Science Magazine Podcast
Transcript, 14 September 2012
http://podcasts.aaas.org/science_podcast/SciencePodcast_120914.mp3

Music

Host – Sarah Crespi
Welcome to the *Science* Podcast for September 14th, 2012. I'm Sarah Crespi.

Host – Kerry Klein
And I'm Kerry Klein. This week: do-it-yourself lab equipment [19:17]; the Higgs boson, or is it the Weinberg or the CERN boson [09:19]; and a look at an unusual phenomenon in killer whales…

Interviewee – Emma Foster
These whales have a really, really long post-reproductive lifespan: they stop reproducing in their 30s or 40s, but they live right up into their 90s—and that's a really, really unusual thing to occur [00:58].

Host – Sarah Crespi
Plus, a few stories from our online daily news site [28:56].

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Music ends

[00:58]
Host – Sarah Crespi
There are only a few species on the planet that undergo menopause and live decades beyond. Besides humans, certain types of female whales live well past their reproductive age. Using a census spanning four decades, Emma Foster and colleagues revealed that the extended lives of these female whales affect their male offspring for the better. Foster spoke with *Science*'s Edward Hurme about her research from her office at the University of Exeter.

Interviewee – Emma Foster
So there's lots of different populations of killer whales around the world, and each population has a slightly different social structure and social behavior. And a lot of that has to do with the fact that they feed very specifically on different types of prey. And the type that I work on are known as resident-type killer whales, and they feed mainly on salmon. And the resident killer whales have a very unique social structure. Both the sons and daughters will remain with their mothers throughout their lives, so there's no

dispersal from the family group. And you can have about four or five generations in one family group, and that's known as the matriline.

Interviewer – Edward Hurme
So your work tracks the lives of individual whales in two separate populations over several decades. How did you go about studying these animals for such a long time period?

Interviewee – Emma Foster
So the majority of this data was collected by Ken Balcomb from the Center for Whale Research in the USA, and by in Canada. And in the early 1970s, biologists were tasked with going out and counting the whales in the Pacific Northwest. What they did was for the first three consecutive years is they passed out questionnaires to anybody who lived or worked around the water. So that was people like lighthouse keepers, ferry boat drivers, fishermen, tugboat drivers, fishery patrol boats, and people just living and using the water recreationally. And the survey simply asked them on a given day to go out and just to count the whales. And so for three years, they went out and they took a count of the whales. And in addition to that, they went out and they took a lot of photographs as well. And on further investigation of these photographs, they realized that each killer whale had a very distinct dorsal fin shape and a gray area behind the dorsal fin known as the saddle patch. And that was as unique to each killer whale as our fingerprints are to us. And from that, they found out that it was the same group of whales using this water year on year. And so since then, biologists have been tracking these whales and following them and using very similar techniques since the 1970s. Each day, the whales in the area, they're located, either by searching from the shore, or we'll receive reports in when they're in the area. And then once they've been found, if conditions are suitable, we'll launch boats, go out on the water with them, and document who's there and who's traveling together, and also collect other additional environmental data.

Interviewer – Edward Hurme
So you've been running this census for a couple of decades now. Just how long are these whales actually living for?

Interviewee – Emma Foster
Well, the census has been running now for about four decades. And killer whales have a very, very long lifespan. Females live up to about 98 years. The oldest one in the southern resident population right now is actually 100 years old.

Interviewer – Edward Hurme
Wow.

Interviewee – Emma Foster
Whereas with the males, they only live up to about their 30s or 40s.

Interviewer – Edward Hurme

So in your study, you focused on grandmother whales. And so could you talk a little about what was happening with the grandmothers in your research?

Interviewee – Emma Foster
What we wanted to look at was these whales have a really, really long post-reproductive lifespan. They stop reproducing in their 30s or 40s, but they live right up into their 90s. And that's a really, really unusual thing to occur. And it happens in two other species – in humans and in pilot whales – and so we wanted to look at what these grandmothers – well, what these old post-reproductive females – were doing. So we were looking at how their survival impacts the survival of their offspring. So we used the data from the two populations and we explored what happens in the years following a mother's death. So we're looking at the presence or absence of the mother. And we found, really interestingly, with adult sons, if their mothers die, they have a 14-fold increase in the probability that they're going to die in the year following the mother's death. And that effect was seen to a much, much lesser extent in the daughters.

