Ask A Biologist Vol 070 (Guests Peter and Rosemary Grant)

Learning from Darwin's Finches

What happens when you mix part Robinson Crusoe and Swiss Family Robinson with biology? You get an adventure that has filled many lifetimes (bird lifetimes). Dr. Biology had the opportunity to sit down with **Peter and Rosemary Grant** to talk about the more than 30 years they spent studying what have come to be called Darwin's finches.

Transcript

Dr. Biology: This is "Ask A Biologist," a program about the living world, and I am Doctor Biology.

I can still remember my trip to the Galapagos Islands even without looking at the thousands of photographs I took during my stay. And even though my trip was short, I felt the same way as many visitors have felt. These Islands are unlike anything I have seen before.

As I visited each island, I wondered who was really watching whom? The animals, especially the Marine Iguanas, stacked alongside and on top of each other; as if in the bleachers of some stadium or seats of a theater watching the players Me, walk by, dressed in my colorful yet unmatched clothes, and wearing a large floppy hat to protect my head from the sun.

My stay at the Galapagos Islands might have been short, but my guests today, Peter and Rosemary Grant, have spent many lifetimes, that would be bird lifetimes, studying the famous Darwin Finches. Their research on the tiny island of Daphne Major has a touch of Robinson Crusoe and Swiss Family Robinson, especially with the Grants' two daughters being part of the story.

I'm not the first to feel this way, in fact, the two biologists are the subject of a Pulitzer Prize-winning book The Beak of the Finch by Jonathan Weiner. The two scientists have added to their impressive list of honors, the Kyoto Prize in Basic Science.

For those that don't know what the Kyoto Prize is, it's a Japanese award similar to the Nobel prize recognizing outstanding work in the areas of Philosophy, Arts, Science and Technology. I want to welcome you, Peter and Rosemary Grant.

Rosemary Grant: Thank you.

Peter Grant: Thank you.

Dr. Biology: How long did you really spend researching Darwin's Finches on the Galapagos?

Rosemary: We started in 1973 and we've been back every year. We go back for about three months on average. Once it was as long as six months and it's usually never shorter than two months. Three or four months is usually the average time that we go there.

Dr. Biology: Three or four months.

Rosemary: Every year. Since 1973.

Dr. Biology: Since 1973? Wow. When you say you go back, it's one of the tiny islands called Daphne Major?

Peter: That's right, but we don't always go to Daphne Major. Sometimes we go to other islands as well. I don't think there's been ever a year when we've not gone to Daphne, but there have been years when we've scarcely visited the islands and spent much more time on another island on the northeastern part of the archipelago called Genovesa where we did a long term study on the Darwin Finches for eleven years.

Dr. Biology: Daphne Island, when I read the description of it. It doesn't sound like much an island to me. I went to the map, and I hate to confess, but I couldn't find it on the map.

Peter: On the maps that we use to illustrate the work that we've done, is no bigger than a dust speck. It's three quarters of a kilometer long, about half a kilometer wide, and a 120 meters high. It isn't a very big island. It's a very steep, sloped island with a crater in the middle and it's not the sort of an island that you would pick for a holiday.

Dr. Biology: What does it look like?

Rosemary: Somebody has written a poem about it and they described it as a barnacle. Really what it looks like is the top of a volcano just sitting above the surface of the sea.

Dr. Biology: Just barely. What's it like to live there for three months. Do you have running water?

Rosemary: No. We take all our water with us. It's because if there is no water on the island, we take every drop of freshwater with us. We take all our food. We've got to be extremely careful to wash everything.

We live in tents so we've got to make absolutely sure that the tent is washed and all our clothes are washed, all our equipment is clean, because we must be very careful not to introduce any insects or any seeds, anything on the island. For example, we cannot take any fruit that has seeds in, because there's a possibility that those seeds will grow.

Dr. Biology: Right, it would be an introduced or an un-invasive species even.

Peter: Boots have to be checked. Socks have to be checked, before we get off the boat and onto the island for exactly that reason.

