Video Transcript - Mineral Transformations – Demystifying Microbes

Announcer:	Microorganisms play a vital role in ecosystems and affect every element in nature. How can we harness the oldest lifeforms on earth in order to restore areas that have been polluted by human activity?
Announcer:	Scientists are now exploring ways to optimize microbes' hidden ability to transform their surroundings. [00:00:30] Join us now for a conversation with Geologist Cara Santelli to learn how microscopic lifeforms can help in our effort to make a healthier planet.
Announcer:	Now, here's your host, Maggy Benson.
Maggy Benson:	Welcome, everyone. Thanks for joining us for another episode of "Live from Q?rius: Smithsonian Science How?" I'm Maggy Benson.
Maggy Benson:	We're really excited to have you here today, and even more excited to have with us Geomicrobiologist, Dr. Cara Santelli from the Smithsonian's Natural Museum of [00:01:00] Natural History. Thanks for joining us, Cara.
Cara Santelli:	Thanks for having me, Maggy.
Maggy Benson:	So, Cara, you are a geomicrobiologist. That's a mouthful. Can you break it down for us?
Cara Santelli:	Yeah. It's actually a question I am asked all of the time when I introduce myself. Geomicrobiologist - there're two giveaways in that word, okay? "Geo," meaning geo, geologist, okay? So, I study Earth and the Earth's processes.
Cara Santelli:	I also study microbiology. That's the other part of that word. I study microbes that are living in the environment and influencing [00:01:30] the environment all around them.
Maggy Benson:	So you're really an interdisciplinary scientist, as both a biologist and a geologist?
Cara Santelli:	Yeah, I am an interdisciplinary scientist. In fact, I also do a little bit of chemistry as well. So, yeah, geology, chemistry, biology.
Maggy Benson:	Very cool.
Cara Santelli:	Yeah, it's a lot of fun.
Maggy Benson:	So, what processes, exactly, do you study?

Cara Santelli: One of the things that I'm really interested in these days are the interactions between minerals and microbes. For example, did you know that microbes [00:02:00] make minerals?

Maggy Benson: I had no idea.

Cara Santelli: Yeah, it's actually a really common process. It happens all of the time in the environment, everywhere we look. There are microbes just living and growing and producing minerals. In contrast to that, I study another process. Microbes are also responsible for degrading or weathering minerals.

Cara Santelli: You probably learned about the rock cycle at some point, and how there are things like wind and water that play a role in weathering rocks and minerals?

Maggy Benson: Yes, of course.

Cara Santelli: Well, microbes actually help [00:02:30] influence the weathering process as well. They secrete acids and do other things that help weather minerals.

Maggy Benson: Very cool. So microbes are both making and breaking down minerals?

Cara Santelli: Absolutely.

Maggy Benson: But let's take a step back. What exactly is a mineral?

Cara Santelli: Minerals are all around us. We see them every day. So a good example of something that's really common is quartz. Right in front of us we have a great quartz example.

Cara Santelli: And then another example-

Maggy Benson: It's beautiful.

Cara Santelli: Yeah, I love this quartz specimen. Another example are these three little cubes. And this is something, [00:03:00] you've probably heard of fool's gold? This is a mineral called pyrite, okay? What makes them a mineral, per se?

Cara Santelli: So there are three parts of the definition to a mineral. First of all, it's naturally occurring solid substance.

Cara Santelli: Second of all, the composition, the elemental makeup of each of these minerals, is the same from mineral to mineral. So, for example, all quartz minerals are made up of the elements silicon and oxygen. And pyrite, in contrast, is always made up of the elements iron and sulfur.

Cara Santelli: [00:03:30] The third part of that definition is that the arrangement of all of those elements, or those atoms inside the structure of this mineral is constant.

For example, if you look at the structure of pyrite, the atomic structure of pyrite, the arrangement of iron and sulfur within that pyrite cube is always the same from cube to cube.

Maggy Benson: So, in all three of these cubes, even though they're different sizes, the arrangement of all of the iron and sulfur is exactly the same.

Cara Santelli: Exactly. And that's how we identify it as pyrite.

