## *SCIENCE* MAGAZINE PODCAST -- 28th March 2008

***Music***

**Host -- Robert Frederick**
Hello and welcome to the *Science* Podcast for March 28th, 2008. I'm Robert Frederick. This week: rats can learn rules and apply them, 50 years of carbon dioxide monitoring, how genome wide association studies are raising questions for doctors and patients, the biomechanical properties of a squid's beak, and we read from your letters to *Science* magazine. All this and more, plus our usual roundup of stories from our free, online daily news site, *Science*NOW.

***Promo***
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**Host -- Robert Frederick**
Rats may not be your ideal pet, but they certainly can be taught to perform tricks, use a litter box, and even come when called. But can they learn and apply what they've learned to new situations? In this week's *Science*, Robin Murphy and colleagues from University College London and the University of Oxford have shown that indeed they can, an ability once considered to be a keystone of human intelligence. I asked Murphy what prompted he and his colleagues to test rats for this ability.

**Interviewee - Robin Murphy**
The experiments were motivated by a finding in the baby literature, showing that babies were able to acquire simplified rules even before they were linguistically aware. And the suggestion by the researchers was that this was evidence of a early language-specific ability that only humans possess. Subsequent work showed that primates could do this as well, but we were interested in looking at what we might consider an animal that wouldn't have any sort of language. So, my expertise in it is in animal learning with rats, and so it was an obvious point of contact that we would look at the same sort of ability in a rat. I mean, we're not, we didn't use language stimuli so we don't use the phonemes or the language sounds that the previous researchers used. We thought if this was a general ability to learn about sequences of sounds and the rules that underlie sequences of sounds or potentially lights or any sort of stimulation an animal could perceive – if they could learn about those sequences and patterns that underlay the sequences, then that would be something you'd find in any species.

**Interviewer - Robert Frederick**
So what kind of test did you and your team devise to test for rule generalization by rats?

**Interviewee - Robin Murphy**
We used a standard Pavlovian conditioning, which is a method often used to look at auditory and visual stimulus learning in animals, in which an animal is trained exposed with a, in this case with a sequence of, in one experiment, visual cues – so it was lights of different intensities. And in another experiment with auditory cues of different frequencies of the same intensity level, and we trained them to expect food at the end of some sequences and not others, and the ones that they received food for were ones that obeyed an underlying rule – and in our case we call it XYX, which is the same stimulus was at the beginning and the end of a sequence and a different stimulus was in the middle. In one situation an animal would expect food whenever there was an XYX sequence, but they wouldn't receive food when it was either XXY or any of the other combinations of X and Y. And with enough training the animals came to show a conditioned response so, much like Pavlov's dogs showed salivation to cues that predicted food, in our case the animals showed an, an anticipation of food to response, which is that they go checking a food trough for food pellets whenever that sequence that was a signal for food actually came on. And the animals learned that in both the visual and the auditory experiment. But the really interesting result is whether or not the animals will also show this transfer ability – which is the ability to learn a rule – but then in a new domain or in a new stimulus environment, take the rule and apply it. So in our case they were trained with a set of auditory cues that obeyed the rule – they learned that – but now we gave them new sounds that they hadn't heard before – new frequencies – and we applied the rules to these frequencies using that, for example, the XYX rule. And what, with sounds that they hadn't been exposed to in the training phase. And the result is that the animals, when they heard these new sounds, the sounds that obeyed the rules – they looked for food – which to us was evidence that they had learned the initial rule and were able to apply it in this new domain when they were given these new sounds.

**Interviewer - Robert Frederick**
So when the pattern matched what they'd been trained with, they went to the food trough, is that right?

**Interviewee - Robin Murphy**
That's right.

**Interviewer - Robert Frederick**
And, how did you measure how well they had learned?

**Interviewee - Robin Murphy**
Well, animals, rats, in a conditioning chamber trained for food will go check for food. And to the extent that they check for food, you take that as an index of how well they've learned the training stimuli. So if you find that when you turn on a stimulus they just check once or twice, you don't think they've learned as much as when they are constantly or repeatedly checking more. So, in our measure it was the amount of time in fact that they had their heads in the food troughs looking for food. We use that as an index of how strongly they associated these patterns with the food reinforcement.