Interviewer – Edward Hurme
So yes, there's definitely an impact of having a grandmother around. What are some of the theories on why there might be this evolutionary advantage for wanting to live longer if you're not actually reproducing?

Interviewee – Emma Foster
So there's two theories that can potentially explain why individuals cease reproduction partway through their lifespan. Firstly, it could simply be a byproduct of living longer, and that's not adaptive. And alternatively, it could be an evolved adaptation in which females that cease reproduction early can increase the transmission of their own genes by ensuring the reproductive success of their offspring. In the case of the killer whales, we think it's the latter, and we believe that the killer whales' post-reproductive lifespan is involved to increase the transmission of their genes through their sons' reproductive success.

Interviewer – Edward Hurme
So these whales are becoming what we would consider grandmothers of the pod. They're taking care of their grandchildren, right?

Interviewee – Emma Foster
That's a really fascinating question. In humans, there's something called the grandmother hypothesis, which is really well-documented. And that's where all the females will help to ensure the survival of their genes through helping their grandchildren. However, in the killer whale populations, we believe that the mothers are directing their support more towards their adult offspring, particularly their sons, because their sons will mate outside of the family group, and therefore, her offspring don't require any support from either the father or the grandmother. So they help their own children by ensuring their reproductive success and the survival of their own children.

Interviewer – Edward Hurme

What exactly can a whale do to help another whale?

Interviewee – Emma Foster
This is still somewhat of a mystery, and it's something that we really hope to explore in the future. I think the fact that we're struggling to answer this question right now just illustrates how difficult these animals are to study in the wild. But particularly problematic is they spend the majority of their time below the water, making them very difficult to observe. However, we have a few ideas what could be going on here, and we can speculate that they may provide help with foraging or support during encounters with other whales. But this is something we really hope to explore in the future.

Interviewer – Edward Hurme
So looking at menopause, it's a natural event that we see in humans and also now in killer whales after they reach a certain age. Are there any other animals in the animal kingdom with this pattern of a long post-reproductive lifespan?

Interviewee – Emma Foster
Biologically speaking, menopause is a very bizarre concept, and very few species have a prolonged period of their lifespan where they no longer reproduce. There's some evidence to suggest that this may occur in pilot whales; however to the best of my knowledge, that's the only other example, aside from humans and killer whales. The thing that all three species have in common is they all have incredibly stable social structures. So humans lived in the same villages and had very strong family units. Killer whales have this strong matriarchal society where there's no dispersal. And pilot whales have quite a stable social structure as well. So that is able to facilitate helping.

Interviewer – Edward Hurme
So you also touched on this earlier, but what are some of your next steps for understanding what's going on in killer whale societies?

Interviewee – Emma Foster
I think this is a really exciting question, and it's definitely a really exciting area to be involved in at the moment. And the menopause remains one of nature's great mysteries. And we're very lucky to be working with a fantastic data set which spans four decades. And this has allowed us to make exciting breakthroughs in the evolution of menopause. The current paper that we're just having published is part of a much larger project which aims to look at the mechanisms underpinning this prolonged female post-reproductive lifespan. And what we really want to focus on next is exactly how mothers are helping their sons. So really start to get a grip with what they're doing to help increase their survival.

Interviewer – Edward Hurme
Well, Emma Foster, thanks for talking with me.

Interviewee – Emma Foster
Thank you very much.

Host – Sarah Crespi
Emma Foster and colleagues examined the influence of long-lived female killer whales on their male offspring in this week's issue.

Music

[09:19]
Host – Kerry Klein
Six thousand people helped discover the Higgs boson, but it's only named after one person: Peter Higgs, a physicist who theorized about the particle in the 1960s. So if the discovery of the particle wins a Nobel Prize, he takes it home, right? Well, as it turns out, Higgs was neither the first nor the only scientist to predict the particle's existence, making the Nobel committee's decision all the more difficult. News Writer Adrian Cho has the story of just who was involved in the discovery of this elusive particle.

