Ask A Biologist Vol 072 (Guest Scott Parazynski)

Space Physiology

Extreme environments can be found on Earth, in space, and in the depths of the ocean. Dr. Biology and biologist, astronaut, and mountain climber Scott Parazynski sit down and talk about what life is like to explore these environments. Just what are they teaching us about our bodies and how might they hold up on long voyages in space?

Transcript

Dr. Biology: This is, "Ask A Biologist," a program about the living world, and I'm Dr. Biology. Now let's take a trip. It's going to be a long, long one. To be exact, it will be a 140 million miles, and for those that are more comfortable with kilometers, 225 million, 300 hundred thousand kilometers. It's likely to last more than 260 days.

Have you figured out where we're going? It's the planet Mars. Now whether a human should go to Mars is a popular topic in debate, and no matter which side you're on it's clear that just planning for such a trip, we're going to learn a lot about the human body. My guest today is Scott Parazynski, a physiologist, doctor, mountain climber, and if that wasn't enough, former astronaut.

Currently, he's the new University Explorer at Arizona State University, and he's taking a little time out of his day to sit down, chat about space, what he learned and experienced and what the future might hold for people who travel to distant planets like Mars.

Welcome to the show, Scott Parazynski, and thank you for visiting with me today.

Dr. Scott Parazynski: Great to be with you, Dr. Biology.

Dr. Biology: When I sat down and started thinking about questions, I wanted to ask you, I realized, I was going to have a really difficult time keeping my list short. To start off with, I thought I would stay with the theme of the show and ask, how a biologist/physiologist ends up becoming an astronaut?

Scott: Well, you know the space program requires all sorts of different skill sets. We need, of course, pilots to fly the space shuttle, spacecraft. We need people to conduct the science, to take care of our astronaut crews in orbit.

We need to have scientists to operate different types of experiments astrophysics and engineering and so on. My role, among many others, was to take care of the crew as a physician.

Dr. Biology: That's a perfect segue for me, thank you. We have a story on Ask A Biologist on, "Spaced Out Physiology." In the story we talk about NASA's plane, the KC-135.

Scott: Love it.

Dr. Biology: Yeah. I'm glad you say you love it, because it's got a nickname of, "Vomit comet."

Scott: Right.

Dr. Biology: Since you say you love it, I suspect that means you've done some training in it?

Scott: I probably have more time in that aircraft than any other astronaut. I have thousands of parabolas aboard the aircraft, indeed.

Dr. Biology: Perfect. How did it compare with your experience in zero gravity in space?

Scott: It compares very closely. The challenge, of course, is if you're flying on a windy or "buffety" day, the parabolas aren't perfect. We tend to get about 25 to 30 seconds of weightlessness and the only problem with these parabolas is that they're too short.

You want them to go on forever, as if you were in space. But they're a great environment to test out hardware, to do experiments, to test things out before you take them up to the International Space Station.

Dr. Biology: You use the word, "Parabola." We're really talking about this giant arc that goes across, right?

Scott: Correct.

Dr. Biology: At a certain point on that path, you end up with zero gravity, so you feel weightless. You say they're too short. How long are they?

Scott: They're about 20 to 30 seconds in length typically, and that's the fun part. When we're pushing the nose of the plane over, we float inside the aircraft.

The payback, though, and the part where it's called the vomit comet, is we then have to pay for that by having a 2G pullout. That transition from zero gravity to 2G can be very provocative for some people, and they get quite ill. Thankfully, I never had that problem.

Dr. Biology: 2G, in simple terms, that means you're twice your body weight?

Scott: If you weigh 100 pounds, you would weigh 200 pounds in that aircraft. Right.

Dr. Biology: Another question I have, and this one might be really tough to answer. For the earthbound people, those that have never gotten into space, can you describe what it's like to be in space in zero gravity?

Scott: It's such a dreamlike wonderful state. If you've ever been on the surface of a pool, on a float, for example, or if you've ever been snorkeling, and just allowed the waves to take you where they will, the current been SCUBA diving is an even better example, where you're underneath in three dimensions of water, and you're what we call neutrally buoyant.

You don't sink to the bottom of the ocean, you don't float to the top. That, for all intents and purposes, is what it's like to float in space.