Maggy Benson: All right, though. Thanks for [00:04:00] helping us understand what a mineral is, the geology side. Now what about a microbe?

Cara Santelli: So, a microbe is just simply a very small, living organism. And, in fact, we actually need advanced techniques, like microscopes, in order to see these living microbes.

Cara Santelli: One example (is) bacteria. We hear a lot about bacteria in the news, don't we?

Maggy Benson: We do.

Cara Santelli: Another common example of a microbe (is) fungus. We actually work on fungus here at the Smithsonian in my laboratory. This is an example of two different fungi [00:04:30] in Petri dishes and in the flasks that are growing here right in front of us.

Maggy Benson: I have heard about microbes in the news, and sometimes what I hear isn't so good. Do all microbes make you sick?

Cara Santelli: No, I think microbes get a bad rap. And, yeah, of course there are microbes that do make you sick. There are pathogens, for example. But, most microbes that we know about are actually good for us, good for the environment. So there are microbes, all different kinds of microbes, living everywhere. All over surfaces, [00:05:00] inside of us. And most of 'em are doing either not much at all or they're doing very good things for us and the environment.

Maggy Benson: So, I wonder, if microbes are everywhere and they're doing very good things, they're making minerals, they're degrading minerals. I wonder, actually, why they're interacting with minerals in the first place. Should we ask our viewers?

Cara Santelli: I think that's a great question to ask our viewers.

Maggy Benson: All right.

Maggy Benson: Now's an opportunity for you to participate in a live poll with us. Tell us what you think. Why do microbes interact with minerals?

Maggy Benson: [00:05:30] Is it:

Maggy Benson: To get nutrients?

Maggy Benson: To get energy?

Maggy Benson: To attach to surfaces?

Maggy Benson: To build communities?

Maggy Benson: Or for protection?

Maggy Benson: Take a moment to think about it and put your answer in the window that appears to the right of your video screen. And remember that this is the same place that you can post questions for Dr. Santelli to answer on the air today, or for the experts in our chat to respond to.

Maggy Benson: [00:06:00] The results are still coming in. They're kind of spread out between "A" and "D," with most people thinking that it is to get nutrients. What do you think?

Cara Santelli: Wow. Well, that's a great answer. But, in fact, all of the answers are really correct [00:06:30] answers. So-

Maggy Benson: Little bit of a trick there.

Cara Santelli: Yes, so it's a little bit of a trick question.

Cara Santelli: So, if you think about the first answer, nutrients, which is what most people responded to. Yes, that is definitely what microbes get from these minerals. They are living on these minerals, and they are degrading them, as we talked about earlier. But, there are nutrients inside some of these minerals. There could be trace amounts of iron, or zinc, or something that the microbes really need to grow, that are actually in these minerals. So, they do get nutrients directly from the minerals themselves.

Cara Santelli: Energy. [00:07:00] So, that was another thing that all of the students ... a lot of students responded to. So, you and I have our breakfast in the morning. I'm not sure what you had for breakfast?

Maggy Benson: Bowl of cereal.

Cara Santelli: A bowl of cereal. So, you were eating the cereal, and you were doing that so you could get energy, right? Your body was converting the sugars that are available in the cereal into energy. Well, it turns out there are certain microbes that don't actually need those types of sugars to get their energy. So there are certain microbes that can live, for example, off of iron and [00:07:30] instead use iron as an energy source that is in the mineral itself.

Maggy Benson: So are they transforming that energy source into something else?

Cara Santelli: Yeah. So, they're turning it into energy, and it helps fueling their metabolism to help them grow and reproduce, for example.

Cara Santelli: So, here's an example of a fungus that's growing along and those long filaments that you see, that are kind of branching off? That's the fungus. Those are called hyphae. And those little dots that are appearing [00:08:00] along the hyphae as it's growing, those are the minerals that it's producing as it's growing.

Maggy Benson: So, if microbes are creating minerals all over the place, what kind of minerals are they making? Are they common? Are they special?`

Cara Santelli: Yeah, it turns out they're really, really common. And, in fact, there are probably over a hundred different minerals made by microbes, probably even more. Scientists are still studying this all over the world. But they're really common. In fact, if you were to go outside and scoop up a handful of soil, you would probably be holding hundreds, if not thousands, of different [00:08:30] minerals made by microbes.

