

AirSpace Season 1, Episode 13

Under Pressure

Nick:

(singing)

Welcome to AirSpace. We're your hosts. I'm Nick.

Emily:

I'm Emily.

Matt:

And I'm Matt.

Speaker 1:

The sea floor is a place full of excitement. Lava bombs are being spewed out of these volcanoes. There's lots of entanglement hazards.

Emily:

And it's increasingly a place where NASA scientists can learn about and practice space exploration.

Speaker 2:

By using the underwater experiences, we can get people used to assimilating all this additional input, learning how to live there and cope with it and deal with their crewmate going through the same metamorphosis.

Nick:

In this episode of AirSpace, we'll talk about how living in cold, wet, dark places on earth can prepare explorers for extreme environments in space.

Matt:

And what life deep underwater might tell us about watery life on other planets.

Emily:

And watery life on icy moons.

Nick:

The deep sea and deep space, that's coming up next on AirSpace from the Smithsonian's National Air and Space Museum with help from PRX.

Not counting underwater environments, what is the most otherworldly place that you guys have ever been to, landscape-wise?

Emily:

I think the weirdest landscape I've seen would probably be Craters of the Moon National Park. Scabby and bizarre, and then sticking out like a sore thumb in the middle of all of it is like these big, black triangular, what we would call cinder cones. I know that sounds like the total typical answer that I should be giving you as a planetary scientist. But I don't know. Have you guys been?

Nick:

No.

Matt:

No, but you're making me think also of Meteor Crater in Arizona, which is also kind of a weird, surreal spot in the desert.

Nick:

I think the weirdest landscape that I've ever actually been through was the Dead Sea. No life anywhere to be found. And you're walking and you're walking and you're walking through the cold, alien, barren, salt environment. And then you get to the water, and the water's not cold because of the density of salt. Not only as the water not as cold as you would expect in January, but your body just bobs like a cork. It was the strangest place that I've ever been in the natural world.

Emily:

You know, what I think is interesting actually, is all three landscapes that we each pick are all places that are relatively devoid of mostly vegetation, right?

Matt:

Not just isolated from other humans, but isolated from the other animals that help to sustain human life on the planet, right?

Emily:

The Dead Sea being famously dead, yes.

Matt:

There might be some kind of like heliophilic-

Emily:

Yeah, high, salt-loving life forms. There's got to be something in there. A lot of work has been done now, not just at the bottom of the ocean, but all other kinds of extreme environments on earth. What they're finding, no matter how inhospitable the place, from the bottom of a diamond mine to an underground lake in Antarctica, we are finding microbial life and ecosystems in places where we never thought we'd find them.

Matt:

To quote Dr. Ian Malcolm, life finds a way.

Nick:

Life-

Emily:

Life always finds a way.

Nick:

... finds a way.

Matt:

My outside reader, Dr. Ian Malcolm.

Emily:

There's still a lot to learn about life in extreme environments.

Matt:

About extremophiles.

Emily:

Yes. Studying life in extreme places on earth could end up really guiding future missions to find life in other parts of the solar system.

Matt:

It's pretty cool.

Emily:

So guys, I want to introduce you to another doctor, besides Malcolm, Dr. Julie Huber. She's an oceanographer and deep sea microbiologist at the Woods Hole Oceanographic Institute in Massachusetts. And she's really into studying the tiny life forms in these super extreme, almost unimaginable parts of the planet. Primarily the deep, deep ocean. I actually got her to do this interview from the water. She's been spending time living on a boat with her family in between running some pretty incredible deep sea missions. I asked her to describe the boat where they were staying

Dr. Julie Huber:

Right now, we're sitting in the cockpit, which is where you steer the boat from. That's where you control the sails from and stuff.

Speaker 5:

What's your location?

Dr. Julie Huber:

And then you go down into the galley, which has a stove and a ice box. And then forward of the galley, so toward the front of the boat, is my very messy bedroom. You walk back through, there's actually two more bedrooms-

Emily:

Wow.

Dr. Julie Huber:

... in the aft part. Provisioning a boat for a family of four for three weeks is an awful lot like going to sea. So yeah, that's the grand tour.

Emily:

Can you describe for our listeners the science that you do?

