Ask A Biologist Vol 100 (Guest: Colleen Hansel)

Superoxide, Superhero, or Supervillain?

Diving deep into the ocean is likely the most extreme place someone can set out to collect data, but sometimes that is what scientists need to do. In this show, Dr. Biology finds himself on board the research ship Atlantis in the floating laboratory of Colleen Hansel who is teaming up with the deep sea submarine called Alvin to track down and capture an elusive molecule that might help us understand how corals are, or are not adjusting to the rising ocean temperature.

Transcript

Dr. Biology: This is Ask A Biologist, a program about the living world and I'm Dr. Biology. Superoxides, are they a superhero or supervillain? So we all know we need oxygen to live, but did you know that our bodies can take that molecule and by adding a single electron, turn it into a bacteria killing tool? Pretty cool, right? And that's one type of superoxide.

Dr. Biology: But this molecule also has a dark side. It's been linked to cancer and might also be one of the reasons we age. Today, you probably can hear the background sounds. We're out of the studio and on the road, or to be more exact on the ocean and aboard the research ship Atlantis. We're here because this is where Colleen Hansel, a scientist at Woods Hole Oceanographic Institution, has her temporary laboratory and where she is teaming up with the pilots of a human occupied vehicle called Alvin, which really is an amazing submarine used by scientists to dive deep into the ocean.

Dr. Biology: Alvin is a critical part of an experiment for Hansel and her team, because they need to dive down to some deep sea corals to test out a new instrument designed and built by Hansel and her lab group. The instrument is called Solaris and can measure superoxide that disappears so quickly (actually in less than 30 seconds) that it's made it impossible to measure in the ocean. Her work might also help us learn more about corals and the role superoxides have in their health. This podcast is also the first of a two part series. On our next show, we'll go inside Alvin for an interview with one of its pilots, so be sure to come back for that trip. Right now, let's head into Colleen's lab to learn more about the world of superoxides and corals.

Dr. Biology: Welcome Coleen and thank you for letting me join you in your floating laboratory.

Colleen: Nice having you here.

Dr. Biology: What do you do as an oceanographer?

Colleen: I study the chemistry and the biology of the ocean and how the chemistry and biology interact.

Dr. Biology: Oh, okay. So we're talking things like, humm, minerals?

Colleen: Yes, minerals, and also chemicals in the water and how different organisms all the way from little tiny creatures like microbes to corals, larger organisms, how they impact that chemistry. And then on the flip side, how the chemistry impacts the animals.

Dr. Biology: Typically when you think about animals, you think about, well they need food and you don't usually think about minerals and other things like that. How are the minerals making a difference in particular with some of the organisms you're working with in the ocean?

Colleen: So you and I, the way that we live and the way that we breathe as we breathe the oxygen. So you know, we eat carbon and we breathe oxygen, but there are other that live in the ocean that can use other things instead of carbon or oxygen. And some of those are minerals. And so they can either eat or breathe minerals. And so they use those as their life form. And by doing that, they end up changing the chemistry of the ocean. They end up changing the mineralogy of the sediments and in the water column.

Dr. Biology: For those that spend much time on Ask A Biologist, on the podcast, we are usually in the studio. And once in a while we do get out and do some podcasts on location. And in this case, we're actually on location. You can tell it from the sound we're on Atlantis. Why are we on Atlantis?

Colleen: Atlantis is an oceanographic vessel, a ship that we're using to go out to the ocean and study different sites that you can't get to on smaller boats. So we have to use a big oceanographic vessel, a big ship. And on Atlantis is Alvin, which is a submarine that we can use to go down to the bottom of the ocean and study places that you can't get to otherwise.

Dr. Biology: You're on a cruise.

New Speaker: I am. Not the type of cruise you would be thinking about. We're not playing shuffleboard. So instead we're on a research cruise, which is going out to sea for weeks at a time and going to different what we call stations or sites in the ocean that have different, unique characteristics. So maybe different organisms live there. Maybe there are coral reefs that live there or the chemistry is different or the mineralogy is different and then we're studying those sites from Atlantis and using Alvin.

