***SCIENCE* MAGAZINE PODCAST—28 September 2007**

Music

Interviewer — Robert Frederick
Hello and welcome to the *Science* Podcast for September 28th, 2007. I'm Robert Frederick. This week: how did social insects evolve to be altruistic, new evidence that confirms that ancient Polynesians traveled thousands of kilometers by canoe to engage in trade, and what makes a good scientific image -- the results are in from our visualization challenge!

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Interviewer – Robert Frederick
Would you give up sex and just work to feed your siblings? That's what drone honeybees do. And, if you've ever been stung, you also know that a honeybee gives up its life with that sting to protect its colony. This altruistic or eusocial behavior of bees and some other insects has intrigued scientists for a long time. Now, Amy Toth and colleagues have looked to the genes expressed in paper wasps for clues to understanding that behavior. I spoke to Toth from her office at the University of Illinois in Urbana-Champaign.

Interviewee – Amy Toth
We are interested in trying to understand the origins of social behavior in animals. And the reason that is so interesting is because it's really been a long standing mystery that has intrigued many biologists -- even since Darwin -- because typically you think in evolution any animal's goal in life is to survive and reproduce, so how do we explain something as extreme as, for example, a honeybee, that stings and loses its life to defend its colony. And so basically the question we are asking is where does this type of unselfish or altruistic behavior come from.

Interviewer – Robert Frederick
Now, aren't there several hypotheses out there to account for this: inclusive fitness and super sisters, super organism, things like that?

Interviewee – Amy Toth
Yep, so these kinds of questions have been of great interest for quite a long time and I think there are many ways to approach it, one is trying to understand the forces of evolution that create this type of behavior. Our approach is a little bit different. It's to look at the proximate cues that may have led to the evolution of this type of behavior: so,

trying to understand what types of precursor behaviors may exist in certain forms of animals that may predispose them to becoming highly social.

Interviewer – Robert Frederick
Okay, so what was your hypothesis going into this experiment, then?

Interviewee – Amy Toth
We hypothesized that there would be a similar biological basis underlying maternal behavior and altruistic or worker behavior in a social insect. And so if those two behaviors were related in an evolutionary sense, then you might expect them to have very similar types of underlying biological basis.

Interviewer – Robert Frederick
So the one evolved from the other?

Interviewee – Amy Toth
Yeah, so the idea would be that maternal or parental behavior is much more widespread across the animal kingdom. You see it in many different groups of animals. And so the idea would be that could have come first and could have served as sort of a stepping stone towards higher forms of sociality.

Interviewer – Robert Frederick
Okay, so how did you test this hypothesis?

Interviewee – Amy Toth
So, we tested this by measuring patterns of brain gene activity or gene expression and we focused on naturally occurring behavior and on native species, North American species, of paper wasp called *Polistes metricus*.

Interviewer – Robert Frederick
Why did you focused on them?

Interviewee – Amy Toth
So, paper wasps are really ideal for addressing this type of evolutionary question. They have complex societies with queens and workers, but their social organization is somewhat more primitive than what you see in honeybees, for example. And, in fact, when colonies begin they start with a single mom, which is called the foundress, and these were actually a key group for our study because they are performing maternal behavior in the absence of any other colony members. And you don't see anything like that in honeybees. And so this single mom will work to rear a set of daughters, and those become the workers, and after the workers emerge they take over caring for the offspring and the foundress becomes a queen, and you have your complex society forming.

Interviewer – Robert Frederick
As compared with bees, which start off with a...

Interviewee – Amy Toth
Exactly. So when bees start a colony they are found in swarms and so the queen actually never is, although she lays lots of eggs, she never is engaging in maternal behavior.

Interviewer – Robert Frederick
So, you looked at DNA, or RNA, or what in looking at these two different groups?

Interviewee – Amy Toth
Right, so we are interested in looking at patterns of gene activity in the brain and how those differed between the different groups of wasps that I just described. And we focused on RNA. So, that would be genes that are being actively transcribed in the brain.

