Ask a Biologist Vol 007 (Guest Ron Rutowski)

Butterflies and Insect Vision –

Learn about one of natures most fashionable animals, the butterfly. In this three part series Professor **Ron Rutowski** talks about the role of butterflies in the ecosystem, and the amazing migration of the monarch butterfly (Part 1), along with his research on butterfly coloration and insect vision - are butterflies legally blind? (Part 2). In the last part (Part 3) of the series we learn about Ron's other life as a musician and listen to a song from his solo album titled "Violinalone."

Transcript

Dr. Biology: This is Ask-A-Biologist, a program about the living world, and I am Dr. Biology. In today's show we'll learn about one of the most fashionable of all insects, butterflies, and also some answers to a few very interesting questions, such as, are butterflies legally blind, and just how do butterflies and most insects see the world?

To help us understand these amazing animals, we will be talking with biologist Ron Rutowski, who is a professor in the School of Life Sciences at Arizona State University. We will discuss his research that includes butterfly vision and coloration. Dr. Ron, as he is also known in his other life, as a musician, plays fiddle in country-western, bluegrass and jazz bands. He has released a solo album called "Violin Alone, " and we'll get a chance to listen to one of the songs later in the show.

Right now, let's welcome our guest scientist. Welcome, Ron.

Professor Ron Rutowski: Thank you for having me here.

Dr. Biology: Before we get to the details of your research, I'd like to talk just a little bit about butterflies in general. We know that butterflies are a popular topic for people of all ages. Their wide range of colors and patterns are certainly one of the reasons butterflies get so much attention. However, their role in the food web is maybe more important than their beauty. Just how do butterflies fit into the ecosystem?

Ron: Well, we tend to think of ecosystems as ways in which systems, by which energy from the sun, moves through plants to animals and on into various forms of energy or nutrients, things like nitrogen, carbon, oxygen. So your question is, what roles do butterflies play in that movement of nutrients through the ecosystem? Butterflies play both the roles that animals typically play in those situations.

One is that they get eaten, and so they serve as a source of nutrients for other animals, and there are lots of interesting things about that. They do get eaten by birds, sometimes small mammals, by other insects. I mean, there are so many different kinds of butterflies, it's hard to make a generalization. But they do get eaten by them. Their larvae also get eaten by a variety of animals in the ecosystem. So they serve as a way for energy to get from them to the next level in the ecosystem.

They also consume material in the ecosystem, and in particular, the larvae eat plants which have gathered sunlight, energy from the sunlight, and turned it into plant material. So the larvae, actually, serve to move nutrients from the ecosystem into the butterflies, and also, the adult butterflies consume nectar from flowers, and so gather energy from flowers that way and move it into their own bodies.

They also eat pollen, some of them, amazingly enough. Even though they have this long straw-like proboscis that they use to suck up nectar from the plants, they sometimes pick up pieces of pollen, and they use their saliva to dissolve the pollen and extract the protein from it, take it in. Not very many butterflies do that, as far as we know at the moment. That's another way in which butterflies help move nutrients through the ecosystem.

Dr. Biology: Do they end up being pollinators as well?

Ron: Yes, very much so. Butterflies are among many animals that help pollinate plants by moving the pollen around from one flower to another.

Dr. Biology: Right, and pollination, of course, is really important, for the plants to actually flower and begin to produce fruits.

Ron: There is one other thing that I would say that's kind of interesting, about their role in the ecosystem, is that in many species the larvae feed on plants that contain compounds that are very distasteful, very sour, very bitter, cause indigestion, stomach problems in the predators.

Those compounds, those chemicals that they get, that are in the plants that they are feeding on, larvae, very often the larvae will take those on, and they become part of the larvae's tissue, and then when the larva goes into the chrysalis or pupis stage, they are still there, and then when the adult emerges from the pupa, those chemicals are still there and make the adult distasteful.