Interviewee – Adrian Cho
The discovery of the Higgs boson, some physicists will tell you, is the biggest thing ever to happen to particle physics. It's certainly the biggest discovery in the last 30 years in particle physics. And it seems entirely likely that the Nobel Committee will at least consider giving the Nobel Prize to the theorists who predicted it. This is all the more likely, given that the two teams of experimenters that discovered the thing number 3,000 members apiece, so picking three – there can be no more than three winners – out of 6,000 would seem an almost impossible task. So it would seem much easier to give the prize to the folks who predicted this thing theoretically, but it turns out that there are five of those people, and there's a real issue of who amongst the five should get the credit.

Interviewer – Kerry Klein
Well, the boson itself is named after a physicist named Peter Higgs. I would think that maybe he would be a shoo-in for the prize.

Interviewee – Adrian Cho
I think that that's the sentiment shared by many people. Certainly, Peter Higgs, who's a theorist at the University of Edinburgh, played an essential role in all of this. But it's also true that there were two other groups who came up with basically the same idea. And in fact, Higgs was not the first person to publish this idea. That honor went to two researchers from Belgium – François Englert and Robert Brout.

Interviewer – Kerry Klein
Aha! So part of the puzzle here is in figuring out amongst this group of scientists just who did what and when. So let's start with Higgs. What was significant about what he found back in the 1960s?

Interviewee – Adrian Cho
To understand what Higgs did, you have to really understand the problem that they had and that needed to be solved, right? And basically this comes down to an issue in the so-

called standard model of particle physics, which is this theory of all the particles that we know. And this theory was bolted together in the ‘60s and the ‘70s. But a key element of this theory is the fact that forces – like the electromagnetic force or the strong force that binds the nucleus – they’re carried by force-carrying particles called gauge bosons. So the photon is the gauge boson that carries the electromagnetic force. A particle called the gluon carries the strong force. A fellow named Sheldon Glashow put together a theory that incorporated both the weak nuclear force and the electromagnetic force, and assumed that they were carried by these particles called gauge bosons. There was one problem with this theory, which was that those gauge bosons had to be massless. There was no way to make the theory make sense if they had mass. It would go mathematically haywire. But people knew that the weak interaction had to be very short-range. That meant that the gauge bosons that carried the weak force had to be very massive. And Peter Higgs and five other people were the people who found a way to explain how these gauge bosons that carry the weak force can get mass without blowing the whole theory up. So that’s where the mass element comes in.

Interviewer – Kerry Klein
But as you state in your article, Higgs and his colleagues may have solved one problem, but they still didn’t really see the big picture of what these bosons – about what the Higgs boson – actually achieved. So what was he missing?

Interviewee – Adrian Cho
So how Higgs and these other folks came at it was they were thinking about something entirely different. They were thinking about a thing called spontaneous symmetry breaking. And spontaneous symmetry breaking is the kind of thing that happens when the lowest energy state of some physical system has less symmetry than the internal dynamics of the system has. So that sounds very, very complicated, but here’s a way to explain it. Suppose you have a round-bottomed bowl and you stick a marble in it. The marble will settle right in the middle, and that’s the most symmetrical part of this round-bottomed bowl, right? And so the symmetry is maintained. But suppose that instead of a bowl, you’ve got like the bottom of a wine bottle that’s got this raised punt in the middle. Then the marble will roll down off the hill in some random direction, and it will break the symmetry of the situation, so that the wine bottle bottom is still symmetric, but in settling into the lowest energy state, the marble breaks that symmetry.

Interviewer – Kerry Klein
Right.