Interviewer – Robert Frederick
And how had you identified which genes you wanted to look at, where these from the much more widely studied honeybee?

Interviewee – Amy Toth
They were from, all derived from honeybee studies, and there were genes that had been previously identified from various different labs and different methodologies as being associated with foraging behavior in honeybees, which is an important element of the worker behavior, and then some of them also had appeared to have roles in determination of who becomes a queen and who becomes a worker in honeybee societies. So, they all seemed like very interesting candidates that could potentially show differences in the wasp species.

Interviewer – Robert Frederick
So, what kind of overlap was there then between the paper wasp and the honeybee?

Interviewee – Amy Toth
Yeah, that's a good question. So, we can't answer that definitively because we handpicked our genes. And so what we would really need to do is pick a random set from wasps and a random set from bees to get an unbiased estimate of what the overlap was. And so what we can say is based on the 32 genes that we did look at -- and we probably picked genes that are more interesting and potentially more likely to show differences -- we saw about 62% of those showed differences in the wasps that were associated with behavior. So, a very high percentage were showing interesting differences in gene activity in the brains of the wasps.

Interviewer – Robert Frederick
Did the expression of these genes backup what had been observed in the wasp as far as how it was different than the honeybee in terms of the rearing behavior of the wasps?

Interviewee – Amy Toth
So, a lot of them did, I would say follow up with an expectation we had. So, as I had mentioned before some of the genes that we chose were associated with foraging behavior in honeybees, and, in fact, a big part of being a worker or being a maternal

foundress in these wasp colonies is foraging. And so we actually saw quite a few of the genes that were associated with foraging in honeybees. They also appeared to be turned on or turned off in specific ways in the brains of wasps that were foraging. And this foraging is an essential part of being maternal or being a worker.

Interviewer – Robert Frederick
So, both groups are eusocial, but wasps are more maternal in their gene expression than the bees are, at least the ones that were queens?

Interviewee – Amy Toth
Right, so the wasps they have a maternal group whereas the bees don't and so that was the important comparison. And so what was unknown from previous studies with honeybees is what did a maternal gene expression pattern look like. And so we were able to do that with the paper wasp because we have this interesting group called foundresses and compare that to workers. And then I think some of other things that we would like to do in the future would be to do more cross-species comparisons and see if the types of gene expression patterns we see in the brains of honeybee workers are also similar to maternal gene expression patterns in paper wasps or other types of insect that show maternal behavior.

Interviewer – Robert Frederick
Okay, well thank you very much.

Interviewee – Amy Toth
You are welcome.

Interviewer – Robert Frederick
Amy Toth is lead author of a paper on the evolutionary link between maternal behavior and eusociality, published online this week by *Science* at www.sciencexpress.org.

Music

Interviewer – Robert Frederick
Also on *Science* Express this week: a burst of radio waves from outside our galaxy. On the hunt for pulsars, Duncan Lorimer and colleagues report that they instead found millisecond bursts of radio waves. They estimate these waves were generated more than three billion light years away, and that their source could be used to probe the distant reaches of the universe. Read the paper, "A Bright Millisecond Radio Burst of Extragalactic Origin," at www.sciencexpress.org.

Music

Interviewer – Robert Frederick
How far would you go for a good woodworking tool? How about 4000 kilometers without a map, in a canoe, with no land in sight? This is not a typical dash to the hardware store. Instead, it describes what is thought to be a trade route that islanders in

the Pacific took between what is now French Polynesia and Hawaii. Kenneth Collerson and Marshall Weisler report in a paper in this week's *Science* that they've traced this four-thousand kilometer route by examining the geochemistry of centuries-old stone tools called 'adzes' that are used in woodworking. I spoke to Collerson from Brisbane, Australia, where he works at the University of Queensland.