Maggy Benson: So, if they're that small, I mean, these are microbes making these minerals, they can't be so big. How do you actually recognize which ones they're making?

Cara Santelli: Yeah, they are very small. You think about a microbe, a microbe is small, and then the minerals are even, often times, smaller. So, we have to look at these minerals that we are studying and compare them to something we know more about.

Cara Santelli: For example, we can compare our unknowns to something known. We have, in our collection at the Smithsonian, a [00:09:00] great collection of known minerals. Minerals that have been well-characterized, well-studied in terms of their chemistry, in terms of their atomic structure. So, we can take the properties that we're studying and our unknown minerals and compare them to these knowns, and learn something more about them.

Maggy Benson: Very cool. So, thanks for helping us understand how microbes are actually creating minerals and how we figure out what those minerals are, but you said that they also break down minerals.

Cara Santelli: Mm-hmm (affirmative)

Maggy Benson: Can you give us an example?

Cara Santelli: Yeah, well, I would say one of the best examples, and one of the most visible that [00:09:30] you can see, is if you go into the forest, or out anywhere, and you see boulders and the boulders are sometimes colored in these crusts. So, you see this here on your screen, there's that yellow crust, and sometimes a blackish crust. But, that's a crust of a community of living microorganisms. They're living on this rock for a reason. Something we just talked about. They're getting nutrients, so they're degrading, they're producing acids. The acids are breaking apart the minerals in the rocks, and they're getting the nutrients out of those rocks.

Maggy Benson: [00:10:00] You said that this process, these processes that microbes do, degrading minerals, are beneficial. How is that beneficial, or are there any other examples of beneficial ways that they break things down?

Cara Santelli: Yeah, so it is a really common process for microbes to break down different things, in addition to minerals. But they do it for a number of reasons, including things like cleaning up pollution. They can degrade complex compounds and organics and plastics and clean up landfills, for example.

Maggy Benson: [00:10:30] Wow, that is very cool. We owe a big, "thank you" to microbes then.

Cara Santelli: We do. Microbes are pretty awesome.

Maggy Benson: Cara, we actually have a video question from one of our student viewers. Do you want to take it?

Cara Santelli: I would love to take it.

Maggy Benson: All right. Let's take a look.

Aiden: Hi. My name is Aiden. I go to school at Upper Mississippi Academy. And I was wondering, in summary, how do microbes deteriorate the pollution in the environment?

Cara Santelli: Well, that's a really good question. How do the microbes deteriorate the pollution? And it, there's kind of a couple of answers. [00:11:00] But, really, you need to think about what the pollution is.

Cara Santelli: So, for example, if it's something like a petroleum spill in the environment, the microbes are kind of, in a way, eating the petroleum products. They're breaking down those complex organic compounds into smaller ones that are less hazardous for the environment.

Cara Santelli: Secondly, one of the things that they do is they convert the pollution from one form to another. So, for example, if you have some metals that are pollutants that are dissolved in water, microbes [00:11:30] or other living organisms could take up that pollution when it's dissolved like that. So, what they do, what microbes do, is they convert the dissolved form to a solid form, a mineral form. They produce these biominerals. Then the other organisms can't take up that, those metals, for example.

Maggy Benson: Great question, Aiden.

Cara Santelli: Very good question.

Maggy Benson: We have another question, and this one is coming from Susan.

Maggy Benson: How old are microbes? Did they live with the dinosaurs?

Cara Santelli: Ah, that's a really good question. So how old are microbes? Well, microbes go [00:12:00] way back. Way back before the dinosaurs. In fact, microbes we know are the first living organisms on our planet. So, they go way back in time to not much long after the formation of our planet.

Maggy Benson: Great. This question comes from Todd. How can microbes make a rock fall apart completely?