The only thing that's different is that the views are quite a bit different when you're up in space. Secondly, if you were to kick in the water, of course, you're going to propel yourself, but up in space, you just look silly.

[laughter]

Dr. Biology: All right. How about this? Does lack of gravity ever get old or tiring?

Scott: Microgravity, or weightlessness never gets old. In fact, you enjoy it more and more with each subsequent mission. You get better at it.

If you look at the astronaut crews that are living aboard the International Space Station now, they look like Olympic gymnasts or divers. They can fly with the greatest of ease. They can do barrel rolls and aileron rolls like an aerobatic pilot. It's really graceful and beautiful. The more time you have up there, the more fun it gets.

Dr. Biology: You've done a lot of spacewalks as well.

Scott: I've been very, very fortunate. That's the ultimate astronaut experience, to get outside in your own personal spaceship. Everything that you need to sustain life in a spaceship, you need to have on your back or around you to take you safely out into the vacuum of space.

The temperature extremes when we're behind the Earth and in shadow, what we call orbital night, can be 200 degrees below zero – [it is] incredibly, brutally cold. When we're in direct sunlight, in orbital day, we can be 300 degrees above zero. In one orbit of the Earth, in a 90 minute period, we can see a 500 degree temperature change. Just amazing.

Dr. Biology: The suits are really doing a lot of work.

Scott: They're doing a lot of work for us. We couldn't imagine going outside without them.

Dr. Biology: Let's talk about the one-year experiment that NASA's just started. It's with twin astronauts Mark and Scott Kelly. Scott will be in space for a year while his brother Mark will be on Earth.

Scott: Correct.

Dr. Biology: What tests will be conducted? What are we likely to learn?

Scott: Mark and Scott are good buddies of mine and I'm really excited for Scott's big adventure. He'll be in orbit for 342 days, almost a full year, whereas his astronaut brother will be grounded. He is also an astronaut, so we have lots of data going back to his initial selection, actually for both of the astronauts.

We'll be able to look at how Scott's body adjusts to weightlessness for a long period of time. When astronauts go into space it's essentially an accelerated aging process. The heart doesn't need to pump against gravity, so it atrophies. It grows weak. The muscles and bones that hold us up here on Earth, they don't have to work as hard so they atrophy as well.

Scott's going to try and exercise as much as he can and keep his physical integrity the best that he can. But it won't be the same as being on Earth. Comparing these two individuals at the end of his mission will be very, very interesting. Looking at all sorts of different physical parameters.

Dr. Biology: Do you know what kind of tests they'll use?

Scott: Yes. They'll be looking at bone density, muscle strength, they'll be looking at balance. They'll be looking at the vision to see if there's any visual shifts. Scott will have a really tough time with a fluid shift coming back to Earth. He'll feel very lightheaded once he initially lands. Looking at his re-adaptation to gravity will be interesting.

I have some funny stories just from space shuttle astronauts getting back to Earth, forgetting how to throw things. When we're up in space we have a meal together. We can toss tortillas across the cabin just like a Frisbee and you can catch it in your teeth.

When you get back to Earth and you try and shoot a basketball for example, every shot is an air ball. You can't relearn that arc. It takes quite some time. Balance is very challenging the first few days back on Earth as well. Scott will need to go basically through physical therapy to get his strength back over several months.

Dr. Biology: This is just with one year.

Scott: That's correct. When we think about going to Mars, it could be a two to three-year round-trip mission.

Dr. Biology: When we're talking about spending time in space, while you haven't spent years in space or even...I guess you could say...

Scott: A couple of months.

Dr. Biology: ...a couple of months, five missions, eight weeks. What differences did you notice most about your body when in space and when you returned to Earth?

Scott: Great question Dr. Biology. I think up in space I was really stunned by how quickly I adapted into that environment, how natural it was for human beings to be there. How quickly we learn to move, how quickly it feels like home. I think the human being is so adaptable to many different challenging environments.

The real challenge is coming back home to one gravity. You feel like a 100-year-old man. I remember my first mission I had my orange pumpkin suit on which has oxygen cylinders and a parachute harness, and all the survival gear on me.

The reentry profile we feel about one-and-one-half times our body weight, or 1.5 Gs. Carrying your own body weight, let alone 70 additional pounds, plus that acceleration squeezing you down into your seat, I felt very, very heavy and it was very uncomfortable initially. Slowly we got out of our suit and we readjusted to Earth's gravity.

