Science Magazine Podcast

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Music

Host – Robert Frederick
Hello and welcome to the *Science* Magazine Podcast for December 3rd, 2010. I'm Robert Frederick. This week: a bacterium that grows using arsenic instead of phosphorus; molecular imaging of live skin in real time; and Brazil's growing scientific enterprise. All this, plus a wrap-up of some of the latest science news—including a story about why diets fail—from our online daily news site, *Science*NOW.

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Music ends

Host – Robert Frederick
All life is thought to require six elements: carbon, hydrogen, oxygen, nitrogen, phosphorus, and sulfur, and uses these elements to make DNA, RNA, proteins, and fats.

Interviewee – Felisa Wolfe-Simon
Could you change C-H-O-N-P-S? Could you change one of the six dominant elements that we know of?

Host – Robert Frederick
Felisa Wolfe-Simon is a geobiochemist with the U.S. Geological Survey and NASA's Astrobiology Institute. She and her team thought that arsenic – normally considered a toxic substance – could be a substitute for phosphorus, at least in a microbe.

Interviewee – Felisa Wolfe-Simon
Well, if you want to search for a microbe that might utilize arsenic instead of phosphorus, go somewhere in the environment where you are hedging your bets.

Host – Robert Frederick
The team went to California's Mono Lake, which has naturally high levels of arsenic. They took samples of mud from the lake that would contain microbes that lived in the naturally high levels of arsenic. And then, back in the lab, they cultured the bacteria from the mud, sterilized other mud from the lake to make sure nothing was in it, and then introduced individual strains of bacteria back in, diluting it in such a way so that, over time, there were higher and higher concentrations of arsenic.

Interviewee – Felisa Wolfe-Simon
So, you do this 1 in 10, 1 in 10, 1 in 10 – so after, for example, the 1 in 1,000,000th dilution from the original lake, losing all the memory of the original lake solution – we still had microbes growing and swimming and clearly very active at a physiological level.

Host – Robert Frederick
But it wasn't just surviving high levels of arsenic. The team deprived the microbes of phosphorus, too.

Interviewee – Felisa Wolfe-Simon
The microbe we've discovered appears to be able to use arsenic if not given any phosphorus. So everywhere we expected phosphorus, we found arsenic.

Interviewee – Barry Rosen
This is a proof of principle.

Host – Robert Frederick
Barry Rosen is a biochemist at Florida International University and is not associated with the paper.

Interviewee – Barry Rosen
You know, they're not demonstrating that there's life hidden out there that uses arsenic in place of phosphate. That's unlikely, at least on Earth. But what they're demonstrating is that life can use arsenate. And so if they have to put selective pressure on the cells to do that, it's really a demonstration that it's possible.

Host – Robert Frederick
In other words, because phosphorus is pretty much everywhere on Earth, including in Mono Lake, the bacterium Wolfe-Simon and her colleagues isolated may have evolved during the experiment to live using arsenic instead of phosphorus. Again study author Felisa Wolfe-Simon.

Interviewee – Felisa Wolfe-Simon
These cells will grow on phosphorus, and that's something critical to remember. So, we're very cautious in the paper to say that arsenic can substitute for phosphorus. We're not claiming that this is some alien microbe or that its some other form of life from another planet. No. It's something we can recognize. It's on the Tree of Life. It's just doing something a little differently.

Interviewee – Barry Rosen
Yes, I'm convinced that the arsenic is being incorporated.

Host – Robert Frederick
Again, Barry Rosen of Florida International University.

Interviewee – Barry Rosen
I think that the most persuasive observation is that the cells required either phosphate or arsenate to grow. So they aren't just picking up extra phosphate from someplace, because otherwise they would grow in the absence of arsenate. It's the kind of thing that really has considerable implications about the possibility of life on other planets and life that uses a different kind of chemistry from what we have on Earth.

Host – Robert Frederick
But study author Felisa Wolfe-Simon cautions that it's not entirely clear that arsenic is taking the place of phosphorus in the functioning of the cell and in the DNA.

Interviewee – Felisa Wolfe-Simon
So in the paper we used what we would think of as every available type of technique to really show that the arsenic was really inside and being used. So we know they are growing on arsenic with no added phosphorus and they seem to grow well. We see that the arsenic is intracellular, and we see that the arsenic is associated with a band of genomic DNA and that arsenic in the cell appears to be in a structurally similar environment at length scales that would correspond or correlate to what phosphorus would look like in the backbone of DNA.

