Episode 2: Bodies in Orbit

This transcript is based on the second episode of *Moonstruck*, a podcast about humans in space, produced by *DraftHouse Media* and featuring analysis from the *Center for Strategic and International Studies' Aerospace Security Project*. Listen to the full episode on **iTunes**, **Spotify**, or on our **website**.

BY Thomas González Roberts // PUBLISHED April 4, 2018

AS A DOCENT at the Smithsonian National Air & Space Museum I get a lot of questions from visitors about the grittiest details of spaceflight. While part of me wants to believe that everyone is looking for a thoughtful Kennedy quote to drive home an analysis of the complicated relationship between nationalism and space travel, some people are less interested in my stories and more interested in other, equally scholarly topics:

Kids: *I have a question. What if you need to go to the bathroom while you're in a spacesuit? Is there a special diaper? Aren't you like still wearing the diaper when you are wearing a spacesuit?*

Alright, alright, I get it.

But before humans could use the bathroom in space, a lot of questions needed to be answered. Understanding how human bodies respond to the environment of outer space took years of research. It was a dark, controversial period in the history of spaceflight. This is Moonstruck, a podcast about humans in space. I'm Thomas González Roberts.

In the late 1940s, American scientists began to focus on two important challenges of spaceflight: solar radiation and weightlessness.[1]

Thomas González Roberts is the host and executive producer of **Moonstruck**, *and a space policy researcher at the* **CSIS Aerospace Security Project**.

Solar radiation is made up of high-energy particles that emanate from the sun.[2] Typically, Earth's atmosphere protects us from these particles. And we should be thankful it does, because they can do some serious damage to humans. Exposure to a small amount of radiation can cause vomiting, nausea, and diarrhea. Exposure to a bit more can cause cataracts, sterility, and even death.[3] To protect a living organism in space from solar radiation, the organism must be contained inside a protective shell, treated to block the most harmful solar particles from coming through.

Weightlessness, on the other hand, the second major difference between aviation and spaceflight, comes across as much more harmless. That being said, humans rely on Earth's gravitational pull to keep our balance, strengthen our muscles, and ease our stomachs. Without it, we start to lose bone mass, and our muscles weaken.

Together, radiation and weightlessness placed a huge burden on those designing the systems responsible for keeping a life form safe in space.

At the dawn of the space era, some engineers in the space community argued that humans should be sent to space as soon as the technology was available to get them there.[4] Research scientists, on the other hand, disagreed. They pushed a more conservative approach; conducting tests on animals before turning to human missions—squeezing them aboard tiny capsules and measuring their response to the extreme circumstances of a space mission.

The research scientists convinced the engineers to develop a robust animal testing program in the 1950s; a cautious measure to preserve the lives of the soon-to-be-selected American astronauts. To test the animals' responses to the space environment, engineers designed sub-orbital rocket tests; short flights designed for just a few minutes of weightlessness.

Radio Voice: *Dressed in protective space suits and wired so that readings on their physiological reactions can be transmitted to the ground...in a sense the monkeys were hitchhikers.*[5]

From 1948 to 1951, six monkeys were killed in a row in sub-orbital flight tests. The first American space monkey suffocated onboard the spacecraft.[6] The second survived his flight, but was killed in a rough landing.[7] A third was killed in a mid-flight explosion.[8] The fourth monkey died on impact. All four monkeys were named Albert. Modern-day animal rights activists would be livid at what was happening. It was brutal.

Finally, in May 1952, two monkeys, sharing a cockpit, survived their mission and became the first primates to endure spaceflight. Around the same time, the United States ran out of its supply of V-2 rockets, the vehicle responsible for most of the animal tests, and the age of animal testing in the U.S. slowed.

On the other side of the world, the Soviets began developing their animal space program around the same time. Unlike the Americans, Soviet scientists chose to study the space environment with dogs instead of monkeys. They considered apes, too, but they thought it'd be easier to dress dogs in their special space suits and keep them healthy for longer.[9]

The first Soviet space dogs fared much better than their American monkey counterparts. On July 22, 1951, two strays dognapped from the streets of Moscow became the first living creatures to be recovered from spaceflight.[10] Like the American monkeys, the first Soviet space dogs weren't flown to orbit, just a quick jaunt up and down.

Over the next few years, there were a total of nine dog flights, four of which ended in death. The news of the Soviet space dogs didn't make much of a splash in the United States. In fact, the Soviet space agency wasn't world renowned at all at the time. But that all changed on one day in the fall of 1957.

Radio Voice: *CBS television presents a special report on Sputnik I, the Soviet space satellite...*[11]

Sputnik I was the world's first satellite. And it was designed for just one purpose: to be first. The metal sphere was aggressively polished to both reflect the heat of the sun and appear as shiny as possible in the night sky.[12] Sputnik's launch on October 4, 1957, was forever memorialized as the transition between the human race's Earth-bound history and its space-bound future. That beeping sound you hear was the satellite's key feature. It was proof. People across the world could tune in and hear it. No one on Earth could claim it wasn't real.