Then when we have fresh vegetables and there is very little that we can take to the island, limes are one item that we are allowed to take onto the island. They go into the water when we arrive. Get washed, scrubbed, put in a bucket and carried up to the top of the slope.

Bananas are the same. We take half a head of bananas and dip that in the water, swish it around, get rid of all insects, if there are any. Typically there are none because the bananas have been washed back at the research station on the other island where we work.

Rosemary: We should say that the limes have no seeds in them.

Peter: Yes, that's right.

Rosemary: Those are the ones that we're allowed to take.

Dr. Biology: That would make sense and is it possibly because they have vitamin C or is it just because you like limes?

Rosemary: No. It's just because it's the only fruit that we can take. There is no choice.

Dr. Biology: That makes sense. We're going to be talking about evolution and this is in an area filled with wonder and in many cases misunderstanding. For example, most of us have been taught that it takes a really long time for evolutionary change to occur. I'm not talking about those long car trips when we were kids and it seemed like it took forever to get there.

What I'm talking about are things that take hundreds or thousands of years, even millions. Your research actually shows that evolution can happen in pretty short periods and that's if you can consider 20 or so years short. When you started your project did you have any idea that you'd be able to see evolution in action?

Peter: No. We didn't. At least not on the magnitude, not on the scale that we have seen it. It's not that it was out of our minds.

I'm sure thinking back to 1973, we would have been speculating that maybe once in a while it is possible that there will be a very slight, small evolutionary change in the population, if weather changes and the food supply changes. We had no real conviction that this would happen on anything like the scale that it really has occurred over the last 30 plus years.

It occurs in a very short space of time. It's not a matter of evolution taking 20 years before it can be observed. Rather, when the weather changes and we have either a very wet year or a very dry year and the vegetation changes, the conditions for the birds alter.

Then when a drought sets in, after a period of production of seeds and insects and it becomes difficult for the birds to find enough food, that is the time, the crunch time when

finches are subjected to pressures only few of which can withstand them and that is the time when natural selection occurs and evolution occurs in the following generation.

Really we're talking only in terms of about a year or maybe two at the most for evolution to take place on the scale where it can actually be measured.

Dr. Biology: What were you measuring?

Rosemary: The first time we measured it, there was drought, a very severe drought. More than 80 percent of the birds died on the island and there was a large variation in beak size.

On the island, in the soil on the ground there were large hard tribulus seeds [*Tribulus terrestris*]. The birds with the small beaks could not crack those tribulus seeds. They eventually stopped and died. The birds with the very biggest beak were able to crack those large, hard tribulus seeds and they were the ones that survived.

At the end of that drought, which took a year, there were a few birds left on the island and they were all the large birds with the large beaks.

Dr. Biology: We saw them change or we saw those evolutionary change or survival of the fittest. Is that good time, because you hear that a lot and that's not necessarily correct?

Rosemary: In some ways survival of the fittest is not a very good term because most people think that fit means, the ability to run around a racetrack or something like this. In biology it's more used, the ones that actually are capable of surviving. The next year, which was what happened in this case, those birds were able to breed and produce young and those young were large like their parents.

This is because often small parents will produce small children and very tall parents will produce very tall children. It's exactly the same with the birds. Those with large beaks will produce large young with large beaks and those with small beaks will produce small young with small beaks.

What we saw was this change in average beak size in the population, which is natural selection and the evolution was what happened the next year when the young grew up to be the same as their parents.

Dr. Biology: Instead of the survival of the fittest, it's the survival of the ones with the best set of tools to survive.

Rosemary: To survive, yes.

Dr. Biology: It would be the beaks this time for these.

Rosemary: Yes.

Dr. Biology: Then the rains do come back as they do. What happens then?

Peter: Then the survivors breed. They produce young as Rosemary just explained, that they're like themselves. The beak size of the finches is inherited. Their offspring, the children inherit factors or characteristics of the mothers and the fathers that produce them. They also are large.

The evolution that has taken place then is one of a shift in the average beak size from the parental generation before natural selection occurred, before any of the members of that population age group died, all the way through to the next generation. That is the measure of evolution.