Interviewee – Barry Rosen
But as the saying goes, the devil is in the details. And as a biochemist, I'm obsessed with details.

Host – Robert Frederick
Again, Barry Rosen of Florida International University.

Interviewee – Barry Rosen
So I thought to be truly convincing the next step has to be to demonstrate that specific molecules, whether small molecules of intermediary metabolism—like glucose-6-phosphate or phospholipids—or larger molecules—like phosphoproteins—they really have to demonstrate that these molecules, purified from the cells, have arsenic in them, and that they are still active.

Host – Robert Frederick
And so used by the microbe. But, both Rosen and study author Wolfe-Simon say it could be years before they can sort that out. You can read Wolfe-Simon and colleagues' paper, "A bacterium that can grow by using arsenic instead of phosphorus," online, at sciencexpress.org.

Music

Host – Robert Frederick
There are lots of ways to image parts of the body, inside and out: X-rays, magnetic resonance imaging, thermography, ultrasound, fluorescence microscopy…. But until now, there was no way to image the chemical make-up at the molecular level of what you

were imaging, in vivo, without either a long delay between each image or a lot of distortion that made it hard to see. That lack of real-time imaging has meant that the current practice in removing cancer by surgery, for example, is for the surgeon to cut out the tumor and hand it off to a pathologist who then freezes it, slices it, stains it, and uses a microscope to see whether or not the surgeon has gotten all the cancer cells and enough of a margin of healthy cells to stop cutting. That all takes about 20 minutes each time, and most such surgeries require this kind of procedure multiple times. Real-time, in vivo imaging could lead to faster, less-invasive diagnostics. And there are many other potential applications, says Sunney Xie, senior author of a paper in this week's *Science*, who reports that he and his colleagues have developed such an imaging system – more than a decade in the making. Xie is a researcher at Harvard University. I spoke with him from his home in Massachusetts.

Interviewee – X. Sunney Xie
We have developed an imaging techniques that allow images of human skin or human tissue in a label-free manner very similar to nuclear magnetic resonance, MRI, imaging widely used in hospitals, but it is complementary to MRI in that it offers much higher spatial resolution and time resolution for label-free bone medical imaging.

Host – Robert Frederick
You say this is a complement to MRI, what about compared to other optical imaging techniques. What, if any, advantages does this technique you and your team been working on have over that?

Interviewee – X. Sunney Xie
Well, the medical imaging techniques based on optical spectroscopy and microscopy have seen a lot of advances in recent years. OCT, for example, is optical coherence tomography, is widely used in hospitals. This technique allows identification of lesions, tumors with much faster time resolution than MRI. However, it does not offer chemical specificity. Now, chemical specificity means we want to see what kind of molecules are involved in the tissue, whether it is a protein or lipids or DNA or water. So, this is where we need Raman spectroscopy. Indian scientist, Raman, discovered the phenomena of inelastic scattering of light by molecules 82 years ago. He won a Nobel Prize for this work. Raman spectroscopy has been widely used in chemical laboratories. So, the question is can we have a point-by-point chemical map of human tissue based on Raman spectroscopy. Normally, people would acquire a Raman spectrum in one second, a fraction of a second. So, if I want to take an image of 200 pixels by 200 pixels it would require a fraction of an hour to acquire the image and that is too slow for medical imaging.

Host – Robert Frederick
So, it was that time lag that had been the limitation in Raman microscopy. That is what you and your team have tried to overcome?

Interviewee – X. Sunney Xie
Yes, so our technique has four to five orders of magnitude increase in the acquisition speed of image based on the Raman contrast making it possible for medical imaging in situ in real time. So, coherent Raman microscopy is something that my group has been working on for 11 years. We developed a technique called coherent anti-Stokes Raman scattering microscopy 11 years ago and in recent years there has been a lot of research activity in this field. In the year of 2008, my group developed this high-speed stimulated Raman scattering, which is a different type of non-linear Raman microscopy. It offers many advantages over the previous coherent anti-Stokes Raman scattering microscopy. So, it's probably fair to say that with this publication, the work of Brian Saar and Chris Freudiger, two graduate students in my lab, stimulated Raman scattering microscopy has superseded the previous technique in almost all aspects.

