Ask a Biologist vol 035   Topic: Bird Feathers Co-host: Brian Varela
Guest: Kevin McGraw

Feather Biology -

Dr. Biology and his co-host Brian Varela from Dunbar Elementary School get a close-up view of bird feathers. The pair interview biologist Kevin McGraw an expert on animals coloration who studies birds to unlock their secrets. They learn about the many ways birds use their feathers. What they find might surprise you.

Transcript

Dr. Biology: This is "Ask-a-Biologist", a program about the living world, and I'm Dr. Biology, here with my co-host Brian Varela. Welcome to the Ask-a-Biologist show, Brian.

Brian Varela: Thank you. Very glad to be here.

Dr. Biology: Tell us a little bit about yourself. Where do you go to school?

Brian: Well, I go to Paul Lawrence Dunbar Elementary School. I'm in fifth grade. I like football a lot.

Dr. Biology: All right. Are you thinking about science, or are you thinking about journalism? You entered this contest, and you did really well, that's obvious because you're here. What do you really like besides football?

Brian: Let's see. I really like math.

Dr. Biology: You really like math? Good, because we need math in, and use math in, science, especially in biology.

All right, Brian. You and I have been wondering about birds and bird feathers.

Brian: Yeah.

Dr. Biology: All right. Well, our guest scientist today is going to help us answer our questions. Kevin McGraw is a professor in the School of Life Sciences, and he's a returning guest. In an earlier show, we were able to talk about his research with birds, animal coloration, and the importance of color when they want to find a mate.

Today we're going to talk about bird feathers, and in fact, you and I got to see some a little earlier. Turns out feathers do a lot of work besides helping a bird fly.

Brian, if I asked you, how many different ways do you think birds use feathers? If I ask for a number, how many ways would you say?

Brian: Well, once you said that there was more than one way, I would've said one.

Dr. Biology: You would've said one? And now, you got to see a couple things up in Dr. McGraw's lab. How many things, if you had to count, how many different ways you think they could use them?

Brian: Well, from being here, I would say, like three.

Dr. Biology: About three? OK. Well, I could come up with about a dozen different ways birds use feathers, but I'm guessing our guest has even more to tell us about. Kevin McGraw, thank you for being on "Ask-a-Biologist", and is it OK if we call you Kevin today?

Kevin McGraw: Sure, no problem.

Dr. Biology: All right. Brian, what do you have to ask Kevin McGraw about birds and bird feathers?

Brian: I'm going to go outside the box of bird feathers, why do birds have hollow bones?

Kevin: Well, birds have hollow bones to stay light. Birds fly, and in order to get in the air, you can't be too heavy otherwise you'd sink to the ground. So one of their strategies in their body is to lighten their bones so that the bones, actually scientifically called "pneumatic bones", which essentially signifies that they're hollow, sort of having almost a Swiss cheese type of arrangement to allow them to have air, and thus, air being light, will allow them to stay aloft when in flight.

Dr. Biology: So when you say Swiss cheese, they're not exactly like a straw hollow?

Kevin: No, absolutely not. No, they've got sort of patches of air interspersed among patches of solid bone.

Brian: Well, I'm holding a bird feather. One side is blue, purple, the way you see the angle of it, and one side it's red-orangeish. Why does it do this?

Kevin: Well, the outside and the inside of a feather, actually, may serve different purposes. The outside of the feather is displayed to the world. It can be seen by predators, it can be seen by mates, it can be seen by rivals, so depending on the species, you may want to advertise something about yourself, or you may want to stay camouflaged to stay hidden.

On the inside of your feather, however, where no individual is necessarily going to see it, you may want to do things that have nothing to do with the color, but maybe have something to do with the protective abilities or nature of the feather, some way to keep the feather strong. For example, we've done some research on parrot feathers, actually, to show the pigments that they deposit under their feathers, often the reds, oranges, and yellows, actually help stabilize the feather and keep them durable, resist the degradation and damage that bacteria on feathers can create.

So what you might be looking at is, on the outside they want to be fancy and blue, but inside they want to be stable and protective, that's why they put red pigment on the inner layer of the feather.

Dr. Biology: I noticed that we have two feathers of even maybe the same bird, one of them, the one that you have, Brian, it's red on the inside. What's the other color?

Brian: Like yellow.