Dr. Julie Huber:

I'm interested in basically life in the dark. I'm interested in single cell life form, so microbial life at the bottom of the ocean where there's no sunlight. The extremes that life has to face are pretty tough. These microbes are basically running our planet right now and they were running it billions of years ago also. Thinking about how understanding that could help us understand the potential for life beyond earth. That started to play a really big role in my research, even as an undergrad.

Emily:

So is it fair to say you spend most of your time studying what people would describe as tiny stuff in deep water?

Dr. Julie Huber:

I study these very small organisms, but I think about them over very large timescales and planetary scales, really.

Emily:

How deep as deep?

Dr. Julie Huber:

I would say sunlight disappears within a few hundred meters. And I mainly study at the sea floor or even beneath it. I'm really interested in underwater volcanoes for a lot of different reasons, but in particular, the very interesting microbial life that they support.

Emily:

How deep have we been able to explore scientifically?

Dr. Julie Huber:

We have been to the deepest part of the ocean, the Mariana Trench. There've been some recent observations of fish at 10,000 meters or so, so really, really deep.

Emily:

Wow.

Dr. Julie Huber:

But it is a very tough place to access. Even just putting something as simple as a sample over the side on a wire, it takes hours and hours and hours and hours to get to the bottom. We actually don't know that much about the really deep parts of our ocean, studying at those depths.

Emily:

So to do your research, you sometimes go down underwater in a submersible vehicle, like a small submarine. You don't actually have to go down very deep before it gets relatively calm. Is there kind of a floating sensation, similar to space, when you're in one of those submersibles?

Dr. Julie Huber:

Yeah. There's so many remarkable things about diving in a submarine to the bottom of the ocean. The surface is the most dangerous place to be because you're near a ship and it's rough. They try to get you down as quickly as possible. It gets calm within less than a minute, most of the time. You don't feel like you're sinking. You feel neutral, which I found really surprising. You're also spinning as you go down, spinning, not in the vertical sense, just horizontally around your center. You don't feel that at all either.

Emily:

Really? I would think that that would be the worst part.

Dr. Julie Huber:

No, it's very mellow. The lights are off, most of the power is off because you're just, you're trying to save battery power. It's very, very peaceful and quiet. It's dark. Once you get out of the sun lit layer, the world around you kind of lights up with all the bioluminescence that's associated with all these different, fascinating, deep sea creatures. You can't see the creature, you can just see the light coming from them. It's really amazing, actually. It very much surprised me. I know other people completely freak out when they've got to that point, but I found it very comforting.

Nick:

Okay, wait, pause. We'll get back to Julie a little bit later in the episode. But she just said that this experience of sinking was comforting. Tell me guys, have you ever enjoyed a sinking sensation?

Matt:

Well, some people, they find that whole sensory deprivation experience to be relaxing and comforting. High-strung people tend not to. I think their minds wander to strange places.

Emily:

Maybe it's not the sensory deprivation. Do you think you'd get claustrophobic in such a small space?

Matt:

Yeah. I don't know how would react, to be honest, because it's not just being in the tight space. It's knowing that there's so much pressure outside of the vehicle.

Nick:

Okay. Question on the count of three, let's all say the number of times that we read Michael Crichton's book Sphere in middle school. One, two, three.

Emily:

None.

Matt:

Zero.

Nick:

Zero?

Matt:

I've never read Sphere.

Nick:

Zero?

Emily:

I've never even read, heard the book. I bet it was an episode on Space Track.

Matt:

I read Jurassic Park.

Nick:

Okay. How many times-

Matt:

That's where I met Dr. Ian Malcolm.

Nick:

How many times did you read Jurassic Park? Sphere?

Emily:

Sorry we ruined your punchline. Tell us more.

Nick:

Sphere is Jurassic Park under the waves, but no dinosaurs. It is about, how best not to spoil it?

Matt:

Spoil it.

Emily:

It's been out for a few years, I think you can spoil it.

Matt:

I don't care.

Nick:

It's about a group of scientists who go on-

Emily:

Do you call a group of scientists a gaggle?

Nick:

Ooh, what do you call it?

Matt:

It's a cohort.

Emily:

We'll take a poll.