So some butterflies actually have color patterns that announce this distastefulness, and they serve as models for other species of butterflies, who by virtue of mimicking their coloration, also gain some protection from predators.

Dr. Biology: Right. In this case, there are those that really do taste really bad...

Ron: Yeah.

Dr. Biology: ... and there are those that pretend to be like the ones that taste really bad, and both get the benefit.

Ron: That's right, yeah.

Dr. Biology: Of all the butterflies, I'd have to say monarch butterflies are probably the most well-known. I think one of the most intriguing parts of the monarch story is their migration. Can you talk just a little bit about monarch butterflies and their impressive yearly migration?

Ron: Of course you can find lots of information on the migration of monarchs on the Ask-A-Biologist web site, as well as other places on the web. The key characteristics are that you have, in the fall, these butterflies that grew up, say, in Southern Canada or the Northeastern United States, they emerge from their pupae or chrysalis in the fall, and then they head south in the fall to these huge aggregations that form in the mountains near Mexico City. That's in the East.

In the West, we know that there are these winter aggregations that occur in the fall and stay in place through the winter, all along the California coast between San Francisco and Mexico, basically. Those, we're not really as sure about where the butterflies in those aggregations come from, but we reckon they're from the mountains that are nearby--Sierra Nevada in California or other places in the Rocky Mountains.

Then, of course, in both these locations, in the spring, both along the California coast and in the mountains in Mexico, when the spring comes the butterflies head back north, or head back to where they came from, we think.

So the two questions, for me, that I think are really interesting about that, one is, since I live and work in Arizona, one of the questions is, we're sort of halfway between the East and the West.

Where do the butterflies here go? We do see a lot of monarchs flying through this area, during the fall in particular; and there is a group of people in particular at a place called the Boyce Thompson Arboretum that are trying to sort this out by marking lots of butterflies out there, which is one of the key techniques to figure out where they go. So they see all these butterflies out there in the fall, they'll mark them, and then see if they end up in aggregations back in California, or in aggregations down in Mexico.

Dr. Biology: When they mark them do they use, is it a paint?

Ron: No, it's a little sticky paper tag that they put on the wing. They sort of wrap it around the front edge of the wing, and it stays on pretty well, and it works quite well. And it has phone numbers and stuff on there so you can...

Dr. Biology: Really tiny.

Ron: Yeah, and if you find one of these it tells you where to call and provide the information. So that is really interesting to me: where do these butterflies, not just in Arizona, but in what's called the "intermountain west" in the Rocky Mountains, where do the butterflies go? They may go to Mexico, they may go to California. We're not really all that sure.

And of course the other question, for me, since most of my work is in the behavior and ecology of animals, is how they know where to go. In other words, during the fall, we know that they head south. Well, how do they know which way is south? I mean, we have no way of knowing that unless we have a compass, or if we know what time of day it is.

So if you step outside and you know it's in the morning, and you see the sun in a specific direction, the sun comes up in the east, that is probably east. So you know which way to go then. You know that if you face the sun at that time of day and you head right, you will be headed south.

Dr. Biology: Correct.

Ron: And what's interesting is that there is now evidence that that's what monarchs do. They have an internal clock--they don't carry a wristwatch or have a clock on the wall to look at, but they have an internal clock--that tells them what time of day it is, so when they look at the sun they can interpret its location and figure out which way they have to go to head south.

There are other experiments that are less clear in their results, that have suggested that they might use wind currents, and so there is some feeling that maybe the prevailing winds, across the Eastern United States, anyway, during the fall, are sort of southward, and that that sort of propels the butterflies south, but that doesn't seem to be wholly satisfactory.

Another proposal that has been made is that the butterflies actually have, as is known for other animals, an internal ability to detect the orientation of the Earth's magnetic field, in exactly the same way that a compass does, pretty much. I mean, that's what a compass responds to, is the Earth's magnetic field.

Dr. Biology: Right.