With the success of Sputnik and the space dog program, the Soviet space agency moved on to its next goal—placing a living creature in orbit around the Earth. While a sub-orbital flight allowed for just a few minutes of weightlessness, a satellite in orbit would leave a space dog immersed in the space environment for over an hour. This would give us all new insights into the effects of the space environment on a living organism.

As the Soviet Union rejoiced over Sputnik, the United States was concerned. American engineers had been busily working on their own first satellite when the Soviet's appeared in the sky. Their project was ironically called Vanguard, indicating their confidence that they would be first.

But despite the Soviets' huge accomplishment, the Sputnik engineers did not have time to rest on their laurels. According to a space system engineer working on the project at the time, Nikita Khrushchev, the leader of the Soviet Union, hand-delivered an order to the Sputnik program. He was proud of his space agency, but wanted even more. He wanted another major accomplishment to celebrate the 40th anniversary of the October Revolution.[13]

But here's the catch. The 40th anniversary of the Soviet holiday was only one month away. The Sputnik engineers would need to design a new system and ready it for launch on an incredibly short timeline—a timeline even shorter than what we use today for the simplest satellite launches. They also knew that Khrushchev was watching; the whole world was watching. They needed to do something big.

Radio Voice: *In a masterpiece of propaganda timing, the Soviet Union has announced it has launched Sputnik number two, carrying a live dog.*[14]

The Soviets had done it. Not only did they launch a second satellite in just 30 days, beating the Americans again, they continued the work of the space dog program, putting a pup on board an orbital spacecraft. The dog on board, Laika, became an instant national hero.

Radio Voice: *This is reportedly history's first space traveler.*[15]

The moment her paws stepped back on Earth's surface, she'd be the most prized animal in the history of humankind. But that's where the magic ends. Laika would not be coming back.

With just over a month of planning time, there was no time for complicated add-ons to the Sputnik program; no time for design tests or safety checks. No time to design a safe way to bring Laika back home. Sputnik, the world's first satellite had no way of coming back to Earth and Laika's spaceship would be no different. The anniversary of the October Revolution in 1957 came with a cost: flying the world's first astronaut and sacrificing her at the same time.

It was originally reported that Laika lived for days aboard Sputnik 2, nervously lapping up the dog food included in the capsule. Most official stories suggested she died without pain or suffering. A report by the U.S. Naval School of Aviation Medicine reviewed published materials from the Soviet government and concluded that Laika died of hypoxia, or a depleted oxygen supply.[16] Others suggested that Laika was euthanized with poison food or an injection.

But in 2002, over four decades after Laika's death, a Russian doctor revealed the true record of what really

happened to her. Chained to the walls of the space capsule to keep her in place, Laika's heart rate tripled during launch. The heat and humidity inside the capsule climbed to rates higher than the engineers anticipated. The onboard cooling fan did little to reverse the problem. Helplessly trapped, Laika died of overheating and stress within hours of take-off. [17]

Laika, Alberts I through IV, and the rest of the space animals of the 1940s and 50s paved the way for the earliest age of human spaceflight, creating a new field of medicine in the process. Now there's a burgeoning class of medical professionals studying the way outer space affects the human body; not just for short trips like Laika's, but for much longer ones, too.

Dr. Kris Lehnhardt: *My area of expertise is extreme environmental medicine, but of those extreme environments, the most extreme is space. And I focus on aerospace medicine.*

That's Dr. Kris Lehnhardt, who's now a deputy scientist at the NASA Johnson Space Center in Houston and Senior Faculty at the Baylor College of Medicine. I caught up with him about animal testing in space and how it contributed to both early spaceflight and current research in the field.

KL: *...we didn't know much about what was going to happen to people. Everything that we did know, came from previous animal studies. And that's where we first started to learn a little bit about the physiology of spaceflight. But one of the primary concerns in initial first few space flights were whether people's eyes would work properly.*

Our eyes rely on a delicate balance of internal pressure to function. Changes in this pressure can cause optic nerve damage, leading to loss of vision or blindness.

KL: *So there was a concern that pressure changes or the lack of gravity, would actually change the shape of the eye, and make it such that you wouldn't be able to see your instruments properly. And in a spacecraft that has to piloted home, if your pilot can't see properly, that's a big problem.*

Animal testing only provided a limited window into understanding how the space environment could affect our eyes. Animals like Laika could have been silently losing their vision during their time in space, with no way of telling us what was happening. So, were the first astronauts in danger of going blind?