Nick:

Okay. So it's about a cohort of scientists who go on an extreme, deep sea mission with the US Navy to investigate what is ostensibly a crashed spacecraft, alien spacecraft. The, on like chapter three, discover that it's not an alien spacecraft. It's an American spacecraft from the future. As much as I love-

Emily:

What?

Nick:

Yeah.

Matt:

I saw the movie, I think.

Nick:

No. We're not talking about the movie.

Matt:

Dustin Hoffman, right?

Nick:

Some of the casting choices were acceptable is as far as I'll go on that film.

Matt:

Okay.

Nick:

So the thing that I loved about this book in particular, which is why I read it probably three or five times-

Matt:

There are other books out there.

Nick:

No, there weren't. Is the description, the colorful exhaustive description of the hardware that you need to survive in these extreme environments, the oceanographic research vessels, and then the sub that takes them down. But then this giant under sea habitat, and you get the dampness on the floor because they can't control the humidity and it's freezing cold down there. And all of the sounds ping in a very unusual way because this whole pressure vessel reverberates anytime anything touches the outside. The size of the bolts, the size of your fist that have to hold the windows, which are very, very tiny. It really does this evocative job of putting you in this extreme environment. And then there are bioluminescent jellyfish that people swim with and allegedly it's really serene until the horror-

Matt:

It's always serenity before the horror.

Nick:

Serenity before the horror. The story was great, but it was really the techno part of the techno thriller.

Matt:

Pulling back from the abyss here for a second. People often talk about space as a place that's nearly impossible to really anticipate what it's going to be like until you're there.

Nick:

Unfortunately for rookies, minimizing the shock on a space mission involves maximizing the shock in a training scenario.

Matt:

NASA tries its best to help future astronauts prepare for the foreignness and the extremeness of space.

Emily:

My new favorite fun fact that I learned from Sonny Williams recently, who's an astronaut, mentioned that they send you home with like astronaut diapers so that you can spend time laying on your back in a bathtub, training yourself to be able to pee on your back. Because as grownups, we-

Nick:

Maximum absorbency garments.

Emily:

Is that what they're called?

Nick:

Yes.

Matt:

They're diapers.

Emily:

That's just one of the parts.

Nick:

It's an important part.

Emily:

It's an important part.

Matt:

Who even likes to take a bath?

Nick:

I mean, that's so gross and now you're peeing in the bathtub. Well, they didn't say you had to fill the bathtub. I would advise against filling the bathtub before you attempt this exercise.

Matt:

I don't know if that's better or worse, Nick. I don't know. It's not good.

Nick:

We'll call it the Alan Shepard simulator.

Matt:

Yeah, there you go.

Nick:

Because he famously went in his space suit.

Emily:

They showed you that in The Right Stuff.

Matt:

They did, yeah.

Speaker 3:

Jose, permission granted to wet your diapers anytime.

Emily:

That was a big scene.

Matt:

So moving on to another astronaut, you both know Randy Bresnik. He was selected to be an astronaut in 2004. But before he went into space, into the dark, vast emptiness of that cold place that we call space, he got some extra special training in an environment even more extreme than your bathtub.

Nick:

All joking aside, bathtubs are one of the most dangerous places in the home.

Matt:

I thought rugs were the most dangerous things in your home.

Nick:

Dangerous things in your home.

Matt:

Oh.

Nick:

Places?

Matt:

I don't know. Well anyway.

Nick:

Either way, take care out there.

Matt:

He got some extra special training before he went into space to live on the International Space Station. He went to an environment even more extreme than your bathtub, even if you pee in it, the deep sea, which probably has tons of pee in it from fish, swimmers, everything. Anyway, he was part of something called NEEMO. It stands for NASA Extreme Environment Mission Operations.

Speaker 4:

I've been diving, I've been under water 30 minutes, 45 minutes during scuba, but I never lived under water. Because space is such a completely foreign, physically and mentally and visually environment. It can be overwhelming at first. By using the underwater experiences, we can get people used to assimilating all this additional input, learning how to live there and cope with it and deal with their crew mates going through the same metamorphosis. When we've been able to do one or two of those before we go to space, then hopefully space is just the next extreme environment, not an overwhelming sensory experience.