Ron: Those experiments are less clear. I won't go into details about what has happened with those experiments. But right now the best evidence is that the monarchs, to figure out which way they have to go, to go south, are using sort of a combination of the sun's position as evaluated using an internal clock.

Dr. Biology: Right. So they have this built-in sundial?

Ron: Yeah, yeah, that's one way to look at it. Yeah.

Dr. Biology: Very neat. It's also interesting, with the monarchs, we need to mention a little bit again about the ecology and the concern about what we're doing to the planet.

Their wintering homes, certainly in Mexico, have been shrinking; and we have also had discussions about the use of pesticides in their migration paths. How are we doing? For example, we had a really hard freeze, what was it, two or three years ago, and we lost a lot of them, and they were really concerned, but it seemed like they were more resilient than we thought.

Ron: You mentioned two issues. One is the issue of these genetically modified corn in the flight path of their migration. This corn has certain anti-insect agents actually built into its genome. When it produces pollen, these genes that produce these sort of anti-insect agents are in the pollen.

It was proposed that this pollen might be bad for the insects to eat, in particular since the milkweeds on which the larval monarchs feed are right near these fields where this corn is grown, or often grows up right in them. The worry was that these genetically engineered corns were having a very bad effect on the insect populations, and in particular the monarch populations. That is up in the air at the moment.

I think there are still some people who think it's a very real issue, others who think it's not so significant, but it is something we should be concerned about. I like Lincoln Brower. He refers to the monarchs not as an endangered species, or a potentially endangered or threatened species, but as a "threatened phenomenon." The monarch is the one engaged in this fantastic phenomenon, which is its yearly migration, and so he says we need to be very concerned about it, and the concerns have to be international, because the monarchs are flying from Canada, into the U.S. and into Mexico.

The other issue is the one that Lincoln Brower is particularly concerned about, is the decimation of the forests in which the over-wintering habitats are found. So the monarchs have very specific habitat requirements during the winter, in order to be able to survive the three months or more that they spend at these over-wintering sites.

They can't be too hot or they dehydrate; they can't be too cold or they freeze to death. They can't be too wet, they can't be too dry. Again, it is tricky for an animal of that size to survive three months of winter under these exposed conditions.

The mountains where they occur are subjected to very intensive logging, and when you say that the over-wintering areas have been decreasing in size, what has been decreasing in size are the patches of forest where the habitats that are suitable for spending the winter are found. So various groups, both in Mexico and in the U.S., are working very hard to make sure that those habitats are protected.

If you look, there are certain web sites you can go to, and you can actually see plots of the size of the over-wintering aggregations and how it has changed over the years.

And you're right, a couple of years ago it was way down; but in the last couple of years it has come back up. I don't know if it is quite at about the average, it's not the highest it has ever been--I think that was sometime in the early '90s or 1980s when it was just immense, or at least during the period of time that they have been sampling this. But they are a reasonable size, if you look at the history of them over the last 15 or 20 or so years.

Dr. Biology: Well if people need to learn more about monarch butterflies, they can do this by visiting the Ask-A-Biologist web site. Just click on the Articles link and look at the "Migrating Monarchs" story, or click on the Experiments and Stuff to get to our Coloring Page section, where you can find a coloring page on the life cycle of the monarch butterfly.

Now, let's talk a bit about your research. Part of your research includes butterfly vision. I think one of the most interesting things, when I got to talk to you about this, was the common belief that insects see multiple images at the same time, kind of a kaleidoscope of the same image, something that people have seen over and over in the movies, and most likely due to the way insect eyes look.

When you look at them with, say, a microscope or up close, they have this collection of what are called omatidium, and it's a bunch of little lenses or little eyes that are all clustered together. What people began to think, of course, is that they had this large collection of a bunch of different images; but in reality this isn't really true. Can you give us a clearer picture of insect vision?

