HEALTH

Q&A: Solving astronauts' health challenges in deep space could have payoffs on Earth

By Nicholas St. Fleur Feb. 16, 2024

Dorit Donoviel speaks during the 2022 STAT Summit.
SARAH GONZALEZ FOR STAT

Space is famously known as the final frontier for human exploration. It may also be the final frontier for human medicine.

That's what Dorit Donoviel, executive director of the Translational Research Institute for Space Health, and her team are working towards. TRISH is a consortium between Baylor College of Medicine, Caltech, and the Massachusetts Institute of Technology that partners with NASA to solve the health challenges of humans exploring deep space.

It funds a variety of experiments, such as research into balance in microgravity, and ways for astronauts to produce their own drugs in space. It has even partnered on projects that assess people's mental fortitude in hazardous and isolated environments like Antarctica. TRISH also collected data from astronauts during the Axiom Mission 3, which splashed down off the coast of Florida last week after completing the third-ever commercial astronaut expedition to the International Space Station.

Donoviel is also an associate professor in the department of biochemistry and molecular pharmacology, and at the Center for Space Medicine at Baylor. Before that, she was deputy chief scientist of the National Space Biomedical Research Institute, and she previously worked in metabolism drug discovery at Lexicon Pharmaceuticals.

She sat down with STAT to discuss the risks of deep space travel, her excitement over the Artemis III mission scheduled to return astronauts to the moon's surface in 2026, and how preparing humans to survive extreme, otherworldly environments will breed medical innovations that could be used here on Earth. The conversation has been edited for clarity and length.

What are some of the human health challenges in exploring deep space?

Most people may not even realize this, but we've been living in space consistently since 1998 when the International Space Station (ISS) started to be constructed. We figured out how to keep humans healthy in what we call low Earth orbit, which is still within the protection of our atmosphere. If we have a problem, any health situation, we bring those people back immediately. If they are experiencing a health issue you pick up the phone, there's an

immediate connection and you call the best doctors in the world and they're all there supporting the astronauts' health and the flight surgeons.

What's different is that deep space means that we leave the protection of our atmosphere. That would include the moon, a space settlement outside of low-Earth orbit, or going to Mars. That completely changes the paradigm of how you do health care and also the actual risks.

What are the risks?

Space radiation is definitely going to affect the entire body. We know even a little bit of radiation can actually cause a lot of problems for every organ system in the body.

Second, you'd be surprised, but it's actually mental health because you're in a confined space. You don't have direct communication with your loved ones. You may not even have a view of the Earth. If you're going to Mars, you have no ability to open the hatch and take a breath outside. You're having to smell the same people for a long period of time and that could start driving you insane.

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Then the third concern would be the ability to provide health care, because you can't bring everything with you. You can't imagine every possible medical scenario, and then even if you did imagine it you might not be able to deal with it because you didn't bring the right medications. So we have to provide health care on the spot.

Then fourth on the list is food, because we actually have no ability to feed people for long periods of time without the food losing some of its nutritional benefits. In other words, there's a lot of shelf-unstable nutrients that we know we need for health, and we don't know how to provide those in a stable way.

How do you address those risks and concerns? Let's start with food.

We don't believe that you should just keep reinventing the wheel. Henry Ford made a statement a long time ago, "If you'd asked people how they could transport themselves faster, they would ask for a faster horse." They never even imagined an automobile. We're approaching food by going after engineered biology. It's basically taking biological organisms, like bacteria, yeast, fungi, molds, and plants and making them genetically engineered to make a product that they wouldn't normally make. So all those nutrients that are degraded, the vitamins, maybe even medications that we want made on the spot, we're going to have the microorganisms make those.

Even medications? Like a pharmacy in space?

Yeah, so just-in-time medications. It's being able to make what you need on the spot. We've funded researchers that use plants to make medications, for example, biologicals like EPO [erythropoietin] or GM-CSF [granulocyte-macrophage colony-stimulating factor].

Also, we funded a research project at MIT at Bob Langer's lab. We funded him to generate pharmaceuticals by bacteria. He goes the next step further, he made these devices, they're star-shaped. You take a pill and it goes into your stomach and it opens up in your stomach, and then it starts to elute out. So you can either use these star-shaped things to release the medication in a slow rate, or you can load them up with bacteria that are actually making the medication and spitting it out, because sometimes it's better to have it come out as a precursor and then have the body activate it as needed.

So rather than sending you on a spaceflight with a whole bunch of pills, which takes up a bunch of space, you would just take a few of these things and maybe they last for six months. You pop a pill, this thing sits in your stomach and it elutes out a radiation countermeasure or radiation protectant, or it elutes out an anti-inflammatory, or it elutes out an anti-bone resorption medication or something like that.

That's mind-blowing. What kind of work or research are you all doing with mental health?

For us, it's all about diagnosis before there's a problem and prevention and mitigation rather than waiting for the problem to really get out of hand. The problem is nobody has ever experienced the duration that we're envisioning for a Mars trip. People have put people in a chamber and they pretend that they're on a mission to Mars. But it doesn't have the same kind of fear factor, which completely changes things when you're truly in a hazardous environment.

