Ask a Biologist vol 024 Topic: Bee Movie Maker Guest: Brian Smith

Bee Movie Maker -

Bee Movies are not just for Hollywood. Dr. Biology catches up with bee movie maker and neurobiologist Brian Smith who uses film and video to unlock the mystery behind bees and how they sense and communicate with the environment. This movie director may not bee up for an Academy Award, but he will let you in on the life of bees including bee vomit and their interesting dance steps. Bees Dance?

Transcript

Dr. Biology: This is Ask-a-Biologist, a program about the living world and I'm Dr. Biology.

Today we're going to be learning about how we interact with the environment. What am I talking about? I'm talking about how animals use many different senses to navigate the world we all live in. Smell, sound, touch and taste are all senses that help us find things we need, you know like food and shelter. Or maybe for modern humans, we should say, how to get to school or find your classroom and of course the local mall where we can shop for eye-catching clothing or maybe watch a new movie in a multiplex theater while eating some popcorn full of buttery flavor and smell.

To help us learn about senses is our guest scientist, Professor Brian Smith. Dr. Smith is a professor in the School of Life Sciences at Arizona State University who studies bees to learn how we process sensory information. To do this, he uses many techniques including bee – B-E-E- movies that he directs, well, so to speak. He also has an interesting sport that allows him, if only for a short time, shall we say fly like a bee -- without any mechanical devices.

We're also going to take a trip inside a beehive and "beelieve" it or not, listen to some music composed by Nicolai Rimsky-Korsakov that was inspired by bees. We'll do that later in the program so you'll have a chance to think what the name of that tune could be. Right now, I want to welcome to the show, Professor Smith. Thanks for joining us today.

Brian Smith: Well thank you. It's my pleasure.

Dr. Biology: So you're a bee movie director and actually you've been filming bees for quite some time. What got you started in the bee movie business?

Brian: Well, my interest in bees really is what did that. When you watch bees, they move so fast, many times. If you really want to know what they're doing and understand how they move, for example, many times, you really have to take videotape of the bee. While we're watching it, they do something very fast that takes half a second for them to do and I'm worried that I miss it or I don't understand it in some way.

Well I like to take the videotape because you can go back and play 30 frames a second, one frame at a time and watch bees, basically in slow motion, do whatever it is they just

did. You can really get a detailed picture of what they're doing. For example, if you watch a honeybee dance, while it's trying to recruit another bee to a good food source, well one of the things they do, is they waggle back and forth and buzz their wings. They buzz their wings about 200 times a second.

Dr. Biology: Two hundred times a second?

Brian: About 200 times a second.

Dr. Biology: Wow!

Brian: If you really want to see this, you really have to break it down in slow motion so you can see the wings start to flicker back and forth. If you're really good and have expensive equipment, you can take videotape that would see each wing beat.

Dr. Biology: That's amazing. I can't imagine. Two hundred times a second -- a blink of an eye doesn't even come close to that.

Brian: No. No.

Dr. Biology: Well there's a new movie coming out which is rather interesting because it's called Bee Movie. With all your experience with bees, I can see you as a consultant for the job. Did they give you a call?

Brian: No and I'm not worried about the competition either at this point [Dr. Biology laughs] but I look forward to seeing the movie. I've seen many of these movies come out of Hollywood about insects and animals and I look forward to taking my children to see it because I think it would be wonderful and entertaining. Hollywood, of course takes artistic license, if you will. They feel free to interpret things to make a good story.

Dr. Biology: Right.

Brian: Which is fine. We all enjoy a good story but what I would want everyone to understand is they're not always learning about the biology. For example, I was listening to an interview with Jerry Seinfeld who is the voice star of the movie.

Dr. Biology: Right.

Brian: And in 20 seconds I realized he made a few significant errors about honeybee biology. Again, I'm not criticizing or saying that's bad, as long as everyone understands what they are learning is not necessarily what bees do.

Dr. Biology: For example?

Brian: For example, in the movie, Jerry is a boy and Jerry's involved in making honey. Boy bees don't make honey. The only thing they ever do is mate with the queen bee.