Host – Robert Frederick
Now that you have this ability to optically image living things in real time on a molecular scale without using any dyes or stains, what have you and your team been able to see that hadn't been seen before?

Interviewee – X. Sunney Xie
Well, we have seen the distribution and penetration of drug molecules into the skin in real time and that was extremely difficult to see, if impossible to see, with conventional Raman microscopy. People have obtained depth scans, different depths, different layers, with hours of averaging time, but we could see this in three dimensions at a video rate.

Host – Robert Frederick
So, did your imaging suggest that there was a different way that drug molecules are getting into the skin?

Interviewee – X. Sunney Xie
Well, people did not know how these drugs penetrated into the skin. These drug molecules are small molecules. You do not want to label them with fluorophores like people do in fluorescence microscopy because the fluorescence labels are bigger than the small drug molecules and this applies to small metabolite molecules as well. So, this label-free method allows us to see where the molecules are inside a tissue, and tissue is heterogeneous. It really requires microscopy, and this information was not available before from Raman microscopy, just because Raman was not fast enough to do this on live tissues and did not have the spatial resolution and time resolution needed to see the so-called pharmacokinetics, how this drug interacts with tissue and penetrated through the tissue. This is for topically applied drugs on skin. So, for example, in the case of retinol, which is a drug used for acne, we observed that the drug diffuses into the skin through the hair follicles. In the literature, people discussed different mechanisms of how does it penetrate into the skin, and we were able to observe this experimentally. Now, I should say that this is not actually discussed in this particular paper, but in this paper we showed skin images tuning into a protein and a DMSO, which is an enhancer for delivering drugs, but we are able to image the drug penetration of several drugs by now.

Host – Robert Frederick
What, if any, other applications do you and your team have in mind for this technology?

Interviewee – X. Sunney Xie
We have been collaborating with doctors at Harvard Medical School trying to use this technique as a diagnostic tool for tumors. When the surgeon gets to the lesion, they have to rely on biopsy. That is the conventional technique, the gold standard technique. Basically, they have to take the tissue out and freeze it and slice it to thin layers and then stain with two types of dye molecules. So, this is done in a histology lab next to the surgical room and one can identify what kind of tumor. They can distinguish a solid tumor, tumor margins and metastasis. However, this is a long process. Each cycle takes about 15 to 20 minutes and usually the doctor needs multiple cycles in order to decide where to stop in cutting the tissues and what we can do with the stimulated Raman scattering microscopy is to do this in situ, right there on the tissue, without taking a biopsy and we are able to obtain identical images as the conventional staining. So, we can also do three-dimensional sectioning because this technique is a nonlinear technique. The signal is generated only at the laser foci of these two laser beams we used. So, if we do three-dimensional sectioning layer by layer, we can reconstruct a three-dimensional image so we do not need to do the actual sectioning of the tissue.

Host – Robert Frederick
And to what depth can you get this kind of information? How deep does the…

Interviewee – X. Sunney Xie
That is a good question. The depth is about 150 microns. That is not very deep compared to MRI; however, we are developing endoscopes; that is to use optical fibers to deliver these laser pulses and use a catheter to get into blood vessels inside an organ to do the image. That way, there will be a minimal invasion. This is where our technique is complementary to MRI. MRI has the penetration depth, but does not have the high spatial resolution. We have the high spatial resolution and time resolution, but we do not have the large penetration depth. So, hopefully, this question will be addressed by endoscope development, something we have already done. We have a paper submitted.

Host – Robert Frederick
And how reliable is this stimulated Raman scattering microscopy, this system that you and your team have invented?

Interviewee – X. Sunney Xie
Well, it requires two pulse lasers at two different frequencies. I admit at this point the laser system is complex; however, we are working with laser developers to construct fiber lasers that would offer stable operation for a long period of time and does not require an optical table, it can be mounted on an instrument rack, something like a shoe box laser. We are hoping that the fiber lasers will offer a reliable operation in hospitals or clinics.

Host – Robert Frederick
You say you have already been working with doctors at Harvard Medical School. How long before this kind of imaging system is available more broadly?

Interviewee – X. Sunney Xie
Well, I hope in a few years we can take this into the hospital.

Host – Robert Frederick
Sunney Xie, thank you very much.