Ron: I can certainly try. I mean, it's one of the really difficult things about this, Dr. Biology, is trying to figure out how the world looks to another organism. Butterflies can't talk, so we can't say to them, "Well what does it look like to you?" And they can't give us any answer to that question.

I mean, we could say it to them, but there's no response, at least verbally. But there are experiments, behaviorally, experiments that we can do that we can probe the vision of insects, and provide them with stimuli and see how they respond to them. And we can also study the structure of their eyes. There are a lot of conclusions that we can draw about how they see the world from even looking at the structure of their eyes.

And of course we have to start with the observation that their eyes are very, very different in structure from ours. We have a single lens that focuses light on a retina, a sheet, basically, at the back of our eye, that is full of little individual photoreceptors called "rods" and "cones." Butterflies, it's almost like every rod and cone has its own little lens that is gathering light and shining it on that rod or cone.

In fact, what you have is each lens in a butterfly or insect eye shines light on, oh, I don't know, about six or nine different cells, each of which gathers light at a different wavelength. The basic conclusion that comes from the studies of eye structure, and also from the study of their behavior, is that butterflies and most other insects don't see the world anywhere near as clearly as we do.

So imagine this: imagine I was standing 200 feet away from you, and I had this big E, and I put it out there, and I asked you, "Can you tell me, what letter is this?" And you said, "It's an E." So then I made it smaller. "Now can you tell me what letter it is?"

And I kept making it smaller until you couldn't tell what it was, and then I made it a little bit bigger so that you could see, at 200 feet we knew what the smallest, how small the E could be and you could still recognize what it was, what letter it was.

If we then took that same size E and got a butterfly, and started it at 200 feet, and asked it, "Can you see that this is an E?" they would say no. You then take the butterfly and you move it to 100 feet, and ask it, "Can you see that this is an E now?" And they would say, "No." Well that size E, the butterfly would have to be about 20 feet away before it could see that and recognize that it was an E.

So that's what is referred to as 20/200 feet. In other words, a butterfly has to be 20 feet away to recognize an E that's the size that a normal person can recognize at 200 feet.

Using the scale that we use in people, 20/20 vision is perfect vision. Butterflies have about 20/200 vision, which according to legal definitions is legally blind. That doesn't mean that the butterflies can't see detail. But it does mean that in order to be able to see it, they have to be pretty darn close.

As we look at butterfly coloration we see amazingly intricate color patterns. Even on the monarchs, with the black veins on their wings. It's not that the butterflies would never be able to see that. It's just that they would have to be just a few inches away in order to be able to see it.

Since we're very interested in how males find females, we got real interested in the business of how far away a female can be from a male and have the male still be able to see her, to distinguish her from the background, to even be able to detect her at all.

We designed some experiments where we flew little model devices, little model butterflies by males out in the field. The results from the optical studies from the eyes as well as the results from the behavioral studies were pretty much the same.

They suggested that for this butterfly we were studying, which has a wingspan of about two inches from tip to tip, for a male to see a female she could fly no more than about 10-12 feet away from that male. What this means is that for most species of butterflies, they are only going to be able to detect one another at distances of maybe 10-15 feet.

For smaller butterflies, it's worse. It's closer. Not only because they're smaller, but because they have worse vision. Larger butterflies are larger and have better eyes. So they can see each other at distances of 30 or 40 feet.

Dr Biology: They actually are larger too, so they can be picked up, right?

Ron: That's right, yes.

Dr. Biology: That's good.

You also work in another area. We know that color plays an important part in the life of a butterfly. But the color in the life of a butterfly is not the same as the color that you and I see.

Ron: Right.

Dr. Biology: At least without being able to ask the butterfly.

Ron: [laughs] Yeah, that's right.

Dr. Biology: Could you talk a bit about butterfly colors, patterns, and the differences between what humans see and what butterflies see? Or, what we think they see.