We're going down there. We're living in a school bus sized habitat called Aquarius. I'm with a crew of six. We're talking to a simulated mission control up top, on top side. We're doing science and running a timeline as if we were living on board a space station or a terrestrial exploration facility, on the moon or Mars. We're not inside a spacesuit staying in dry. We were actually doing hardhat diving, but our bodies, neck and below, are all wet. We go out and do these simulated spacewalks in the NEEMO outside of Aquarius. It's physically very strange because our whole lives here on earth, we're used to being wet maybe for a bath or scuba diving or swimming. But our bodies aren't used to being wet for hours at a time. It's also strange having your head dry and your body wet. These are things that are physical things that you get used to during the NEEMO experience but you haven't experienced before. Very much like when you go to space for the first time, you haven't felt zero gravity on your body for any extended periods.

Matt:

Did you ever go on the submarine ride at Disneyland or Disney World?

Nick:

Oh yeah.

Matt:

Do you remember, as you went through it, Captain Nemo was talking to you and he was telling you all the things you were going to see. You see all of the people who live in his underwater colony out harvesting things that they were growing in their underwater garden.

Emily:

Like the octopuses garden?

Matt:

That's the Beatles. I'm surprised you know that reference, but yes.

Emily:

I'm here to surprise you, Matt, and to keep you on your toes.

Matt:

Sometimes you actually do know popular culture.

Nick:

The submarine was yellow though, right?

Matt:

Yes, it was. The submarines at Disneyland are yellow submarines. I don't know.

Emily:

I thought you were talking about the Beatles again. I was like, "I know that one too."

Nick:

This is an important intersection, an important cultural intersection.

Matt:

That's right. They are yellow submarines. It's a weird mash up, I guess, of The Beatles and Jules Verne.

Emily:

Jules Verne, the author of 20,000 Leagues Under the Sea.

Nick:

250 feet of 20,000 leagues under the sea?

Matt:

Yeah.

Nick:

Story and fiction aside, when did we seriously begin exploring the sea floor?

Matt:

Well, what's interesting is that the study of the sea floor is not a story of how we've gone deeper and deeper. We actually went to the deepest point in the ocean in 1960, and we've been going back to those deep points in the ocean ever since then.

Nick:

You were on that submarine?

Matt:

I was not on that submarine. I'm using the historical "we", if there is such a thing, in which historians insert themselves into different points in time, pretending that we can travel-

Nick:

What a poser.

Matt:

... through time and space. Yeah. In 1960, around the same time we were putting a lot of money and time into space exploration, there was a vessel, the Trieste, a Swiss vessel, and it went into the depths of the Mariana Trench.

Emily:

Can you explain what that's close to?

Matt:

So off the coast of Guam, there's a point called Challenger Deep in the Mariana Trench. And so the Trieste did go down there in 1960. Once it got down there, there wasn't much it could see. They didn't have the kinds of bright water and pressure resistant lights that we have today on these vessels. They couldn't really do much either. There were no arms with which to manipulate anything. They were in a small metal sphere that was about five inches thick.

Nick:

What is the last thing you want to hear when you get to the bottom of the deepest part of the ocean?

Matt:

I would think a crack sound.

Nick:

Their window cracked right as they got to the bottom.

Emily:

No, it didn't.

Nick:

Yeah.

Matt:

It wasn't a problem. Everyone was fine. The vessel went on more... In fact, it was bought then by the US Navy and was used by the US Navy to study the ocean floor after that.

Nick:

We can all name the 12 people who have walked on the moon, right?

Matt:

Mm-hmm (affirmative).

Emily:

Yeah.

Nick:

Emily's nodding her head.

Emily:

Yes, I am nodding my head.

Nick:

So 12 people have walked on the surface of the moon. Three people have been to the bottom of Challenger Deep. Can we name the three people who have been to the bottom of the ocean?

Matt:

Jacques Piccard.

Nick:

Jacques Piccard. Don Walsh was the other crew member with Jacques Piccard on the Trieste in 1960. One other person has been to the bottom of the Challenger Deep, by themselves.

Matt:

James Cameron.

Nick:

James Cameron.

Emily:

The James Cameron?

Matt:

Mm-hmm (affirmative).

Nick:

The James Cameron. Yeah, he was filming the sequel to avatar.

Emily:

Those first two people that you mentioned, they were the ones that went down in the '60s and nobody's been down into Challenger Deep until James Cameron did it again?