Biologists use the definition that evolution is a change in genetic characteristics of a population from one generation to the next.

Dr. Biology: It can go both ways there?

Rosemary: It can go both ways and we actually have seen it go the other way too. Nothing really happened for many years, then we had an enormous El Nino year. That is a year when he had an enormous amount of rainfall. The rain lasted for eight months and the birds bred every month for eight months.

Those plants that were producing the large hard seeds got smothered and other plants grew up, which produced small soft seeds. Then after that, when the next drought came, we again had large numbers of birds die. Now in the ground were a lot of small, soft seeds and this time it was the large beaked birds that died and the small beaked birds that survived.

Dr. Biology: We know that the small beaked birds are the ones that survive.

Rosemary: When there were small soft, seeds.

Dr. Biology: If I'm sitting in the classroom, and I'm getting this lesson from Rosemary and Peter Grant, I'm along with this ride in the Galapagos. It's great, but, if all the birds that had, in the first round, the small beaked ones died and I only had a large beaked ones, then the conditions changed. Where do you get the small beaked ones to start up again?

Peter: Not all of the small beaked birds died, when the large beaked birds had the survival advantage in the first drought. There were still some small beaked birds left. They bred, and, gradually, their numbers increased in the population.

When the next drought occurred, and small beaked birds had an advantage over the big beaked birds, there were quite a number of small beaked birds, as well, of course, a large number of the large beaked birds.

Dr. Biology: When we talk about Darwin, and if you read a little bit more about Darwin, when he went to the Galapagos, first of all, the whole trip he took was five years. The thing that really amazes me is he is basically seasick the whole time. I'm impressed that

anybody could take good notes and do some good drawings, but he collected the finches. Even he didn't know what he had.

What got him to look at his specimens, when he returned?

Peter: He handed his specimens over to an expert, at the British Museum, a man called John Gould, who compared them with a lot of other specimens of other birds collected in South America beforehand.

Then, he gave the verdict to Darwin in 1837 that they were all members of the same group and that they weren't, as Darwin had previously thought, in some cases related to blackbirds, in some cases, related to warblers, and, in other cases, related to finches. Nope. They were all of one group and that made Darwin really sit up and take notice.

Dr. Biology: Wow. When you talk about your research, and there's so many years worth of research. I read a little bit in the book about going out and capturing the birds. As tame as I thought a lot of the animals were, especially the iguanas, the iguanas were amazing to me, but these finches some of them are pretty tough to get.

How do you capture your finches and when you capture them what are you measuring?

Rosemary: We capture them in mist nets. These are nets made in Japan. We put those nets up very early in the morning, usually, just before it gets light. Then, we catch the birds. Then, we take the birds out immediately, when it's still cool, so that they aren't harmed at all.

Then, we measure them. We measure their bill length, their bill depth, their bill width. We measure the length of their legs, the length of their wing. We weigh them. We also take a tiny little bit of blood, and that's enough for us to get DNA out of that blood, so that we're able to do the genetics on the finches.

Dr. Biology: How many birds have you done this with over the years?

Rosemary: I can't tell you how many, but thousands.

Dr. Biology: In one of the Ask a Biologist shows, we talked about bats, bones and biology. Of course, when you do a show like that, you have to include vampire bats. What I didn't know is there’re vampire finches?

Rosemary: Yes. This, again, in the droughts in the dry years, and this bird - it belongs to a member of a species, which is called the sharp beaked ground finch, and it occurs up on Wenman Island, during the drought, there were no seeds or very few seeds on the ground. There is very few nectar in the flowers that do flower during the drought like cactus.

What they do is they resort to jumping on the back of sea birds, pecking at the base of the feathers, pecking at the base of the tail, and drawing blood. We think that this habit probably arose, because they were pecking out little flies, Hippoboscidae flies, which

suck blood from the seabirds. By going straight to the blood source, they are bypassing this.

Dr. Biology: There's also one that's a vegetarian. I'm a vegetarian. There is one there I think is my favorite is the one that actually makes tools with its beak.