Interviewee – X. Sunney Xie
Thank you.

Host – Robert Frederick
Sunney Xie of Harvard University is senior author of a paper on video-rate molecular imaging in vivo with stimulated Raman scattering. Find it in this week's *Science*.

Music

Host – Robert Frederick
In Brazil, fewer than 1 in 5 people of typical university age are in fact in university. The poor simply don't have access. And the disparity is regional: the Brazilian Amazon, a poor area half as large as Europe, is home to fewer than 3,000 Ph.D. scientists; in São Paulo, Brazil's wealthiest state is also its science leader, and researchers there publish half of all Brazilian papers. But as contributing correspondent Antonio Regalado reports in a package of stories in this week's *Science*, Brazil's fast-growing economy and oil discoveries have been propelling the country's scientific enterprise so fast, for example, that there aren't enough students in the education system to meet the country's growing demand for researchers and engineers. I spoke with Regalado from São Paulo, Brazil.

Contributing Correspondent – Antonio Regalado
Well, you know, Brazil is an enthusiastic country, and its economy is growing fast and that is affecting all aspects of life here including science. Science has not been left out.

Host – Robert Frederick
Traditionally, what research paths have scientists in Brazil pursued?

Contributing Correspondent – Antonio Regalado
Well, there are some bibliometric studies that show that Brazil has a slightly different profile than countries in Europe or Asia. Research here is much more focused on agriculture, clinical medicine, biology, and space science as compared to countries in Asia and in Eastern Europe, which tend to be a lot heavier in physics and chemistry. So, some people have called the Brazil profile a kind of bioenvironmental model of research.

Host – Robert Frederick
And to what extent are Brazilian leaders and politicians committed to science?

Contributing Correspondent – Antonio Regalado
Well, that's a pretty good question. I think Brazilian leaders are pretty committed to science and they have been ever since World War II. The oldest university in Brazil is the University of Sao Paulo. It is 76 years old. It was founded in the last century. So really, compared to other countries like the United States and Mexico, which have universities that are several of hundred years old already, the tradition of academic research in Brazil is extremely short. However, starting after World War II, Brazilians began to take science a lot more seriously. There was a very strong group of nuclear physicists. There was actually an atomic bomb program that wasn't successful, but went on for a couple of decades during military rule in Brazil. And, so, the military rulers of this country, you know, had strategic ideas about science, and they actually invested quite a lot in the university system in areas like physics and so I would say Brazil has always had a strong commitment to science that continues. The problem is it has been a poor country and so sort of only the elite of Brazil have participated in scientific research. Over the past few decades, Brazil has invested more in basic research and somewhat less in applied research and so part of the changes occurring now are pretty big thrusts in applied research. That includes biofuels where Brazil is already quite advanced, there is a lot of ethanol use here about, you know, half the gasoline in Brazil is actually ethanol used instead of gasoline and also in the area of genetically modified crops and in petroleum research. So, there is a strong effort to try and get something for those research dollars, to get products, because Brazil, for all its research, has not been particularly good at technology innovation.

Host – Robert Frederick
So, with all of this research, it's not that the scientists are working with or for industry as a result, they are still in universities?

Contributing Correspondent – Antonio Regalado
That is right. I mean most research in Brazil occurs inside universities, inside the Ivory Tower. The number of researchers working in industry is very, very small. In fact, we have here some data about the number of U.S. patents won by Brazil, and in 2009 Brazilian inventors had just 103 U.S. patents, which is quite a low number. Germany, by comparison, has about 9,000. So, there is a real disconnect in Brazil between industrial research and academic research and the government is currently doing their best to bridge that gap.

Host – Robert Frederick
So, has it been then a new funding source that has led to this shift in what scientific fields researchers are pursuing?

Contributing Correspondent – Antonio Regalado
The amount of funding for research in Brazil has grown very quickly over the last 10 years. There are two reasons for that. The first reason is that Brazil's economy is growing quickly and so research funding has grown along with that, but much research is also paid for by a tax on big industries like the oil industry, the plastics industry, the electrical generation industry. They have to pay a research tax and that money had been

held up by the country's treasury for many years and then only recently has it been released so that has really increased the amount of money available and that pool of money, part of it is earmarked for industrial research, for research that will help these industries become more competitive.