**Interviewer - Robert Frederick**
Are there any other explanations for the rats' behavior other than that they learned this pattern?

**Interviewee - Robin Murphy**
The straight answer is, there's no other explanation, other than learning the pattern as a cue for food for their checking behavior. We know that they don't check for food when the stimuli aren't on, or they check very infrequently. So, we know that when the cues come on, and there's an elevation in checking behavior, we know that the animals are anticipating food. We obviously compare the levels of behavior before the cues come on and after the cues come on, and obviously it's important that during the other pattern – the XXY for instance, or the XYY patterns – we look at behavior during all of those timeframes. And what you find is that the most behavior appears on the trials with the pattern that was paired with food in the initial training – then you use that as evidence that certainly nothing other than the learning is driving the behavior. So it's nothing simply about their motivational state –- how hungry they are; it's something about stimuli that are "on" that drives their behavior towards food troughs.

**Interviewer - Robert Frederick**
Now you had very specific reasons for looking at rats. But rats aren't typically thought of as the "smartest" of animals – is it likely that this rule learning ability will be found in other species that we do think are smarter, like pigs or dogs or . . .?

**Interviewee - Robin Murphy**
My guess would be yes – that you would find it in other animals. I mean I wouldn't be surprised if birds have an ability to pick up auditory sequences because they use that in their communication, and being able to identify similar sequences of auditory cues, I would have thought, would be quite likely to be found. What's nice about the rodent is that you, as you just said, you wouldn't necessarily expect them to be the "brightest" of all of the animals. And we used, in particular, non-species-specific, just tones and lights – so that there was no reason before the experiment was conducted that they should be adapted specifically for these stimuli. And in some sense animal learning theorists use that approach, of taking a very neutral, initial stimulus – to see whether or not some of these abilities are very general, rather than specific to an animal. And so the argument would be that all animals are required to pick up sequences of events over time and learn about any irregularities that they perceive.

**Interviewer - Robert Frederick**
Well, Robin Murphy, thank you very much.

**Interviewee - Robin Murphy**
Well, thank you.

**Host – Robert Frederick**
Robin Murphy is lead author of a paper on rule learning by rats. Read the paper in this week's *Science*.

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**Host -- Robert Frederick**
Also this week in *Science*:  you are how your genes are regulated.  This week's *Science* includes a special section on gene regulation, which includes several perspectives and a news article.  In particular, researchers are expanding their understanding of the many roles RNA plays, suggesting that RNA, not DNA, may have been the original molecule of life.  You can see a complete list of articles and news, plus an accompanying video, at www.sciencemag.org/generegulation.

*Music*

**Perspective Author -- Ralph Keeling**
We cannot afford such a rigid view of the scientific enterprise as simply hypothesis testing.

**Host -- Robert Frederick**
Ralph Keeling is a professor at the Scripps Institution of Oceanography and writes about recording Earth's vital signs in this week's *Science*.

**Perspective Author -- Ralph Keeling**
We particularly cannot afford that view when our planet is being propelled by human action into another climate regime with incalculable social and environmental costs.  The only way to figure out what is happening to our planet is to measure it, and this means tracking changes decade after decade and poring over the records.

As it happens, this year marks the 50th anniversary of the beginning of one of those records: the start of the Mauna Loa $CO_2$ record, the longest continuous record of $CO_2$ in the atmosphere.  Initiated by my father, Charles Keeling, of the Scripps Institution of Oceanography, the record provided the first compelling evidence that the concentration of $CO_2$ was rising.

At the outset, the decision to place the instrument at Mauna Loa was a gamble.  That's because existing measurements suggested that atmospheric $CO_2$ concentrations varied widely depending on place and time.  But my father was armed with evidence from his postdoctoral research that the $CO_2$ concentration in the remote atmosphere was a lot less variable than previously believed.

And the value of the Mauna Loa data soon was apparent.  By the second year, a regular seasonal cycle was evident, reflecting the "breathing" of land plants in the Northern Hemisphere.  Together with a more limited $CO_2$ data set from the South Pole, begun in 1957, the record documented a global rising trend attributable to the burning of fossil fuels worldwide.

Along the way, there were critics, and the program faced many challenges, including being briefly shut down in 1964 following congressionally mandated budget cuts. But a more serious challenge loomed in the 1970s, when my father was asked to draw a line between the part of the $CO_2$ program that was basic research and the part that constituted "routine monitoring."

