Ask a Biologist vol 019 Topic: Grasses & Fungi Guest: Stan Faeth

Watching Grass Grow -

Travel to Northern Arizona to the research site of ecologist Stan Faeth and learn about his research with two native grasses. Who would have thought so much could be learned from these simple plants and the microscopic ecosystem that is part of their success. We also find out how Sleepy Grass got its nickname and the secret of why a particular fungus found in plants could end up helping humans.

Transcript

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

Have you ever heard the saying that something is about as exciting as watching grass grow? Which is to say that it's *boring*. Well guess what? We're going to do that today. We're going to get a chance to visit with a scientist who's been studying how grass grows. His name is Stan Faeth, and he's a professor in the School of Life Sciences at Arizona State University.

And for quite a few years, he's been studying particular grasses that grow in northern Arizona. He's been studying Arizona fescue, and also, another one called robust needle grass. Now the robust needle grass also has another name called, "sleepygrass", and I really want to know why it's called sleepygrass. So we'll be asking him about that later in the show.

But what we're really going to be learning about is that this grass, which we said might be too boring to watch grow, actually has a lot of really neat things going on. It's got a little ecosystem that's really important, not only to the plants and animals that are associated with the grasses. It could turn out that these grasses also hold a really important secret for humans.

Now let's get out of the studio. And next up, we're going to be learning about the special grasses with Dr. Stan Faeth.

[car driving on gravel road]

Well we've made it up to the field site. We're actually in the parking lot. You might have been able to tell that from the gravel road sound. And I'm just about to park.

[car stops and engine turns off – sound of light rain]

I'm out of the car and I'm standing with Professor Faeth, under my umbrella, I might add. It looks like we have a little bit of rain coming our way. How are you doing today?

Stan Faeth: Great. How are you doing, Dr. Biology?

Dr. Biology: I'm doing very well, thank you. And from the look of the sky and these sprinkles coming down, it looks like maybe we're going to have quite a rainstorm.

Stan: Yeah, typically in the summer, we'll have afternoon showers. We just hope we can get our fieldwork in before the showers, and particularly, the lightening starts.

Dr. Biology: And it also is a little bit cooler up here than down in the desert.

[thunder rumbles in the background]

Stan: Definitely. That's one of the advantages of doing fieldwork in northern Arizona.

Dr. Biology: Now before we get started with a tour of your field site, I'd like to talk about the other participants. And when I say participants, I mean the other species, other than the grasses that are part of this story. It's interesting because they form this really neat little ecosystem. Most of us start to learn about ecology, but we don't always think about it in this really tiny world.

So could you tell me what else we're going to be talking about, other than the grass that I see here?

Stan: Sure. The grass is sort of the star of our research because it's our main focus. We can easily measure and see things about the grass. But there are a lot of things that are going on inside the grass that you cannot see, at least, without a microscope. These are fungi that live inside the grass and the above ground parts of the plant.

[thunder rumbling the background]

There are also other types of fungi that live in the roots. All of these fungi have very important effects on the growth of the plant, which in turn, then affects things that feed on the plants, like bugs, elk, deer and so forth. And it affects the things that eat the bugs, like other bugs, birds, lizards and so forth. So we're really looking at this entire community that's centered on these grasses.

Dr. Biology: When you say fungi, most people might think of fungus. When I think about fungus, I'm usually thinking about athlete's foot.

Stan: Right. This fungus is a very special fungus. It is one that you don't see on the outside of the plant. It doesn't cause any kind of disease on the plant. You would not be able to determine if one plant had this fungus or didn't have it, unless you examined it under a microscope.

And it is special in some other ways. Most fungi are transmitted to the next generation by spores. So if you have a piece of moldy bread, those will produce millions and millions of spores that are floating in the air, and that's how the bread gets moldy. This one, however, grows into the seeds. So the fungus actually grows into the seeds, and then when a new plant starts from those seeds, that plant will also have the fungus.

Dr. Biology: Now did you come across this fungus directly, or was it something indirect when you were doing some research? How did you get started on this?

Stan: There's often a lot of serendipity involved in research. We initially worked with insects feeding on plants. We were interested in why certain insects were on certain plants, and why they eat more of some plants than other plants and we began focusing on what's going on inside the plant.

When a bug takes a bite out of a plant, it's not only consuming the plant, but it's also consuming all these microorganisms inside the plant, the fungi. These fungi can determine whether the plant is eaten or not.

[loud thunder in the background]

Dr. Biology: Is it taste or just because they know they can get sick from it?