Dr. Biology: Ahh.

Brian: So they're not involved in doing that. In this interview, there was a short clip where Jerry's character is talking to his father. Honeybees never meet their father, unfortunately. It's kind of sad but that's the way the biology is because the father mates with the queen and then dies long before the children, if you will, the worker bees are born.

Dr. Biology: That is sad.

Brian: Or long before they emerge. It's very sad but it's biology. It's true.

A third point is the father mentioned that Jerry, as a boy has a stinger. Male honeybees don't sting. The stinger is actually an apparatus that female honeybees have that originally was used to lay an egg. And of course, only females lay eggs. So the stinger is a modified apparatus or device for laying an egg. So only female bees can sting.

Dr. Biology: OK.

Brian: This is sort of what I mean. As I say, I think it will be a wonderful story but as they probably needed to make a good story, they took some liberty with honeybee biology.

Dr. Biology: Let's talk a little bit more. Actually the plot of the story is kind of interesting. We have Barry B. Benson who's played by Jerry Seinfeld, as you mentioned. He finds out that humans are selling their honey -- the bee honey -- and decides to sue humans for stealing honey from bees.

If you think about it, it's interesting because the bees do work hard for that honey. If you take a typical honeybee hive, say about 60,000 bees, collectively, they've got to fly 50,000 miles which is like going around the earth twice, just to make one pound of honey. My question is, do you think they have a basis for a lawsuit? Are humans stealing the honey from bees?

Brian: No.

Dr. Biology: We're not stealing honey?

Brian: Well, if you look at some really, really early drawings from humans, many, many, many tens of thousands of years ago that are recorded on caves, for example, I think in Africa or in Europe, you have pictures of human beings climbing up a tree and breaking into a honeybee colony. So yes, in that sense, they're stealing honey from the bees. But the nice thing about honeybees is that they give us honey in return for us doing something for them.

Dr. Biology: You're talking about today.

Brian: Modern day, yes. Beekeepers now keep honeybees. We've domesticated honeybees. We've made them like cows and horses and pigs and chickens. They're animals that we maintain. What does it take to maintain them? Well we give them a very, very nice place to live that is really well designed for them. It's sort of like if someone

comes up to you and says, "Well Dr. Biology, show me your best house where you would really love to live. Let's make a drawing of it." So you make a drawing of it and I go out and build it and say, "There you are. You can live there."

Okay? Well let's say the honeybee colonies get sick, which they do. There are lots of diseases of all kinds that will make a honeybee sick just like diseases that make us sick -- viruses that give us colds. There are viruses that infect bees. When that happens, beekeepers go out and treat the honeybees with medicine to help them get over whatever illnesses are afflicting them.

When the honeybees have to go through winter -- and when you think about it, in cold climates in the United States, up in the North, the winters can be very, very, very cold. In those situations, the bees huddle up in a ball, about the size of a basketball -- maybe a little smaller. They huddle over a lot of honey in their colony, and they sit their and shiver their muscles. When they shiver they generate heat, and that keeps the colony warm.

So if you were to go out and stick your hand in the middle of a honeybee colony, and believe it or not you can do that--they're very gentle animals if you know what you're doing, and you do that in the middle of the winter, you'd find it very warm, something about maybe 60 degrees inside that mass of honeybees that are shivering.

They need food to do that. So when it's time for them to go in for the winter, we can move their colony's into a place that's sheltered from the environment. We can give them food if they need it, and help them get through the winter. So, I always think of it as in return they give us a little bit of honey.

Dr. Biology: So, you have this business deal?

Brian: So we have a business deal with bees, exactly. Now the thing that I think everybody needs to do, and this is something that I do because I love honey. Every time at the bottom of my honey jar there's always a little bit of honey that you can see sitting there. Well, what I'd like everybody to do now is when they see that little tiny drop of honey--lots of bees worked very hard for that little drop of honey, so I'm always trying to be very, very good about using every little drop of honey, because I respect what the bees have to do...

Dr. Biology: To make that.

Brian: ...to make that for me.