For a short shuttle flight we can do quite well. It's much more of a challenge for those crew members who spend six or more months up in space.

Dr. Biology: I started the show talking about a trip to Mars. What are likely the biggest challenges for humans who travel to Mars?

Scott: I think there are a number of challenges that can be met. One is the radiation risk to crew members. It's a long time outside of the Earth's magnetic fields, which protect us from radiation. Radiation of course can give us cancer. It actually can prove fatal in very high doses. We call it acute radiation poisoning. It's a very serious thing.

We need to design our spacecraft to help shield the crew from that radiation and make our trip to Mars as quick as possible so that we limit the integrated exposure to radiation.

The other thing that's going to be difficult is it's a long time for our radio waves to get to Mars. It could be several minutes one way. We're very accustomed on the International Space Station to just pick up the microphone and talk to Mission Control, and they have an immediate answer for us.

But say we have a surgical emergency, and the crew medical officer on board has never done that kind of a surgery before, or we have a faulty piece of equipment that is life critical and we need to act quickly, we need to have the resources on board to be able to deal with lots of different contingencies.

Selecting the crew, selecting the kinds of training, selecting the provisioning of the spacecraft, what are we going to take with us? Will we grow our own food, or will we take it all, freeze-dried, with us? Lots of different exciting challenges for engineers and scientists to figure out.

Dr. Biology: On an earlier show, we had microbiologist Cheryl Nickerson.

Scott: Sure.

Dr. Biology: Cheryl's done quite a bit of research in space. Not that she's been in space, but her experiments have. She spends a lot of time thinking about microbes and things that could actually make you rather sick.

Scott: Correct.

Dr. Biology: Is this another area that we need to explore for our trip to Mars?

Scott: Indeed, it is. Studying how pathogens, that they're called, the bacteria that can infect the body and be a problem for us, is an amazingly important area for us to look at. Also, how our immune system, the part of our body that protects us from infection changes as well. We need to learn more about that.

Secondarily, I think it's important that we study these areas because it can actually help us here, on Earth. If we can understand how salmonella, like Dr. Cheryl Nickerson studies, how that can mutate and be more pathogenic, or harmful to the body up in space, perhaps we can design better antibiotics or other treatment strategies to fight these deadly pathogens.

Dr. Biology: When we talked about the challenges with being in space and the lack of gravity, I've read that astronauts can exercise up to two hours a day. I also was doing some research on you, and I understand that you've been involved with design of some of these exercise equipment.

Scott: Correct.

Dr. Biology: Tell me a little bit about these.

Scott: When we go into space, basically our body goes on holiday. We don't need to lift our muscles and bones, our body weight, against the force of gravity, so our muscles grow weak. Our bones grow weak. It's called atrophy.

To maintain our muscle and bone health, we need to somehow figure out a way to replicate what we call the loading history. We need to have our muscles and bones see the same amount of work, such that when we come back to Earth, or when we land on Mars, we'll have the physical strength to get up and get out in an emergency or to go to assembling a Mars colony, or what have you.

We need to have strategies that keep the body healthy, muscles, bones, as well as the heart. The problem is it's very costly to fly up a full gymnasium into space. We can't take stacks and stacks of weights because they would be meaningless.

We have to think of different ways to provide resistance to the body. We use hydraulic systems and other types of resistive mechanisms to give ourselves that loading history when we get up into space.

We have treadmills that have special harnesses that pull us down onto the treadmill surface so that we can feel like we're running on Earth. We have big hydraulic systems that press down on our bodies and we can resist those as if we were doing a squat or something like that.

The things that I've been interested in working on are devices that are very small and lightweight and compact because, when we go to Mars, we won't have the ability to take a huge system like even onboard the International Space Station, it's quite a large facility.

We'll need something that can fit in a tiny capsule with four or six crewmembers, so thinking about how we can miniaturize these technologies but still provide the workload that they need.

Dr. Biology: What about sleep?

Scott: Sleep is really fun and interesting in space, especially in weightlessness. I think, perhaps sleeping on the moon or Mars would be more like sleeping here, on Earth.