Kevin: Yellow on the inside is a similar pigment type, different subtly in its chemical composition, to the red form. We find that the yellow forms tend to be somewhat, I guess I'd call them, antimicrobial, or help resisting bacterial damage, maybe not as well as the red, but still successful.

So one hypothesis is maybe this bird, or this species, which has red on the inside, may be more susceptible to bacteria, infections, and damage, and had to deposit red pigment there, as opposed to this other macaw, which has yellow on the interior and may not have as much of a need.

Dr. Biology: So it's interesting because even though we perceive it as color, it's actually this bacterial protection, possibly, and has nothing, really, to do with the color, it's just a byproduct.

Kevin: Exactly right. So, have you ever wondered, Brian, why carrots are orange? Carrots are underground, they're a root essentially, and neither you nor I would ever see them if it weren't for digging them up and eating them.

So is the carrot saying something about itself by being orange? Answer is probably not, right? But they tell you to eat your carrots, and do you know why?

Brian: No.

Kevin: No? Carrots are good for you. They have molecules, chemicals in there that make you healthy, that make you see well, and so when your mom tells you to eat your carrots, next time you can tell her, "I'm eating carrots, and they're orange, and the orange pigments in there are what are making me healthy." So like Dr. Biology says, it's not necessarily the color of the material that matters, but the activity of the molecules which happen to be colorful, that are beneficial.

Dr. Biology: And you know what? I didn't know that either, Brian. That's pretty cool. I actually never thought about the fact that carrots are underground, and they're orange. Why should they be? Pretty cool.

All right, what other questions have we come up with?

Brian: Does weather have to do with anything of the colors?

Kevin: Yeah. There actually are some good ideas out there about how an animal's environment, its humidity, its temperature, can affect both the thickness of the feathers, but as I'm really mostly interested in, the colors of their feathers, so I'll tell you a little bit about that.

One idea is that in humid climates, it's particularly challenging to keep your feathers dry and thus to keep off things like bacteria. So something an animal might do is deposit pigments in there, like melanin, which colors our hair and our skin, to help sort of resist any wear or any bacteria that might degrade the feathers.

So some interesting comparative studies have been done recently to support this idea, which is not mine, and actually it was someone that came up with this idea in the 19th century. So back in the 1800s, the late 1800s, a man by the name of Glozher came up with the name of a rule which is known as Glozher's Rule, which says that any animal that lives in a humid environment should be favored to be darker. Because the darker the feathers, the darker the hair, the more likely it is to resist this sort of weathering and rain and humidity, and all that goes along with it, you know, the bacterial and fungal degradation that can be associated with it. So that's one interesting link between a color of an animal and its environment.

Dr. Biology: You also brought in, and I have to reach over here to get it, this beautiful skin?

Kevin: Yeah, that's the skin of a golden pheasant.

Dr. Biology: And Brian and I have been playing with this, and we're mesmerized because, how many colors do you think you see in this, Brian? I'm counting.

Brian: 3, 4, 5, 6, seven about 11, 12.

Dr. Biology: 11 or 12. Yeah, I bet, and if we do shades, it could even be more.

Brian: It also depends because the angle you see some of the colors.

Dr. Biology: That's right, right. When we look at them in one direction, they're one color, when they shift to another, they're yet another color, so maybe it's an infinite number of colors in the end. That's really good.

I also noticed they're all, they look different to me. Do they look different to you?

Brian: These kinds of feathers, the greenish blue ones, they turn different colors, and not the other one, they just reflect off the light.

Dr. Biology: Right. I was even thinking just the shape of them, you know? When you look at them and these golden ones have these long, almost hair-like ends. Some of them look like a typical feather that you might think of. And these green ones, these emerald green ones have almost a fan-like, or if you think of a broom, on the end, a broom-end to them.

You know, to me, not spending a lot of time with feathers, a feather's a feather, but obviously they're different.

Kevin: Yeah.

Brian: At the bottom of this wing, it looks like some pigeon feathers.

Dr. Biology: Right, while others it doesn't. So what is the difference?

Kevin: Well, the shape of a feather is essentially dependent on all the different functions that a feather serves.

So we think of, you know, fluffy baby chicks, which have this just really nice light airy coat of feathers. Actually tends to be really thick, but there it serves as a really nice insulation; it keeps them warm. As a baby, they don't have a good job of staying warm themselves, so they need to put on a big coat in order to stay warm. This is, in turn, something that's soft and fluffy that we know use to stuff our coats and pillows, so we've used the animal way, sort of animal engineering, to engineer our own lifestyle.