Dr. Biology: You just mentioned that, "If you know what you're doing that bees are rather gentle animals." You have a wonderful photograph of you, you're covered from head down to mid-torso with bees.

Brian: Yeah.

Dr. Biology: Your face--you can see your face is open just a little bit. To some people that might be scary, or at least creepy. How did you do that, and why did you do that?

Brian: Yeah, I always get that question when I show that picture. In fact when I give a really technical scientific talk, sometimes for fun I show that picture at the end. It's almost always the case that the first question I get is, "Really interesting talk Dr. Smith, but how did you do that with the bees?"

Dr. Biology: [laughs]

Brian: So, it's … I won't say easy to do. But you have to realize that honeybee workers, they're all female...

Dr. Biology: Right.

Brian: ...and they have stings. They need a queen, because the workers are sterile. They can't produce new eggs themselves, they need a queen to do that. So if I go into the colony and see that the queen dies or disappears--a lot of times the queen is just gone and I don't know or the beekeeper doesn't know what happened.

Well the workers at that point--if bees panic, that's when they panic. Because they have to take a newly laid egg by that queen and start feeding it a lot of food, much more food than normal worker larvae would get. That larva will then develop into a queen, only because she gets much more to eat.

Dr. Biology: Very interesting.

Brian: It is. The queen looks very different, anybody can see the difference between the queen and the worker. But the queen has a pheromone, an odor that she gives off. In fact, one of the worker's specializations in the colony is to take care of the queen. These workers hang around the queen, and pick up the queen's odor. Then they walk off to the far reaches of the colony, far away from where the queen normally goes, and they distribute the queen's odor that way.

So everybody in the colony knows the queen is present, because they can smell this pheromone. Well when the queen is gone, the pheromone is gone. The workers go into what's called "emergency queen rearing," because they need a new queen.

In those situations the workers can become sometimes very docile, especially if they're confused. So if you take about 5,000 or 10,000 worker honeybees who don't have a queen, and you dump them out on the ground in a big pile of bees, they get confused. In that situation bees tend not to be very defensive. What I do then is I take a honeybee queen who's giving off this odor, and you can put her in a little cage with some eyeglasses hooks around your ears so the queen is hanging under your chin, then you stand next to that pile of confused workers who desperately want a queen. They take off, smell the queen, and they collect right on your face--just like that.

Dr. Biology: Wow!

Brian: They're so happy they have a queen--I think if I can say bees are happy, that they don't sting. So, I did that. I had probably a few thousand workers hanging off my face and all over my head, and I didn't get stung once.

Dr. Biology: How long does it take?

Brian: Oh, it took about three for four minutes...

Dr. Biology: Oh, pretty quick.

Brian: ...for that to happen. When I wanted to get them off, I just jumped up and down, and they let go and they all fell off.

Dr. Biology: Well, that's amazing! Of course we won't try that at home, because you're a professional and not everybody should be doing that.

Right now--you know what I'd like to do? I'd like to go inside a beehive. So you and I, let's use our imagination. We'll put on our bee suits, grab out flashlight, and shrink down so that we can just walk right into the beehive. As a matter of fact I can hear the hum right now, the activity going on inside the hive. Tell us, what's happening?

[bees humming]

Brian: Well, the first thing you have to keep in mind and the first thing you would notice is, you can't see anything because it's completely dark.

Dr. Biology: I do notice, it's pretty dark in here.

Brian: It is. If you look inside of a beehive, you'll see the bees are all hanging off vertical cones. Because they lay their eggs, and they store their honey in the cells inside these cones.

Dr. Biology: OK.

Brian: Each of the little cells has six sides....

Dr. Biology: Yeah, I see that.

Brian: ...and the tip is pointing up. So it's what people call a "hexagon, " OK? The tip is always pointing up so that each of the cells is hanging from the tip. That's actually structurally the most stable kind of structure for honeybees to build, and they do that naturally.

Dr. Biology: So are the bees flying in here, or are they just walking around? I can't quite tell.