Host – Robert Frederick
To what extent has that worked?

Contributing Correspondent – Antonio Regalado
I think it is too early to say. Brazil is still trying to rewrite its laws to encourage industrial innovation. There were two important laws that were passed in 2004 and 2005 and really there is not a clear read on how effective that has been. However, innovation is definitely becoming a big subject in Brazil. Brazilians realize that they do not innovate enough, and that they may have trouble being competitive in kind of a global economy unless they have inventions and spend money on corporate R&D. So, there are a lot of examples of new projects that are starting up. One I can mention is the company Vale, it's the world's largest miner of iron ore, kind of a low-tech business, but they are spending 180 million dollars to create new science institutes that they hope will become the MIT of Brazil. I mean, in the area of industrial research in Brazil, there is one standout and that is the oil company, the state oil company, Petrobras, which has gone in search of oil into extremely deep waters off of the coast of Brazil. They are drilling wells that are about eight kilometers beneath the surface of the ocean, and so that has taken them to depths where there is not really any experience anywhere in the world and so, you know, they have had a commitment to R&D for some time, but now they really are spending a lot of money including a 700-million-dollar laboratory they just built and this is an extremely ambitious oil company and extremely ambitious national project to pull up all this oil that is down there and that has led Brazil to make huge investments in geophysics, petroleum engineering and related fields and they have become, you know, very good.

Host – Robert Frederick
And are there any indicators that there is growing government support for science and technology in Brazil beyond that related to industrial innovation, oil exploration and recovery, things like that?

Interviewee – Antonio Regalado
Well, I believe that Brazil's percentage of the GDP invested in science R&D has not changed significantly. It is currently about 1.1% of GDP. That puts Brazil way ahead of other countries in Latin America, but still behind the United States, Europe, or many countries that spend about 2% of GDPs. So, the government here makes all the right noises about science, but science has not been, I would say, has not been prioritized above other needs. Brazil still is a country that fights problems like poverty and deforestation. There is a lot on the agenda, and I would say that science has neither been treated specially nor has been left out.

Host – Robert Frederick
Does Brazil have the educational infrastructure that it sounds like it needs for the long run assuming there is continued economic good times for the country?

Contributing Correspondent – Antonio Regalado
Well, in the article, we have kind of concluded that the answer is probably not. Brazil is about the 13th largest producer of scientific papers in the world. That puts it right around where say countries like the Netherlands are, so its scientific output is that of kind of a midsized European country. And the fact is that in Brazil the number of people that have access to universities and that have access to higher education that can get a PhD is sort of the size of a small, midsized European country. There are millions of people that really have no chance of ever becoming a scientist, basically. That is because they go to schools, rural schools, where the teaching is sort of, you know, rote teaching by very badly paid teachers so a lot of people are just simply left out. And so Brazil, to the degree that it wants to grow and become a technological power, is going to have to try to pull more of those people into the system and the government has been trying. It has been opening new universities, it has been opening technical schools and, you know, it has been trying to get more people into the education system.

Host – Robert Frederick
Antonio Regaldo, thank you very much.

Contributing Correspondent – Antonio Regalado
Thank you.

Host – Robert Frederick
Science contributing correspondent Antonio Regalado reports in a package of stories in this week's issue on science in Brazil and how the country's fast-growing economy and oil discoveries are propelling its scientific enterprise to new heights.

Music

Host – Robert Frederick
Finally today, David Grimm, *Science*'s online news editor, is here with a wrap-up of some of the latest science news, including a story about why diets fail. People start eating again, Dave?

Online News Editor – David Grimm
They do, Rob, and the reason, it may turn out to be, has to do with stress. The study is all about yo-yo dieting. This is the dieting where you try to diet, you lose some weight and then you start eating again. You gain the weight back. You try to diet again. You lose some weight and then you keep on eating. This constant cycle that some people call yo-yo dieting turns out it may have to do something with stress, at least in mice. The researchers took a bunch of mice and they reduced their food intake by about 25% over three weeks. That is equivalent to sort of a moderate diet for us and the rodents lost about 10 to 15% of their body weight, so actually lost quite a bit of weight. But then,