Interviewee – Adrian Cho
And Higgs was thinking about this. Lots of people were thinking about this – you know, maybe this could be applicable to particle physics, because it turns out you can explain things like superconductivity as a form of spontaneous symmetry breaking. You can explain magnetism and magnets as a form of spontaneous symmetry breaking. So there was this hope that it would be a new tool for particle physics. But this guy, Jeffrey Goldstone, who’s now at MIT, proved something about spontaneous symmetry breaking – or it appeared to – that said that if you do this, you’ll end up with all these massless

particles flittering, you know, hither and yon. And since there aren't lots and lots of massless particles cruising around the universe, this seemed to suggest that spontaneous symmetry breaking is not really applicable to the real world. Enter Higgs and company. And what they did is they looked at the exact same model that Goldstone had looked at, but they realized, hey, what Goldstone doesn't put in this are these sort of force-carrying particles. And they say, "Okay, well what if we do that, right?" What if we add these force-carrying particles – these so-called gauge bosons. And it turns out that if you do that, two really weird things happen. First thing is that all the little massless particles that were running around in Goldstone's model disappear – they evaporate. And the other thing is that the force-carrying particles in your theory all of a sudden gain mass. So when these guys did this – Higgs and these five other people – at some level, their real interest was to show that you could get rid of all these massless particles that the so-called Goldstone theorem said had to exist, right? What they missed was the fact that they had now found a way to give mass to force-carrying particles, and that would be the key step in bolting together the standard model.

Interviewer – Kerry Klein
So that may sum up Peter Higgs's contribution to the standard model, but you mentioned that there are other possible contenders for the Nobel here. So who are they, and what were their roles in all of this?

Interviewee – Adrian Cho
So Higgs was not the only guy to come up with this idea. In fact, there were three groups that basically all had the same idea at roughly the same time. And the first people to spell out this mechanism for giving mass to force-carrying particles was the duo François Englert and Robert Brout of the Free University of Brussels. Then Higgs followed. And then there was a team of two Americans and a Brit – the Americans being Gerald Guralnik and Carl Hagen, and the Brit being Tom Kibble of Imperial College London. And they all basically had the same idea. The details of their paper are somewhat different, but they all came up with the same basic mechanism for giving mass to force-carrying particles. But none of them actually figured out that what this was good for was to give mass to the particles that carry the weak force, right? And that fell to a fellow named Steven Weinberg, who is now at the University of Texas Austin, and a Pakistani physicist, Abdus Salam, who died in 1996. And Weinberg and Salam, along with Sheldon Glashow, shared the Nobel Prize in 1979 for putting this theory together. At the same time, there's this issue of whether or not these six people actually predicted the thing that you call the Higgs boson, because, you know, the real Higgs boson – the one with all the properties that have been so precisely predicted and, you know, appeared to be verified in the experiments – the real Higgs boson comes out of the theory of Weinberg, Glashow, and Salam.

Interviewer – Kerry Klein
So we have all of these scientists, all with partial contributions to, you know, the idea that we now know as the Higgs boson. So who do you think the frontrunners are for the Nobel? Is it too early to tell?

Interviewee – Adrian Cho
Well, people tend to think that Higgs is a shoo-in, in part because in this crazy mechanism whereby there's this field in the vacuum that's giving mass to the force-carrying particles, that field in the background is itself made up of quantum particles, which are kind of hidden in the vacuum. And those particles hidden in the vacuum are, in fact, the Higgs boson. And Higgs was the only person in the 1964 papers to mention that this field would be made up of massive bosons. And so a number of people have told me, well if you need to find a way to make a distinction, you can make this distinction that Higgs was the only guy to say "and this field has to be made up of quantum particles," and that quantum particle is the thing that they were looking for. So people seem to think that Higgs is pretty much a shoo-in. People say that Englert has a real shot at this because, in fact, he was the first guy out with this basic physical mechanism to give mass to force-carrying particles, which is now called the Higgs mechanism. There seems to be some sentiment out there that Guralnik, Hagen, and Kibble were simply too late, but obviously they see things differently. It's also entirely possible that they could try to pick somebody out of these two teams of 3,000 people apiece to give the Nobel Prize for the actual experimental work that discovered it, but that seems like an even harder challenge.

Interviewer – Kerry Klein
Well, I am sitting at the edge of my seat. Adrian Cho, thank you so much.

Interviewee – Adrian Cho
It's my pleasure.

Host – Kerry Klein
News Writer Adrian Cho asks the question, "who invented the Higgs boson?" in a News Focus this week.