Ron: What I just talked about was the business of what we call resolution. If you have two objects, it's about the ability of the eye, under difficult conditions of low light or great distances, to recognize that those are two objects and not just one blurry object. That's one very important aspect of vision.

Another very important aspect of vision is the ability of animals to discriminate objects of different colors. Of course, we do this all the time. People say, "don't eat green apples." That's because green apples are often not ripe and they contain strong chemicals that can make our stomach uncomfortable.

That's an example of one sort of discrimination that we make using color. You can have two objects that are exactly the same size and shape, but one is green and one is red. You're likely to pick the red apple.

Similarly, I think of every time I open a container of Lifesavers. There, we're making a whole bunch of color discriminations. I happen to like the red ones best.

[laughter]

Ron: So, if I see a green one or an orange one, I'm less inclined to eat it than if I see a red one. We make all of these color discriminations.

With butterflies, there are 14, 000 species of butterflies. We're very good at telling those apart because it can largely be done on the basis of our vision, our color. The color and the patterns of colors that they display.

We can ask a couple of questions. One is, do butterflies see color? Can they discriminate colors?

You can't ask them, but you could presumably give them a task in which you could put two flowers out, one of which is one color and one is another color. Provide one with lots of nectar and the other not, and see if they can learn that a certain color is associated with nectar.

These sorts of experiments have been done by people in Japan and also Sweden. Butterflies are pretty darn good at it. They can discriminate colors. As with other insects, we find that they can discriminate colors across a broad range of colors. And that range actually extends into some wavelengths of light that we can not see.

There is a quantitative scale that you can use for the color that we see. It goes red, orange, yellow, green, blue, indigo, violet, lined up like in a rainbow. That set of colors spans a set of wavelengths that goes from 700, for the red, down to about 400 nanometers for the violet and the indigo.

The electromagnetic radiation that hits the earth and exists in nature extends well beyond that range. If you go to wavelengths longer than 700, you go out of the red into what's known as the infrared. Those wavelengths are largely responsible for what we feel as heat. Most heaters glow red. They're giving off a lot of infrared, which we feel as heat.

At the other end, there are many wavelengths of electromagnetic radiation which are much shorter than the short wavelengths we see. We can see down to about 400 nanometers. If you go beyond that, shorter wavelengths, you're getting into what is known as ultraviolet.

Although we can't see ultraviolet, it turns out that insects can. This has been known for almost 100 years now that insects are capable of seeing in the ultraviolet. There are, again, studies of the eyes that suggest this.

We can put electrodes into their eye and record what sorts of nervous signals we get out of the eye when we give them different wavelengths of light. You give them ultraviolet wavelengths, and you get a lot of nerve signals coming out of the eye. That suggests they can.

Of course, there are also behavioral experiments that have been done.

So, butterflies can see many of the wavelengths that we can see. In some cases, it's broader. In some butterflies, their sensitivities run all the way from the ultraviolet right down to the red. In others, they go from the ultraviolet to the yellow or orange. But virtually all butterflies can see in the UV.

So, what difference does this make? Well, it makes differences in a couple of ways. One is that many flowers have special ultraviolet patterns and reflect more or less ultraviolet light which affects the way the butterflies respond to them.

Also, since we've started looking, there's quite a bit of variation in butterflies and in how much UV they reflect. There are elements of color pattern that are in the UV that we can't see. These are special spots of UV reflection on a certain part of the wing that just looks all the same color to us.

And they pay attention to that. They can see that.

Dr. Biology: You actually had an article published in Scientific American in July of 1998. It actually talks about this, and you actually have the cover from that.

Ron: Right. Yeah, I was very pleased from that.

Dr. Biology: So, it's nice that if someone wants to go to the library and look that up, you can actually see what you're talking about as well. The pattern that you and I are looking at and the colors that we're looking at very likely are not at all the same that the butterflies are looking at.