Dr. Biology: You couldn't just scuba dive down there?

Colleen: We can't because you can only go to a certain depth depending on what you're rated as a scuba diver, but most people can't dive deeper than about, you know, a hundred feet or 30 meters or so. But what we want to study is things that live much deeper than that. On this cruise we were looking at deep sea corals, so these are corals that live, a thousand meters under the sea floor, so they live much deeper than any person could scuba dive.

Dr. Biology: I recently had Greg Asner on Ask A Biologist and he's doing work on corals, although mainly from the air and he has some rather interesting insights. What are you learning about corals?

Colleen: What I'm trying to study is how corals are functioning under different conditions. We know that our oceans are changing right now. They're getting warmer. They're acidifying, so the pH of the ocean is getting lower. We know that we're having more intense storms. We have a lot of nutrient runoff, we have overfishing, and these are all stressors that are impacting our corals and impacting the health of corals. And so what I'm interested in is how the chemistry of the ocean is changing and how that's impacting the health of corals. And to do that, I'm studying a chemical that corals make.

Dr. Biology: When we look at corals, are we talking about one living organism?

Colleen: Well, corals are what we would call a mega organism or a holobiont. So it's a lot of organisms living together. So you have the coral animal and then we have small microorganisms that live with them and they form what are called the symbiosis. So they rely on each other.

Colleen: Now in the shallow corals, ones that live in the sunlight, we know that they rely on algae or the plants of the sea, right? That fix CO2 and make organic carbon that can then feed the corals and provide them nutrients. In deep sea they don't have that right there in the dark, but they still have bacteria and other organisms that have a symbiosis. It's just not as well known what a symbiosis is. And there are other organisms that live on corals, larger ones like crabs and spiders, basket stars, and they're called coral associates. And we don't really have a good understanding of that relationship either.

Dr. Biology: I was kinda curious about your work with manganese oxide and what's interesting to me is why would that matter to a coral?

Colleen: Yeah. So the manganese story is a little bit parallel to what we're doing with corals, but it's all linked. So everything is linked in the ocean. So corals are making a chemical that we think is important for their health and this chemical is really reactive and this chemical makes manganese oxides and we think that that's not necessarily what the coral is trying to do. It's a byproduct of the coral making this chemical for another reason. But in the rock record or in the sediment, we can look and see that these minerals are being formed.

Dr. Biology: On this cruise, even though it's a working cruise. My understanding is that you are actually testing out a new instrument that you designed.

Colleen: That's right. So the chemical that we're trying to measure for understanding the health of coral, so this chemical that I mentioned that's really reactive, it's a form of oxygen. It's a form of reactive oxygen. So we all know what oxygen is, but oxygen can come in lots of different flavors. And some of it is really reactive and one of them is called superoxide. And we're trying to measure superoxide. The tricky part is it has a lifetime of 30 seconds. So there are no measurements of this chemical in the ocean, let alone in the deep sea. So, uh, at WHOI I put together a team of scientists and engineers to make the first sensor to be able to go into the ocean and to make the first measurements of this chemical in the ocean in general, and then also down at the sea floor and associated with corals.

Dr. Biology: When you say who are, you're talking about Woods Hole Oceanographic Institute?

Colleen: Institution. Yes, that's right. We call it WHOI (hooey). It's a lot shorter.

Dr. Biology: You built this instrument, but there was one before this that you created. And if nothing else, the name caught my eye.

Colleen: [Laughter]

Dr. Biology: What caught my eye was DISCO. Can you talk about DISCO?

Colleen: That's right. So DISCO was the predecessor of the current instrument that we were testing, which is called Solaris. And disco was the first attempt that was making a sensor and an instrument that could measure superoxide within the water. So a submersible, an instrument that could go in the water and make these measurements. And DISCO is a handheld instrument. A handheld sensor that can measure superoxide. It's scuba diver operated so it can only go down to 30 meters or you know, about a hundred feet. And we've been using that to measure superoxide associated with shallow corals. So we've done work in Hawaii and Cuba to look at how is stress, how are things like coral bleaching, how is increased temperature impacting the concentrations and the production of this superoxide within corals.