But that's not just the only function of feathers, right? You can have feathers that play a role in flight, and so now I'm getting closer to sort of understanding the shape. If something's going to be used to fly, it's got to generate a lot of force against the air. In other words, it's going to need to be really durable, really strong, in order to push hard against something like air. So if you look at the wings of that pheasant, you see very long, very thick interlocking barbs and barbules, create almost a firm, flat-like surface for generating force against the air and generating lift for flight.

Dr. Biology: Yeah, I felt it, and it does. It actually is stiff, isn't it?

Kevin: Very rigid, that's right.

Dr. Biology: Right.

Kevin: And so if you go further on to the functions of feathers across different regions, you'll get some that look very flat and large. And animals that tend to flatten and enlarge their feathers tend to want to spread them out probably for some sort of a display or advertisement. So in a lot of pheasants you'll see around their neck that when they display, they'll sort of puff out their air sacs in their neck and really sort of stand out and look big and either threatening, or look big and impressive as a potential mate.

And so you'll really see, in those iridescent green feathers lined with that black tip, those are really fancy feathers that are used in signaling. And so that's why you see, the increased surface area will just increase the amount of area that they can cover when they try and fluff them out and look either threatening or fancy.

Dr. Biology: Attractive. OK.

You know, we're getting into the function of feathers, and Brian, I think I heard you, you were interested in a particular kind of bird that, you know, a lot of people may not even think they have feathers. Weren't you talking about penguins?

Brian: Yeah, penguin. Looks like it's just skin. Do they have feathers?

Kevin: Penguins do have feathers, and they have an absolute ton of feathers, almost to the point to where they're so many, and dense, and overlapping, that like you say, they look like a continuous matte of almost skin.

But what they are is a very modified feathers. So the feathers that you see on a bird like a pheasant, which runs around in the forest or on the ground, are used for and presented in different ways than a bird which lives in absolute freezing cold, or that spends its life in the water and needs to be resistant to water so that they don't get waterlogged, as well as be flat and aligned against their body so that they can be streamlined and swim well through the water.

So what penguins have done is essentially modified their feathers to be long plumes, just single long projections, that almost look like hairs more so than feathers. And that carefully overlap to the point of being, like you say, just a continuous mat of what appears like black and white skin, when in fact it's tens of thousands of feathers.

Brian: I was also thinking of something else about penguins. You know how sometimes they slide on their stomachs? Does that have to do anything about how they're formed?

Kevin: How the feathers are formed?

Brian: Yeah.

Kevin: Yeah. They definitely stay very streamlined, like I said, and so if you had feathers like this, they'd get in the way, they'd get abraded and broken off, but if you have a nice single file of aligned feathers that make your appearance very slick and smooth, absolutely. They can swim through the water and slide on the ice with equal success.

I will say, though, that penguins' feathers, like the feathers of most other birds, serve tons of different purposes. I think the first thing, besides some of the insulative properties, are that they protect them from the sun. So you imagine sitting on an iceberg, all day every day, with no trees, and essentially getting blasted by the sun rays day after day after day, you could get some serious sunburn if you were a bird unless you've got a really thick coat of overlapping feathers, which essentially prevents access from the sun to your skin. So I think UV or solar protection is one potential function.

The other thing is, I don't know if you've thought much about just animals that live in and around water much, but the typical black and white appearance of a penguin, right? White on the belly, black on the back, is a very common color pattern among animals that live around water. And the idea is, is if you're going to get eaten by something, believe it or not, the black back and the white belly is this animal's strategy of staying hidden.

And the idea goes like this: If you're in the water and you're swimming, and if someone beneath you, like a predator, is looking up at the sky, have you ever done this in a pool and looked up at the sky? What does it sort of look like?

Brian: It's white, sometimes you see yellow.

Kevin: That's exactly right. You see a nice white background, and so if you've got a white belly blending in against a white background, the predator isn't going to be able to see you as a potential food item.

Now, think of it the other way. If you're a predator swimming at the top of the water and you're looking down at something, have you ever looked down in a pool or down in a lake? The further you look down in a lake, what color does it look?

Brian: Black, like dark blue.

Kevin: That's exactly right. You can almost just see almost no color. All the light's being absorbed, therefore it's black. So a penguin, by being black on its back, can't be seen by things that are swimming above it.

So it's got the best of all worlds, right? It can't be seen from above, it can't be seen from below, and that's why they're black and white.