Ron: Yeah. There was a really neat thing that, unfortunately, the news stand version didn't have it. But if you subscribe to Scientific American, they had this butterfly on the cover. I'm trying to remember, I think it was all one color. But then they had a fly leaf that only covered half the page and had some other advertising on it.

But, it also had the butterfly as it appeared when you imaged it with ultraviolet light. It's not necessarily how butterflies appear to one another. That's, I think, nicely demonstrated on an image from Ask a Biologist site that you can go and look at it.

It nicely shows the appearance of a butterfly to another butterfly as a combination of the ultraviolet and the other wavelengths of light reflected off of the wing, and not just the ultraviolet wavelengths, which is what is often shown in those ultraviolet images.

Dr. Biology: It's a combination of the two. Very good. How about any simple experiments you might have, or suggestions for young scientists that might want to go out and learn more about butterflies?

Ron: Well, I don't know about experiments, but I certainly can think of an observation. You know, butterflies, there's a lot of them. There's not only a lot of them in numbers, but there's also a lot of different kinds. Some people say there's as many as 20, 000 different species of butterflies that occur around the world.

One of the questions that I think is fun to get at is the question, "Well, which ones are in my backyard?" That obviously is going to change a lot depending on the time of year, depending on where you live. I live in the desert, and almost any day that's warm enough out there in my backyard, I can see a butterfly or two.

During the summer, I can see quite a few butterflies. Exactly how many there are, exactly what species are out there, what different kinds varies from one time of year to the next.

So one of the things I've done over the last few years is I keep a notebook. It's near my back door, basically. When I see interesting butterflies and things, I write them down in there, and often write down something about what they were doing or what time of day I saw them. I write down which species I saw.

That's a challenging thing in and of itself, trying to identify what the species are. There are lots of books, field guides to help with that, as well as a lot of online resources.

There's a really excellent Butterflies of North America website that has a lot of good information. Actually, they put out a website where they pull out the different species for each state. So for me, I can get a list of all the butterflies of Arizona.

Dr. Biology: Perfect.

Ron: You can do that for other states. So that's sort of a fun thing, just to learn more about the natural history that's in your backyard, which can be very interesting and compelling.

Dr. Biology: Well, there are, actually, butterfly gardens.

Ron: Right. Many cities now throughout the United States have two sorts of things that are interesting to people who want to learn more about butterflies. One is butterfly gardens. Here, we have butterfly gardens that are most effective at attracting lots of butterflies in the spring and summer, as in most places. In many colder climates it would be only during the summer when won't see them at all.

Those are great places to go. They attract the butterflies by doing two things: planting plants that have flowers that produce a lot of nectar, and also planting plants that the caterpillars feed on. Females lay eggs on those plants.

So when you go to these butterfly gardens, you can make observations. You can videotape them, you can write down observations on what flowers you see the butterflies feeding at, which species are feeding at which flowers. You can also look and you may be lucky enough to see a female actually ovipositing on one of the plants.

Dr. Biology: Laying eggs? [laughs]

Ron: Laying eggs. Right. [laughs] Laying eggs on one of the plants. It's fun to see a female. You can see them curl their abdomen out to touch the leaf, and then they'll fly off. You can run over and if you look at that leaf, very often you'll be able to see that little, tiny butterfly egg that's been deposited there.

But I wanted to say, also, that many cities now, throughout especially the southern US, but there are even some in the Northern US, have these butterfly houses or butterfly pavilions, which are walk-through facilities with lots of plants where they have live butterflies.

I'll never forget once, I was in New York City in December. We went to the American Museum of Natural History and I was just stunned to walk in there and find out that they had put up, inside the American Museum of Natural History, in the middle of winter, a butterfly house - a walk-through butterfly facility that was just full of all different species of tropical butterflies. [laughs]

Dr. Biology: Absolutely marvelous. We've had a chance to learn about your work with butterflies at ASU. You also have another life. You're an accomplished fiddle player.

Ron: It's my evil twin. [laughs]

Dr. Biology: Your evil twin? How long have you been playing the violin?