Rosemary: Yes.

Dr. Biology: Can you talk a little bit about that finch?

Peter: The woodpecker finch makes his own tool for extracting the bee larvae that are inside a dead or rotting wood. What they do is, they pick either a twig or a cactus spine or even the long stalk of a leaf. They trim it down, whatever it is. They trim it down to a size about twice or three times the length of its own beak. They hold it slightly crosswise, but pointing forward and probe it into a hole to tease out the insect larvae on the inside.

We think one of the interesting things about that peculiar, unique behavior is the question still not satisfactorily answered, whether there is any genetic predisposition of some to feed like this and others not to. Because it is known that in some times of the year, in some places, it's much easier to see the tool using habit than in other places on the same island.

Dr. Biology: I picked my favorite finch. Do either of you or both of you have your favorite finch?

Peter: We're not allowed to have favorites.

[laughter]

Peter: From time to time, Rosemary has had favorite individuals. One was called perfect. It was called perfect, because, in some ways, it was a beautifully designed finch, for feeding in a variety of ways.

I think one of the extra reasons for calling it perfect was that it seemed to have a very good understanding of when I was around, and it would avoid me. When Rosemary was around alone, it would come up to her. There have been lots of other birds with funny habits.

For example, one year, we saw two cactus finches, only two of them, pecking at the tail of lizards. A lizard if it's attacked at the tail end will wriggle its tail very fast, break his tail off and run away, very good defense. Better to lose the tail than to lose the life.

Two finches decided, somehow or other, they managed to discover that the tails could be gained from the lizards by grabbing hold of them and then, eating them. There are lots of other idiosyncratic behavioral tricks that these finches get up to, and, if we have any favorites at all, it's those individuals that display these unusual behaviors.

Dr. Biology: You just wish you could see them learning. What was the trigger you'd love to see that or have you ever seen that?

Rosemary: Actually, yes. You do see them going around together, especially young ones. It's usually the young ones, after they've finished being fed by the parents. Then, they go around, sometimes in groups, and there they copy each other doing things. One would do something, and they'll copy it. There's a lot of copying and trial and error learning that goes on.

Dr. Biology: Was the process of collecting data in the Galapagos a family affair and two daughters went along?

Rosemary: Yes and also we've home-schooled them, on the islands too. When they first came in, they were six and eight-years-old. Then right up to University. Even when they were at the University, they would decide they wanted to come down with us.

They did do their own project. Thalia worked on the dolphin. Nicola worked on the mocking bird. They both worked very well on that and got a publication out of it.

Dr. Biology: You answered my question, but I still am amazed that they decided to go back every year, and I could understand when they were younger but, as they got older...

Rosemary: I know.

Dr. Biology: ...you would think that, "Oh, no. I'm going to go off to -- it's not the Riviera, it's not something really posh.

Rosemary: There's no television.

Dr. Biology: No television.

Peter: No distractions.

Rosemary: No friends.

Dr. Biology: No video games, because...

Rosemary. No.

Dr. Biology: Did you have any electricity?

Rosemary: No. Wait. Not then.

Peter: Not at that time.

Rosemary: Now, we take solar panels, which we use just for charging up batteries and things like that.

Peter: They also had a lot of freedom to read and make observations and do whatever they wanted to do in the way of immersing themselves, as naturalists on that island.

Your earlier question was, "What did they do? Did they help you?" and the answer was, "Yes, they did help us." Putting up nets, for example, requires help. They engage themselves in those activities, but that was a minor component of their total daily activity. They were often doing their own thing. If they weren't doing schoolwork, they were doing their own thing.

Rosemary: I should say that, we didn't force them to, because every year I would say to them, "You don't have to come down with us." No, No, they definitely wanted to come down. Now, they're grown up and have children of their own, and they now say that this is one of the best things that ever happened.

Dr. Biology: You stumbled upon what I think is probably the reason they kept coming back is they weren't doing your work.

Rosemary: No. They were doing...

Dr. Biology: They had their own projects.