Interviewee – Kenneth Collerson
In this paper that we just had published in *Science* is really a unique discovery. What we have found is an adze, which is a tool, stone tool manufactured from a basalt that we have been able to identify the source of the basalt was coming from Hawaii and this is really a fantastic discovery. Other people have looked at stone tools in Eastern Pacific for many years and have tried various techniques to identify their sources, but until our discovery none of these techniques really were definitive and none of them actually allowed the identification of an adze that had come from Hawaii. Other sources that had been identified were all in the region of French Polynesia, whereas Hawaii is more than four thousand kilometers away from this locality.

Interviewer – Robert Frederick
Where were these adzes found?

Interviewee – Kenneth Collerson
The adzes that we studied were actually sourced from the Bishop Museum in Hawaii and this ability to obtain this material from the Bishop Museum largely came about as a result of the contacts that my collaborator, Marshall Weisler had developed over many years through his studies in Hawaii, mainly working on West Molokai and in other areas. So, we were able to sample stone adzes from the Bishop Museum. Now, these adzes had been collected in the 1930s and they came from a low coral island in the northwest Tuamotu Archipelago in French Polynesia, and this is about four thousand kilometers from Hawaii. They were collected in this island archipelago during the course of phosphate mining activity, and the person who was able to collect them was an anthropologist called Kenneth Emory and he lodged his collection with the Bishop Museum. Now, we were able to sample small volumes of these adzes by drilling out a centimeter-diameter core that was about a quarter of a centimeter deep and with this very small amount of material, we could do not only major element chemistry and trace element chemistry, but also a suite of trace of isotopic compositions involving lead, strontium, and neodymium isotopic compositions.

Interviewer – Robert Frederick
What exactly did you find in these adzes?

Interviewee – Kenneth Collerson
Okay, well, we analyzed 19 adzes and they were collected from an archipelago in French Polynesia where there was no rock outcropping except for limestone and phosphate rock. So, there were no local sources. And what we did was measure the isotopic composition as well as the major element and trace element composition, and this provided us with the database with which to try and compare the adze compositions with the chemistries that

had been identified by other workers and by ourselves for volcanic sources in Polynesia and in Hawaii.

Interviewer – Robert Frederick
Do those sources differ somehow?

Interviewee – Kenneth Collerson
Oh, yes. Within… one of the important features of the so-called "ocean island basalts" – these are the little volcanic chains that punctuate the Pacific Ocean basin and also occur in the Atlantic Ocean and Indian Ocean, Hawaii is one example of one of these very long-lived ocean island basalts -- what we have learnt from geochemistry is that individual ocean island basalts are different in certain of their isotopic compositions and trace element ratios. And these differences have been interpreted to reflect differences in the sources of these basalts, either in the upper mantle, or possibly even in the lower mantle. And so the unique chemistries that are available for the ocean island basalts allows us to compare the chemistries of the adzes and therefore try and identify the sources from which the basalts that the adzes were fashioned from or might have come.

Interviewer – Robert Frederick
Now, these adzes came over as part of the trade?

Interviewee – Kenneth Collerson
Now, in the course of the study, we have found that not only have we discovered an adze that came from Hawaii, but we have also found sources in the Marquesas, the Australs, societies in the Pitcairn Island group. And this covers a vast area of French Polynesia. So, it shows that there was a tremendous amount of cultural exchange going on within East Polynesia.

Interviewer – Robert Frederick
Are there any other explanations for how this particular adze from Hawaii came to be within the French Polynesians?

Interviewee – Kenneth Collerson
We can see no other explanation. It was clearly made in Polynesia or in the Tuamotu region because of the style of the adze. According to Marshall's interpretation, it's not a typical Hawaiian-style adze and we made that point in the paper, but the rock is unlike anything from in French Polynesia and the rock has to have had to come from Hawaii. There is no question about that.

Interviewer – Robert Frederick
Now, to the science of that a little bit, what in particular, is there a chemical composition or some sort of other main change?