So a couple of months ago, we signed an agreement with the Australian Antarctic Division, AAD for short. In this program they are truly, truly isolated for nine months at a time. In Antarctica, it's like less than 20 people, they have four stations, they are isolated and they train their people to deal with their own problems internally. So that kind of simulates what might happen on a space mission. We had to get this deal in place, it took us four years to get there, but we want to test some of these mental health tracking and prevention measures in the Antarctic continent.

So these people will be in Antarctica and they'll just be isolated and such.

Yes, and it's an operational environment. Those people are there to dig, collect samples, and operate machinery and go out on the ice. It's extremely hazardous and extreme conditions. What we're most worried about is the boredom and the lack of variety. There's no change in the landscape, so that kind of stressor is much like spaceflight.

Would you sign up to do that experiment?

I would do it once, because it really tests your mental resilience to get through something. If you build up that knowledge base that you could get through anything. And what are your coping mechanisms? What kinds of things keep you going when you really feel like you just can't take it anymore? You have that resilience and to me, I think that would be really valuable.

Now tell me a bit about human hibernation and surviving that journey to deep space?

We've gotten some really good preliminary data. We can reduce human metabolism by approximately 20-30% with medications, similar to those you would take before surgery just to sort of chill you down. We've done it for short periods of time, like overnight or 24 hours. Now we want to move to like two weeks. The whole idea is that you would sleep for the majority of the day. You would wake up, eat, void, exercise, go back to sleep. It would get you through days of very mundane, difficult periods.

I think there's applications for cancer patients undergoing treatment where you just kind of want to sleep through the day where you're really suffering. There's lots of really cool applications for this. Think about the next pandemic, you could just, kind of sleep your way through it.

What is TRISH's involvement with Axiom Mission 3, the Ax-3 mission?

We're collecting blood, urine, saliva, stool, all those things. We're looking at skin swabs for microbiomes. And we're doing omics analysis in a standardized way on everything. We're not even going in with a hypothesis, we're just collecting it. Somebody's going to figure out what to do with these things. That's preflight and post-flight. We are trying to also get some blood in flight. That's always a complication, but we're nearly there.

Now in addition to that, we're also looking at neurovestibular changes, which is something that NASA is really worried about, particularly with the moon mission. So what is that? Balance. Our bodies have proprioceptors that sense gravity and which way is up. Like if anybody has ever gotten tumbled by a wave in the ocean or taken a really bad fall in a snow slope and you can't tell which way is up. All of these changes are so interesting from a neurological perspective, how the body adjusts so quickly to a new environment. We're learning about this because when you go to the moon, it's going to be a reduced gravity situation, one-sixth of Earth's gravity, and we're going to have to train people on how to walk properly and do it quickly.

What excites you the most about a return to the moon?

Look, we've been there before. We know we could do a moon mission. I'm not worried about that. We could go back to the moon.

But learning how to live off-planet when you don't have immediate return, that really forces you to innovate. Now if you have a medical emergency on the moon's surface, it's two or three days. You've got the crew in real hazardous conditions. Also the radiation. We have to solve the problem of radiation because we're still protected within our atmosphere on the ISS, but once you go to the moon, you're going to be exposing people to galactic cosmic rays. The longer you're up there, the more damage the astronauts' bodies will accumulate.

What's exciting for me — for Earth — is, I actually think the ways we're going to keep people healthy through medications may be a cancer preventative. Radiation is not unlike a lot of mutagens and other kinds of events that damage your DNA or damage your body's immune system. We have to arrive at something really good to prevent the problems from space radiation, and when we do, we might have some new therapeutics for cancer.

About the Author

Reprints

Nicholas St. Fleur

General Assignment Reporter, Associate Editorial Director of Events

Nicholas St. Fleur covers the intersection of race, medicine, and the life sciences. He hosts STAT's health equity podcast, Color Code.

nicholas.stfleur@statnews.com
@SciFleur

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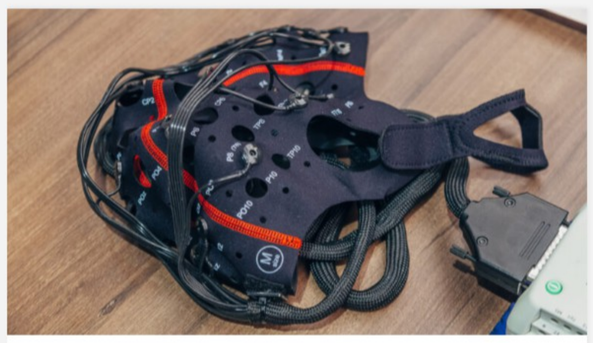

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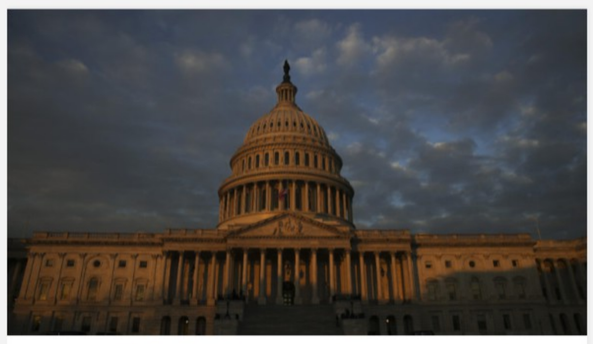

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