Stan: Sometimes these fungi produce chemical compounds that you might be familiar with called alkaloids. These alkaloids are the same group of compounds that are in some of the poisons that we know of, things like strychnine. Some of the drugs that have been abused like nicotine or mescaline are also alkaloids. But these are being produced by the fungi, supposedly to protect their plant against herbivory.

Dr. Biology: Now we talked just a little bit about the protection this fungus can provide the grasses. It turns out though that this fungus might also have some very interesting properties for humans.

Stan: Yes. These fungi are found in all plants that have been examined so far. They are not only found in grasses, but there are other types of these fungi found in desert plants. And they produce some very unusual chemical compounds that are not produced by any other organisms. Some of those compounds have been known from previous research to have anti-cancer properties.

So we have been examining some of these other endophytes, not in these grasses that you're seeing out here in this field, but in some desert plants and examining those chemical compounds, testing them for anti-cancer activity, and have actually found some positive responses in that category.

[thunder in the background]

Dr. Biology: You used a neat word, "endophyte". And actually, that's just another word for, in this case, the fungi, right?

Stan: Endophyte just means "living inside the plant". And so there are fungi that live inside the plant, but there are also other microorganisms, like bacteria that you can't see except with a microscope, and viruses that are very small that you also can't see except with an electron microscope. Other microorganisms that live inside the plant would all be considered endophytes.

Dr. Biology: I see. Very good. Well let's walk over here just a bit.

[sound of walking on gravel]

And as we're walking over, I just want to describe what your field site looks like. I see rows of these clumps of grass, and it almost looks like you're caging them to protect them, as far as, getting away. But I bet you're going to tell me some other story.

And then you have this black covering that you see sometimes when they're doing gravel desert-scaping with some tubing. And then, there are these curious red cones, or inverted funnels. What's going on? What are you doing here?

Stan: This is a very large field experiment. And in experiments, we, of course, want to control different factors that we're interested in. What you're seeing out in this field is a field experiment where we control multiple factors all at once. And the cages are not to prevent the plants from escaping. Plants don't get up and move on their own except perhaps in horror films.

Instead those cages are there to prevent small mammals from eating the plants. So that is one of our treatments. Some of the plants have these cages, and then they're also sprayed periodically with an insecticide. And that's to reduce things that eat them. The other plants are not caged, so those are the ones that are freely accessible to the herbivores.

Dr. Biology: Ah yes, herbivores. These are animals that eat plants. We also have animals that eat animals. In other words, they eat meat. Those are carnivores. And those animals that eat both plants and meat are called omnivores. So what else do we have here?

Stan: You also see that black barrier that's put down there. That is a weed barrier so we can prevent unwanted plant growth, so we can isolate these effects on our plants. You also see black tubing running along through here. That black tubing are irrigation lines that are precisely controlled so we can control the amount of water to plants. Some plants get additional water, some plants get reduced water. That's another factor that we wish to control.

[loud clap of thunder in background]

Dr. Biology: Now that's an interesting point, but the storm seems to be getting rather close. You can't control for all the water, unless you can control Mother Nature. What does that do to your experiment?

Stan: That is part of our experiment, actually. With the water treatments, there are three water treatments. One of those is additional water, through the irrigation lines. One of these is reduced water, and beneath that black barrier on the reduced water plants is a sheet of clear plastic that prevents water from penetrating into the plant. And then the third treatment is just what normally falls from the sky - normal precipitation. So those are the three water treatments.

Dr. Biology: I see, I see. Well, what's the story? What are we learning?

Stan: Well, let's see. First I should tell you about those pink cones you see out there.

Dr. Biology: Yes, I forgot that we hadn't talked about those.

Stan: So those plants have the reduced water treatment with the plastic. We know from previous experiments that putting plastic down around plants can change the interaction between the soil microbes that are exchanging gases with the atmosphere. And so those cones are to allow those gases to be exchanged, while still keeping those plants without water.

Dr. Biology: Oh I see. By taking those funnels and inverting them, you keep most of the rain out, if not all of it, but you still have that little opening that lets the gases exchange back and forth. Oh - and those gases that are being exchanged they are?

Stan: They would be things like carbon dioxide. The microbes in the soil are respiring, just like we do, as we breathe. That's a byproduct of respiration. So that would be the main one that's being exchanged, carbon dioxide.

[loud thunder]

Dr. Biology: All right. So I want to continue this conversation, but it looks like this storm really is going to being picking up here. So can we get under cover? It looks like a tarp area you have right here.

Stan: Sure, we can move over here.

Dr. Biology: Now, you've been doing this for quite some time. How many years?

Stan: This particular aspect of my research, about 15 years.

Dr. Biology: About 15 years. Would you describe yourself as an ecologist?

Stan: Yes, my training is in ecology.