Brian: No the bees are walking around. In fact the next thing you notice after you notice you can't see anything, is that you're hanging off one of these cones. Now, think about it for a second. Now what if I took you, I put you in a completely dark room. I made you climb up on a ladder, and hold on tight. I started to turn the ladder, rotate it. I rotate it a

little bit to the right. Well you would know which way is up, right? Because suddenly you'd be hanging off the ladder in different positions.

Dr. Biology: OK.

Brian: You always know because of gravity, which way is up. So that's how honeybees know how to navigate through the colony, is a sense of gravity--which way is up. My angle is a little bit to the right, because I have to hold on differently than if I'm angled a little bit to the left. The best way to think about doing that is you on a ladder in a dark room, and I'd rotate the ladder to different positions--you'd always know which way. If I said, "Now go up," you would know which way to go.

Dr. Biology: OK.

Brian: So, that's the next thing you notice is you're hanging on to this vertical wall all the time. Third thing you notice is, you're always bumping up against somebody.

Dr. Biology: Yeah, I've noticed it's pretty active in here, and it's pretty crowded.

Brian: It is absolutely very crowded. The bees are always pushing up against one another, and they're always touching each other. A lot of times bees are vibrating their wings, so they communicate with each other through vibrating their wings. Sometimes you will bump up against another bee, and that bee is hungry. It just so happens that you've got a stomach full of honey, and suddenly that bee says, "Give me some." So, you press that honey out of your stomach. People call this "bee vomit,"...

Dr. Biology: Oh, great! [laughs]

Brian: And you would take that from some other bee. It's a process in biology called trophallaxis. So, the honeybees exchange food. One bee eats something, regurgitates it, they bring it back up and they feed it to another bee.

Dr. Biology: I just heard a bee and I see it flew in, and it has landed. You talked a little bit earlier about a bee dance and I have to say, it looks like there's a dance going on there. Why is it dancing?

Brian: Well there's an area of the colony that people call the "dance floor".

Dr. Biology: Really?

Brian: Yeah because there's an area of the colony where bees are doing this really, really weird looking motion. It's near the entrance of the colony and it turns out, the bees that are moving this way are foragers. So, they've been out looking for food or water or something the colony needs. They come back, they go to this area of the colony and they start to make this dance. The dance is like a big circle eight.

The bee turns to the right, comes back, then turns to the left, comes back and they literally make a circle eight. Well if you'll notice, the point where the two circles on the

eight meet, there's a little straight line the bee makes, right before it turns in the opposite direction to make the other circle.

Dr. Biology: I've noticed that.

Brian: That's called the straight run of the dance. During that straight run, the bee is waggling back and forth and buzzing its wings. Now, remember, you know which way is up. Let's say that straight run is angled 45 degrees to the left. That's half way between up and completely to the left. So, you know as a bee, because of your sense of gravity, which way the bee is pointing when it is making that straight run. Well if you go and look where that bee just found food, it’s about 45 degrees to the left of wherever the sun is right now.

Dr. Biology: Oh, so these are directions!

Brian: These are directions. So they're saying, "Go in this direction." Now, the length of that straight run, the longer the run, the longer that is, the farther away...

Dr. Biology: ...they have to fly.

Brian: ... the distance.

Dr. Biology: Ohh.

Brian: So the bees get some information about distance and direction that they have to fly to find wherever it was this bee was foraging.

Now the last thing you'll see with this bee, is once in a while, while it's making all of these circles and these figure eights -- and you can see always one or two or three bees that are following behind it and almost falling all over themselves to stay in contact with this bee, because it's buzzing its wings and they can pick up the buzzing -- once in a while, this dancing bee will turn around and engage in trophallaxis. It will regurgitate some of the nectar it just collected. Those bees that are following it will feed on that nectar.

They know how good the nectar is. Is it concentrated? Is it not concentrated? And they also get the odor of the flower. That's called a dance. People call it a language, a dance language. That's how it's commonly known. It's not nearly as complicated as the language of humans, for example, or primates, chimpanzees. But, for an animal with a tiny brain, it's very impressive.

Dr. Biology: It's very, very impressive. OK so that's the bee dance. Is there anything else that we're missing inside the beehive here?