Ron: Oh, since I was about 10.

Dr. Biology: About 10? And performing?

Ron: Well, if you count recitals that I did when I was a kid, for the benefit of my parents, mostly, it was since that time, since the recitals were mostly part of most music instruction programs. In terms of actually playing with bands and doing gigs, if you will, since high school.

I played in orchestras all through junior high and high school, including my first years in high school. I actually toured Scandinavia for three weeks with the youth symphony. Classical music didn't stick with me, and by the time I was a senior in high school I was very heavily involved in folk music and bluegrass.

I continued to be involved while I was a student going to college, and then when I was a graduate student. I was playing with bluegrass bands. Then I got this job at ASU and I just never quit. [laughs] I couldn't. My wife says I'm addicted.

Dr. Biology: Well, it's a good addiction, I have to say. And on that note, no pun intended, let's take a moment to listen to a song from your solo album Violinalone. The song is a short piece. It's just a little over a minute and a half in length, and is called - I love this title - "Stronger than Dirt".

[song]

Dr. Biology: Well, now that we've had a chance to listen to "Stronger than Dirt, " where did the title come from?

Ron: Well, there's a quote in the middle of that tune from an old Cream song - Cream was a rock band from the 1960s - a quote from a tune they did called "Sunshine of your Love." To my ear, that line always sounded like a commercial. It's a bunch of odd connections, but that always sounded like a commercial that was popular, or frequently aired when I was growing up for some dishwashing soap, called "Stronger than Dirt." [laughs]

So that's where it came from. I have a bunch of really odd associations and connections.

Dr. Biology: Now that you have the evil twin, and you have your science career.

Ron: [laughs]

Dr. Biology: Do you find it difficult juggling the two careers?

Ron: Being a professor and being associated with a university provides a much more stable form of employment with better benefits and all of that. So, that has in a sense always taken priority. But I've never really been willing to let the music go completely, as I know many of my colleagues have.

There are a large number of my colleagues who were pretty active in music until they graduated from high school or graduated from college. The years of graduate school, working on a PhD or a Master's degree seem to be times that are especially common to let people's firsthand involvement in music go.

I never did. So I always remained first and foremost committed to a career in academia. But I always managed for whatever reasons, and there are a variety of reasons for that, to maintain an involvement in music.

As a graduate student working on my PhD, people would hear me play and ask me to join their band. When I got here, I think within three months of having arrived in Phoenix I had made connections with the music business here and was performing.

I've always been able to control my involvement in music so it never interfered with my academic pursuits and my life as a faculty member at ASU.

The hardest time was when I was trying to do road gigs and stuff like that on weekends. It was interesting, because on the road I could get a lot done on airplanes that I couldn't get done at my office because I was undisturbed.

If there was anything that became particularly difficult at that time, it was not just juggling those two careers. It was juggling those with a family.

Dr. Biology: Right.

Ron: I had a family growing up at that time. It all hung together OK, I'm happy to report, but that was difficult.

Dr. Biology: You've pretty much answered this, but is there a crossover between music and your science career? In other words, what I'm asking is, do you find one enhances the other?

Ron: Well, they certainly do for me in terms of my mental health. [laughs] Being able to go out and play gigs puts me in situations that are so removed from academia that it's refreshing in a way.

I think it works both ways. I think my being in academia means I'm not thinking about music constantly. So, when I go out on gigs I may be a little fresher than some of my friends who have been working five nights a week in a bar.

The connection that I've always puzzled about but never made is that of taking a scientific, behavioral, and sensory perspective on music. And somehow that has never happened.

Recently I was watching a news program the other night. They were interviewing this fellow who is an actively gigging saxophonist playing jazz. He has also made a career out of studying the neuroscience of music by looking at what parts of the brain respond to music, what parts of the brain are responsible for recognizing music as such, and what musical expectations we bring when we listen to it.

