

Science Studio Vol 008 (Guest Jon Harrison)

Giant insects: Not just in B movies

Professor Jon Harrison sheds light on the evolution of his scientific career and nature's biggest order: arthropods. How big is big? In the Paleozoic, cockroaches were the size of housecats and dragonflies the size of raptors. Tune in and find out what made it possible, and what may have changed everything.

Transcript

Peggy Coulombe: This is Peggy Coulombe with School of Life Sciences at Arizona State University. Welcome to Science Studio. Today we are going to talk about two completely different things: the evolution of a scientific career and giant insects from the Paleozoic.

What do these two things separated by, say, 300 million years have in common? That would be Professor Jon Harrison. Welcome, Jon.

Jon Harrison: Hi, Peggy.

Peggy: If you go to Jon's website, there's a picture of him standing in front of what looks like an elephant-sized Staghorn Beetle statue. For those of you who have never seen a Staghorn Beetle, it's like a Darth Vader-ish ladybug on steroids, a large, armored beetle with huge attenuated horns on its faceplate, a virtual stegosaurus of beetles!

So, Jon, given my description, why do you think bugs hold such a fascination for people?

Jon: Well, Peggy, I think because they have the exoskeleton on the outside, they look so different from the vertebrates and mammals that we're used to. Their eyes look so different. I think this is why for many science fiction movie makers they use insects as models. They are in many ways our concept of alien.

Peggy: Why do they hold a fascination for you?

Jon: Well, I've been interested in insects as models to understand how animals respond to environmental change for years. I think they're wonderful models to use. You can raise them in the lab; you can find them in the field and observe them; they're much cheaper and easier to raise than mammals, and they're just fun.

Peggy: Maybe this fascination with insects--yours, mine, and everyone else's--is why big bugs are a part of our popular culture. You mentioned movies; one of my favorite movies when I was about nine years old was "The Ants," a flick where a colony of behemoth, social insects invade a small town, accompanied by the screams of that classic, B-movie heroine. Here, I'll demonstrate [screams].

Jon: I'm scared!

Peggy: Though the statue and the movie we've been talking about are complete and utter fantasy, there was a time long before people when insects actually were gigantic.

Dragonflies had wingspans of more than two feet across. Now the largest insect in the world is merely inches long. So tell us, Jon, what's changed?

Jon: Well, lots of things have changed. Back then, of course, there were no mammals and no birds, so insects had the terrestrial world to themselves to a large extent, at least in the air. So that could have been a very important thing, maybe that those big insects were eaten by birds.

The food was different, there were totally different kinds of trees at the time, so maybe the food was a little bit better.

One of the things that has fascinated us and many people have wondered about is related to oxygen. Right now, we have 21% oxygen in our atmosphere that we're breathing; back then, the current models suggest that atmospheric oxygen was about 30%. So, some people have thought "Maybe this higher oxygen is what enabled insects to get bigger."

Peggy: Is it known what caused the shift in oxygen levels?

Jon: The models suggest that the rise in oxygen at the time correlated with the period when the oil that we're driving our cars around in was created. Many, many plants were buried under anaerobic conditions where no oxygen was available and bacteria could not break them down. That means that oxygen wasn't taken out of the atmosphere, and that allowed oxygen to rise.

Certainly another aspect that was different between now and then is that we think the average temperatures were quite a bit warmer in the late Paleozoic than they are now, but in general, warmer temperatures tend to make ectotherms like insects and lizards smaller.

Peggy: So does this mean with global warming our insects are actually getting smaller?

Jon: It's possible.

Peggy: How can you model something in the lab that gives insight into what was happening millions of years ago?

Jon: Well, we've taken two main approaches. One is just to ask whether or not if we raise insects in atmospheres with different oxygen, does it affect their size? So for some of them we can do this for multiple generations, and we can see if we lower the oxygen, do they get smaller? If we raise the oxygen, do they get bigger? In fact, in quite a few insects that's true.

Peggy: How did your early research lead toward examination of insects from the distant past?

Jon: Well, I've been interested in how insects get oxygen from the air into their tissues for many years. I've been studying their tracheal systems, which are these little tubes that carry oxygen from holes in the side of their body down to the cells, for a long time trying to understand how it was regulated, how the structures were determined. This was kind of a natural question for me. When I first heard about this hypothesis, I had to know.

Peggy: Where did you hear about the hypothesis?

Jon: I was sitting, having beer with a friend of mine, Robert Dudley, now at UC-Berkley. He, Jeff Graham, and Carl Gans were the first to compare the fossil record for insects to the current models of how atmospheric oxygen changed. I heard about their ideas before it came out in *Nature* in a hypothesis paper in the mid-Nineties.

Peggy: Did you always know that you were going to be a researcher?

Jon: No. [laughing]

Peggy: [laughing]

Jon: In middle and high school, I was torn between becoming a forester and a medical doctor. Then I kind of settled on the idea that I would be a medical doctor in college until my last year at University. I really started taking courses more back toward those forestry ideas about environmental biology.

At the time, I was really interested in plant taxonomy, identifying plants and how they develop. I realized that I loved that a lot more than I loved medical stuff. I did go to med school, and there I was convinced that I liked environmental biology better than medical science. Interestingly, at the time I thought you couldn't get a job in biology, so I spent five years doing other things and finally was told "Yeah, you can get a job," and that person was right.