Music

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[19:17]
Host – Sarah Crespi
Ordinary items around the lab can be extraordinarily expensive. Some with good reason, like specialty devices built for specific experiments. I spoke with Joshua Pearce about the do-it-yourself, or DIY, lab movement that uses 3-D printers to create common and uncommon tools.

Interviewee – Joshua Pearce

As we take the process of development that has succeeded in open source software and apply it to hardware, an opportunity has arisen to radically reduce the cost of experimental research in the sciences. Specifically, the combination of open source 3-D printing and microcontrollers running on free and open source software enables the development of powerful research tools at unprecedented low costs. We are on the verge of a new era where low-cost scientific equipment puts increasingly sophisticated tools into the hands of the public and amateur scientists throughout the world, while driving down the cost of research tools at our most prestigious laboratories.

Interviewer – Sarah Crespi
In your Perspective, you talk about a solution to this problem that's grown out of the open source software movement. How does that fit in with this?

Interviewee – Joshua Pearce
The free and open source software movement has really established itself as a superior method of making software code, and the trick, or the secret, behind it is just that you have a lot of people collaborating. You have a large team working to innovate together. And that same trick can be applied from open source software to now open source hardware where you're sharing digital designs. And you're getting lots of people to comment and to make improvements that we can all build off of.

Interviewer – Sarah Crespi
And so what do you do with these digital designs? How are they used?

Interviewee – Joshua Pearce
One of the most powerful tools that has come out of open source hardware is the Arduino microcontroller. And this is an open source microcontroller that's very easy to program and learn how to use, and they're relatively inexpensive to purchase, so you can buy one for, say, $20. And from that, people have made all different kinds of scientific tools – from the ArduinoGeiger, which is a radiation detector, to a pHduino, which is a pH meter. They've made oscilloscopes for electrical engineers and OpenPCR to do DNA analysis. But the most powerful tool that's kind of come out of it is the open source 3-D printer. And so you can use an open source microcontroller – sort of the brain of the machine – to make additive layer manufacturing, where you lay a 2-dimensional surface down – a melted plastic usually – and then move up a fraction of a millimeter and lay down another layer, and continue to do that until you've built up a 3-dimensional object. And you can take then the designs – the digital designs – either a CAD, or an open source code – like a computer code – to make a 3-dimensional object that then anybody else can replicate anywhere in the world. And the beauty of this is that the first person to make an open source 3-D printer also made it partially self-replicating. So the RepRap can print to 50% of its own parts today, and it continues to evolve into this open source paradigm so that today's version is better than the one last week, and will continue to do so indefinitely until we have it down.

Interviewer – Sarah Crespi
Alright. So besides printing itself, what other kinds of things can this 3-D printer make?

Interviewee – Joshua Pearce
Okay. So for scientists, it can do all the simple stuff in, say, a typical chemistry lab – bio racks or a Buchner funnel. They can do microwell plates for doing little tiny test tubes. It can also be used to print customized reactionware. And this is an area of chemical research that we haven't really looked into yet because we didn't have the capabilities. And so now you can use the geometry of the design or the ability to embed catalysts inside the actual reactionware and you're printing those designs. And so that means you can change the CAD very quickly on the computer, and then print out another set of reactionware to test a new chemical process.

Interviewer – Sarah Crespi
So what you're talking about there is very specifically shaped vessels so that you can have chemical reactions occur on tiny scale in a certain order?

Interviewee – Joshua Pearce
Correct. And in a way that maybe hasn't been tested yet. And so you could test a whole new bunch of them very quickly to get access to new chemical species that you haven't looked at before. Then it can be combined with things that, say, you can buy in the hardware store. One of my favorites is the DremelFuge. So you take a Dremel, which is just a high-speed drill that you probably already have in your home, and you can print out a chuck for it that can hold little vials so that you can create a centrifuge. And this is high-quality. It has excellent rpm and g-values for basically a cost of the drill. So for about $50, you can have yourself a high-speed centrifuge that would normally cost several hundred.

Interviewer – Sarah Crespi
But that kind of brings up some of the limitations that there might be about this technique is that there's precision, and then there's how sturdy something is, and those kinds of things. Is that going to be a problem when you're printing your own equipment?