The idea was that routine monitoring would be transferred to a government agency. But my father did not comply with the request.

The distinction between research and routine monitoring may seem clear when applied to an activity like weather forecasting. But in the case of a program aimed at long-term change, "research" and "operations" cannot be separated cleanly. Finding and correcting for the inevitable systematic biases is a job for scientists who understand the measurement technology, are passionate about data integrity, and are motivated to unravel how the Earth system operates.

And if long-term observations are fundamental to understanding global change -- as they have proven to be -- why have they proved so hard to support? Prioritization is clearly an issue, because the costs of sustained measurements can be high. But, so far, the Scripps program has proved that a long-term observational program is not necessarily incompatible with the normal peer review system.

After all, the Scripps program to monitor $CO_2$ continues to be funded -- if perilously -- one grant at a time. Perhaps that's because what is now known as the "Keeling Curve" or the Mauna Loa $CO_2$ record, has never realized a point of diminishing scientific returns.

I'm Ralph Keeling.

**Host -- Robert Frederick**
Ralph Keeling is a professor at the Scripps Institution of Oceanography. You can read his full perspective, "Recording Earth's Vital Signs," in this week's *Science*.

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**Host -- Robert Frederick**
Suppose a doctor told you that you were likely going to get type-2 diabetes unless you changed your diet and exercise routine. Now suppose the doctor said also that -- based on a comparison of your DNA with that of others with type-2 diabetes -- you had an increased likelihood of getting type-2 diabetes compared with most of the rest of the population. That kind of information may soon be regularly available to doctors and patients. But *Science* news writer Jennifer Couzin reports that scientists say it's early days for understanding all the information these genome-wide associations are providing.

**Interviewee - Jennifer Couzin**
So the story is about what are called genome-wide associations, which are these scans of large stretches of the genomes of people who have a certain disease compared against

those of people who don't have that disease and then looking for variance, genetic variance, that appear to increase the risk of a particular disease. Now these scans have been around for about a year or two, and they're turning up a lot of different genetic variants. And this story was really looking at how are researchers using this new information – which is very different than the kind of genetic information we've had before – and how are they thinking about conveying these kinds of disease risks to people who might have them.

**Interviewer - Robert Frederick**
Now, you say risks – are any of these diseases 100% guaranteed by having a specific genetic variant or gene?

**Interviewee - Jennifer Couzin**
Not in this case, no. These are pretty different than what we think of as disease genes. So a sort of "old school disease gene" might be a gene for cystic fibrosis, and in that case if you have that bad gene, you get cystic fibrosis 100% of the time. These genes are really – or some of them aren't even genes, they're just stretches of DNA – increase your risk of disease, but they don't even increase it all that much. So, you might have a risk of bipolar disorder that's 1%; these might raise your risk to 2%, for example. Or heart disease might go from 10% to 15%. So it's a small, a modest increase in risk.

**Interviewer - Robert Frederick**
So these diseases sound like ones that aren't conferred entirely by genetic factors, right?

**Interviewee - Jennifer Couzin**
That's right. These are what are called common chronic diseases, mostly diseases of adults, different kinds of cancers, heart disease, diabetes, various psychiatric disorders. And they're generally thought to be caused by a mix of genes and then different environmental influences.

**Interviewer - Robert Frederick**
So the researchers are able to look at people who have these diseases, test and have this genetic variant, and then tell you, based on your genetic information, whether or not you've also got this variant, and therefore you might also possibly have an increased or decreased chance of having this disease.

**Interviewee - Jennifer Couzin**
That's right. So, what they might do hypothetically, they might recruit 1,000 people who have heart disease and then 1,000 people who don't have heart disease – and they look at large stretches of the genomes of all of those people – find that maybe 10% of the people with heart disease have a certain variant. And only 2% of the people without heart disease have that variant, or maybe 5% have that variant. So you're much more likely to have that variant if you have heart disease. And then they can look at my genome and say, "Okay, you have that variant too, so you're a bit more likely to get heart disease than someone who doesn't have that variant."

**Interviewer - Robert Frederick**
What do people do with this information once they've got it? I mean if you smoke your chance of lung cancer goes up. Now you've got a gene variant that suggests that you have a higher chance of a disease. What are people doing?