Cara Santelli: Ah, how can microbes make a rock fall apart completely? Well, I suppose if you start degrading all of the different minerals that make up a rock - [00:12:30] if you start degrading it, it's kind of like the glue. All those minerals that are interlinked together, it's kind of like a glue. You start degrading the compounds, and you basically are degrading the glue that holds it together. And you can just wind up with a crumbly mess.

Maggy Benson: Okay. This question is coming from Nina. When did microbes originate?

Cara Santelli: Ah, well, we just kind of talked about when microbes originated. We don't know exactly the timing of when microbes originated, probably [00:13:00] over three-and-a-half billion years ago, maybe as long as four billion years ago. We're still trying to get that metric right, but there's a lot of evidence that suggests not long after the formation of our planet, which was 4.6 billion years ago. So, it could have even been closer to that.

Maggy Benson: All right. Thanks for all the wonderful questions.

Maggy Benson: Cara, and thank you for helping us understand what a geomicrobiologist is. And all of these interactions between microbes and minerals.

Maggy Benson: I know that you study a very specific interaction between microbes and minerals, and it deals with some kind of human pollution from abandoned [00:13:30] mines. Can you tell us about that research?

Cara Santelli: Yeah, so, my colleagues and I have been studying something called Acid Mine Drainage. So, Acid Mine Drainage is a really common problem throughout the United States, throughout the world, really, and it happens a lot of times where you haven these abandoned mines, as you said.

Cara Santelli: So, what happens is, you have all this material that's around from all these abandoned mines, all the mining waste, if you will. And it's just sitting there being exposed to the elements, exposed to the water, the air. What happens is [00:14:00](that) when it's exposed it starts, it starts producing acid. So, you have all this acidic water, kind of sitting around. Acidic water can start dissolving the rocks and minerals, releasing toxic elements like metals - zinc, lead, mercury. These are things that we think of all the time as pollutants in the environment.

Cara Santelli: And then, so you have two problems, really. You have acidic water and you have this metal-rich water, which [00:14:30] is also a big problem.

Maggy Benson: So, is this a problem for humans or for all living things?

Cara Santelli: It's a big problem for all living things, really. I mean, if you were to look at an environment that has been impacted by Acid Mine Drainage, like if it was a wetland, for example, the entire ecosystem would be wiped out from all of this pollution.

Maggy Benson: Oh that's a shame! So, where do you study this exactly?

Cara Santelli: Well, I happen to do most of my field work out in Pennsylvania. Central Pennsylvania, Western Pennsylvania has a big problem with Acid Mine Drainage [00:15:00] from all the abandoned coal mines. But, the great thing is the state is very active in clearing up all of this Acid Mine Drainage.

Cara Santelli: So, we've been studying the cleanup of the Acid Mine Drainage. So, they, what they do is they build these giant pits. You can see on your screen right now there's these giant pits, and they fill them with limestone rock. The limestone helps bring up the pH of the water, so it neutralizes it, making it less hazardous for organisms.

Cara Santelli: So we sort of study this process.

Maggy Benson: [00:15:30] So you've talked a lot about how microbes can be the solution here to toxic pollution. How do you apply your research on microbes to the Acid Mine Drainage problem?

Cara Santelli: Yeah, so, as I mentioned Acid Mine Drainage really has two problems right now. It's the acid that's being helped out by all of the limestone in these treatment systems. But we still have this other problem, and that's all the metals that are in all of this Acid Mine Drainage.

Cara Santelli: And, so, how do we clean up the metals? Well, the microbes are what's key really here. So, microbes are helping [00:16:00] transform the metals that are dissolved, as I mentioned before, in the Acid Mine Drainage. And they convert them to a mineral phase. So, they're making these little tiny bio minerals as we just talked about. These biominerals get trapped in the treatment systems, and then clean water flows out the end. So, they're kind of like these giant Brita filters where you pour dirty water in and clean water comes out the end.

Maggy Benson: That's really amazing. Seems like a huge undertaking. Is there a big team that works with you to do this?

Cara Santelli: Yeah, I definitely do not work alone. I work with a lot of different [00:16:30] scientists, in particular, one of the people I study this research with is a person named Bill Burgos, he's a collaborator of mine. He's a professor at Penn State, you see here in the middle.

