can't draw either. What seems to be important in drawing to learn is to be very explicit in this visual form, and that seems to be much more important than trying to draw beautifully. But I have to say this is one of the sort of areas where we we don't know the full answer to this question. We don't know if learners benefit from being taught to draw in a particular way in the science classroom, don't know if people who are naturally better at drawing are also those who would be better at learning by drawing. So there's a lot of unanswered questions and of the specific mechanisms of drawing. And we certainly know that people draw a HUGE variety of different things when they read the same text or illustrate the same concept. I've got maybe 10,000 different drawings of the cardiovascular system in my office in boxes. But also I guess people might want to look at some of these. So, if they were going to go to something like the Picturing to Learn website, there are about 3,000 different drawing created by university students and high

school students there of different scientific concepts. And they might be a simple line drawing, a sketch, or a beautifully realized graphical image that's completely realistic.

Interviewer - Stewart Wills
Well, you mentioned there's a lot to learn and and a lot of open questions about how this works. But just thinking about how this would fit into an actual classroom setting in the 21^{st} century, do you have any thoughts on how a science curriculum could better embed this sort of thing?

Interviewee - Shaaron Ainsworth
I think we're beginning to see signs of this happening. So I would talk to one example, which is a project in Australia called the RiLS project – that stands for Representations in Learning Science. And here what's going on in the classroom is that teachers and students over a number of months for using a whole range of representational practices – they're role playing, they're drawing, they're writing. And what's happening in those classrooms is that teachers are working with children to use drawing in a large variety of ways. So they might be drawing in public on white boards; they might also be drawing in private in their notebooks; they might, for example, take place in a hands-on activity like putting a wet handprint on a piece of paper but then go back and draw in their notebook what scientific processes they think are going on. And one of the things that's really nice about drawing to learn is teachers have a really fundamental role to play. So we know that they can help learners start to understand how drawing should work. We'd like them to label their drawings, be explicit, they need to develop conventions to share with others. And we also know that inventing your own representation prior to seeing typical ones can be really helpful, as well.

Interviewer - Stewart Wills
Shaaron Ainsworth, thanks very much for talking with us today.

Interviewee - Shaaron Ainsworth
My pleasure.

Host – Stewart Wills
Shaaron Ainsworth is coauthor of the article "Drawing to Learn in Science." The Web site she mentioned, Picturing to Learn, can be found at www.picturingtolearn.org .

Music

Interviewer - Kerry Klein
Finally today, David Grimm, *Science's* online news editor, is here with some of the latest stories from our daily news site. First, David, we've got an unusual story comparing civil strife to changes in climate.

Interviewee - David Grimm
Yeah, this is a very controversial study or bound to be a very controversial study. It basically is stating that the weather can influence how much people fight in various

places of the world. And this is a study that's actually built on some other studies. For example, in 2009 researchers showed that spikes in temperature played a dramatic role in African civil wars, and this was also a very controversial study. What's new about this study is that it's a different group, and they're looking at various different climatological phenomena – drought, temperature changes, other things.

Interviewer - Kerry Klein
This certainly does sound controversial. How did they frame this study?

Interviewee - David Grimm
Well, it wouldn't strike you as a very easy study to do because scientists aren't able to turn the temperature up and down like they would in a normal control experiment and see, you know, if people in hotter temperatures or different types of climates respond differently. What they did instead was they went back to historical record and looked at two types of events: La Niña events, which are basically a cooling of the tropical Pacific; and El Niño events, which warm the Pacific. And these shifts in climate can be pretty rapid. And the researchers wanted to see, you know, after these relatively rapid shifts in climate, was there a change in the conflicts between people in these regions? They were especially looking at equatorial regions because that's really where these events have the most dramatic weather impact. They looked at 234 clashes that cost more than 25 lives each between governments and rebel groups across the globe from about 1950 to 2004. And they found that in tropical nations like Peru, Sudan, and India, the likelihood of civil violence erupting doubled during El Niño years. And again, these are the years where the weather tends to be hotter, where there tends to be more droughts. In fact, the likelihood of conflicts in these areas increased from about 3% to 6% during these El Niño events. That amounted to an extra 48 clashes between different groups of people. And the researchers saw much more dramatic impacts in these regions than in regions that are less affected by El Niño and La Niña – places like the U.S., France, and China – the chances of civil strife remain pretty low regardless of whether there were these rapid changes in climate.