Matt:

They've been to other parts of the Trench, but not to Challenger Deep part.

Emily:

But wait, it wasn't long after visiting Challenger Deep that there were more surprises that they found.

Matt:

Right. not that long after that, the Navy commissioned the construction of the Alvin submersible, which became the Navy and Woods Holes' go-to submersible for doing research on the bottom of the ocean.

Emily:

The one I'm thinking about is 1977. Alvin made what I would think, especially from a scientific perspective, Alvin made a really big discovery in the Galapagos.

Matt:

Yeah. One of the predictions of plate tectonics was that there would be deep sea hydrothermal vents. One of the things that researchers-

Emily:

So, like volcanoes.

Matt:

Volcanoes on the bottom of the ocean, because you've got all kinds of hot rock-

Emily:

Boiling.

Matt:

Boiling temperatures and water circulating down there in the deep sea. So the thought was that if you actually had sea floor spreading and plate tectonics and mantle convection at work down there, then you should have these underwater volcanoes or deep sea hydrothermal vents. And so scientists set out looking for them in the Alvin in the 1970s. And in 1977, they hit pay dirt or pay volcano.

Nick:

Every bit of that description makes me think that we should do a prog rock concept album about this discovery. In the 1970s, you've got mantle, convection, hot rock at the bottom of the ocean.

Emily:

But they found something they didn't expect, right?

Matt:

Right. So the other big thing is, what they discovered previous to this, in 1969, was the first extremophile, heat loving bacteria, living at temperatures that they didn't think bacteria could live at. The surprise was that they found similar types of bacteria down in these hydrothermal vents where not only it was too hot for conventional bacteria to live, but there also was no sunlight, which was also believed to be very important for life on earth.

Emily:

Didn't they also find huge tube worms sticking out of the surface?

Matt:

Yeah, turned out the-

Emily:

Surface, the sea floor.

Matt:

It turned out that these extremophile bacteria were the basis for a whole ecosystem that surrounded these hydrothermal vents.

Nick:

So musicologists who study prog rock at the bottom of the ocean, are they exorockologists?

Matt:

But you know what we can name our program rock band, Nick?

Nick:

What?

Matt:

Thermus aquaticus.

Nick:

I'm on. Yes.

Matt:

That was the first extremophile ever discovered.

Nick:

Let's do this.

Emily:

So pretty much since then, there's been this increasing amount of collaboration between NASA scientists and microbiologists, oceanographers, and another group of scientists like exobiologists, which essentially means biologists who are studying things that will help them understand life that formed outside of this planet.

Nick:

So that means just Mars, right? Because we're not expecting to find life anywhere else in the solar system.

Emily:

No. Icy satellites, Nick. Get it together. We already talked about this at the top of the podcast. You have to listen.

Matt:

Yeah, you better watch it, buddy.

Emily:

Ocean worlds. We have to call them ocean worlds.

Nick:

Ocean worlds.

Matt:

Ocean worlds. They're being rebranded as ocean worlds.

Emily:

Researchers are collaborating and exploring more about the deep sea as a way of understanding deep space. I want to pick up my conversation with scientist, Dr. Julie Huber.

Dr. Julie Huber:

One of the reasons I love going to sea is because you do bring together this group of people, half of whom are just running the ship. From the engine room, to the galley, to driving, to everything. They are absolutely essential to the mission. And then the other half are scientists and engineers. In my case, we use a lot of robotic technology to get access to the deep ocean. Most of that, not all, but most of that is remotely operated. So the vehicles are tethered back to the ship and there's nobody in the vehicle. All the telemetry, all the data, all the videos are coming back up through the wire. We're all sitting up on the ship with the remotely operated vehicle team, running the operation with them.

Emily:

I love that.

Dr. Julie Huber:

So the engineers are moving the vehicle, taking samples. And the scientists are running the dives in terms of where we're going, what we're looking for, what maps we need and things like that. The samples come back, we do our experiments, we process them and we start all over again. The vehicles have tons of cameras with lots of different angles and views on them. In the control room where you can see all those different cameras, there's something like 16 different video screens. You're kind of trying to recreate this 3D vision of the sea floor in three dimensions. What I love about that is everybody on the ship gets to participate. There's three components. There's scientists on land, there's scientists on the ship, and then adding to that, we also are using a remotely operated vehicle off of the ship. There's sort of three points of communication that have to all work to complete the mission and do the operation.