Interviewee – Joshua Pearce
Yes, to some degree. So for some applications, I would say that the printers aren't there yet – the open source versions. We have the ability to print in all different kinds of plastics. The most common are ABS and POA. So ABS is sort of like what you make Lego blocks out of. But we can also attach a syringe to the printer and start to print in things like silicones, or any type of paste material, or even ceramics that you then fire later. So you can get very close to the same capabilities that you could through another manufacturing process, but in general, these low-cost kind of RepRap printers that cost less than a thousand dollars to make can't get really high tolerances, or really fantastic material and mechanical properties. This is an evolving process. Right now we're kind of at the hacker stage. So you have to be willing to mess around with things a little bit in order to get them to do what you want.

Interviewer – Sarah Crespi

And so you also mention that there's a way of depositing these tools and making them available to all. What kinds of things, what kind of recipes can you find on the site?

Interviewee – Joshua Pearce
Well, Thingiverse is probably the largest site for sharing of digital designs of real physical objects. I just checked this morning and there's over 30,000 things available. And they range from art and toys – and little toys like Lincoln Logs to very complicated toys like Quadcopters – household items, learning items. But kind of most interesting to scientists are scientific equipment and tools. And that is a small but growing rapidly area of interest in this kind of DYI design community.

Interviewer – Sarah Crespi
So have you made anything for your lab using this technique?

Interviewee – Joshua Pearce
Oh, absolutely! One of the biggest success stories in my lab, we took a design for an open source laser cutter that a Canadian had worked on, and we turned it into an open source laser welding system. And for that specific line of research, we're looking at microchannel polymer heat exchangers. And nobody's really looked at this yet, and so it's kind of a wide-open design space. And we needed a way to be able to make prototypes very quickly. And the first prototype that we ever got working, we actually used a German firm, and it cost us thousands of dollars to make a single heat exchanger. Well, now we can make one an hour using this open source tool. And because the original design had a Creative Commons license on it, that indicated that we had to share any designs that we took and share it back to the community. We shared ours back to the community. So now anyone in the world that wants to replicate what we're doing with polymer heat exchangers can very easily do that. And so this saved us thousands and thousands of dollars on, you know, having someone else do the prototypes for us, but also in the design time itself, because the Canadian had already done all the mechanical work on it. We changed the electronics and a small amount of the mechanics, so we had to make a couple new prints. But our design time was much lower. And so now we're saving literally, I mean, we're printing some out now, so we're saving thousands of dollars. We've also done a whole big bunch of stuff in our lab concerning optics. We primarily look at solar photovoltaics, so we've printed out everything from lab jacks to optical filter wheels to chopper wheels, sample holders, lens holders, mirror mounts – anything that would be useful for our lab that we would need anyway. In each one of those cases, we're decreasing the cost by sometimes, say, $25 for a simple lens holder, but sometimes it can be quite substantial.

Interviewer – Sarah Crespi
Wow! Whenever we talk about sharing and free software, and all that kind of stuff, it brings up the question of copyright and patenting. Is that something that you have to consider when you look at what's been deposited in Thingiverse, or other places like that?

Interviewee – Joshua Pearce

To date, the things that have been put on Thingiverse have been designed by either other scientists or hobbyists, and so they're normally under some sort of Creative Common license, which means that you're allowed to print and use it for yourself. And at some point, we might run into trouble, but I know for at least on the open source 3-D printing side of things, any additive layer manufacturing patents that would infringe on it have long since gone out of date. And so what we're basically doing is building up a separate repository of open source designs. Like that's what the US Patent Office is, only in their case, they have sort of like a 20-year backlog. In this case, everything is instantaneous. And so just as an example with that lab jack - that lab jack is basically like a car jack, only it's much smaller and a little bit more precise. In our case, we want to use it to move a sample up and down very precisely in front of a laser beam. And we'd gotten a quote for one that was a thousand dollars. And that seemed abhorrent to me for something that's so simple. There's cheaper versions that are available on the web for a few hundred, and even some really kind of questionable quality ones down to about $25. So we designed one that could be printed from scratch. So it's not like any of the other ones, because that wasn't a design consideration they were putting into it. But as soon as I posted it, within an hour someone from Finland had made recommendations for how to make it a little bit better. And so we, of course, made the alterations, now so we have a superior lab jack to the one that my lab was capable of designing, because we had help from someone that we'd never met and is completely unaffiliated with our lab. And that will continue to happen. So dozens of people have said they like the lab jack because they're going to be using it presumably for their own work and altering the shape or the conformation or how it's attached to it for their own applications. And so every day the technology behind that open source lab jack gets better.