Rosemary: Yes.

Dr. Biology: That really is a big difference.

Rosemary: It's very big difference, yes, yes.

Dr. Biology: With over 30 years of experience on the Galapagos and many people have never been there but if you look to the list of where people would like to go that's got to be very high. Is there a story or an event that the two of you can think of that's...

Rosemary: So many. There’s one. This is on the island of Genovesa. This is an island up in the northeast of the archipelago. It is very isolated. You can't see another island from it.

We had two students, who were working on the island. We weren't there, actually, at the time. We had been there. We left, and we left the two students to follow on the work. They were sitting in camp one day, and not a boat to be seen. All of a sudden, a man walks into the camp, carrying a briefcase and a rolled umbrella.

Dr. Biology: This is out in middle of nowhere, right?

Rosemary: This is out in the middle of the nowhere, an uninhabited island, no boats anywhere. They couldn't see anything, and in he walks, with a road umbrella. What had happened was that he was in a lone boat, traveling around the world, in a little lone sailboat. He'd gone to sleep, and the boat had crashed, on the other side of the island.

He had taken his little bag, which had all his precious passport and various things in, and, for some reason or other, he also had his umbrella. He walked around the island. The island is quite large. It's about five miles in diameter.

He walked around and, fortunately, for him, he found students on the island, because they were able to feed him and give him water. He was able to stay there, until a boat came, and they could take him off the island. [laughs]

Dr. Biology: That's a very lucky man and a very interesting one there. I can see this vision. They must have thought they were hallucinating.

Rosemary: Yes.

Dr. Biology: On Ask A Biologist, my scientists never get out of here without answering three questions, and I have the two of you. We'll just trade off here. The first one, pretty simple, to get you warmed up, when did you first know you wanted to be a scientist or a biologist? I'll start with Rosemary.

Rosemary: Before I even knew the word biologist, I was brought up in a small village, in the Lake District, and it's a wonderful little village. It's on the coast. It has carboniferous limestone cliffs, with lots of fossils. Then, behind those cliffs were fells with rare plants and butterflies. I grew up with my mother, hunting for fossils and looking at plants and butterflies. I was always curious about the diversity of animals and plants.

When I got a little bit older, my father suggested that I should read Darwin's Origin of the Species and then, when I was a teenager, I thought that studying genetics would be fundamental to this. I wanted to go to Edinburgh University and study genetics at Edinburgh University. I was one of these weird people who knew, from the very beginning, that I was really interested in plants and animals and the diversity.

Peter: Rosemary married another weird person.

Dr. Biology: Besides you.

Rosemary: [laughs]

Peter: I don't know. I am very weird, in exactly the same way, in that my own interest started at a very early age. My earliest recollection actually is, smelling flowers and catching butterflies with my hand. I was fascinated by natural history, I would call it, as I was growing up and interested in a lot of other things as well.

In fact, I did better in my exam as a 16-year-old at school there, in a couple of other subjects -- mathematics was one, and English literature and language was another -- than I did in biology, but my passion was for biology. When I went to university, I started zoology, botany, and two other subjects, which I had to do. Organic chemistry was one and geology was another.

I didn't know whether I was going to become a scientist until I went to graduate school, became a graduate student. There I learned that one could do research on the topic of one's own choosing and teach. I thought my Gosh, these two activities are just what I love to do, and, if I am qualified to do it, they pay me for it. That's it. That's my career.

Dr. Biology: That's your career. The next one is a little tougher. I'm going to take it all away from you. You have such a great career. I know this is very, very difficult, but I am going all your science away from you, and I am going to take academia away from you. It takes the teaching away, because I know my scientists like to go to the mode of teaching, which is great. I want to stretch you a little bit. I'm going to start with Peter this time.

What would you be or what would you do if you couldn't be a biologist or a scientist? What would you do?

Peter: I'll be a cricketer.

Dr. Biology: Really?

Peter: I had two passions, as a schoolboy. One was biology, as I told you, and the other one was sport. I was almost -- you might say -- keen on anything with the ball running around, tennis, cricket, grass hockey, and soccer. All of those, but the ones in which I did best of all were cricket and grass hockey, and I could have pursued those for a while.