Interviewee – Kenneth Collerson
There are several chemical features that really point to Hawaii. In terms of trace element composition, there is a critical trace element ratio of barium to thorium. So, we did take

the barium-to-thorium ratio. Most ocean island basalts have barium-to-thorium ratios less than a 100.

Interviewer – Robert Frederick
And Hawaii?

Interviewee – Kenneth Collerson
Hawaii, and one location in the Atlantic Ocean, has a barium-to-thorium ratio of greater than a 100, and one island in the societies we have identified has a barium-to-thorium ratio greater than a 100. So, the options are this adze came from this one island in French Polynesia with a barium-to-thorium ratio over 100, or from Hawaii. Now, the main difference with the island in French Polynesia is that its lead-isotopic composition is totally different from that of Hawaii, but the adze has an isotopic composition in lead that is identical to the lead-isotopic composition of Kaho'olawe rocks.

Interviewer – Robert Frederick
That seems like you have pretty well settled that and that the rock is from the area, what's next then along this research path?

Interviewee – Kenneth Collerson
Oh, look, this opens… what this discovery does, it opens up the field of archaeometry to a new approach in terms of sourcing. And what we have done, I believe, is set the bar very high in terms of the techniques that now must be applied in studying the sources of stone artifacts to look in much more detail of the sources of different artifacts, adzes throughout Polynesia.

Interviewer – Robert Frederick
Is that what you would be looking at next, more adzes, or…?

Interviewee – Kenneth Collerson
Yes, if we can obtain funding to do it. As you now, with science these days it's all down to funding.

Interviewer – Robert Frederick
I understand. Well, thank you very much.

Interviewee – Kenneth Collerson
Well, I appreciate being approached and we look forward to seeing the paper appear in *Science*.

Interviewer — Robert Frederick
Kenneth Collerson, together with Marshall Weisler, report on the composition of stone tools and early Polynesian travel in the September 28th issue of *Science*.

Music

Interviewer – Robert Frederick
Also this week in *Science*: prehistorical genomes from hair. Tom Gilbert and colleagues examined the hair shafts of thirteen woolly mammoths and found that they could sequence the DNA in the mitochondria: the cells' energy producer. The researchers hope that this new source of ancient DNA will lead to a better understanding of organisms from long ago, including extinct species like the woolly mammoth. Read "Whole-Genome Shotgun Sequencing of Mitochondria from Ancient Hair Shafts" in this week's *Science*.

Music

Interviewer – Robert Frederick
Finally today, what makes for a winning science visualization? I spoke with Felice Frankel about it. She's an artist and senior research fellow at Harvard University, and, among her other accomplishments, has done many covers for leading scientific magazines, including *Science.* She was also a judge in the 2007 International Science and Engineering Visualization Challenge, the results of which are published this week in *Science* and on the journal's website. I spoke to her from her home office in western Massachusetts.

Interviewee – Felice Frankel
The idea is to find ways of communicating ideas and data visually and the important work here is communication. And that's what the challenge was about. Not only is it to clarify ideas, but clearly express them and communicate them and that's why we chose the winners we chose.

Interviewer – Robert Frederick
So, the images can't just be beautiful or technologically advanced or superbly accurate, they really need to say something right off the bat when it hits you or do you need…

Interviewee – Felice Frankel
Yeah, well, exactly, at some point they have to say something and get you to want to look. I think that's a really important piece that so many researchers miss. In my opinion, the idea is to get people engaged, but not just making a pretty picture -- that term is used often. There is nothing wrong with a pretty picture, if, in fact, there is information in the picture. But first and foremost, I think, the idea is to engage somebody to want to see what's going on in the image or whatever expression they are creating.

Interviewer – Robert Frederick
It doesn't matter so much if the picture or visualization or whatever it is -- website even -- uses something that's been digitally manipulated given all the different technologies that are out there. It just needs to communicate?