Brian: Well, let's come back to the Bee Movie for a second.

Dr. Biology: All right.

Brian: Honey is the only industry for Jerry's character to work in. That's another thing that you have to understand about a bee colony; honey isn't the only industry. A honeybee colony is really like a small city.

Dr. Biology: OK.

Brian: You have a queen. She's the head of the colony. She lays all the eggs. Everybody takes care of the queen. She literally is the queen. In a colony that is a normal sized colony in one of these white boxes that you frequently see driving down the road, there might be 40,000 bees in there. Think of how many people live in your city. Forty thousand is a moderate sized town, OK.

What do you need in that town? You need police officers. Well, we have guard bees, bees who specialize in defending the colony because there are lots of things that want to break in to the colony to steal the honey.

Dr. Biology: Ah not just the humans, huh?

Brian: Not just the humans. You have nurse bees. These are bees who stay in the colony. You might have 10,000 larvae, baby bees that are developing. They have to be taken care of; they have to be fed. They're not given all the food they need. They have to be fed constantly so you have nurse bees who take care of the young bees as they're developing. You remember we talked about all these cones that are made of wax and the bees produce the wax themselves. There are bees that specialize in building the cones.

Dr. Biology: So they're the wax producers.

Brian: Exactly. There are forager bees who go out and collect the food. There are undertaker bees.

Dr. Biology: Ooh.

Brian: Sometimes bees die in the colony and they have to be taken away. So these bees collect dead bees and fly out of the colony and leave them somewhere well away from the colony so the dead bees don't infect the colony with something. So there are lots of different ways that bees do something for the colony. I don't think of honey as being the only industry; it's an important industry. But, I think a better way to think about it is that bee colony is really a small city.

Dr. Biology: And I suppose what we're talking about is a small city that's trading again with the humans for care and feeding and even medical because you say they're taking care of that so it's kind of a good deal.

Brian: When a bee is a nurse bee, by the way, that's not the only job it's going to have in its lifetime. Young bees are nurse bees. As they age, they get older. A honeybee might live for 40 days; that's a normal lifetime for a bee. It will actually do several different jobs. It might change into a guard bee as it gets older. It might change into a forager bee. It might turn into a bee that takes care of the queen. A bee will not just have one job. A bee will have several different jobs.

Dr. Biology: I didn't know that.

Brian: There is lots of opportunity in the bee world.

Dr. Biology: Wow. OK let's leave the beehive this moment here. We're going to go back out and we're going to talk about your research. As part of your work, we've mentioned, you do a lot of filming of bees. How long have you been a bee moviemaker?

Brian: Well, probably, believe it or not, over 20 years. I started out long ago with an interest in bees and I've progressively become more and more interested in them because as I told you sometimes, the behaviors are very fascinating. One of the things that fascinates me most is for any bee to do its job, it has to be able to learn. So a honeybee can learn -- they're not as sophisticated as we are about it, but honeybees can learn a lot of things. They don't come into the world knowing which flowers are out there and which flowers are going to be important.

So a forager bee goes out every day knowing that it has to learn where the good flowers are and come back and communicate it. The next day, it may be different flowers in a different place. So, the bee has to realize that what it learned yesterday isn't any good anymore so "I have to learn something new."

Dr. Biology: So bees can learn which is one of the questions I was going to ask and you've done a good job of answering it. They're not pre-programmed. It's not like they come out and they're going to do one thing only; they can have many jobs. And they have to learn on a daily basis.

Brian: That's right.

Dr. Biology: That's pretty impressive, especially when we're talking about something that has about how many neurons in its brain?

Brian: About one million.

Dr. Biology: About one million. And how many do we have in our brain?

Brian: About five billion neurons.

Dr. Biology: About five billion. Wow. I know that you and I have talked about this before, so if we take collectively a typical bee colony, we have the equivalent of a human brain, right?

Brian: The same number of neurons - approximately the same number of neurons.

Dr. Biology: Right.