Cara Santelli: Colleen Hansel is another close collaborator of mine. She's a scientist who mentored me when I first started doing this research. She's a scientist at the Woods Hole Oceanographic Institution, and Dominique Chaput, who is here also at the Smithsonian. She's a post-doctoral fellow working here in the laboratory with me, and she's actually behind the scenes right [00:17:00] now helping answer some of the questions.

Maggy Benson: Wonderful! So, keep sending your questions for Dominique and Cara today.

Cara Santelli: Yeah. Thank you.

Maggy Benson: So, I'm really interested. You said that microbes are living organisms. So, what kind of nutrients do these microbes need to be able to flourish, to be able to transition these toxic elements into something a little less harmful?

Cara Santelli: Yeah, and that's one of the things we're really trying to understand right now, Maggy, is, "What do they need to grow?" And one of the keys to this is understanding the essential elements, [00:17:30] or the essential nutrients that promotes growth.

Cara Santelli: So, microbes need very similar nutrients to humans. Carbon is a big one, sulfur, phosphorous, some other trace metals like lead, and zinc, and nickel are good examples of some of the trace elements that these microbes need to grow. So, those are the things that we're studying right now in the laboratory.

Maggy Benson: Have you found that any conditions can be studied better in the lab or the field? I think we should ask our students. What do you think?

Cara Santelli: I think we [00:18:00] should ask our students.

Maggy Benson: All right. Now's another time for you to tell us what you think using the live polling feature.

Maggy Benson: Tell us: how do you isolate factors that affect microbial growth to be able to understand which nutrients they need to be able to grow?

Maggy Benson: Experiment in the lab? or Observe in the field?

Maggy Benson: Take a moment to think about it, and put your answer in the window to the right of your video screen.

Maggy Benson: [00:18:30] So, Cara, the results are still coming in, but right now 63 percent of the students think "experiment in the lab." What do you say?

Cara Santelli: Yeah, actually that is the correct answer to this question. And the key to answering that question is the term "isolate." So, we really want to be able to figure out which specific condition or which specific [00:19:00] nutrient it is that impacts their growth, because as I mentioned, those pits that are out in the field are enormous. They're just out in the open, right? We can't really control the conditions in which the microbes are growing.

Cara Santelli: So, you know, they're affected by things like sunlight, they're affected by things like seasons. Yeah, and so those are things we can't control. So, if we want to look at, and really control, and figure out which specific ... for example ... nutrients it might be, like carbon, for example. We have to control these conditions. [00:19:30] and, we do that in the laboratory.

Maggy Benson: Wonderful. So, have you seen any results. I mean, what makes them grow more or better?

Cara Santelli: Yeah. So, one of the key things we've been studying lately, and what we've been finding, is that carbon is really important. What I mean by that, is the carbon source or the carbon concentration.

Cara Santelli: And so, for example, here you see I have different microbes. These are two different fungi growing in these flasks. So, we've designed media, for example. [00:20:00] These fungi are growing, you can kind of see them-

Maggy Benson: So it's this cloudy material?

Cara Santelli: Yeah, it's the kind of cloudy, fluffy looking stuff. And so that's a, that's a fungus, and it's growing. And, right, it's growing. It, it's growing just fine, right?

Maggy Benson: Very happy.

Cara Santelli: But, the problem with that is, it's growing, but it's not doing what we want it to do. And that's make these little biominerals that are helping clean up the pollution. So, in this case, we've given this fungus over here, a different nutrient, a different carbon source.

Maggy Benson: It's much darker.

Cara Santelli: Yeah. It is darker, and so, [00:20:30] so what's different about this is it's growing, but it's also producing these little, tiny biominerals. These biominerals are this blackish or brownish color that you see. And so, that's what it's doing. This is what we really want to see, right? We want to see these microbes growing and producing these little tiny bio minerals.

Maggy Benson: But they're so small, how do you actually know that those are actually producing minerals?

Cara Santelli: Yeah, well we've been studying these different biominerals for a while, and, what we really need to do is use a lot of microscopy, as I mentioned. So, microscopes [00:21:00] are really important for us to look at. So, if a fungus is growing and is growing along - .