Interviewer - Kerry Klein
And have these researchers put forth any interpretations of why this might be?

Interviewee - David Grimm
Well, they don't really speculate as to why this may be. They just say, "You know, this is a correlation, but it seems to be a very strong correlation," and the data really seem to support it. One idea is that the societies that were most likely to have more conflicts were also those whose nations had economies that were very deeply rooted in agriculture. And you can imagine if there's dramatic weather changes, that's going to have a dramatic impact on agriculture, the economy, and that could make people a lot more nervous, a lot more sort of upset with the government perhaps if the government is not doing enough to step in. Of course, this is all speculation.

Interviewer - Kerry Klein
So how are other researchers responding to this study?

Interviewee - David Grimm
Well, as I alluded to at the beginning, this is controversial, at least bound to be controversial. And some of the same critics that stepped up and criticized the previous study about African civil wars and temperature change are also criticizing this study as just a correlation. Although they are saying it's intriguing, and if it is indeed a true effect, it could actually be really helpful for humanitarian organizations that sort of would like to have a better sense of when they should really sort of beef up their efforts, and if they could tie that to changing climate events then that could help them out a lot.

Interviewer - Kerry Klein
And next up is a new spin on the study of religion?

Interviewee - David Grimm
Right. Well, this is actually another correlation. And the correlation here is whether religion influences epidemics and vice versa. The point of evolution – if you can ascribe a point to evolution – is just sort of to pass our genes down to the next generation. And, if we're going to help people out, especially people that are sick or dying, if we're going to make any preference at all, we should really help the people closest to us because they also share a lot of our genes, and if we help them out, they'll pass their genes down. But this hasn't always happened. Obviously there's tons of instances in society where people helped complete strangers often at risk to themselves. And this was an even more risky activity thousands of years ago when we didn't have modern medicine. And so why were people helping out other people that weren't related to them if, from an evolutionary perspective, it wasn't doing them much good?

Interviewer - Kerry Klein
And then, that's where religion comes in.

Interviewee - David Grimm
Right, exactly. Religion, or a lot of major religions sort of enforce this idea that we should help others and be kind to others. And so, the researchers wanted to see, you know, did religion play a role, especially in early society, in causing people to help others that they might not otherwise help? And these researchers looked back from about 800 B.C.E. to 200 B.C.E. This is a time when cities were flourishing but also when deadly plagues were arising that were capable of wiping out vast swaths of people. Also, at this time, coincidentally or perhaps not, a lot of modern religions emerged – religions like Christianity, Judaism, Islam. And what these researchers found by studying text and talking to a lot of religious scholars is that the Christian tradition especially sort of enforces this idea of helping others, especially helping strangers, whereas early Islamic teachings basically disavowed the existence of contagious disease, so Muslims believed at that time that there was really no sense in trying to avoid sick people and the emphasis was really on caring for one's family. And the Jewish tradition really ascribed death to God's will. And so, if somebody was sick, there was really no reason to help them per se because if God wanted somebody to be sick, they were going to be sick, and you shouldn't really interfere. So all of this sort of comes together and suggests that religions

really played a role in how people treated other people, and especially religions like Christianity could counter these sort of evolutionary ideas about, you know, well, we shouldn't help people who aren't related to us, whereas Christianity and other religions came in and said, well no, you should help these people, and it sort of balances out.

Interviewer - Kerry Klein
Okay, so that's all about how religions may have affected the propagation of disease. But then how on the flip side has disease influenced religion?

Interviewee - David Grimm
Well, that's a good point. And they found that during this time where there was a lot of disease and a lot of societal strife, these were the times when a lot of today's major religions cropped up. And the researchers say the likely reasons for that is when people feel threatened they tend to form cooperative groups, they tend to try to get together, especially if they're living in cities, maybe they're far from their families, and so they're trying to find substitutes for families. And religion may have filled this sort of social void that people may have been feeling. And, really interestingly, researchers looked to see if there were any correlations to what they were seeing a couple of thousand years ago to today. And they looked at Malawi, which is this African country that has really been slammed by the AIDS epidemic. One in 14 people there has AIDS, and it's the leading cause of death there. And what's interesting is that there's sort of a mix of Christian communities and Muslim communities. And about 30% of the Christians regularly visit the sick, whereas only 7% of the Muslims do. And on the flip side of that, in the areas that were really hard hit, a lot of people were shifting religions and many of them were moving to the Pentecostal or the African Independent Churches where sick people are more likely to get help from strangers. And especially if you're suffering in one of these countries and maybe you don't have family around to help you, there's a big lure for a religion that's more likely to give you a helping hand.