**Interviewee - Jennifer Couzin**
Well, it's still really early. And so people are only just starting to get some of this information about themselves. One hope, I think, is that a lot of these diseases can be somewhat prevented by lifestyle changes that we already know about. So we already know there are things you can do to help prevent type 2 diabetes, for example. And the thinking is maybe if you have some of these genes that confer an extra risk of type 2 diabetes, you might go ahead and do the things like exercise more, lose weight, that your doctor may be telling you to do anyway, but you're not doing. So there's hope that the genetic information could motivate people to make certain lifestyle changes they're not making, but we really don't know if that's the case, and that is something people are trying to understand – how people will respond to this information; will they care, you know, what will they do with it.

**Interviewer - Robert Frederick**
So researchers are actually studying whether or not people are actually doing anything with this information.

**Interviewee - Jennifer Couzin**
That's right. They're just starting to run a couple of studies that are either looking at exactly this kind of information or something comparable. So, for example, in my story I talk about a study that's going on in the U.K. that's looking at people who are at risk for Crohn's disease, which is an autoimmune disorder of the digestive tract, and those people are also smokers, which puts you at an increased risk of Crohn's. And, some of the, the people in this study will be getting genetic information, and some of them will be counseled on their risk, just based on family history. And the question is, "Are those who are given genetic information more motivated to quit smoking than the people who aren't?" And that's something that researchers are looking at.

**Interviewer - Robert Frederick**
Now, you said each of these variants may confer a tiny little bit or change in risk – what about combinations of these things? Are there combinations that might even decrease risk – even if you have, say a variant that might increase your risk?

**Interviewee - Jennifer Couzin**
Yes, it's also something that researchers are just starting to look at. In particular, they're interested in whether, if you have, you know, 5 different variants that independently might raise your risk of say a certain cancer by a little bit, does having all 5 of them really raise your risk a lot? And even it does, are those variants just kind of added on top of each other, the way you would expect, or are they actually influencing one another to drive risk even higher than you'd expect by just adding the numbers? And this is something people haven't looked a whole lot yet. In prostate cancer researchers did

report recently that having 5 variants did raise your risk substantially – the variants were just added on top of each other. But in that case, for the couple percent of men who have that combination, their risk of prostate cancer is substantially higher than for people who don't if they also have a family history of disease.

**Interviewer - Robert Frederick**
Will all of this be solved by researchers if they eventually just go out and find more and more genes and gene variants that are associated with particular risks? Or is there some other way of getting at this question of, "Am I genetically, sort of, predetermined to get this disease?"

**Interviewee - Jennifer Couzin**
I think there's definitely a hope that finding more and more genes – and also different kinds of genes or different kinds of variation in DNA – will help. I think most researchers don't think that with these particular diseases there will be any combination of genes that puts you at 100% risk of disease, because all of these diseases have environmental influences, and may be preventable, even if you have a lot of the genes that put you at risk. But there's hope that with the genome-wide association studies are helping pick up certain kinds of genes and DNA variants, the kind that raise your risk just a bit – but those variants are pretty common. There are also rarer DNA variants that need to be found by different methods, and those could be playing a role too. And there are even other kinds of changes in DNA that could affect disease. Plus, we're finding that there's research out there that RNA and even other kinds of molecules might be behind all sorts of genetic variation. So, there's a whole lot out there to be looking for.

**Interviewer - Robert Frederick**
Jennifer Couzin, thank you very much.

**Interviewee - Jennifer Couzin**
Thank you.

**Host -- Robert Frederick**
*Science* news writer Jennifer Couzin reports on the questions raised by genome-wide associations. You can read her article in this week's *Science*.

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**Host -- Robert Frederick**
Also in this week's *Science*: stretchable circuitry. In a paper published online, Dae-Hyeong Kim and colleagues have developed a silicon-based integrated circuit that can be folded and stretched. One of the team's design integrates aligned arrays of nanoribbons of single crystalline silicon within ultrathin plastic and elastomeric substrates. Collectively, their various designs suggest new electronic devices, including personal health monitors and "smart" surgical gloves that might enable doctors to see wherever their fingers might be, literally, with tiny, flexible, electronic eyes affixed to the ends of the gloves' fingertips. Read the paper online at www.sciencexpress.org.