Dr. Biology: All right. Since I brought it up at the beginning of the show, you're talking about it. Let's take a little bit of time to talk about superoxidants and things like antioxidants because both of these are in the news these days.

Colleen: The way I try to explain it is you eat blueberries and chocolate and you get an energy drink at the store and it has antioxidants in it. What's an antioxidant? And an antioxidant is something that gets rid of oxidants and oxidants are reactive forms of oxygen. And those are things like superoxide and hydrogen peroxide. And these are were - we all are breathing oxygen right now and we breathe oxygen all the way to water. We take oxygen and we turn it into water and that's how we breathe. And that's how we live. Sometimes though we don't breathe at all the way. We breathe it only part of the way and when we do that, we formed these motor called intermediates. So they're not oxygen, they're not water, they're in the middle. And so it's these types of oxygen. And so there are types of oxygen.

Colleen: They're flavors of oxygen, but they're much more reactive. And so they're called reactive oxygen species or oxidants. And so when your body makes them, if you make them inside your cells, inside your body, they're toxic. And so that can cause a lot of diseases. So these oxidants have been linked to cancer, to premature aging, to diabetes, wrinkles, all kinds of things that have plagued humans forever. And they also plague other organisms, including microorganisms, including corals. And so these oxidants have been implicated in bleaching corals. So what's causing corals to lose their color and then ultimately die. So the way that you fight these oxidants is you produce antioxidants, which for us that's, you know, you eat blueberries and maybe some dark chocolate and uh, have you know, these energy drinks that have these antioxidant properties to them or you take vitamins. The only problem is that these oxidants also are good for you. You need a certain amount of them.

Colleen: So the science is in a really big transition right now. So we used to think that all oxidants were just bad and we now know that they're also good. So they're kind of a Jekyll and Hyde molecule. So we now have what I call the Goldilocks scenario, where if it's too high, it's bad. If it's too low, it's bad. You've got to be right in the middle. It has to be just right because these oxidants are also good for your immune system. So when you get a cold, the first thing that your body does is produce more of these oxidants to fight off your infection. It fights off the bacteria or the virus or whatever is trying to invade your cells. And we believe that's the same thing that's happening in corals, that they're producing these oxidants including superoxide, which we're trying to measure to fight off infections when they get stressed, when they get too hot or when the pH of the ocean starts to get too low. And so these oxidants are a really interesting and complex class of chemicals to study, but they're really difficult because they have such a short lifetime, you know, just on the order of seconds.

Dr. Biology: Right. And you also mentioned has to be just right. Too much isn't good, too little isn't good. We also were mentioning about pH. So acids and bases. You know, we have to have that nice neutral realm in there or we don't do well. And this is one of the things with science, it's so important that we don't always know all the answers or we don't know all the details. But one thing I know about scientists, we're really good at filling in those holes.

Colleen: That's right. Yeah. It's always changing and we're always building on the foundation of the people before us or even our own science. And so we've known for a long time as I said that, you know, these oxidants were bad when they're produced at high concentrations inside yourself. But then evidence started to build and there was just a little bit of evidence saying, well wait, but there's also these good things that are coming up. And then more and more that's just kind of building on itself. And then the whole field just starts to shift. And then research goes into, okay, well let's look at these other beneficial properties that these oxidants can have. And then that can change how we approach things like aging and cancer and coral bleaching. And so it's all very much linked and how can we come up with solutions? And so we really understand that system really well.

Dr. Biology: The, uh, coral story is one that I started talking about 10 years ago and it hasn't gone away. I was a little bit relieved because Greg Asner said it wasn't quite as dire as we anticipated or were thinking 10 years ago. But it's still really critical because some of them aren't going to survive. I mean they're just certain parts of the world that the corals just aren't going to make it. And others where the corals are doing pretty good, that work is from the air. You're actually not only digging into it, you're actually diving into the science that's really important about the corals and it's one piece that's going to maybe tell us how different corals are able to survive with this change in weather.