Peggy: What were a few of the other jobs that you did before you had it all come together?

Jon: I worked for two years with emotionally disturbed youth in a wilderness program. It was a lot of fun, building our own homes and making food and taking lots of canoe trips. Seeing kids really change, that was really fun and gave me a lot of experience useful for dealing with faculty now.

Peggy: [laughs]

Jon: I worked for two years as a solar systems installer, and that was actually really good background, too, because I learned about electronics and plumbing, and that comes in very handy in a physiology lab.

I spent about a year traveling, and that gave me some broad interest in the world and a background, again, that I think was really good for science.

Peggy: So what was, then, the defining moment, the one that made you ultimately choose science?

Jon: Well, as I said, I think I've always wanted to do environmental biology. It was probably getting admitted to graduate school. I didn't know if I... I'd spent quite a long time kind of floundering, really, trying to figure out what my career was going to be. Then I think it was actually my first semester, when I took an environmental physiology

course from Cindy Carey at the University of Colorado, Boulder, and I just fell in love with the topic, and I've never looked back.

Peggy: So who was most influential in your life?

Jon: Oh, certainly my parents to start, who gave me just, I guess, a drive to succeed and to look for the kind of job that I loved. And then secondly, my Ph.D. advisor, Todd Gleason, who was just the best advisor anybody could have.

Peggy: What defines a "best" advisor? What are the characteristics that you would use to describe someone who would be the best?

Jon: Well, I think that you really have to care about the students and what's really best for them. It takes a lot of time. You have to think about, what is it going to take to succeed in the field that the person wants to go into.

Peggy: So what pulled you to the study of insect metabolism and energetics?

Jon: Well, Todd Gleason, my advisor, studied lizard metabolism and muscle. He was really interested in what makes a lizard fast, how does muscle vary among a sit-and-wait predator versus a more roaming kind of predator.

My first semester at UC Boulder--well, I mentioned the part to you about medicine, my having some difficulties with medicine, well, this came up again. I was TA'ing in a Human Anatomy and Physiology class, and had to deal with rat surgeries. I was just unable to handle that at the time. I did do it, but it really bothered me. It really bothered me killing rats.

I was taking a course in social insect biology from Mike Reid, who was one of my other great mentors in my graduate career. I really got interested in insects, and I thought, "I don't think I'd mind killing insects, and I could still find out all these interesting things about their physiology. Plus, nobody hardly knows anything about them, and very few people are studying them." So that's how I ended up doing that.

Peggy: What's most fun about the work that you do?

Jon: It is two things. One is just solving problems. I mean, it is really neat to spend time thinking about things, designing an experiment, and then have it actually come out to tell you an answer. I think that is really fun.

Then I think, I mean, I love the animals. I mean, I just find that insects and animals really fascinating and fun to learn about and to observe. I really enjoy the people. I mean, I have a really great group of students in my lab that are always teaching me things.

Peggy: Yeah, I noted that you had three post-docs, four graduate students, and five undergraduates working with you. That's quite an investment as a mentor. What do you tell your students about, in terms of building their careers in the sciences?

Jon: Well again, I think it has to be driven by every individual. So people have to decide what they really want to do, and then for some people industry might be the right

approach, for others a real teaching position at a community college, and for others it'll be really a research position. People need to decide really honestly what they most want to do, and then do their preparations properly for those kind of jobs.

Peggy: So as a mentor you look at each person as an individual case, and find out their strengths and weaknesses and interests, and then help them shape their career toward whatever their ultimate direction is that they've decided.

Jon: That's what I try to do. I mean it's really ultimately their decision, what direction, and then it's my job to help them get there. Having had the experience of seeing lots of people, now, go through these different tracks, I have pretty strong ideas about what you need to do to succeed.

Peggy: So tell me what jobs have some of your students gone on to do?

Jon: Well, my first graduate student, Steve Roberts, is now a tenured professor at the University of Nevada, Las Vegas, and is doing just fantastic there.

I have other students who are teaching at community colleges, that really decided that they wanted to be teachers and really were fascinated with, how do you get people to learn basic principles and have them focus on their teaching, and getting teaching experience.

Mark Perkins is a professor at Orange County Community College and just loves that. So I think that sort of illustrates two really kind of disparate paths, and really you have to figure out what's right for each person.

Peggy: What kinds of research will you pursue in the future? I read on your web site that you're developing cyborg insects. Can you tell me something about this work and what you hope to accomplish with it?

Jon: Now this is a really fun project that we're doing in collaboration with some engineers at the University of Michigan. The goal of this project is to create some insects that can carry wireless transmitters and transducers within them. So for example, we could measure their heart rate, beat frequency, body temperatures, while they are flying around, and send that information back by radio to the scientists. I think that would be a really fascinating project if we can get that to work.

Peggy: Sounds exciting. Jon, I want to thank you for sharing your adventures with insects, large and small, with us.

Jon: Thanks, Peggy. I always like talking about it.

Peggy: If you're interested in learning more about Jon's research, you can go to the SOLS web site. That's SOLS.asu.edu, and thank you for joining us. This is Peggy Coulombe and you've been listening to Science Studio. Science Studio is produced by the School of Life Sciences in the College of Liberal Arts and Sciences on the Tempe campus of Arizona State University. Have a good day.