***Music***

**Host -- Robert Frederick**
You might typically think of a squid as a soft, squishy animal.  But within the mouth or buccal mass of the Humboldt squid lies one of the hardest, wholly organic materials known:  its beak.  With a similar role to that of teeth in other animals, the squid uses its beak to snap the spinal cord or otherwise disable its prey.  But unlike teeth, the squid's beak contains no minerals like those that make up enamel in teeth.  So how does a soft, squishy animal control its knife-like beak?  In a paper in this week's *Science*, Ali Miserez and his colleagues at the University of California Santa Barbara describe the specific chemical composition of each section of the beak back to its soft, compliant muscle.  The research suggests a path for creating better biomechanical prostheses for people.  I spoke to Miserez from Indonesia, where he was collecting samples.

**Interviewee - Ali Miserez**
What we were interested in was trying to study the beak, that they have absolutely no minerals, yet their abrasion or resistance is predicted to be almost as good as in human teeth, which have 90% ceramics on the outside.  But, when we started to look at the chemistry of those beaks we saw there’s absolutely no minerals whatsoever.  So, the question is how nature does this**,** you know, how is it possible to make materials that work as the teeth, like most mammals, but yet doesn’t use any minerals.  And those marine organisms provide interesting examples for that, that's what we found from the squid.

**Interviewer - Robert Frederick**
And so you looked at the squid beak?

**Interviewee - Ali Miserez**
Yeah, the beaks of the squid.

**Interviewer - Robert Frederick**
And what is the squid beak, briefly?

**Interviewee - Ali Miserez**
So, it’s, it’s a free organic – when I say organic it means no minerals – biomaterials, which is only made of protein and polysaccharide.

**Interviewer - Robert Frederick**
And how does the squid use a beak?

**Interviewee - Ali Miserez**
It has the same function as the teeth, in, like, mammals, right – it’s just a biomechanical device, used to crush a prey and to masticate so that the animals can feed itself.  So it’s just basically a jaw.

**Interviewer - Robert Frederick**
We typically think of squid as rather soft and pliable.

**Interviewee - Ali Miserez**
Yeah, exactly.

**Interviewer - Robert Frederick**
So, when it's not feeding or not hunting, it may have a soft beak. But then when it's about to feed it may stiffen it up?

**Interviewee - Ali Miserez**
Oh, no, no. It's always, it's a stiff structure always there at the tip, you know. It's always present. The structure itself has graded mechanical properties but they exist already; it doesn't change it.

**Interviewer - Robert Frederick**
So, where else is this combination of polysaccharides and proteins found in nature?

**Interviewee - Ali Miserez**
Mostly the closest example are the cuticle of insects.

**Interviewer - Robert Frederick**
So the exoskeleton?

**Interviewee - Ali Miserez**
Yes, exactly, the exoskeleton of insects.

**Interviewer - Robert Frederick**
And is this purely the purview of research, or might there be some applications for having this understanding of the squid's beak that could be applied to engineered materials?

**Interviewee - Ali Miserez**
Oh, yeah, of course. So, what is interesting is we could maybe imagine creating a full prosthesis.

**Interviewer - Robert Frederick**
Full prosthesis?

**Interviewee - Ali Miserez**
Yes.

**Interviewer - Robert Frederick**
Okay.

**Interviewee - Ali Miserez**

Yes, that mimics the chemistry of the beak, so that it would match the elasticity, for instance, of cartilage on one side, and on the other side you could create a material which is very stiff and abrasion resistant.  All this by controlling the gradients that you see in the beak.  So you could imagine making a new kind of biomaterials, which also are biocompatible.  Those materials, they're made under very mild energetic conditions.  So it's made in a room temperature lab under low pressure, and also with much cleaner chemicals compared to many synthetic polymers.  So, from the environmental perspective, if you can mimic these kind of structures I think it would be very interesting, because you could do it using much less energy.

**Interviewer - Robert Frederick**
So the squid beak is something that potentially could be constructed without need for a high-pressure or a high-temperature situation – is that right?

**Interviewee - Ali Miserez**
Yes, because that's how the animal does it, right?

**Interviewer - Robert Frederick**
So if we can figure out how to do that, then we'll be able to make materials out of much less energy cost.