Colleen: Yeah, that's the hope. So we're really hoping that we can gain a better understanding of what makes coral healthy and what allows some corals to withstand increased temperature and bleaching and other corals not. We just really don't have a good sense of that yet. What's the underlying processes that impact the health of coral systems? And we don't understand that in shallow corals and we definitely don't have a good sense of that in, in deep sea corals either. And you know, we've been making these measurements of this chemical superoxide and finding some really interesting things where we see really high concentrations associated with corals that seem to be really resistant to stress. And so we are thinking that maybe this chemical, because it is so reactive that maybe it's a means of defense. It's protecting corals. Because just like when you're sick, when your immune system goes down, that's when you get infections. That's when you know bad bacteria come in and take over. And the same thing can happen with a coral when they're stressed because the water is too hot, or when the pH is getting too low, that's when organisms, bacteria or viruses can come in and attack. So we believe that this chemical that we're trying to measure is maybe part of the immune response or their ability to protect themselves from these organisms that are trying to invade.

Dr. Biology: The other thing that I learned was that we can make a difference ourselves in particular with something as simple as our sunscreen.

Colleen: That's right. Yeah. So there's little things, yes, that we can do. That's right. There's the big problem. There's climate change of course.

Dr. Biology: So we went from DISCO to Solaris and the really cool part about that is Solaris is paired up with Alvin and we're not talking about the chipmunk, right? We're really talking about that submarine. So what's it like to be able to partner with Alvin?

Colleen: It's incredible. It was a life changing experience to be able to go down in Alvin, to be in the submarine, to be able to see the sea floor, to be face to face with the corals and to be able to take our instrument, be able to make those measurements right there and to see it happening in real time. And the way that the instrument works is, we have a little wand on it that you have to - the Alvin. Alvin has arms, you know, so the pilots are very skilled and can use the arms and pick up the wand and go bring it over. And place it just really close to the coral. And again, the chemical has a lifetime of 30 seconds, so it's gone really quick and it doesn't get very far away from the coral, right. So we have to get really close, but you don't also don't want to touch the coral. And the Alvin pilots are just very skilled and grabbing the wand and moving it and putting it right next to the coral. And then we're watching the data come in in real time on our computers. It was an amazing experience and allowed us to do science that you just couldn't do otherwise. There's no other way to do that.

Dr. Biology: So Alvin trips, how long are they?

Colleen: Depends on how deep you're going. So a typical day is we launched the submarine around 8:00 AM and then you have to be up at a reasonable hour. It is an exhausting experience and you have to be alert and on top of things all the time. And we get up by about 4:30 or so back on the ship and how much time you get to be on the bottom of the sea floor and collecting your measurements and looking at the corals are collecting your samples. Depends on how deep you're going. So if you're doing some shallow sites, then you know, you get down there pretty quick and backup pretty quick. So I think we go about 30 meters per minute. So you can do the math. Alvin can go down to about 4,500 meters right now. So some of those transits can be a couple of hours to get down.

New Speaker: You have children, right?

Colleen: I do, yes, three. I have three girls and the oldest is 12 and then two 9 year old twins.

Dr. Biology: I got to ask, what do they think about mom diving deep into the ocean?

Colleen: Well, on one hand they think it's very cool and on the other hand they're scared, of course. And so they were very happy to hear when I was back on the ship, but they're super excited about it. You know, they uh, tell all their friends that mommy's going down in the submarine and collecting samples and they like to say I'm saving the corals, which it's a little bit of a stretch, but I think they all want to be scientists when they get older. So I think it's a great experience for them to see that.

Dr. Biology: Any of them want to get in Alvin?

Colleen: I think they do. Yeah. Not yet, but some day. My oldest daughter has said she wants to learn how to scuba dive this year now that she's old enough. So they are really in love with the sea. So they want to be a part of it. And so I think that each one of them has very different visions of what that will be. I would love one of them to become a, an Alvin pilot. I wouldn't be wonderful. We need more female Alvin pilots.