Dr. Biology: So it's great camouflage, right?

Brian: Yeah.

Kevin: The word we use is "countershading".

Dr. Biology: Countershading. That's cool, I like that. You going to do any countershading there, Brian?

Brian: No, not really.

Dr. Biology: Not really? OK. Hey.

Kevin: Next time you're around water, yeah, you can paint your back black, paint your belly white.

Dr. Biology: Right. Well, and, that's really good, Brian. See? This is why I needed you here. That's a better question than I was coming up with.

It's curious, though, because when they're out on the ice, they're really obvious. Is that a problem?

Kevin: Absolutely not. Most of the predators of penguins are aquatic, so they live in the water, or marine, I guess we would call them. Occasionally, they'll get some animals like seabirds that can be really pesky and that occasionally will take like a young animal that's maybe injured or ill.

Brian: Isn't a skua one?

Kevin: Yes, like a skua, absolutely, yeah. So a species of seabird that's a predator of penguins is known as a skua, so arctic skuas.

Brian: Yeah. They eat penguins, little penguins, and fish.

Kevin: Very good. Yeah. They've got a nice sharp-tipped beak that helps them sort of peck at and unfortunately damage the poor, helpless little baby penguins.

But for the most part, all of the big mammals, and you know, seals, sea lions, things that would take penguins from the water, don't have access to them on land. So as long as they're a sufficient distance away that these things can't climb up, they're safe as can be from predators, windstorms and blizzards aside. Those are separate challenges.

Dr. Biology: How many different functions do feathers have? Because we won't be able to go through all of them, I'm guessing, on this show, but how many are basically noted out there?

Kevin: Well, as best I can tell, there are at least confirmed evidence in the dozens of functions of feathers. Famous ornithologist and avian anatomist Dr. Peter Stettenheim, who literally wrote the textbook on avian anatomy back in the early 1970s, has written an article for a popular magazine which argues that there are nearly 40-some potential functions of feathers, which include sledding, and sensory perception, sound generation, actually silence, so preventing sound from being made.

Dr. Biology: Stealthy.

Kevin: Exactly, which again, if you're a tasty little critter, as a bird in a forest, you want to prevent yourself from making noise. So feathers function to prevent sound from being made, which is a pretty tough challenge for an animal that flies, that has to flap, and that has to wing-beat through the air. I mean, you've heard birds take off, you know, on a pond let's say, and a duck, it creates all sorts of noise.

You know, I can continue to go on with ways that animals can fight with their feathers. Some feathers tend to be long and stiff, and maybe even sharp to the point where they can, even sometimes will help themselves swim or walk with them. Some animals actually use their wings to sort of push off of surfaces, not just air.

Sensory perception is an important function of some feathers, in that they have nerve endings attached to the feathers, and the feathers are found often around their face, almost like little bristles, like little whiskers on a bird. And they can sort of sense all the various insects that might be around it. Or if they took a meal, ate an insect and had sort of some rotting insect flesh that had gotten stuck on their moustache, they can sense that with their bristles and keep their face sort of clean.

Brian: What would happen if you take a bird from Arizona and take it to like New York, Utah, anywhere?

Kevin: That's a great question. The answer would be, like most things in ecology and evolution and nature, it depends. So some species are very well adapted to live all across the world, all across different continents, from deserts to mountains, wet to dry.

One of the species that we study here in Arizona is known as the house finch. Don't know if you've ever seen a house finch at a birdfeeder, but the females are kind of streaked and brown, and the size of a little dinosaur figurine or something, that'd sit on your desk at home. The males, though, are kind of sexy; they have these red feathers on their breast.

Anyways, they breed opportunistically in the desert, meaning that they can deal with dry, they can deal with wet, and so it turns out that they've been actually introduced into the East Coast and found to proliferate all through New York, New Jersey. They've radiated north suddenly into Canada. They've radiated west in the United States, down south almost towards Florida, and so they can literally live almost anywhere in the United States.

Some animals, however, are very, very adapted to living in the desert and can't survive outside of the places where they can't get the right foods or can't thermoregulate. And so you might imagine that things like desert thrashers are very, very adapted to living in and around cacti, depending on the annual changes in temperature. And if you were to get them up in the high elevations and get them where it's real cold, where it snows, their body temperature would drop too low, they wouldn't have an ability to survive.