**Interviewee - Ali Miserez**
Exactly.

**Interviewer - Robert Frederick**
Okay.  Well, Ali Miserez, thank you very much.

**Interviewee - Ali Miserez**
Okay, so thank you.

**Host -- Robert Frederick**
Ali Miserez is lead author of a paper on the transition from stiff to compliant materials in squid beaks.  Read the paper and a related Perspective in this week's *Science*.

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**Interviewer - Robert Frederick**
Now, David Grimm, editor of *Science's* free online daily news service, *Science*NOW, joins us to talk about the latest science stories.  Hi, David.

**Interviewee - David Grimm**
Hey, Rob.

**Interviewer - Robert Frederick**
So what stories do you have for us today?

**Interviewee - David Grimm**
Well, Rob, we're going to talk about how small farms might save the planet; what a plant sounds like; and finally, how rewiring of the human brain led to our development of language.

**Interviewer - Robert Frederick**
Okay. Well let's start with how are small farms saving the planet?

**Interviewee - David Grimm**
Well, it's a good question, Rob. And the answer is "biodiversity".

**Interviewer - Robert Frederick**
Why?

**Interviewee - David Grimm**
Well, Rob, biodiversity is important, and it's especially important for plants, and crop plants that are grown on farms. And the reason is, is because plants are susceptible to a whole bunch of things, especially diseases and insect pests. And if a particular variety of plant becomes especially susceptible to one of these things, what breeders usually do is they'll cross it with related plants to try to develop hardier strains. And the more strains you have around, the hardier plants you can develop. So it's a good idea to have as many varieties of specific types of plants as possible.

**Interviewer - Robert Frederick**
So how do small farms fit in?

**Interviewee - David Grimm**
Well, Rob, there's a belief that small farms tend to raise more varieties of crops than other farms do, especially larger, more corporate farms that are known to cultivate less diverse crops. But researchers weren't really sure if this was the case. So, a team of researchers went on a worldwide quest of these small farms, and they looked at 27 different types of crops, 2,000 farms, and 5 continents.

**Interviewer - Robert Frederick**
How long did this take?

**Interviewee - David Grimm**
This took about 10 years, which is not surprising – it was a really big survey. And what they found was that indeed small farms tended to grow more varieties of certain types of crops. In fact, every farm they looked at had more than one variety of a specific type of crop. And some farms they looked at, especially farms in Vietnam and Peru, grew more than 60 varieties of different types of crops.

**Interviewer - Robert Frederick**
So these were different varieties on the same farm.

**Interviewee - David Grimm**
On the same farm.  So this is great evidence that these small farms indeed are these very good reservoirs of crop biodiversity and could play a really important role in crop futures by having the resources to help breed heartier and healthier crops.

**Interviewer - Robert Frederick**
So providing a reservoir for farmers and scientists to use to keep providing food.

**Interviewee - David Grimm**
So in effect, saving the world through saving the world's food.

**Interviewer - Robert Frederick**
Well, from plant biodiversity to plant sounds.  What does a plant sound like – and David I hope you're prepared to demonstrate?

**Interviewee - David Grimm**
Well, I personally don't know what a plant sounds like – but bats do.  And the reason is, is because bats use something called echolocation where they send out chirps of sound when they're looking for prey, or they're trying to find their favorite bush, say.  And when these chirps bounce back to the bats, they're able to figure out not only where these objects are, but in fact, what they look like and how big they are.

**Interviewer - Robert Frederick**
So even if we heard them we wouldn't be able to make sense of those sounds.

**Interviewee - David Grimm**
Right.  Even if we heard these sounds they wouldn't make a whole lot of sense to us.  But researchers wanted to see if they could translate these sounds – could they figure out how bats are doing this, and could they possibly use it for applications for humans?

**Interviewer - Robert Frederick**
With computers or something?

**Interviewee - David Grimm**
Right, with computers.  Using computers they developed data sets called spectrograms.  And basically what these are is, they bounce sonar signals off 5 different kinds of plants – and so this is kind of the bat echolocation.  And when these signals bounce back to them, they characterize them depending on the type of plant they had bounced it off.  And they used things like spruce trees and black thorn bushes.  And they found that, depending on the plant and depending on the number of branches the plant had and even the plant's size, that the response time and the frequency of these sonar bounces that they were getting back changed according to the plant.  And over time they were able to develop characteristic spectrograms for every type of plant.  And in fact, by the end of the study, they were able to achieve near 100% success in identifying 5 different plant species.