Brian: Now remember they're connected differently. All of the neurons in our brains, and we have somewhere around five billion neurons in our brains, and they're all interconnected in some way, and they communicate directly with each other. In honeybees, those neurons are in different bees.

Their collective colony brain is connected a little differently than ours. So the collective colony brain can send one part of its brain, one bee, off some distance to the north to look for something. And at the same time, it can send another part of its brain, another bee, off some distance to the south to look for something. Of course, we can't do that.

Dr. Biology: No. It's the ultimate distributive computing, I would have to say.

Brian: In some sense, that's exactly right. The bees are integrating, to use a word, collecting a lot of information around their environment. They can send, think of it this way, little bits of their brains off in many different directions at once. The honeybee brain has about a million neurons. A million neurons is still a lot. And the bees are very impressive when you sit down and try to train them.

It's fun to do because you realize when you have a bee in front of you, and you're training it, and you're watching it and it's not responding to something at first. Then afterwards, it starts responding to it as a result of me giving them an odor associated with a little droplet of sucrose, which they want. Then afterwards, when you give them the odor, they start responding to the sucrose. And then the fun thing for me is I realize that I've just been communicating with the bee.

Dr. Biology: Right, and we've been talking about this idea of senses and how we interact with the environment, which is the theme of this show. So your research really deals with that on a very fundamental level.

Brian: Yes. Well the way a bee's brain works, especially for the sense of smell, is very similar to the way our own brains work. So what I like to do is say that I'm using honeybees as a way of not just understanding how their brains work, but also, in a more fundamental sense, this is how all brains work - or maybe how all brains work. So we're testing these ideas. What can we find out about brains in general from the way honeybee brains work?

Dr. Biology: When you talk about stimulating the bee, I think about Pavlov and his dog, the Pavlovian response, where you have the dog and the bell. You ring the bell and it salivates because it's associated with getting food. So do you have Pavlovian bees? Is that what you're doing?

Brian: That's exactly what we do. It's Pavlovian conditioning. Whereas Pavlov gave the bell and fed the dogs a little bit of meat powder or a dog biscuit, after a few times, when you give them the bell the dog starts to salivate, as though it anticipates that food is about to come. That's exactly what we do with bees. It's the same kind of behavioral conditioning.

I think about it as a way of asking the bees a question, right? If I want to know Dr. Biology, can you smell something? I can simply give it to you and ask you, and you can tell me. The bees and I don't have a common language so they can't tell me directly. But if I give them an odor and I follow it with sucrose, and afterwards, they change their response to the odor because they start to get ready for the sucrose and I can see that

-well they just told me something. They told me that they can detect the odor.

If I give them one odor followed by sucrose, but sometimes I give them a different odor followed by nothing, they respond to the first odor but not to the other one that's not followed by anything, the unrewarded odor. They've just told me they can discriminate between the two odors. They can tell the two odors apart. So it's a very, very simple straightforward way of, as I say, asking the bees a question.

Dr. Biology: And by the way, we're going to have some of your bee movies up on the Ask-a-Biologist site, and it will be under your profile. I think the title is "Bee Movie Maker"that will go along with this podcast. So people can actually come to the website and look at these movies.

I want to remind people that no bees were harmed in the making of these movies, although it looks somewhat uncomfortable because you need to restrain them. One colleague of yours mentioned that we restrain our children in the backseat of the car with a car seat to protect them - this is probably no worse than that. So they might be a little uncomfortable or a little unhappy, but we're not doing anything to them.

Brian: We have to restrain them because we need to keep them on the video frame, so we can see what they're doing. And we need to know that they're going to be there when we need them to be there to stimulate them.

Dr. Biology: Well Brian, before I ask the three questions every guest that comes on the show is asked, I thought we'd return to the beehive and listen in. Along with it, we're going to hear a piece by Nicolai Rimsky-Korsakov, called "Flight of the Bumblebee". We talked a little about this at the beginning of the show, and we were going to have you guess what we might be playing. This piano version is being performed by Margarita Denenburg.