So even two birds, even of the same size, maybe even living around each other, depending on what they eat, and how long they've lived and have been accustomed to certain environments, some might be able to survive if you flew them to New York, but some probably wouldn't.

Dr. Biology: On a fundamental question, large and small. What's the largest bird feather?

Kevin: The largest bird feather comes not out of Mother Nature, but out of the hands of humans. Humans breed chickens and have so for generations. We've bred chickens to grow feathers of all different types, varieties, colors, patterns, and lengths.

So back in 1972, when a bird show was held in Japan, someone brought officially the world's largest feather, which was on ornamental chicken breed, and was nearly 35 feet in length.

Dr. Biology: 35 feet.

Kevin: So three basketball hoops stacked on top of one another, and then a half of a basketball hoop.

Dr. Biology: Or a third of a football field [sic].

Kevin: That's exactly right, yeah.

Dr. Biology: Wow.

Brian: That's pretty big.

Kevin: That's pretty impressive. Imagine that bird probably couldn't fly with it, probably couldn't move very fast with it, but it was very pretty to humans.

Dr. Biology: How about small? How small do they go?

Kevin: Well, the smallest bird in the world is the bee hummingbird. It weighs about a gram, one gram to two grams, which literally is the weight of a penny, or maybe even less.

Working back from that, the smallest feather probably comes from the smallest versions of bee hummingbirds, which are baby bee hummingbirds, so I would say the smallest bird feather ever is that of the newly hatched or newly grown feather of a baby bee hummingbird, which is found in Cuba.

Dr. Biology: And it's how small?

Kevin: The feather itself would be on the order of millimeter.

Dr. Biology: Oh, so we need to have some kind of a magnifying glass, right?

Kevin: To be able to see it fully, absolutely right.

Dr. Biology: Brian, have you ever wondered where feathers come from? How did they evolve, do you have any idea?

Brian: No, not one.

Dr. Biology: OK. Well, I think we have a pretty cool story.

Kevin: Yeah. So the short story is, birds are flying dinosaurs, and dinosaurs had scales, therefore scales evolved into, feathers evolved from scales.

You can test this in a number of ways. You can look at the fossil record and look at the transitions from dinosaurs to birds and see how their anatomy changed.

Thankfully, if you pick up this feather here and feel it, it's pretty hard. It's light, but it's made out of a material that's really durable and it does fossilize. So we can dig back millions of years and find the first evidence of scales in reptiles.

We found that they changed over time into the scales that dinosaurs had and that early dinosaurs seemed to evolve very primitive forms of sort of extended scales. Thick, hardened versions of what you would see nicely on a snake for example. You can imagine that if it protrudes a little bit more from the body and it things out a little bit, you can imagine the first form of a feather. That is what they call a protofeather. So, really good fossil evidence.

And then you can even test the bio-chemical nature of a feather, or a scale, and find that they have the same general makeup, the same general molecules. And then you can do some developmental studies to look at what forms during the process of growth of an animal and see that the baby bird sort of starts out producing very primitive scales.

The next time you look at a bird, look carefully, if it is in your hand or if it close up, on its legs it has little scales that are overlapping, just like reptiles and just like dinosaurs.

Dr. Biology: Hmmm, pretty cool.

Brian: How come bats have skin on their wings instead of feathers?

Kevin: That's a great question. Bats evolved from other mammals, so flight is not necessarily anything that is uniquely avian or like birds. A lot of insects do it. But not many mammals do it. You have heard of the term flying squirrel, you have heard of one of those animals. It is actually a misnomer, it is actually not correct in that they don't fly.

Brian: They just glide.

Kevin: You got it, exactly right. And so when we talk about flight in science we technically define it as flapping flight. You physically have to move your forelimbs or arms up and down with wings or with skin.

And so mammals, they don't have feathers; they instead have skin covered in hair. Hair, it turns out hasn't evolved into the big robust sort of feather like qualities. Instead you can't use hair to generate a nice wing. And so bats only sort of locomotion with flight is just to use a nice big fold of skin, which, if you look at a bird's wing, and compare it to a bat's wing it is very different in what it is made of. It is very similar in the ultimate form, as being a continuous layer of tissue that can generate force against air.

So, the quick answer is that bats fly with skin because they are mammals.

Dr. Biology: What about their bones. We just learned that birds have hollow bones. Do bats have hollow bones?