Cara Santelli: see, here you have this video again. Where it's growing along and these tiny little dots are appearing, okay? And those dots, we now know are minerals. That's based on an electron microscope image that was taken by one of the post docs, Carla Rosenfeld, who's actually behind the scenes also answering questions.

Cara Santelli: So, Carla took this image, and what she saw were these long filaments, and on them, were these little bundles, these little spheres. Those spheres were made [00:21:30] up of tiny, tiny little minerals, bio minerals.

Maggy Benson: So you use really specialized microscopes to really be able to see what's happening.

Cara Santelli: Absolutely.

Maggy Benson: So those minerals were tiny! How do you actually identify what that is, what kind of mineral you have?

Cara Santelli: Yeah, so it kind of goes back to knowing what defines a mineral, right, Maggy? So, we talked about chemical composition, and we also talked about the structure, and so, we use techniques like X-rays. You know, X-rays are used all the time. If you break your bone, for example, and you go to the [00:22:00] doctor, what do they use to check if you have a broken bone?

Maggy Benson: An X-ray.

Cara Santelli: Exactly. So they are X-raying the structure of your bone to see if it's broken. We use X-rays in a very similar way. We're X-raying our unknown minerals and looking at the atomic structure, the arrangement of all these elements. And that gives us a clue and tells us exactly. It's sort of like a fingerprint almost. It gives, it gives us a fingerprint.

Cara Santelli: So, if you look at the pyrite example that was just shown, we know that the structure of that mineral is pyrite. So that's what we use X-rays [00:22:30] for all the time.

Maggy Benson: So interesting. So, in the lab you're really finding out what makes these microbes grow the best way, how to identify what kind of minerals they're making. But how is this applied to your work with Acid Mine Drainage?

Cara Santelli: Yeah, so we are applying this all the time, studying the interactions between minerals and microbes, but what we really want to do, we're doing basic science, right, in the lab? We're doing fundamental science, asking fundamental questions, but what we really want to do is, apply this then, so that we can help inform the remediation [00:23:00] strategy. How can we clean up the pollution better, and more effectively?

Cara Santelli: So, we work all the time with engineers, people who build these treatment systems, organizations who develop these systems and maintain these systems. This is one of my colleagues, that's Carla and Cliff Denholm from Stream Restoration, Inc. He's been allowing me access to some of the field sites, or some of the treatment systems that they build. So, we work with people like this all the time, to help inform their remediation strategy.

Cara Santelli: But the cool thing [00:23:30] is, they also help us because they often will come up with some questions for us, along the way, that they don't really understand. Things they're seeing in these treatment systems, they don't understand. So they'll come back to us and maybe tell us some information, and (then) we can go test it in the laboratory to make sure we're understanding what's going on.

Maggy Benson: Have you ever seen a transformation of a polluted site affected by Acid Mine Drainage and transform into a healthy system?

Cara Santelli: Yeah, Maggy, its' really shocking. It's really eye opening. I mean it. It does happen within [00:24:00] a couple of years, actually. So, what you see when you see an area inundated by all this Acid Mine Drainage, here you see the treatment system being constructed and all of that red stuff that's flowing, the water that's reddish in color, that's due to all the Acid Mine Drainage. There's a lot of iron in this Acid Mine Drainage, and that's giving it it's red color.

Cara Santelli: So, they build these systems and then after a couple years if they're working successfully, you'll start to see ... What do you see?

Maggy Benson: It looks beautiful, wildflowers-

Cara Santelli: Exactly.

Maggy Benson: [00:24:30] And vegetation.

Cara Santelli: Yeah, so the vegetation can start growing again, wildflowers can start growing again. And you can get whole ecosystems back within, you know, a year or two, even.

Maggy Benson: Wow, that's amazing! So, microbes are really incredible machines for cleaning up Acid Mine Drainage. What about other applications? Are there other kinds of pollution that microbes are used to clean up?

Cara Santelli: Yeah, we talked a little bit about this pollution, but it's really amazing to see what microbes can do in terms of cleaning up the environment.

