Brent Helliker, Ph. D.

Dr. Brent Helliker, Ph.D., is an assistant professor of biology at the University of Pennsylvania. Dr. Helliker earned his B.S. in organismal biology at the University of Kansas and his PhD in biology at the University of Utah. His research focuses on plant ecology, especially with regards to biotic-abiotic interactions through weather variations and climate change, and a plant's evolutionary response to a number of changing environmental factors. He was recently featured in NPR's *All Things Considered* for the discovery that leaves performed optimally at 70 F in every environment.

So could you briefly introduce your research for the readers?

Well, by name, I'm a plant physiological ecologist, which means that in effect I'm interested in how plant physiology responds to variation in climate and weather and how that response allows them to exist in their particular ecological niche. Climate is very much the long-term average weather in a site, whereas weather deals with year to year variation, such as a big storm coming through and other short-term things. Things that interest me are how things like temperature, water availability, etc., affect plant performance, such as photosynthesis and respiration, and how they affect the balance between the two. And, ultimately, how all of that feeds into fitness. Fitness is a measure of how successful you are in breeding, being one of the true measures in terms of evolutionary success. You know, how many kids do you have? That's important.

Do you work with undergraduates in your lab, and if so to what extent?

I do, this is my fourth year here, and I've had undergrads working in the lab almost every year, occasionally working on independent projects but also working as lab techs where they're learning various techniques. I've had five or six now, over the past years.

What kind of things do undergraduates do in your lab?

Well, what I use as a tool to measure plant responses to the environment is something we call stable isotopes. There is a naturally occurring amount of these isotopes. We look at carbon, oxygen, and occasionally hydrogen. Looking at these isotopes we can pull out the ratio of carbon gain versus water loss, or the water loss efficiency. You can potentially reconstruct past climates looking at other things and tree rings. You can also reconstruct the temperature of the leaves of a plant throughout its lifetime, which actually gives you a direct idea of how plants are responding to temperature, since you can measure their leaves as they're photosynthesizing. Undergrads, on the technical side, work on processing samples, like the chemical means of extracting cellulose or water from plant tissue. We have this big water extraction device in the lab that a lot of them work on. For independent projects, they work on anything from looking at short-term changes in isotope ratio of water in plants over a period of the day due to changes in relative humidity or temperature, to looking at the profile of isotopes in the soil water. So it ranges.

You talked about isotopes being one of the tools you use. Do you use any other models or techniques?

Everything we do goes hand in hand with some kind of model. If it's a model explaining a plant or how isotopes work in a plant or the relationship between isotopes and the environment or a plant, if we can extract information about plant responses, all of that's done in a rich modeling frame. In terms of hardware, we use an infrared gas analyzer, which is basically used to monitor CO_2 concentrations. It's not used worldwide, but it's very important. Whenever you see that chart of CO_2 concentration over time within a year, over the past 50 years or whatever, it's all measured by infrared gas analyzer.

How did you get interested in plant evolutionary mechanisms, and evolutionary biology in general?

I'd love to tell you that since I was a little kid I've been really into science and plants, but that's not true. I went to undergrad as an English major and it was a liberal arts program, so I had to take a few science classes to stir it up, with intro bio (with like 400 students). And I got an A! And I thought it was relatively interesting, but more importantly I got an A without trying that hard, and not that many people did get As. So I took a second bio class, under the guise that I'm good at it and I can get a relatively easy A. I took a second class on diversity of life, two parts: animal and plant half. I was absolutely fascinated by the plant half, so I switched my major… and then I took a plant physiology class. I was fascinated with plants and the comparison between how animals work and plants work. And then I found out what professors actually do, in terms of research, and I was like, wow, I can get paid for this?

How do you think evolutionary biology is a scientifically interdisciplinary field?

The classic line is that everything in biology makes sense in the light of evolution. It is, to a large extent, what ties all of biological investigation together. I am, in terms of scale of research, in this department, at the big end of the scale. So for my postdoc work, I did work that was arguably pure meteorology, and it was looking at ways to assess regional meteorology to be able to pull out carbon exchange on the scale of old things. So that's pretty far from evolutionary biology. But it is the regional scale climate effects that really govern what types of plants can live in a certain area. The climate governs the success of the plants, and in a good sense, the plants determine what animals will be there. You're talking about very large-scale events in sciences that technically don't talk to biology all that much, but they are fundamentally linked. I gave a lecture today in Intro Ecology that was largely talking about continental drift. So that's a really big geological process that has a feedback effect on climate and a feedback effect on who's where in the world now and such. So you would say that most everything seems to be connected.

Yeah. So you can say in a sense that climate sets the stage upon which evolution plays out.

What practical application does evolutionary biology have today?

There's an immense amount of interconnectivity. In terms of practical aspects, the most obvious example, even though it's far a field from what I do, is in terms of disease resistivity and the evolution of resistance among pathogens. It's a growing problem now and I think in the future it's going to be an immense problem.

Your research looks at C3 and C4 plants. Could you explain how C3 and C4 plants differ?

They differ in the way they take CO_2 from the atmosphere. The difference is largely that C3 plants use different carboxylating enzymes to grab CO_2 from the atmosphere. Largely it comes down to C4 plants can assimilate more carbon at low CO_2 and higher temperatures, and C3 plants, once you get to below a certain level of CO_2, their photosynthetic pathway becomes highly inefficient. This plays pretty big on a glacial scale, where CO_2 concentrations vary quite widely. When we had a glacial period, citric acid concentrations were very low, which greatly favors the creation of C4 plants. During interglacial periods CO_2 concentration pops back up, which favors the creation of C3 plants. This has a fairly immense feedback on the world: animals differ quite widely in their ability to digest C3 vs. C4 grasses. And so, we think one of the main reasons why ten million years ago the great diversity of horses throughout the world suffered a massive extinction, 4-8 million years ago, is because of a very big expansion of C4 grasses. It coincides with that expansion. There was an inability of the horses to digest those grasses, and it caused the loss. In opposite responses all the bovids, which are anything you think of as a big herbivore like cows, water bison, and buffalo, did incredibly well after the C4 expansion. But we only have 4 or 5 horse species now, which is a major crash from what we had earlier.

If we better understand the C3 and C4 plant distributions, will it provide us another method for understanding and perhaps even controlling climate change?

No, probably not. The C3/C4 thing has a component, yes. But what will give us a better opportunity to predict climate change and future responses to enhanced warming and enhanced CO_2 is basically getting a better feel as to how plants work in general, and how much CO_2 or whatever they might take in under certain circumstances. The distribution of these plants is a big part of it.

I know you graduated with a PhD from the University of Utah. What major differences are there between plant life here and in Utah?

Oh, it's immense! Pretty much everything west of the Rocky Mountains, before you get to the coast, is a warm desert or a cold desert. So, the general plant stature is much smaller, and as soon as you get on the other side of the Rockies, you have this big rain shadow, so you have all these grasses. As you go across the U.S. you get more such. Around here there are trees everywhere; you just don't see them in Utah. The most striking part about it is just the general level of greenness. You get so much more precipitation here than you do out there that in the summertime everything's green, whereas in Utah everything was green for maybe the month of June, and the rest of the year it's brown. Dramatically different systems.

-Interview by Nikhil Shankar