Interviewer - Kerry Klein
And our third story today is about the mating habits of bed bugs?

Interviewee - David Grimm
Right. This is a kind of gross story about bed bug sex. And, although a lot of us probably don't have a favorable impression of bed bugs, there's actually a lot to pity. For example, they spend most of their life hiding between mattresses and headboards, they only feed once a week. Now, this may not make you feel so bad for bed bugs, but female bed bugs have it even worse. Once they've finished feeding, males attack them or "attack" them with bacteria-covered penises. And the reason I say attack is because the male bed bugs are quite likely to not use the proper plumbing, and rather just sort of randomly jab her in various places of her abdomen. So it's very unpleasant to be a female bed bug. So the question with this study is first of all how do females survive this assault? And also, if the the males' penises are covered in bacteria, how do the females protect themselves from getting infected?

Interviewer - Kerry Klein

Well, it does sound cruel and unusual. Can you give me a bit of primer on what is already known about bed bug sex and what they were really targeting with this study?

Interviewee - David Grimm
Well, so researchers already knew that the females had evolved a couple of adaptations to deal with these very aggressive males. One is a groove in their abdomen that gives the males easier access. But also this groove, the females actually line this with immune cells. And the researchers showed that when males inject their sperm into this cavity the immune cells sort of work their magic on killing the bacteria. So that's one way the females are protecting themselves. But the researchers were also concerned about timing. And so the question is, "How do the females ramp up their immune response when they know the males are coming at them?" As I said earlier, the females feed about once a week, and so do the males, and this is usually when they mate with each other. And what the researchers did – which was also kind of cruel and unusual – was they jabbed some female bed bugs with bacteria-laden needles at various times of the week to see if the females would start to sort of develop a response to this and that wasn't the case. Instead, the females were always ramping up their immune response right after they fed, regardless of when the researchers jabbed them. And so, that indicates that this immune response is really tied to the feeding habits of these insects.

Interviewer - Kerry Klein
So a question that is running through my head throughout this is, "Why do we care about bed bug sex?"

Interviewee - David Grimm
That is a great question. And, well, you could say part of it is just sort of for the gory fascination. But the other reason is obviously the immune response is probably protecting these bed bugs from a bunch of other things, and a lot of people want to exterminate bed bugs from their homes, so the more we learn about how they regulate their immune response, the more we can actually take advantage of that and have a much more effective way potentially of getting these bed bugs out of our beds.

Interviewer - Kerry Klein
And what other news have we had this week?

Interviewee - David Grimm
Well, Kerry, for *Science*NOW, we've got stories about how our brains record the passage of time, also a story about a black hole caught in the act of eating a star. For *Science*Insider, we've got a story about human-elephant conflicts in Sri Lanka and what these have to do with banana plantations there, also a story about conflicts of interest in biomedical research. And finally, for *Science*Live, our weekly chat on the hottest topics in science, this week's chat is about the state of women and minorities in science – why women and minorities are not faring as well as other groups and what can be done to reverse those trends. So be sure to check out all of these stories on the site.

Interviewer - Kerry Klein
David Grimm is the online news editor of *Science*. You can check out the latest science news and the policy blog, *Science*Insider, at news.sciencemag.org where you can also join a live chat, *Science*Live, on the hottest science topics every Thursday at 3 p.m. U.S. Eastern time.

Music

Host – Kerry Klein
And that wraps up the August 26th, 2011, edition of the *Science* Podcast.

Host – Stewart Wills
If you have any comments or suggestions for the show, please write us at sciencepodcast@aaas.org.

Host – Kerry Klein
The show is a production of *Science* Magazine. Jeffrey Cook composed the music. I'm Kerry Klein.

Host – Stewart Wills
And I'm Stewart Wills. On behalf of *Science* Magazine and its publisher, AAAS, thanks for joining us.

Music ends