When you're in space, first off, you don't need quite as much sleep because your body hasn't done as much physical labor. We aren't carrying our body around, so we don't get as physically tired as we would on a day here, on Earth, except if you've been out on a spacewalk, which is very physically taxing.

We have sleeping bags, just like on a camping trip. We can Velcro them to the ceiling, to the wall, upside-down, left, right, to the floor, wherever we can find free real estate. You're actually floating inside your sleeping bag.

There are times when you don't have any contact at all with your sleeping bag, you're just kind of floating inside this bag. For some of us, it's kind of disconcerting to not have a physical contact with something.

NASA engineers are very clever. They created a special pillow for us that has a Velcro strap that allows us to Velcro our head to the pillow, and that gives us a sense of connectivity, of grounding. Then, psychologically we're able to then sleep.

Dr. Biology: Very interesting. When we talk about the first step, we could say we had our first step, we went to the moon. Now we're talking about humans traveling to Mars. There's a debate about this, whether we really should go to Mars or not. I suspect you have a view on this.

Scott: I do. I think it's ultimate human destiny that we will go. It's not a question of if, but when. The reason we'll go is to satisfy human curiosity.

There are many things, wonderful things, that we can accomplish with robotic exploration, and these things are happening right now, today, that are just mind-boggling. Of course, the technology's getting better.

In order to really accelerate knowledge, to press technology, to really make the ultimate types of discoveries, did life once exist on Mars? Does it exist to this day in the permafrost, or near Olympus Mons, the tallest mountain in the solar system? I think we're going to need to send human explorers to not just survey point locations in a simple and limited way.

But we're going to need to send explorers that can cover vast distances, make the real time decisions to pick up that rock, and not that rock, to be able to fix and repair and make iterative decisions in science, to really accelerate the growth of knowledge.

The other reason that we'll go is much the reason that we went to the moon, we didn't realize it at the time, I think, but when we take on great challenges like this, we all benefit in terms of new technologies, new industries, new ways of thinking and doing business and, of course, the inspiration that follows.

We don't know how we're really going to get to Mars yet, how we'll sustain life, how we'll bring the crew back. All these things are very daunting challenges that will be very specialized solutions for that mission.

But it will have a huge trickle effect to our national economy, to the world as a whole. Quite honestly, when we do go to Mars, it may be as part of an international collaborative effort. It may actually be something that brings the world together as well.

Dr. Biology: I would not minimize the impact on learning about the human body.

Scott: Indeed. This will be one of the great challenges. What does it mean to essentially move off of planet Earth for a very, very long time, sustain it through a long period of weightlessness, to go live on a partial-gravity system and then bring them back home?

It'll be a unique set of circumstances that I think the International Space Station is helping us get ready for, but we won't really know until we send crews out there.

Dr. Biology: OK, let's come back to Earth. You also like to climb mountains.

Scott: I do.

Dr. Biology: How many mountains have you climbed?

Scott: I've climbed all over the world. I've been very fortunate to climb all up and down the Rockies. I've been in Alaska. I've been to the Alps, the Andes. But perhaps my biggest claim to fame or notoriety is a couple of seasons on Mt. Everest, which was by boyhood dream to get a chance to climb that mountain.

Dr. Biology: Climbing Mt. Everest or going into space?

Scott: Space, but I wouldn't trade the experience of Everest for a second. It's interesting when I think back on Everest, it took me two tries to make it to the top. My first season, I ended up rupturing a disc in my low back and had to limp on down from a very high altitude.

The fact that I didn't succeed my first year, and I was able to persevere, I had to have surgery actually to get a disc fixed, but I returned the next year, and I was successful. I think anything that we really have to fight for, anything that's a real challenge ends up being more rewarding in the long run, so I think back on my successful summit of Everest as one of my proudest achievements actually.

Dr. Biology: One of your interests as a physiologist and a physician is how humans adjust and adapt to extreme conditions and stressful environments.

Scott: Right.

Dr. Biology: Space is one place we can see both extreme and stressful environments, another would be high altitude. Did you find that your experiences in space and climbing mountains had any similarities?

Scott: Great question, and there are many parallels actually. I remember walking, well actually crawling, out of the vestibule of my tent at Camp Four on Mt. Everest the morning of my summit and thinking, "This is just like floating out of the airlock hatch on a spacewalk."