Cara Santelli: Oil spills, a great example. So, we had a major [00:25:00] oil spill in this country, about five years ago, in the Gulf of Mexico. What scientists have been learning, is that the microbes are already there in the environment, living in the ocean, and they're helping degrade all of this petroleum that's being released, and degrading it into compounds that are much less hazardous for the environment.

Maggy Benson: So, the potential for microbes being able to break down pollutants is huge for our future?

Cara Santelli: Absolutely, huge. Absolutely.

Maggy Benson: What would you suggest the students do if they want to actually go into this field to study this?

Cara Santelli: Ah, well [00:25:30] that's a really good question. What would you do to study this?

Cara Santelli: Well, I started out by studying geology, okay? And then I moved on to studying microbes. And so you can start studying all of these fields that will bring you in. And you can learn all about these different techniques that we use, the different disciplines that we study. So, yeah, start studying science.

Maggy Benson: Very cool. Thanks for helping us learn a little bit more about microbes and how they can be applied to Acid Mine Drainage.

Maggy Benson: Let's go to some of our student questions. This question comes from Owen. How long does [00:26:00] an individual microbe live?

Cara Santelli: Ah, that's a really good question, Owen. How long does an individual microbe live? And I think we don't even know the complete answer to that. So, some of the microbes that I grow in my laboratory, for example, might live for a couple of days, because eventually they start, especially if they're grown in a flask like I was showing earlier, they might start running out of nutrients.

Cara Santelli: But, in the environment, they could probably live a lot longer. In fact, they could live for many years even, or [00:26:30] many hundreds of years, even possibly, if they're preserved well. So, we don't even know the limits of life at this moment.

Maggy Benson: Very cool. Mystery.

Cara Santelli: It is.

Maggy Benson: More to study in the future.

Cara Santelli: Absolutely.

Maggy Benson: All right, this question comes from Amara. What's your favorite part of your job?

Cara Santelli: Oh gosh. What is the favorite part of my job? I think I have a lot of favorite parts of my job actually.

Maggy Benson: That's a good thing.

Cara Santelli: I know. It really, I mean, it's a really, it's a really great job, I have to say. I love what I do. I [00:27:00] love every day working with different scientists. Yeah, getting to go places. So, I've been to the bottom of the ocean in the Submersible Alvin. That was really amazing.

Maggy Benson: Wow.

Cara Santelli: So just traveling, interacting with a lot of different people, working on questions that I'm passionate about, right? I'm really passionate about what I do. I love what I do. And getting to work on that on a day-to-day basis? Like nothing beats that.

Maggy Benson: Very cool. Wonderful. Cara, thank you so much for sharing all of this wonderful information with us, and, thank you, all for all your great questions, [00:27:30] but we are all out of time.

Cara Santelli: Well, thanks for having me, Maggy. It's been a pleasure.

Maggy Benson: Can you tell our viewers too where to learn a little bit more about your work?

Cara Santelli: Yeah, so, if you want to learn more about Acid Mine Drainage and the cleanup of Acid Mine Drainage, there's a great website run by the U.S. Geological Survey. You can see this on your screen below.

Cara Santelli: But, if you want to learn more about what we do here at the Smithsonian, the geology that we do, the minerals that we study, you can go to the Smithsonian website also listed below.

Maggy Benson: Great. Thank you so much. And thank you all for all your wonderful [00:28:00] questions. And thanks to the Sheldon Tigers for tweeting us a picture of you watching the webcast, and to Craig Library in Alaska for tuning in today too.

Maggy Benson: If you want to see this broadcast later, it'll be archived at qrius.si.edu later this evening. Thanks for tuning in to "Smithsonian Science How?" and we hope to see you next time.

Announcer: Thanks for watching. [00:28:30] You can explore more "Smithsonian Science How?" shows on our website qruius.si.edu.

Announcer: We hope you'll join us again on Thursday, March 26th for our conversation with Zoologist, Karen Osborn. As we explore water column biodiversity and the habitat of marine invertebrates in the open ocean.

Announcer: Register now at qrius.si.edu.

Return to the web page, Mineral Transformations - Demystifying Microbes.