Dr. Biology: But you have a broad range of interests in ecology. Some ecologists might be only focused on plants, or say only the animals. And if we're talking about animals, we could be very specific about maybe insects, which would be entomologists. Or there maybe others that are interested only in say vertebrates, which are the mammals, like you and I, which have a backbone.

You kind of go the whole range. You pull all the species together - plant, animals and in this case, fungi, which are not really plants or animals. So would you say that's a good description of you and your work?

Stan: Yes, I think that's a fair assessment. I like to look at the big picture. All species that we see are interacting with other species. They're either eating other species, if they're predators, or they're competing with other species, two plant species, for example. Or they're parasitizing, taking small parts of plants, or they're positively affecting them - what we call mutualists.

These endophytes are thought to have positive benefits on the plants by protecting them. And so we're interested in all those interactions. If you study just one interaction in isolation, you will often miss much of what's going on in nature because all these species are interacting with each other. So we like to try to include as much as feasible in a field experiment.

Dr. Biology: You talked about a little bit of this mutual relationship that plants and animals can have. I actually was doing some reading on some of your research, and the word "symbiotic" came up quite a bit. Can you talk a little bit more about that?

[thunder]

Stan: Sure. Symbiotic means just "living together". So organisms that live closely together are called "symbionts". We all have our own symbionts. In our guts, for example, we have bacteria that are important in the digestive process. Those would be our symbionts.

Dr. Biology: Yes, we have talked about these symbionts. Actually we talked about the bacteria that are really important to us in the program called "Bugs in Films" with Dr Valerie Stout. So what are the symbionts in plants?

Stan: Symbionts in these plants would be the endophytes that live closely with them. Just about all organisms have symbionts; even microorganisms have their own microbial symbionts. So there are often organisms living inside or with other organisms.

[rain grows louder]

Symbionic. It's often incorrectly supposed that a symbiont is also a mutualist, that it must positively benefit the other organism, because they're living closely together. But parasites are also symbionts. They live closely together with the other organisms. We have our own parasites. For example, a bacterial infection is actually a symbiotic relationship. In fact, if you have a sore throat, living inside your tissues, that would also be a symbiont that happens to be a parasite, rather a mutualist.

Dr. Biology: What is the symbiont for the grasses that we've been looking at here?

Stan: The symbionts we're interested in are these fungal endophytes and are now also, in some of these experiments up here, endophytes that are living in the green parts of the plant, above ground. But if you went below ground, which not many people know much about, there are also symbionts living on the roots.

So we're interested in both symbionts: the endophytes living above ground, and the other fungi that live below ground, [big clap of thunder] called mycorrhizae, that live on the roots. They're thought to benefit the plants under most conditions.

Dr. Biology: What are the fungal endophytes helping the plants do?

Stan: The mycorrhizae below the ground are thought to increase the ability of plants to acquire nutrients from the soil. Arizona soils are notoriously very poor in nutrients. Those essential nutrients are things like nitrogen, potassium and phosphorus. Mycorrhizae, by forming nodules, also called arbuscular nodules on roots, can increase the uptake of nutrients into the plant.

The endophytes, on the other hand, are also thought to increase nutrient uptake, but secondly producing these unusual compounds that can prevent the plant from being eaten by herbivores.

Dr. Biology: Oh, so I see. One of the functions is to help bring food into the plant, while the other function is, well, not to become food for something else.

Stan: That's a good analogy.

Dr. Biology: Now, from our conversation today, it seems to me that your research is showing that we need to pay attention to those species that we can't see just as much as those ones that we can see, because they play as an important role with the ecosystem and the food web in general as those things that we can see with our eyes.

Stan: That's correct. In fact, if you looked at just the weight, or the biomass, as biologists would call it, the biomass of the fungus, it is a tiny, tiny fraction of what's in the plant. And yet that fungus that makes up this very tiny part of this community has dramatic effects on the plants, on the bugs that eat the plants, on the bugs that eat the bugs on the plants, on the birds that eat the bugs, and on the elk and cattle that might feed on the plant.

So I think the lesson here is these unseen or hidden species in these communities can have these profound and dramatic effects on the entire community, and if we ignore those microbes, then we would miss a big part of how these ecosystems or communities are put together.

Dr. Biology: And the other thing I was curious about - I mentioned it in the beginning of the show - was the other name for this fescue. It's called "sleepygrass". Where did it get that name?

Stan: Sleepygrass has a very interesting history. Sleepygrass is one of the grasses that have this endophyte in some of the grass, some of the individuals, and it produces some very powerful alkaloids. These are the ergot alkaloids. Ergot alkaloids are alkaloids that are things like LSD - lysergic acid. And, in fact, this plant produces a variety of lysergic acid that does not have the hallucinogenic effects that LSD does, but has very strong narcotizing effects.