Kevin: Bats tend to have hollower bones, or lighter bones on average. They tend to be smaller animals too. So, the thing with birds is that you can be very large and still fly, by having hollow bones. But bats don't tend to have hollow bones, which is not as key, because you can be small and thus light and thus fly anyway.

Brian: Is that why they can't really fly straight?

Dr. Biology: That's a good question.

Kevin: It is a really good question. I haven't studied much about bat flight. You are asking a good question about bat flight control. And we know the careful ways, I know the careful ways, that birds can alter the angle of attack of their wings and the feathers on their wings and land in particular ways.

I guess I would say bats probably have the ability to dart and flutter and flit because they are so small. And because they have the ability to change direction with small amounts of tissue at a finer scale then many birds do. It may be more analogous to the way butterflies and other things control their flight with very, very big wings, but still, a pretty small animal.

Dr. Biology: Right. And it seems that just watching them, and this is just purely observation with the bats, the main thing they are hunting insects and they have this ability to turn and corner very quickly, which they need to be able to do to capture the insect.

Again, this is just observation, I don't know the answer. Even if I am Dr. Biology, it means only that I am interested in biology, but I don't have all the answers. So, Brain, guess what, if you become a biologist you know what we need you to find out? Why bats fly the way they do?

Kevin: You've stumped us. Someone may know that answer.

Dr. Biology: Right.

Kevin: If I knew that literature well enough I might know that answer.

Dr. Biology: We'll find out and if it just goes in the show we'll know for sure.

Kevin: Yes.

Dr. Biology: I still want to know, Kevin, since there could be up to 40 different uses for bird feathers, if I ask you to pick your two favorites, or the two most unusual, what would you say?

Kevin: One of my favorites is sound generation. Animals can literally clap with their feathers. Or, a more musical way of describing it would be that they sort of use parts of their feathers in sort of a pick and file sort of way. Have you ever run your finger down a comb and hear it go ziiiip? Well, you can do the same thing if you are a bird of a certain type.

A manakin, for example is know as the club-winged manakin. It actually has things on its feathers, on its wings, that bang and scratch together, to the point to where that when it extends and claps its wings against its body it creates a really really loud snap-buzz sound.

Forever people thought that it was some sort of interesting voice sound, a vocal production. But instead, people did research using high speed video and saw that the birds weren't making any mouth gestures or throat fluttering. But instead it was the sheer action and clapping of their wings to create a noise. They tend to create a sound, which they use to attract mates.

Dr. Biology: Excellent. Well, Professor McGraw I want to thank you for visiting with us today.

Kevin: I have enjoyed it. Thanks for having me again.

Dr. Biology: And Brian, thank you for being a co-host on "Ask-a-Biologist". It has been fun for me. Has it been fun for you?

Brian: Yeah, it is fun.

Dr. Biology: OK, so maybe I'll get you back. I have another question. Now that we have learned all this about birds and bird feathers, are you ready to trade your skin in for some feathers?

Brian: No.

Dr. Biology: No [laughs]. All right, well you've been listening to "Ask-a-Biologist" and your guest has been Kevin McGraw, Professor in the School of Life Sciences. My co-host has been Brian Varela from Dunbar Elementary School in Phoenix Arizona.

Don't forget to visit our companion website. We plan on putting an article up there that will have some pictures of some of the bird feathers and skins that we looked at today. You've got to see them. And it is kind of cool to see them online because we will be able to magnify them, so you can be able to see them better than if you are looking at them with just your unaided eye.

The "Ask-a-Biologist Podcast" is produced on the campus of Arizona State University. And is recorded in the Grassroots Studio, housed in the School of Life Sciences, which is an academic unit of the College of Liberal Arts and Sciences. Both the School of Life Sciences and the College of Liberal Arts and Sciences provided the funding for the co-host today.

I also want to remind you that even though our program is not broadcast live, you can still send us your questions about biology using our companion website. The web address is: askabiologist.asu.edu. Or you can just Google the words: ask a biologist.

I'm Dr. Biology.

Brian: And I'm Brian Varela.

Dr. Biology: And if you're a student in the Phoenix area and you'd like to be on the "Ask a Biologist" audio show, just head up to our podcast area. The address is askabiologist.asu.edu/podcasts.

There you will find information about submitting an audition recording, and hey teachers this is also a great project to do in your classroom or in your school. We have all the information about the contest and how you can create a contest in your own school.

We have details about the equipment, the software used to create podcasts, and much of the equipment, by the way, and software is inexpensive and in some cases free.