I had a big, puffy down suit on. I had on big boots, a harness on. I was clipping into a fixed line, and I had an oxygen mask on, lights, cameras, big, bulky gloves, and complete pitch darkness just as if I was exiting the air lock at orbital nighttime.

I realized that I was also very dependent upon my team and the equipment that I was relying upon and my training and my judgment, and I thought, "I'm well prepared. I've had all these experiences in space, and I'm ready for my summit."

Dr. Biology: Here's a little-known fact. I have actually been on a taller mountain than Mt. Everest, and I want to give the height of Everest is 29,035 feet.

Scott: Correct.

Dr. Biology: It's a little under 9,000 meters, and I want to be really clear. I'm not saying higher than Mt. Everest, but taller. Actually, it's not the tallest. I've been on Mt. Lam Lam, which is on the island of Guam, and there's some controversy whether they call it a mountain or not.

But I can say what you don't know is that little, tiny peak that's above the water actually goes all the way down...

Scott: To the ocean floor.

Dr. Biology: ...to the ocean floor, to the Challenger Deep of the Mariana Trench. Those that don't know this, the deepest point in the Earth is at this location, and it's over 35,000 feet. It's actually 35,814 if you're counting, and that's a little under 11,000 meters.

I bring this up because of your interest in extreme and stressful environments. Have you thought about exploring the Mariana Trench?

Scott: I have indeed. In fact, I've been jokingly referring to it as the "exploration trifecta," but I would love to follow in the footsteps of Piccard and I forget the other explorer, the first to go down. Then of course James Cameron more recently visited. But it's only been visited by three human beings in the history of time. I think it's an incredible technological, scientific feat.

Dr. Biology: Which is really a great topic in the sense that we've sent how many people into space?

Scott: About 550.

Dr. Biology: We only have how many that have gone to the deepest part of the ocean?

Scott: Three. That's right.

Dr. Biology: Three, OK, so what's the main reason?

Scott: Technologically, it's very, very difficult. The pressure extremes are extraordinary, so it's an amazing technological feat to get there. Secondarily, it's perhaps not quite as visually captivating for the public, but I think there's an incredible scientific wealth that could be gained from studying our oceans.

We know more about the surface of Mars and Venus and the Moon than we do of the bottom of our oceans, so I think it's a great unexplored frontier for all of us explorers.

Dr. Biology: Is it one atmosphere difference between going into space and being on Earth?

Scott: Correct.

Dr. Biology: Yeah, so one atmosphere. Is it for every 10 feet?

Scott: 33 feet of seawater? Is that what it is for one atmosphere? I'm not exactly sure.

Dr. Biology: You can see very quickly there's an amazing amount of pressure.

Scott: It's very difficult to engineer systems that will withstand those kinds of pressures.

Dr. Biology: Back to physiology, we have some sea creatures that live in amazing depths. Here's a great place to be doing a lot of learning, right?

Scott: Indeed, I am fascinated by the mid-Atlantic ridges and some of the geothermal vents and the creatures that live there. Every place that we look on our planet, the Atacama Desert to the highest mountains, the bottom of some of our oceans, life thrives.

How does it do that? How has it adapted to these extraordinary environments? That's one of the most exciting realms of biology I can think of.

Dr. Biology: On Ask A Biologist, I always ask three questions of my guests. Some of them I have to modify for you. We'll start with the first one. When did you first know you wanted to be a biologist/physiologist or perhaps in your case a doctor or astronaut?

Scott: I think I crystallized on my vision to become an explorer when I was five or six years old. In fact, we've been talking about the oceans and marine biology, one of my boyhood heroes was Jacques Cousteau. I wanted to be a marine biologist and work for Jacques Cousteau. I was lucky to meet him later in life.

But I think I knew very early that I wanted to be an explorer. My dad worked on the Apollo program, so I was very interested in the space program back then as well, thinking about becoming an astronaut.

Dr. Biology: Did you ever have any detours and not get to where you wanted to go as quickly as you wanted?

Scott: Yes. Everyone's pathway through life has some kinks in the road, so I think what's most important is to have goals and then have the tenacity to continually work towards them. Sometimes you find that your aspirations won't be exactly met, but the people you meet, the doors that open are sometimes very interesting.