what the researchers noticed is these rodents that had lost weight seemed more sensitive to stressful situations like loud noises than other mice. They also had higher levels of cortisol in their blood. Now, cortisol is this hormone that essentially pumps extra sugar into the blood to give us extra energy and it is something we release when we get stressed out, probably from an evolutionary standpoint. If, say, a bear was chasing you, you would pump a lot of cortisol in your blood that would increase your blood sugar and you could use that sugar for energy, energy to run away. But, that could also have bad consequences, as you can imagine. If you are stressed out a lot, you have got a lot of sugar in your blood, this sugar can actually increase your appetite and then you start eating more and then you are dieting to try to take that weight off and that dieting makes you stressed out and you are releasing more cortisol in your blood. It seems like a bit of a vicious cycle, kind of like what researchers see with yo-you dieting and that is what they saw in the mice. These mice that had dieted were more stressed out. They had more cortisol in their blood. They even had changes to their genetics. Their gene expression levels changed where their gene expression had altered in such a way that they had higher levels of cortisol and higher levels also of other appetite-stimulating hormones. All of this would be bad news for a human who wanted to diet because having all of these hormones in your blood is only going to make you hungrier, which is going to make you want to eat more.

Host – Robert Frederick
So, the conclusion that one can draw is not to diet or to do something else if you want to lose weight?

Online News Editor – David Grimm
Well, one possible conclusion is to try not to be stressed out when you are dieting, which is probably a lot easier said than done. A more concrete suggestion is to try to develop medications that could actually target our stress responses. Say you are trying to diet and you are having a really hard time, researchers might be able to give you a drug that would decrease your stress levels and then when you are dieting you may not be as stressed out, you may not be pumping all these hormones into your blood and you may have an easier time keeping the weight off.

Host – Robert Frederick
Okay, well thanks Dave. So what other stories have you brought with you this week?

Online News Editor – David Grimm
Well, Rob, from taking the weight off to putting the water on, this next story is about where all the water came from to fill Earth's oceans.

Host – Robert Frederick
What is the prevailing theory?

Online News Editor – David Grimm
Well, the prevailing theory is that the water actually came, believe it or not, from outer space. About 3.9 billion years ago, when Earth was only about 600 million years old, it

experienced a period of, what astronomer's call, heavy bombardment. Basically, all these big icy comets and asteroids were smashing into the Earth and because there was so much ice in these asteroids that basically supplied Earth with all of its water.

Host – Robert Frederick
And now, what is the new research?

Online News Editor – David Grimm
Well, the new research argues that Earth did not have to get its water from outer space, it supplied its own, and the idea behind this is that even at a very young age Earth actually harbored quite a bit of water and this is actually something that most researchers agree on. This was not a lot of water, it was about 10 to 100s of parts per million, but this was water that was trapped in all the rocks that made up early Earth. But, the reason why astronomers started to look to outer space for explanations is they thought this was not nearly enough water to fill the oceans or even if it was, there was no real feasible way for all this water to get out of the rocks to make up Earth's oceans. But, in this new study, a researcher argues that it actually was. What she did was she looked at a bunch of meteorites. Now, there are tons of meteorites all over Earth in museums, in collections and whatever and the reason she looked at the meteorites is these meteorites provide a really nice analog for what the rocks that formed early Earth looked like and she did a lot of chemical analysis, she did some computer modeling and what she found is when the Earth was really young and still very hot it was so hot that it actually evaporated the water out of these rocks; the water rose as steam, it created a bunch of steam in the atmosphere and this steam rained down on the planet and formed the oceans. Now, this was not a very quick process. It actually probably happened over tens of millions of years, but according to her model, over that time period, there would have been enough water inherently in Earth to create its own oceans.

Host – Robert Frederick
Does this preclude the other theory that the meteorites and comets falling to Earth didn't contribute water?

Online News Editor – David Grimm
Well, it is a little bit complicated. On the one hand, you could argue that these comets and asteroids smashing to Earth supplied even more water, but one researcher says that actually these comets and asteroids smashing to Earth would have created even more heat and would have boiled off any water that was there in the first place. So, this expert actually says even if Earth did have these early oceans from its own water, this heavy bombardment would have boiled off all this water. But, the researcher says she doesn't think that is likely and at the most it would have only boiled off about half of the water in the oceans. What's also interesting about this study, Rob, is that this does not just apply to Earth, it actually also applies to extrasolar planets. Astronomers are starting to find rocky worlds out there that are not exactly like Earth, but resemble Earth in some ways and if Earth, which started out as a very barren, rocky world, could produce its own oceans without having to rely on impacts from outer space, maybe these extrasolar

planets could as well and if these extrasolar planets have their own water they could have life too.