Interviewer – Sarah Crespi
Great. Alright, Joshua Pearce, thanks for talking with me.

Interviewee – Joshua Pearce
Thank you very much, it's been a pleasure.

Host – Sarah Crespi
Joshua Pearce is the author of a Perspective on a new source of lab equipment in this week's *Science.*

Music

[28:56]
Interviewer – Kerry Klein
Finally today, I'm Kerry Klein and I'm here with news writer Carolyn Gramling, filling in for David Grimm, and she's here to give us a rundown of some of the recent stories from our daily news site. So Carolyn, in our first story, we are talking about a creature that we love to make fun of.

Interviewee – Carolyn Gramling

Yes. When people think of lemmings, they probably think of a giant wave of rodents crashing off of a hillside into the ocean. But, in point of fact, they don't actually commit mass suicide in that way. However, they do have these periodic population booms. These are Arctic rodents, by the way. And so as a result of their population booms, they tend to migrate en masse, and that sort of what gives rise to that myth. So their numbers wax and wane over a four-year cycle. And around the turn of the millennium, scientists noticed that they actually did not have their expected population boom in their habitat in northeastern Greenland, and so they were interested in why this was the case. They believe that that's due to changes in their habitat due to global warming. But the thing is that lemmings are actually a popular prey for a lot of Arctic predators, and low lemming numbers, therefore, actually have a really significant impact on those predators also. So it spells big trouble for the predators, such as, for example, stoats and a type of seabird known as a skua.

Interviewer – Kerry Klein
Okay.

Interviewee – Carolyn Gramling
It spells big trouble for them because their prey is vanishing.

Interviewer – Kerry Klein
That's right.

Interviewee – Carolyn Gramling
So a lot of them are potentially going – locally, at least in these regions in Greenland – maybe going locally extinct.

Interviewer – Kerry Klein
So what does this mean for these predators? Is there any chance of them bouncing back?

Interviewee – Carolyn Gramling
Well, one of the things that they're looking at now with some of the predators is, you know, whether or not they're able to prey switch. And that's also a big issue. Some of them are, some aren't. The ones that are, they might be switching their prey to more migratory birds, for example, but of course then that becomes a problem for the migratory bird populations. So it's very interesting because ultimately the point is that the plight of the lemmings is actually felt throughout the entire Arctic ecosystem.

Interviewer – Kerry Klein
Indeed. We can add this to the list of new patterns emerging as climate change continues.

Interviewee – Carolyn Gramling
Yes, indeed.

Interviewer – Kerry Klein
Okay, and in our next story, we're talking about a highly anticipated dengue vaccine.

Interviewee – Carolyn Gramling
Yes. This is something that scientists have been very eager to develop. They're looking for a new vaccine for dengue fever, which is an infectious tropical disease that affects about 100 million people – mostly children – worldwide. And this is a disease…

Interviewer – Kerry Klein
And that's every year.

Interviewee – Carolyn Gramling
And that's every year, yes. And that is a disease that is caused by a virus and is spread by mosquitoes. And the trick is with dengue that there are actually four variants to this disease – to the virus – and right now, of course, there are no approved vaccines for it. But any ideal vaccine is going to be both safe for the vaccinees, and also will protect against those four variants.

Interviewer – Kerry Klein
And so these were the first clinical trials for a new dengue vaccine. Clearly there's a high demand for it. How did the trials turn out?

Interviewee – Carolyn Gramling
Well, there are sort of mixed results. So what they did in these trials was they tested more than 4,000 children in Thailand, splitting them into control groups and into vaccination groups. And what they found was that while the vaccine was fairly effective against three of the types of virus, of dengue virus, it actually did not at all protect against the fourth type, which also happens to be the type that is responsible for the most severe illness in the world and is also currently circulating in Thailand.