Dr. Biology: Right. There's only been one that I know of.

Colleen: That's right. One. So we need more.

Dr. Biology: All right. Future Alvin pilots out there. You know what you need to do. Coleen on Ask A Biologist. I never let any of my scientists leave without asking three questions, so you're ready to start.

Colleen: All right. Okay.

Dr. Biology: The first one is when did you first know you wanted to be a scientist? Was there an aha moment?

Colleen: No, uh, interestingly I started off wanting to be an environmental lawyer and was taking a course in geology and it was a night class cause I was working through college. I was in a geology class and I just loved it and I fell in love with rocks and minerals and I decided through the course of that class that I was going to change over and become a geologist. And so there wasn't any particular moment that told me I was going to become a scientist and as a child I didn't think I was going to become a scientist, but I'm sure. Glad I did. I guess that was my aha moment, but it was a gradual thing.

Dr. Biology: Alright, now you were late to your science career based on what other scientists that I've interviewed, a lot of them started very young but going to be just as cruel to you as I am to them because I'm going to take it all away. You can't be a scientist. Since I know you might've been an inspiring lawyer, I'm going to take that away from you. Most of my scientists love teaching, so I have to take that away. So the question is what would you be or what would you do if you couldn't be a scientist or a lawyer?

Colleen: Oh, that's a tough question. Um, I don't know what I would be. I can be anything? Well there have been a lot of things over the years that I've always thought would have been a really interesting and intriguing career. You know, I actually started off as a basketball player and wanted to be a professional athlete. And so professional athlete would have been great to play professional, women's basketball, but I'm short so I don't know how far I would get. And um, I always thought it would be wonderful to work in the FBI, for instance. To do something where you're trying to help solve problems, to do investigations. I guess it's also a form of science, right? It's just social science, I guess instead of physical science. But it's really hard to think about that because I love what I do so much that I can't really think about what I would rather be doing.

Dr. Biology: Well, the good news is I really can't take it away from you. So don't worry about it.

Colleen: [Laughter]

Dr. Biology: So one of the things I thought you might've said would be an Alvin pilot.

Colleen: Ah, yes. But what's really intriguing is that the Alvin pilots, they're down in the ocean so much that they really do become scientists, right? They learn so much about the ocean and going on these dives, these last, you know, six dives that we just had with these wonderful pilots. They know so much and we don't really realize that until you get down in the water. And we would see a coral species and they would say, Oh well that's, you know, Pterogorgia, for instance. And so they really learn the ocean so much that they are pilots and they are scientists.

Dr. Biology: So what about the young future scientist and also maybe the late bloomers, maybe there's another future lawyer that's ready to make the switch. What advice would you have for them?

Colleen: I always tell my students, and I told my daughters this too, that you follow your heart. You do what you're passionate about and you just work hard and you can achieve anything. And I never thought I would be a oceanographer and a scientist at Woods Hole Oceanographic Institution and be able to do the science that I'm doing right now. And leading a research group. And leading cruises out at sea and going down and dives in a submarine. I never would have ever envisioned this. And so I would just encourage the young budding scientists to just follow their hearts and follow their passion. And they can do anything.

Dr. Biology: Well, Coleen, I want to thank you for joining me on Ask A Biologist and letting me come to see your floating laboratory.

Colleen: It was nice having you here.

Dr. Biology: You've been listening to Ask A Biologist and my guest has been Colleen Hansel, a scientist at the Woods Hole Oceanographic Institution. Her work focuses on interactions between microorganisms, metals, and minerals. The impact of superoxides and corals is just one of her research topics. We also have a link to her website from this episode if you want to learn more about her work. The Ask A Biologist podcast is produced on the campus of Arizona State University and is usually recorded in the Grassroots Studio housed in the School of Life Sciences, which is an academic unit of The College of Liberal Arts and Sciences. Today we're on the research ship Atlantis and want to thank everyone who helped us make this show possible. And remember, 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 can just Google the words, ask - a - biologist. I'm Dr Biology.