Host – Robert Frederick
Okay. So, last story. What is this last one about?

Online News Editor – David Grimm
Well, Rob, from waves of asteroids and comets hitting Earth to herald waves that might predict future disease epidemics.

Host – Robert Frederick
What are herald waves?

Online News Editor – David Grimm
Herald waves, as you might imagine from the terminology, "herald" the oncoming of an epidemic. This may deal specifically with cholera epidemic and specifically the cholera epidemic that was devastating for London in the 1800s. There were several periods during this century when cholera struck killing tens of thousands of people, but what researchers have found, they went back and they analyzed some of the data from these mass epidemics, and they found that with three of the biggest cholera epidemics to strike London, a few months before that there were these smaller outbreaks of cholera that only killed a few hundred people and then seemed to have disappeared. And the researchers wondered were these smaller outbreaks maybe the harbinger of these mass epidemics to come.

Host – Robert Frederick
Sort of like a prequel.

Online News Editor – David Grimm
Exactly and that is exactly what they found. They found that there was a very tight correlation between when these early small-scale outbreaks would happen and these much larger outbreaks.

Host – Robert Frederick
What would cause these prequels to happen and then die out and not become a full-fledged epidemic in the first place?

Online News Editor – David Grimm
Well, what the researchers think was happening was that these prequels were caused by a new strain of cholera bacteria entering the population, a strain that the population didn't have immunity to. But, the worse cholera epidemics in London happened in the summer. That is when there was a lot of heat and that makes it very easy for microbes to spread and proliferate. But, these prequel epidemics were happening in other seasons of the year and it is possible that when these new microbes enter the population, if the weather conditions weren't right, they may have only killed a few people, but it was not warm enough for them to proliferate out of control. So, they basically just laid low, but then all

of the sudden when summer came and that temperature went way up, all the sudden all these microbes that were laying low just exploded and started killing thousands of people.

Host – Robert Frederick
So, all the epidemics in London happened during the summer time?

Online News Editor – David Grimm
The biggest ones did.

Host – Robert Frederick
Does this have any bearing on cholera outbreaks where it's warm all around the year?

Online News Editor – David Grimm
Well, that is what is tough. The reason this correlation seems to work is because of the seasonality of London, but in places like Bangladesh where there are not as many differences between seasons or where there are other seasonal factors like heavy rains, like during the monsoons, that analysis has not been done and it is possible that could complicate the ability to predict a cholera epidemic in those places. But, this really has applications beyond cholera because there are a lot of other diseases that operate this way and if researchers can find ways to identify the prequels of these big outbreaks, they may be able to better tackle the infection before it becomes an epidemic.

Host – Robert Frederick
Okay, well thanks, Dave.

Online News Editor – David Grimm
Thanks, Rob.

Host – Robert Frederick
So what other stories are you looking into for the site?

Online News Editor – David Grimm
Well, Rob, for *Science*NOW we have got a story about how mercury poisoning can change sexual preference in wildlife and also a story about why spiders are not more social. And for *Science's* policy blog, *Science*Insider, we are continuing to cover what impact the new U.S. Congress will have on science funding and there is some new data we have got this week about just what kinds of things this new Congress could do that might affect everything from NIH funding to grant success rates and on down the line, and also a story about the controversial Japanese practice of research whaling. There are Japanese ships that go out and kill whales. The fishermen claim that they are killing the whales for research. A lot of environmental groups and conservation groups are opposed to this and we have got a story about the latest battle on that. So, be sure to check out about all these stories on the site.

Host – Robert Frederick
David Grimm is the online news editor of *Science*. You can check out the latest science news, plus all the stories on the *Science* policy blog, *Science*Insider, at news.sciencemag.org.

Music

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Host – Robert Frederick
And that wraps up the December 3rd, 2010, *Science* Magazine Podcast. If you have any comments or suggestions for the show, please write us at sciencepodcast@aaas.org. The show is a production of *Science* Magazine. Jeffrey Cook composed the music and I'm Robert Frederick. On behalf of *Science* Magazine and its publisher, AAAS, thanks for joining us.

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