KL: *Not in the beginning. So, it's actually fascinating because we have sort of come full circle. In the beginning we thought that spaceflight was going to affect the way our eyes worked in the short term, what we're actually discovering now is that spaceflight affects the way our eyes work in the long term.*

While the earliest astronauts only stayed in space for a few hours, modern astronauts spend months at a time aboard the International Space Station.

KL: *So as we now do long duration space missions astronauts are starting to develop visual problems, related to those long missions.*

What else were the earliest space doctors concerned about?

KL: *Another interesting one in the beginning was—we didn't know if our bowels would work in space.*

Aha! The moment of the show we've all been waiting for.

KL: *So in the beginning, when people first flew into space, they weren't allowed to eat during those missions. And then, on the shorter missions, they were only allowed to eat very specific things because we didn't know if you could poop in space.*

The diets of the earliest astronauts were carefully monitored. In Project Mercury, the astronauts had a dietitian supervise their eating. Whenever the astronauts ate something, the back-up crew had the same thing, in the same apportionment, at the same time.

An additional serving of the meal would be kept in the fridge for 24 hours, just in case one of the astronauts got sick and their food needed to be studied in greater detail.[18] It took years before astronauts were allowed to even attempt going to the bathroom in space. Poop was taken extremely seriously.

KL: *So one of the astronauts in the Gemini program, one of his mission requirements, was actually to be the first person to have a bowel movement in space to prove that it worked.*

You don't hear about it all the time, but it did. They used a plastic collection bag, stuck with adhesive to the astronaut's underside. The poop kit, as it was called, also came with a finger cot —a one finger latex glove of sorts— to make up for the lack of gravity, which normally keeps things moving during a regular bathroom break on Earth.[19] Not a glorious procedure.

Now astronauts aboard the International Space Station use a more robust system, with suction tubes for both number one (attached to a hose) and number two (attached to a seat). The whole contraption is housed in a private cabin on board the Station. Luxury.

Today, aerospace medicine professionals are focusing on the effect of long term spaceflight on the body. If astronauts were to travel to Mars, for instance, they'd be spending months and months in space, likely longer than most astronauts have endured so far.

In 2015, NASA commissioned a Twin Study to study this issue up close. Two astronauts, identical twins Scott and Mark Kelly, were the subjects. One brother, Scott, stayed aboard the International Space Station for 342 days—almost a year; three times longer than a standard mission to the Station. The other brother, Mark, stayed on Earth.[20] Although the flight portion of the study was only about a year, ending in March 2016 when Scott came home, tests continued for the two brothers on the ground. We're still waiting for the final report, but a few preliminary findings have already been released.

KL: *...A few of the things that have been coming out are rather interesting and one of them is actually that the brother in space had some genetic changes, where the ends of his DNA—or his chromosomes I should say—which are areas called telomeres, got longer.*

Generally speaking, the length of someone's telomeres is associated with their age. During a human's life, telomeres slowly shrink by a factor of two or three.[21] Scott Kelly's telomeres growing during his time in space was shocking to aerospace doctors.

KL: *And the theory is, is that the reason his telomeres got longer, is because he was being really healthy in space, he was eating really well, and he was exercising a lot, almost every single day. More so probably than his brother on the ground. So, there is some evidence that nutrition and exercise can help to fight the effects of aging, and we may have just shown that in space as well.*

Although these early early findings from the Twins Study are a bit in the weeds, they're still extremely intriguing to space enthusiasts around the world. In March of this year, several news outlets—including CNN, Time Magazine, and the Huffington Post—actually misreported a press release from NASA, suggesting that 7% of Scott Kelly's DNA changed after his year in space.

But that's not what happened. There was so much misinformation flying around that NASA responded with a second press release to clarify the issue. Here's what it said: "Scott Kelly's DNA did not fundamentally change. What researchers did observe are changes in gene expression, which is how your body reacts to your environment. This likely is within the range for humans under stress, such as mountain climbing or scuba diving."

So, if 7% of Kelly's DNA had actually changed, that'd make him an unrecognizable space monster; not a human who's still practically the same as his brother.

In a matter of hours, the publications reporting on the story changed their headlines and corrected their mistake.

When it comes to the Twins Study, we have to be patient. It may be a while until we know the whole story. But even when the complete results of the study do come out, plenty of people will be eager to cast doubt on any new findings. And they have a point; the Twins Study only focused on one pair of siblings. The constant, Mark, was an astronaut himself. And perhaps most importantly, was a year even long enough?

KL: *What if suddenly new problems start popping up at the year and a half mark, or the two year mark? And we have no idea, so NASA's plan right now is to take more and more astronauts and fly them for longer missions to truly get data to show how the body changes over the long term in space.*

Although we've come a long way from Khrushchev's last minute demand to launch Laika, the key questions of long-term spaceflight still linger. As the International Space Station retires over the next decade, leaders in spaceflight must build new destinations to safely house our astronauts as they make their home in space, perhaps one much deeper into our universe.

Notes

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