**Interviewer - Robert Frederick**

All right.  So now we can understand how bats hear plants – how are we going to use that information?

**Interviewee - David Grimm**
Well, scientists think that this technology could be really useful for trying to identify objects in low light.  Say police were trying to track a crime suspect walking along a dark city street or trying to find somebody that was hiding amid a crowd on a dark mass transit platform.  One could imagine using this technology to pick these people out of a crowd – just like bats pick out their favorite bush among a lot of dense foliage.

**Interviewer - Robert Frederick**
So it's better resolution than infrared or other visual technologies?

**Interviewee - David Grimm**
Right.  We can already do things like this with infrared, but this would supposedly be much higher resolution than the technology we have right now.

**Interviewer - Robert Frederick**
Well, from how bats are wired and computers may be wired to echolocate – to how our brains are wired for language.  Now, by wired, you mean literally, with neuron cells?

**Interviewee - David Grimm**
Well, sort of.  What we're talking about here is really bundles of nerve fibers that connect one region of the brain to another.  And the two regions of the brain we're actually going to talk about here are regions that scientists have known are associated with language, at least in humans.  One is called Broca's area, which seems to be affiliated with how we understand and construct sentences, and the other region is called Wernicke's area, which is more associated with how we determine what words mean.

**Interviewer - Robert Frederick**
Now, you said "at least in humans" – does that mean these regions of the brains are in other animals?

**Interviewee - David Grimm**
Well there's regions that roughly correspond to these areas in other animals – and even other primates like chimps and monkeys.  But they appear to serve other functions other than language.  So, only in humans have these regions been associated with language ability.  But researchers have begun to suspect that it's not just having these two regions that give us the ability to use language and understand language – there must be some sort of connection between these two regions – they must talk to each other.  And in fact, there is this connecting bundle of nerve cells that connects these two regions; it's called the arcuate fasciculus.  And researchers have noticed that in patients that seemed to have disruption in this bundle of nerve fibers, they have difficulty speaking – which would lend evidence to the fact that language isn't just about having these two brain areas, Wernicke's and Broca's; you need to have them be able to talk to each other.  But,

researchers wanted more proof that this bundle of nerve fibers actually does play this important role in “wiring” the brain.

**Interviewer - Robert Frederick**
So how’d they do that?

**Interviewee - David Grimm**
They used a relatively new technique called diffusion tensor imaging. And what this is, is it’s a type of MRI that visualizes tissues by detecting the flow of water within them. And it turns out to be a really good way to trace long nerve fibers, such as the arcuate fasciculus. And when they looked at the brains of a handful of humans and also some chimpanzees and macaques, they saw some very important differences in how this bundle of nerve fibers connects one part of the brain to another. In humans, as they suspected, the arcuate fasciculus connected very well the Broca’s area and the Wernicke’s area, suggesting there was really strong wiring between these 2 regions. But in the macaques and the chimpanzees, they didn’t see these connections that were as strong. In fact, in some of the brains they looked at there didn’t seem to be much connection at all. And so this is really strong evidence that this rewiring of the brain, this connection of these two regions in our brain that are associated with language, was really important in the evolution of our species being able to speak words and understand words and have the conversation that you and I are having right now, Rob.

**Interviewer - Robert Frederick**
So a literal rewiring.

**Interviewee - David Grimm**
Right. It’s a literal rewiring. And experts are really excited about this, although they do say that there was a small number of brains looked at for this study. So, before we get too excited about this, this study should be repeated on a much larger group of humans and other primates.

**Interviewer - Robert Frederick**
All right. Well, thanks, Dave.

**Interviewee - David Grimm**
Thanks, Rob.

**Interviewer - Robert Frederick**
So what other stories are you looking into for *Science*NOW?

**Interviewee - David Grimm**
Well, Rob, we’re looking into stories about making the human sense of smell even more sensitive; how you can use micro RNAs for therapeutic effects in primates; and finally, how pink dolphins use objects they find in the water for sexual displays. So be sure to check out the site.