[music]

Dr. Biology: It's fun to listen to that piece, especially after we had a chance to visit the inside of a honeybee hive earlier. I can imagine the hub of activity in there is probably rather exciting even, where bees are, especially the worker bees are 'busy as a bee' doing the things that they have to do to keep the colony going.

So along those lines of activity and excitement, do you remember the first time you wanted to be a scientist or were thinking about becoming a biologist? Do you remember that moment or was there actually a moment that happened?

Brian: Well I can remember way back when I was six, seven or eight years old, well before cable television, there were only two or three channels, and every once in awhile, one of the channels would transmit a program about a marine biologist by the name of Jacques Cousteau.

Dr. Biology: Oh Yes.

And I remember it looked so adventurous to go off on a ship on the ocean and do research on animals and watch them behave. It was just such an exotic thing that it immediately instilled in me an interest in watching animals behave and traveling.

I am always trying to find ways to go off, when I have time, to exotic places. I've spent a lot of time in the tropics watching animals behave and do these sorts of things. I'm not sure I really understood what it meant to be a scientist at that age, but those programs, in particular, really were very influential for me.

When I was probably only six or seven or eight years old, I would just be glued to the television. Nothing else was allowed to happen that involved me and our family whenever a Jacques Cousteau special came on, because you know it's going to come on. Unlike today when you know it's on 14 times a week, it's on once--so you have to be there for it.

Dr. Biology: Right. I have to say, that we have a lot of questions come into Ask-a-Biologist around marine biology. I think the call of the sea, that adventure, definitely is powerful for students. I bet you're right that Jacques Cousteau and his programs were responsible for many of the biologists and scientists we have today.

Brian: Well, it turns out my wife used to work for Jacques Cousteau.

Dr. Biology: No kidding? She worked for Jacques Cousteau? I have to say I'm jealous.

Brian: Yeah, it was very interesting. When she worked in Los Angeles she worked for Jacques Cousteau, and some of his family at some point. So I loved Jacques Cousteau, and I wound up marrying a woman who at one point in her life worked for Jacques Cousteau.

Dr. Biology: Did you get to meet him?

Brian: No, I never got to meet him unfortunately.

Dr. Biology: Oh, that's too bad.

Brian: I would have loved to have done that.

Dr. Biology: It's too bad that we won't ever be able to have him on the Ask-a-Biologist Program, because I think he would have been a great guest.

Brian: No, he died several years ago, but I think his impact is long-lasting. I think of him, and I put him in the league with some of the other great communicators of science--Carl Sagan for example, the astronomer. There are many essays by Carl Sagan who -- and well I would recommend a lot of students read things that he wrote because he's just a wonderful communicator, and he too has had an influence on my thinking of science.

Dr. Biology: Communicator, inventor, and adventurer--everything we'd like to do in our wildest dreams, right?

Brian: Exactly.

Dr. Biology: OK, now that we know what probably got you started in a career in biology and a life in science--I'm going to take that all away from you. What would you be if you couldn't do any science or be a biologist?

Brian: Whatever I would be, would have to let me travel. I love reading books about travel. For example I'm a big fan of an author, his name is Paul Theroux. I've read many of his books. One of my favorites is called "The Pillars of Hercules," where he did something that most people would think is odd.

He went to the Rock of Gibraltar in Spain. From the Rock of Gibraltar what you can see is a similar structure in Morocco on the other side of the Mediterranean, it's close enough. Those are called the "Gates of the Mediterranean," the Pillars of Hercules. You sail through them to get from the Atlantic into the Mediterranean. So he made a vow to get from the Rock of Gibraltar to the rock in Morocco by land.

Dr. Biology: Oh! [laughs]

Brian: So car, rail, boat--whatever he had to do to go all around the Mediterranean, and he wrote about the things he encountered. So for him I have the impression, and for me, travel is not necessarily about being somewhere, it's the adventure of getting somewhere.

Dr. Biology: Exactly, exactly.

Brian: So in the best of all possible worlds, and maybe I'll still do this someday, is I would do something like that.

Dr. Biology: Now you also have a pretty interesting, if not rather exciting sport that you partake in--you skydive.

Brian: Yes.

Dr. Biology: How long have you been skydiving?