One of the things that I failed to do but I don't consider it a failure, I wanted to be on the US Olympic luge team, so I was competing vigorously for that, didn't quite make the Olympic team in 1988, but I ended up going to the Calgary Olympics as a coach for the Philippines of all places.

A friend of mine needed a coach, and so I ended up marching in the opening ceremonies and living in the Olympic Village for the Calgary Winter Olympics. It was an unexpected silver lining for me.

Dr. Biology: All right, the next question, and this one's a bit hard to ask you because I have to take away more than your physiology, more than your medical career, mountain climbing, and of course being an astronaut. If you were not able to be or do any of these, what would you be and what would you do?

Scott: I think a couple things, actually three fields that I seriously considered. Marine biology I mentioned, which is sort of related, but interestingly enough when I was a kid we lived overseas in lots of different, unusual places.

I went to junior high school in Beirut, Lebanon and Athens, Greece, so I was fortunate to travel to Egypt. I was fascinated with the Egyptian culture, and I thought archaeology and Egyptology would be a really exciting culture and society to understand, and the architecture, the science that they pursued.

Finally, and I don't think I would've succeeded at this in any stretch, but I loved architecture. I can't draw worth a lick, so I think I would've been a horrible failure at architecture, but I think in three dimensions, and I think it would've been a fun thing to be a part of as well.

Dr. Biology: All right, the last question. What advice would you have for a young biologist/scientist or perhaps someone who always wanted to go into space?

Scott: I think it's an exciting time to be alive, to be a young person pursuing those kinds of dreams. The access to information, the ability to collaborate, the discoveries that are going to be possible based on all that we know now is just extraordinary.

If I were a young person interested in biology or medicine, I'd be very excited about what's happening in what's called, "Regenerative medicine," the ability to maybe even grow our own organs in we need an organ transplant, to heal the body.

Nanomedicine is another technology where we're taking nanotechnology and building devices and drug delivery systems that can heal the body. I think that would be an amazing environment to get involved in.

Then in terms of space exploration, there's going to be so many more opportunities for people to fly in the future. In the past, it's been a very highly-select, government astronauts but now we're going to have space tourism.

We're going to have independent space laboratories where scientists can go fly and conduct their experiments. It won't just be NASA and the big government agencies flying in space. It'll be SpaceX, and Blue Origin and Sierra Nevada and Virgin Galactic and Bigelow Aerospace that will be taking other types of astronauts as well. I think it's very exciting for young people's future.

Dr. Biology: It's interesting on Ask A Biologist, we had a podcast with Paul Davies.

Scott: OK, great.

Dr. Biology: Paul is really great on looking towards what life could be out there and even better yet, what do we think of as this life, because we're pretty specialized in what we think about as something that's living.

Scott: We're very myopic I think.

Dr. Biology: Yes, exactly. Do you think life exists beyond the Earth?

Scott: I'm absolutely convinced of it. However, I would say that I don't think that we've ever been visited by little green men. There's a lot of excitement about UFOs and that sort of theme, but there's no evidence that we've had those types of higher levels of visitation so to speak.

I think as we've looked outward at our solar system and beyond to our universe, there are star systems that have orbiting planets, hundreds of them have been discovered, including some that have signatures that would suggest that they could harbor life, the ingredients of life as we currently understand them, water, carbon.

The building blocks for life exist. Even though the distances between all of us are so great, it would be very difficult to imagine traveling between these locations. I think that either life has co-evolved in different places or perhaps comets have helped seed life in different parts of the universe.

Dr. Biology: With that, Scott Parazynski, thank you for visiting with me today.

Scott: I really enjoyed it. Thanks a lot.

Dr. Biology: You've been listening to Ask A Biologist, and my guest has been Scott Parazynski, physiologist, doctor, mountain climber, and astronaut. He's currently the new University Explorer at Arizona State University.

For those of you that might like to explore more about space and physiology, you can visit our companion story called Spaced-Out Physiology. The address is askabiologist.asu.edu/explore/spaced-out-physiology.

That's a long URL, I know, so don't worry, if you couldn't write it down, if you come to our website and look at this podcast, you'll see that there's a link to the story.

The Ask A Biologist podcast is produced on the campus of Arizona State University, and is 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.

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 askabiolgist.asu.edu or you can just Google the words, "Ask A Biologist." I'm Dr. Biology.

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