Now at my tender age, I would not be a professional sportsman, but if I'd been thwarted in trying to become a scientist, that's the direction I probably would have taken. I don't know how long I would've lasted that way. Then what I would've done, when I had to retire from sport, gone into something else. Rosemary jokes that it would be acting, because that's the only other thing I can do.

[laughter]

Dr. Biology: All right. I do enjoy that. Cricket. I have to admit that I'm really terrible. I watch the game but I don't get it.

Rosemary: It's so boring. Isn't it?

Dr. Biology: I'm not saying that.

Peter: I did tell you I was a weird person.

Dr. Biology: Rosemary, what were you going to be or what were you going to do?

Rosemary: Mine would either be dancing, which I loved to do, when I was a child or music, some form of music. If you also gave me the ability, it might be music. I'm fond of all sorts of music. It would be either playing an instrument, violin, piano, cello.

Dr. Biology: Very good. You're my first ballet dancer.

Rosemary: [laughs]

Peter: First cricketer.

Dr. Biology: Absolutely, but not the first sportsman. We have quite a few of them would be play second base for some team or others that would be a surfer or a snowboarder professional. That's amazing to me.

The last question is to help those, and I used to say a young person that wants to get into science. In this day and age there are people that decide, I'm not interested in what I'm doing anymore and I have always enjoyed biology. What would your advice be for them? What would you say to them?

Peter: If the person is at school, high school let's say, and being encouraged to go in one direction but really deep down wants to become a scientist, being encouraged may be to go into politics by parents or what else we say, even sport, it's difficult to advise that person to go against parental wishes.

In general, our philosophy is when anybody asks us, I really would like to become a biologist, but I'm just not sure whether I should or not. Our general advice is, go with your heart, go with what ever really motivates you exceedingly strongly.

If you have a passion for studying plants or viruses or anything that is living and you want to become a biologist, then just take whatever course you can at school and at university, as far as you can until the doors come down, and it no longer become possible to pursue that a career option but just go with your passion, go with where your feelings are really strongest. That's my general attitude.

Dr. Biology: Marvelous and the parents won't be upset, I don't think.

Peter: Some are. We've know some parents who've stressed that the budding paleontologist that we had been teaching really should go into law, because that's where the action is.

Thinking of the parents, who are directing their child in one direction, and the child really wants to go in another one, the advice that I would give and again a very general one and not specific to very young people is, "Don't be put off by adversity. Try not to be discouraged, when it does not seem possible or easy to follow one's heart, but to keep persisting, if that is the decision on where the person really wants to go."

Rosemary: Following your passion is the most important, but once you have done that, then I think I would have a few pieces of advice. One would be to get to know a system really well and to read widely around that system. So that what you're reading you can apply to your system.

Then, the other thing which my father used to drive home to me, was always value your exceptions. When you are actually doing an experiment or anything like that, don't come

to conclusions too quickly. Try and be your own devil's advocate and say, "What would it take for me to disprove this and to do this?"

Then the other thing is that when you are doing an experiment or you are following some observation and you see something which doesn't fit, then don't discard it, but follow that has, with us, led us down some very interesting paths and to new discoveries. Value your exceptions is something that I would say as well.

Dr. Biology: On that note, I want to thank you both Professors Peter and Rosemary Grant for being in Ask A Biologist.

Peter: Thank you.

Rosemary: Thank you very much.

Dr. Biology: You've been listening to Ask a Biologist and my guests had been biologist Peter and Rosemary Grant, two emeritus faculty from Princeton University. The Ask A Biologist podcast is produced on the campus of Arizona State University, and it is recorded in the Grass Roots Studio housed in the School of Life Sciences, which is a unit of the College of Liberal Arts and Sciences.

Remember even though our program is not broadcast live, you can still send us your questions about biology using our companion website. The address is askabiologist.asu.edu or you can just Google the words, Ask A Biologist. I'm Dr. Biology.

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