**Host -- Robert Frederick**
David Grimm is the editor of *Science*NOW, the free online daily news service of Science. You can check up on the latest science stories at sciencenow.sciencemag.org.

***Music***

**Host -- Robert Frederick**
Finally today, we read from your letters to *Science*. Joining me is the Letters Editor, Jennifer Sills.

**Letters Editor -- Jennifer Sills**
This month, we start with a response to a January 4th letter by William F. Perrin, titled, "In Search of Peer Reviewers." In that letter, Perrin writes that it takes 8 to 10 tries to find someone to review articles, and that it would considerably help the process of peer review if reviewing were included in job descriptions and tenure evaluations.

**Host -- Robert Frederick**
Matthew Metz writes in to suggest that the solution to this problem is not wholly in the hands of academic institutions, but in the hands of journals, too.

**Letters Editor -- Jennifer Sills**
Metz writes, "Editorial practices generally lack the recognition needed to make serving as a reviewer a plausible metric of performance, and provide little positive feedback for the effort." In addition, Metz writes, "In my experience with *Science*, submitting a thoughtfully crafted review elicited no acknowledgement. Was the review received? Were the comments instructive? What was the fate of the manuscript in question?"

**Host -- Robert Frederick**
In sum, Metz writes that the editorial establishment could leverage a primary currency of academic science -- namely, prestige -- and find a way to make reviewing count by better acknowledging reviewers' work. Journals could provide reviewers with a letter that they could show to their institution, and even, Metz writes, reward the best reviewers each year. You can read Metz's other suggestions as well as another letter on the peer review process in the March 7th issue of *Science*.

**Letters Editor -- Jennifer Sills**
Turning now to the March 14th issue, a pro saxophonist responds to the Brevia by J. M. Chen *et al.* from February 8th, which was about how saxophonists learn to play the high range of the instrument by tuning the second resonance of their vocal tract to the desired note. Alto player Peter King notes that this is what he and others describe as "singing through the horn."

**Host -- Robert Frederick**
King writes, "I thought it might be useful to offer some practical experiences on the subject.... Professional saxophonists have always been looking for a scientific explanation of the phenomenon.... In general, the higher the note, the more one has to lift the back of

the tongue and restrict the size of the oral cavity.  This explains why using the vocal tract is especially important when playing in the 'altissimo' register of the saxophone."

**Letters Editor -- Jennifer Sills**
You can read King's full letter in the March 14th issue of *Science*.  And finally, a letter in this week's issue: Jürgen Schmidhuber writes in response to the February 29th book review by David Morton.  The review was of Seth Shulman's book, *The Telephone Gambit*, which was about the invention and the inventor of the telephone.

**Host -- Robert Frederick**
Schmidhuber writes in about the focus of both the book and the review on the 1876 dispute between Alexander Graham Bell and Elisha Gray, both of whom filed patents on their respective inventions on the same day.  Gray withdrew his application, and Alexander Graham Bell became a household name.  Schmidhuber writes, "In fact, neither of them was first.  Interestingly, different views on this topic prevail in different nations."

**Letters Editor -- Jennifer Sills**
That's because French, Italian, and German inventors had described the theoretical underpinnings of the phone and even invented a working telephone as early as 1857.  Bell may better be described as the last inventor of the telephone rather than the first.

**Host -- Robert Frederick**
"What can we learn from all this?" Schmidhuber asks. The lesson, as he sees it, is that "When the time is ripe for an invention, it tends to be pursued and developed in various places until someone manages to make a public breakthrough."

**Letters Editor -- Jennifer Sills**
Schmidhuber concludes, "At least in popular culture, much of the credit is bestowed upon the last contributor, even when the essential original insights came from others.  As they say:  Columbus did not become famous because he was the first to discover America, but because he was the last."

**Host -- Robert Frederick**
Alright, well, thanks, Jennifer.

**Letters Editor -- Jennifer Sills**
Thanks, Rob.

**Host -- Robert Frederick**
Jennifer Sills is the Letters Editor for Science magazine.  If you enjoyed this Letters segment of the podcast and would like to hear more, or have other comments about this segment or the podcast itself, please let us know.  You can send your comments to our email address:  sciencepodcast@aaas.org.

And that wraps up the March 28th, 2008, *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.