Interviewee – Felice Frankel
Well, I think the important thing for us in science is to always, always, that's underlined and said a hundred times, tell the viewer if there is any manipulation going on. That's

what separates what we are doing in this challenge and what we look at in the challenge. That's what is different from art. We have to be as objective as possible in the way we communicate science, but, of course, there is nothing completely objective. Even in the notion of taking a photograph, the very nature of framing a picture is a decision that you make. But to your question, I do think it is appropriate to manipulate an image in order to clarify the information that you want to communicate, but once again you must always indicate that you are doing so.

Interviewer – Robert Frederick
Well, with the various ways of manipulating all these different images, besides the framing of a photograph and the technology of a photograph itself, is it still possible to put together a really compelling driving image without needing to use the digital technology in some way?

Interviewee – Felice Frankel
Oh, absolutely. Goodness, I sure hope so! There is one particular winner. It's a quite stunning image of Irish Sea moss made by Andrea, I think her name is, Ottesen, in Maryland. The thing about the image, it is somewhat manipulated in the sense that she removed the background that was on the original image and created a black background. But in reality, the specimen itself was not manipulated, just the background, and I suggest that is even though it's dramatically changed, I don't think that it is a high manipulation in the sense of the original specimen. It's exactly what it should be.

Interviewer – Robert Frederick
To that particular image, what is it that is communicating, what does that get at?

Interviewee – Felice Frankel
Well, I think, first and foremost, I want to look at it. I mean, I have to tell you very honestly I have walked along beaches and sort of seen sea moss I suppose and occasionally picked it up, but I have never wanted to study it the way I want to study this because it's so unbelievably stunningly beautiful. And it's very simple, actually, in that she has spread it out so you could really see all the detail, and the way she lit it was in fact very simple, it was just that outdoor lighting, no manipulation at all in the lighting and nothing sophisticated. But I think the simplicity of it engages you in a sense it's so simple, yet, of course, it's really not because it's a biological system, but you are not embarrassed to look at it. You are drawn to it because of its simplicity. And I think this is one of the biggest problems we have when we see other forms of expression in science. Scientists tend to put as much as data and as much stuff in an image as they can, maybe it is to show that they could do it, but this I think is the mistake all of us make that we just have too much to look at. If we could just edit out material and just focus on -- literally and metaphorically focus on -- what we want to look at, I think that's the direction most of us should start heading and I know that I tried to do that.

Interviewer – Robert Frederick
Would you say that sort of your biggest challenge in working in this field, obviously you have to communicate a lot and work a lot with scientists who are doing this work?

Interviewee – Felice Frankel
Yeah, it is very much of a challenge first of all to have them agree with you, you know, everybody thinks that they know more than you know, and most of the time they do in terms of the science, but as far as what works visually I think the very first question one must ask is "What is the purpose of this image -- what is it you want me to look at?" And you know, you would be surprised how many scientists can't answer that quickly.

Interviewer – Robert Frederick
Well, thank you for sharing your perspective on all of this…

Interviewee – Felice Frankel
Oh, this has been my pleasure.

Interviewer – Robert Frederick
Great! Well thanks so much.

Interviewee – Felice Frankel
You bet!

Interviewer – Robert Frederick
Felice Frankel served as a judge in the fifth annual International Science and Engineering Visualization Challenge, a contest sponsored by *Science* and the National Science Foundation. You can read the stories and view an online slideshow of the winning entries from the competition at www.sciencemag.org/sciext/vis2007.

Music

Interviewer — Robert Frederick
Because of a staff retreat this week, we're unable to have our usual weekly visit with the editors of *Science*NOW, but they'll be back in next week's show. Meanwhile, check out the latest news online at sciencenow.sciencemag.org. For now, that wraps up the September 28th, 2007 *Science* Podcast. The show is a production of *Science* Magazine and of AAAS, the Science Society. The content is provided by the news and editorial staff of *Science*, and Jeffrey Cook composed the music. I'm Robert Frederick. On behalf of *Science* magazine and its publisher, the American Association for the Advancement of Science, thanks for joining us.