Now, narcotizing means it puts you to sleep. So when cows, or sheep, or horses feed upon this grass and they eat sufficient quantity, it literally paralyzes them in place.

Dr. Biology: Really?

Stan: Yes, they freeze in place. And it's been well known from ranchers, where it got its name, sleepygrass. When their livestock ate this grass, they would, for days, remain frozen in place until they recovered from the alkaloid poisoning. The ranchers all tell me in the area where sleepy grass grows that once a horse has eaten sleepygrass, it will never eat it again.

Dr. Biology: It does learn?

Stan: It does learn. Apparently the taste of the infected grass is enough and the response is enough that the horses learn very quickly not to eat that toxic grass.

Dr. Biology: How about humans? What happens if we eat the grass?

Stan: It would probably, again, narcotize you. But I would caution that it's very dangerous. Because if cattle, sheep or horses eat enough of it, not only will it narcotize them, but it will also kill them.

Dr. Biology: All right. So we're not going to go out there and eat it.

Stan: We're not going to do that. But there are legends that Native Americans in the central highlands of Mexico, in order to quiet their babies with colic or so forth, would feed their babies one seed of this plant that had a very small amount of this, and it would put their babies to sleep. So it's used as a medicinal cure for colicky babies by Native Americans.

Dr. Biology: Very neat, very interesting. In each of our programs, I like to ask our guests three questions. The first one is when did you first realize you wanted to be a biologist or a scientist? And along with that, was there a particular spark? Was there an event or a person that really got you going in the realm of science?

Stan: That's a good question. I can remember in kindergarten, when we were asked to write one sentence of what we wanted to be when we grew up, and why, which I guess is probably pretty complicated for a five- or six-year-old. I can distinctly remember writing, "I want to be a geologist." And my reasoning was because I liked rocks. So that was my first scientific, I think, inclination of what I wanted to be.

After that, I thought I liked rocks and I liked fossils, so I thought geology or paleontology would be my field along the way. But it really wasn't until late in college that I decided on biology, and that was really based upon having some very special teachers that sort of lit the spark about biology. That came much, much later and sort of shifted it away from geology or paleontology and then into biology.

Dr. Biology: So you shifted later on. Let me shift you way out of it now.

Stan: OK.

Dr. Biology: I'm going to take all your science and your biology away from you. You don't get to do that. What would you be if you couldn't be a biologist or a scientist?

Stan: That's interesting. It's probably somewhat related to what I do. As you can see, these field experiments look like giant gardens. And a lot of our fieldwork is really just gardening, taking care of plants and measuring plants. I think being a gardener might be in the works. Another possibility is that I like to cook, and that's also somewhat scientific. So I might think perhaps a cook.

[thunder]

Dr. Biology: I see. So maybe there'll be a restaurant with your name on it?

Stan: Yes, but we won't be serving endophytes.

Dr. Biology: Yes. It'll be something like 'Keep the Faeth' restaurant.

[laughter]

What would you advise a young scientist, or someone who wants to be a scientist?

Stan: I think the main trait of all scientists, and I would also argue the main trait of all young children, is curiosity. And I think scientists are just in some ways grown-up children that retain that curiosity. Often, along the way, I think that curiosity gets sidetracked by other things, or even, during school, social things and so forth.

So I would recommend anyone that's young and interested in science is to just maintain that curiosity about the world that you live in, and the way the world works. Whether it be the way life works, as biologists do, or how the world's put together, like geologists would do, or how the Earth once was, if you are interested in things like geology or paleontology.

Dr. Biology: I want to thank you, Professor Faeth, for taking some time out and showing us your research site. I hope that we get to hear more about what you learn about these grasses in the future.

Stan: Thanks, Dr. Biology. And thanks for coming all the way up to Flagstaff to check out our research studies up here on native grasses. I'll be happy to talk with you any time in the future.

Dr. Biology: You've been listening to Ask-a-Biologist. My guest has been Professor Stan Faeth from the ASU School of Life Sciences. I don't know about you, but I have a new appreciation of grass, and certainly grass growing and what's growing with that grass. And even though we said at the beginning of the show that watching grass grow can be really boring, it turns out what's growing along with that grass is anything but boring.

The Ask-a-Biologist podcast is usually brought to you from the campus of Arizona State University. Today we traveled to northern Arizona. And even though our podcast 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 can just Google the words "Ask a Biologist". I'm Dr. Biology.

[Big Clap of Thunder]

And it's just in time. We're really getting some rain here and the thunder, as you tell in the background, is really cranking up. So I'm going to get out of here before lightning strikes just a little too close