Interviewer – Kerry Klein
So it's not quite accurate to say that the vaccine is 75% effective.

Interviewee – Carolyn Gramling
No, not exactly. They do really want something that is going to be able to prevent against all four, because incomplete protection could actually be very dangerous for the vaccinees. So what they're trying to do now is they're actually testing the vaccine in 10 different countries around the world among 31,000 people, and those results we won't actually see until 2014. So they're not yet able to say what's going to come next with this vaccine.

Interviewer – Kerry Klein
Well, alright. And our third story today sheds some light on bioluminescence.

Interviewee – Carolyn Gramling
Yes. Bioluminescence is something that is very common to a lot of different marine species. They use it often to find mates, or to also find food, or as a way of avoiding

predators. So we've known that a lot of floating creatures exhibit bioluminescence – this light that they emit.

Interviewer – Kerry Klein
And so we do already know a lot about bioluminescence. What's new in this story?

Interviewee – Carolyn Gramling
Well so these researchers were actually interested not just in looking at the kinds of creatures floating in the ocean that show bioluminescence, but what creatures on the sea floor bioluminesce. And this is something that has been a lot less studied. So they were looking for organisms, such as sea anemones, coral, shrimp, crabs, that sort of thing that crawl around on the sea floor – so-called benthic organisms.

Interviewer – Kerry Klein
And so what did they find?

Interviewee – Carolyn Gramling
What they found was that actually about 20% of these species do show bioluminescence, and that was higher than they originally expected. But what's also really interesting was not just how many of them showed it, but how often they glowed. And what they thought was that this might have to do with what actually prompts them to bioluminesce. That has to do with how often they actually bump into other objects. Usually these creatures would start to glow when you touch them. What they hypothesize is that creatures floating in the ocean actually don't bump into other objects very often, so that doesn't prompt them to glow. But the creatures crawling around on the sea floor, they're going to hit other creatures, or bump up against corals, or be jostled by other objects, and so that causes them to glow quite often.

Interviewer – Kerry Klein
And so this sort of addresses the bioluminescence paradox, if you will, that there are fewer creatures that bioluminesce towards the bottom of the ocean, but that they luminesce more because of this proximity.

Interviewee – Carolyn Gramling
Yes, exactly.

Interviewer – Kerry Klein
So the title of this story actually includes vomiting shrimp. What role do these vomiting shrimp play in this story?

Interviewee – Carolyn Gramling
Yes, well, so one of these benthic creatures that it turns out bioluminesces quite a lot has a very unusual way of doing it. It actually vomits these bioluminescent chemicals into the water around it, and that is how it exhibits this trait.

Interviewer – Kerry Klein

Wow! Well I am going to have to get myself out to the tropics to see these first-hand. Alright, so what else have we had on the news site this week?

Interviewee – Carolyn Gramling
Well, on *Science*NOW this week, you can find out about how scientists have helped deaf gerbils hear again using stem cells; how a Facebook message influenced the elections in 2010; and how a cliff-dwelling plant is using ants to help it reproduce. And also on our policy blog, *Science*Insider, you can learn all about the Golden Goose Awards, which are for researchers who pursue oddball topics that turn out to have actual health or economic benefits. And finally, next week on *Science*Live, you can chat with experts about whether eating less can actually make you live longer. You can check out all of this and of course a lot more on our Web site, news.sciencemag.org.

Interviewer – Kerry Klein
Great. Thanks, Carolyn.

Interviewee – Carolyn Gramling
Thank you.

Interviewer – Kerry Klein
Carolyn Gramling is a news writer for *Science*. You can check out all of our news at news.sciencemag.org, including daily stories from *Science*NOW and science policy from *Science*Insider. While you're there, be sure to check out *Science*Live, a live chat on the hottest science topics every Thursday at 3 p.m. U.S. Eastern time.

Music

Host – Sarah Crespi
And that concludes the September 14th, 2012 edition of the *Science* Podcast.

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

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

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

Music ends