Emily:

That also doesn't feel completely different to how we envision sort of crude space exploration, other than the fact that your duration is 8 to 12 hours as opposed to days, months, years.

Dr. Julie Huber:

Absolutely. Even when astronauts are in space, they're communicating constantly with mission control. I think that it brings a lot of benefit to the mission, to be able to bring folks who aren't physically there into what's happening on the sea floor.

Emily:

I'm talking to you, who's an oceanographer, classically trained oceanographer, who's sort of also a microbiologist, who's also sort of a geneticist, whose work is actually relevant to the work that I do. Can you think of something that makes you really particularly excited about how we explore deep space or the kinds of things we might be able to find by continuing to study our deep oceans?

Dr. Julie Huber:

What I always have been amazed by is things that we're discovering in our own ocean, earth ocean, that no modeler predicted. So we have to keep a really open mind, I think, as we're bringing data back from places like Enceladus and soon Europa. There's a huge amount of surprises out there. We are surprised almost every single time we go to a new place on the ocean floor. I think there's huge potential. We just need to keep an open mind.

Nick:

Emily, where are we likely to find life?

Emily:

When we think about what it takes for life, just by having water and rock interacting on a regular basis, it means that you can produce things that critters can munch on and actually subsist on.

Nick:

So what are the ingredients? What are we looking for out there? Liquid water.

Emily:

Liquid water.

Nick:

Heat?

Emily:

Rocks.

Nick:

And rocky material equals sometimes potential for organic material?

Emily:

Either organic material or simply they... That's what's so cool about these deep sea environments, is they found microbes who can subsist on silicates. Silicates, it's like literally a piece of quartz, like dissolved quartz. That's not something that you think a microbe would really enjoy eating, but there are microbes who can actually metabolize that or do something with that that is useful for those microbes to continue living.

Nick:

Is this what the scientists call chemosynthesis?

Emily:

Yeah, right. Chemo being chemicals. But photosynthesis, right?

Nick:

Like photosynthesis.

Emily:

You're taking light and you're actually making fuel out of it. In the same way, chemosynthesis, you're taking energy from chemical reactions rather than the light of the sun and making fuel. In this case, it's the stuff you make regular rocks out of. Most of these ocean worlds have a rocky core and a liquid water ocean, and then an icy shell. All throughout our solar system, we have these ocean worlds. Ceres, which is an asteroid actually so it's closer to earth than the rest of the satellites, Ceres is considered an ocean world. Saturn's moon, Titan. We don't have time for me to list them all off, but trust me, trust me, I'm a doctor. I know these things.

Nick:

Have we ever sampled liquid from one of these locations?

Emily:

Indirectly. Enceladus, which is a moon of Saturn, it's very tiny, it's about the size of Washington state, has a plume of water, gas, dust, vapor, coming out of its south pole. It's a big old Faithful except for it's on all the time instead of every once in a while. We actually flew the Cassini mission through that plume multiple times, sampling and tasting what those plumes are composed of. We found that it's briny water. Additional flybys have found things like maybe there's hydrogen there, which says something about what might be going on in the subsurface. They've actually found elements inside Enceladus' plume that suggests that there may be some kind of activity going at that rock water interface where they may have hydrothermal environments.

Nick:

You say briny water. I hear delicious broth.

Matt:

Broth.

Emily:

It could be breath. It could taste like the Dead Sea. We don't know if it would be potable. We'd have to test it.

Nick:

So all of that briny ocean water may in fact be primordial soup. We just need to get there and test it?

Emily:

Mm-hmm (affirmative).

Nick:

Delicious.

Emily:

Get a spoon.

That's it for this episode of AirSpace. We'll be back in two weeks with a new episode.

Nick:

AirSpace is produced by Katie Moyer, Lizzy Peabody, and Jocelyn Frank.

Matt:

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Emily:

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Nick:

This episode was supported by PRX and the Alfred P. Sloan Foundation, enhancing understanding of science, technology, and economic performance. More information at sloan.org. You can follow us on Twitter @airandspace. Find us on Instagram at AirSpace podcast, and please bring a swim buddy. Come on, the water episode.

Matt:

Don't pee in our pool.