Brian: Since I was 16. I've been flying planes since I was 13, although I no longer fly planes. I don't have the time to do it, but I still skydive.

Dr. Biology: How many jumps?

Brian: I'm about to hit 2,000.

Dr. Biology: I don't like the word "hit" in skydive at the same time.

Brian: Well yes of course, it's a metaphor.

Dr. Biology: [laughs]

Brian: I'm about to achieve 2,000 in skydives.

Dr. Biology: Well for a brief time when you're skydiving, you get to sort of fly around. You have nothing mechanical, and therefore you kind of get a bees perspective--only for a short period.

Brian: Well, you're not flying like a bee flies. The best way to describe it to people is if you're driving down the road at 60 mile per hour, and you stick your hand out the window, and hold your hand flat against the wind you can feel a lot of pressure from the wind.

Well when you jump out of an airplane you start falling at 120 miles per hour, and it's hitting your whole body. You have a lot of pressure, so your body has to be symmetrical. If you're not symmetrical you'll start to turn, or you'll start to move forward, or you'll start to move backwards, because your body deflects air just like your hand will deflect air if you angle it a little bit. Everybody has sort of played that game.

Dr. Biology: Right, outside the car window.

Brian: In the car. I don't mean jumping out of an airplane, I meant outside the car window.

Dr. Biology: [laughs]

Brian: So an interesting thing is that you can literally move very fast, and very, very precisely when you're falling through the air at 120 miles per hour, if you know how to use your body to control the air. So, one of the other things that I do regularly is Yoga. I like doing Yoga, because it keeps me very flexible, very healthy, it's good for my mind, but also it's good for understanding how to move my body. When you have 120 miles per hour of air hitting it, you realize how important that can be.

If I have a student who's skydiving, and many times students are very nervous obviously, and they are stiff as a board; they're very tense. If you take a board and throw it off of a building, and watch what happens, it flips all over the place because it can't deflect the air; it can't control the air.

A good experiment is take a piece of paper, eight and a half by eleven, hold it over your head and drop it. The paper will flip over several times, and float back and forth as it hits the ground. That's what you would do, if you're stiff as a board when you're skydiving.

But if you take that paper and just take your fist in the middle of the paper and punch down, so it's not a hole, but the paper is sort of bowed. You make a cup with it, it's coming up at the ends and it's really symmetrical. Now hold that paper above your head and drop it, it will go straight down because it can deflect the air uniformly around it.

That's what will happen if you do something--that seems counterintuitive, but if you relax. You relax when you're skydiving the air pushes your body into that natural symmetrical position, and you fall straight down in a very controlled way.

Dr. Biology: Fabulous! I have not done any skydiving.

Brian: Well, you should.

Dr. Biology: I know. I think about it, but that might be as far as I go. Before I let you go, I have one more question. What advice do you have for someone that's wanting to get into the world of science--it could be a young scientist, and it could be people that maybe like bees, they've decided to switch or shift their jobs, and they want to go onto a different career?

Brian: I say find something you like doing. Which means trying a lot of different things, because you may not know at this point what you like best. So experiment, work a little bit in different kinds of things. When you find something you like doing, don't take no for an answer--but be really persistent.

Dr. Biology: Wonderful advice. Well Dr. Smith, thank you for visiting with us today.

Brian: Thank you, it's been my pleasure.

Dr. Biology: You've been listening to Ask-a-Biologist. My guest has been Professor Brian Smith from the School of Life Sciences at Arizona State University. The piano version of "Flight of the Bumblebee" was performed by Margarita Denenburg, who is a student in Herberger College of the Arts, also at ASU. As we mentioned earlier that piece was originally composed by Nikolai Rimsky-Korsakov, but the piece that you heard was transcribed by Sergei Rachmaninoff for the piano.

The Ask-a-Biologist Program is produced on the campus of Arizona State University. Even though you can't send us your questions while we're on the air because we don't broadcast live, you can always send us questions with our companion website. The address is askabiologist.asu.edu, or you can just Google the words "Ask a Biologist." I'm Dr. Biology.