I've just never gotten into that. Although, like I said, there are ways in which I think that me being involved as a musician has helped me maintain certain kinds of perspective on my life in academia and vice versa.

I've never really gotten involved in the scientific study of music, or in musically expressing scientific ideas.

Dr. Biology: Right.

While I was researching some of the things you've been doing musically lately, I did come across a video clip on YouTube. I'd just like to mention it because a lot of the younger scientists out there are probably addicted to YouTube like a lot of the country.

Ron: [laughs]

Dr. Biology: I just wanted to say that if someone wanted to actually not only hear you, but see you perform, they could go to YouTube and look up your name. The person you're performing with is Jeff Dayton.

Switching gears, or to come to a conclusion of this interview, I always ask three questions of my scientists. When did you first know you wanted to be a scientist or biologist?

Ron: Oh, about the same time I started playing violin, I think. It was when I was about 10 years old. Maybe earlier than that, actually. I was thinking about this the other day.

When I was about seven or eight, my parents bought me a telescope. I used to set this up in the backyard in the evening and look at the moon. We would try to see how many moons of Jupiter we could count on a clear night. We would try to see the rings of Saturn, which even with this relatively crude telescope with poor optics was not difficult to do.

At that time, my mother claims that there were kids in the neighborhood who would come around and listen to me talk about this stuff, and some of them actually called me "professor".

Dr. Biology: [laughs] Oh, really?

Ron: [laughs] Yeah. I don't know, maybe that cut the mold right there.

Then I remember even in sixth grade, when I was about 10 or 11, writing a paper about genetics and finding it just fascinating. This was stuff on the genetics of hair color, simple Mendelian genetics stuff. I thought that was really interesting.

As a teenager, I got interested in natural history and birdwatching. By the time I graduated from high school, I was wholly committed to doing some sort of biological profession. In college, I saw the lives of the faculty and said, "that's pretty sweet."

Dr. Biology: Pretty cool, isn't it?

Ron: So, that's for me. At that point I became committed. It was when I was in college that I became committed to being a faculty member at a university engaged in research. So it's been a long time.

Dr. Biology: If you were not a biologist, what would you be?

Ron: I really don't know. I guess some people say, "you're getting close to retirement, are you going to go into music full time?" I don't know. I like doing both. I wanted to and have been a biologist for such a long time, it's hard for me to imagine what else I might do. I just really love it.

Dr. Biology: And for young scientists, and even old scientists or scientists that always wanted to be, what advice would you have for them?

Ron: Yeah, I always find it difficult to answer a question like that. If one's committed to science, there are lots of venues available for young people to experience science. Certainly at the university we provide programs not just for students to listen to lectures in science, but to become involved in research.

There are similar sorts of services available to students at high school levels and even junior high levels. For them to become involved in research or to learn about research by firsthand participation in it. There are lots of programs throughout the country for this sort of thing.

And you know, you have to keep in mind that science is the business of not just facts and figures. It's a process of trying to answer questions about how the world works and test ideas about how the world works.

Presumably if you want to be a scientist in the first place, you're curious about the world and how it works. So the sooner you can get involved with that, the more exciting it will be for you, the more compelling, and the better it will prepare you for a career in the field.

Dr. Biology: Well on that note, again with our musical theme, I want to thank Ron Rutowski for visiting with us.

Ron: Thanks Dr. Biology. It's been fun.

Dr. Biology: You've been listening to Ask a Biologist and my guest has been Professor Ron Rutowski from the ASU School of Life Sciences. You can read more about Dr. Rutowski on the Ask a Biologist website. Just click on the "profiles" link to see his and other biologists' profiles.

If you would like to read more about butterfly vision, there is a companion web article called "Did you know butterflies are legally blind?" You can find this and other articles under the "articles" link.

The Ask a Biologist podcast is produced on the campus of Arizona State University. 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 just can Google the words "Ask a Biologist".

I'm Dr. Biology.