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From Zero-G To "Gee Whiz:" How Spaceflight is Changing Medicine on Earth

While most of us love the adventure of human spaceflight, the space environment does not like human beings. We evolved to live in a "one-G" environment, protected from radiation by the Earth's atmosphere, and with plenty of oxygen to breathe.

Once an astronaut leaves the planet and rockets into orbit, he or she enters an environment of "zero-gravity," lots of radiation, and nothing but a vacuum outside the spacecraft. Zero-G alone triggers a cascade of physical reactions, such as calcium shedding from the bones, which requires constant exercise so that astronauts can resume normal activities back on Earth.

The question arises, then, how can we learn anything from the spaceflight experience that would help doctors and medical researchers on Earth? Two men, one a physician astronaut and the other a human performance expert, have been seeking answers to that question for many years, and what they have discovered may surprise you.

The Astronaut

Robert "Bobby" Satcher, MD, PhD, has pursued three careers, any one of which would seem to be reward enough for one life. He has been a doctor, researcher, and astronaut, combining multiple areas of interest in an eclectic fashion.

Although he had always had an interest in space exploration, his decision to apply to the astronaut corps evolved over time as he pursued his ambition to practice medicine. After becoming a doctor, he took a position on the medical faculty at Northwestern University.

"I enjoyed what I was doing," he says today, "and had no intention of becoming an astronaut." However, a seed had been planted at an MIT event, where Satcher was an undergraduate. "Ron McNair spoke, and it was the first time I had met an astronaut with a background similar to mine: like me, he was an African American from South Carolina who had gone to MIT."

Finding that he could relate to McNair, who later died in the *Challenger* disaster, spurred Satcher to begin thinking about whether he might, in fact, have the "right stuff."

A second opportunity helped everything to fall into place for Satcher to become a physician/astronaut. During his medical residency, he worked as a researcher at NASA/Ames on the impact of weightlessness on the human skeleton. The research allowed him to meet more astronauts who were helping with the study, and he began to think, "Maybe all of my interests can come together. I'm in orthopedics, they're interested in weightlessness, and maybe I can offer something to NASA on this subject."

Eventually, he decided, "Nothing ventured, nothing gained," and applied to the astronaut corps. He made it through the interviews and the training and became the first (and only) orthopedic surgeon ever to fly in space. Fortunately, he did not need his surgical skills during his 2009 mission on the space shuttle, STS-129, but it was an ideal opportunity to continue his Zero-G research because he managed two experiments on that topic while on the mission.

Back on Earth and almost a decade since leaving NASA, Satcher focuses on orthopedic oncology for his patients at MD Anderson Cancer Center in Houston. He says that the connections between his time as an astronaut and his current role as a physician are indirect, but powerful.

"When I'm in the operating room, trying to help a patient with very serious health issues, my astronaut training helps me to focus on the task at hand and get the job done."

Satcher also points to a recent innovation in surgery that has become routine in operating rooms around the world. “We go through a checklist before we begin the operation, something we never did in the past. That practice derives directly from spaceflight and aeronautics and you ask yourself, ‘Why did it take so long?’”

He says that serendipity played a major role in a major scientific discovery. “We wanted to see if we could grow better crystals in zero-gravity,” he says, “and that led directly to a lot of today’s targeted pharmaceutical agents. It wasn’t planned that way, but we have seen great benefits from that experiment. That’s how science works, though. You never know where exploration and discovery will lead.”

Satcher suggests that space exploration will produce greater medical benefits on Earth as astronauts move much farther away from the home planet.

“We have to figure out how to protect the crews from much higher radiation exposures and how to maintain musculo-skeletal health after months in zero-G. Who knows where that will lead? I am sure there will be a lot of space-based discoveries that will benefit Earth-based medicine; we just can’t predict them in advance.”

The Human Performance Researcher

Unlike Bobby Satcher, Vernon McDonald did not harbor a lifelong interest in space exploration. A research scientist, he was concerned with human performance issues, like balance and coordination in specific situations.

However, space held out opportunities that led to his eventual career. Following his PhD, he secured a fellowship through an NIH research grant, and this experience led to a job at Johnson Space Center. Today, he is senior vice president of KBRwyle, a company providing a number of specialized services to government agencies, including NASA.

McDonald soon found his niche in space medicine.

"I quickly moved from research to operations," he says today.

Perhaps one reason he made the change was the fascinating applications of medical practice in space to similar situations on Earth.

"Training is a great example of lessons learned that have had a great impact," McDonald says. "When you are getting a crew ready for a launch, you have to condense the medical training to a few hours so that an astronaut trained as a fighter pilot, for example, can serve as the medical officer during the mission."

McDonald says that NASA also pioneered "Just in Time" training, an approach to transferring skills only when they are needed, in an on-orbit medical emergency, for example.

Space agencies have found themselves inventing new uses for medical devices as well. "These instruments were originally designed for medical professionals. We had to find ways that non-professionals could use them effectively."

Medical imaging in space represents another frontier for scientists, physicians, and astronauts.

"On Earth, a typical large clinic will have ultrasound equipment, CT scanners, and MRI systems available to the physicians. But you can't put a CT or MRI into orbit, so astronauts have the ultrasound machine and that's it. As a result, we've pushed the boundaries of how ultrasound can be used, and that has led to many more applications on Earth."

McDonald points out that extending the use of ultrasound equipment offers many benefits to terrestrial physicians. Unlike the CT scanner, it emits no harmful radiation and unlike the MRI, it is portable and requires a minimal amount of power.

Understanding osteoporosis represents yet another analogue from the space environment with implications for people living on the surface.

"Osteoporosis threatens the well being of our elders," says McDonald. "The condition makes their bones more fragile, leading to falls, which leads to even greater complications, even death. In space, astronauts face a similar problem, and the countermeasures we develop for them—nutrition, exercise, and pharmaceuticals—can help to protect our older population."

What does the future hold for the space medicine/Earth medicine connection? Like Satcher, McDonald believes that deep space exploration will accelerate the learning process.

"Almost everything we know about non-terrestrial medical issues derive from Low Earth Orbit (LEO) missions," he says. "We have real-time communications with a space shuttle or space station. In an emergency, we might even be able to bring a patient home. None of this will apply on a Mars mission."

Because of the time delay in communications, doctors on Earth may not be able to offer diagnostic and treatment information to astronauts thousands or millions of miles away.

"The key is what they take with them for medical emergencies. It's like a camping trip. You have to decide in advance what you might require, so you imagine the scenarios you might face. We are using artificial intelligence to create a medical model for that purpose."

McDonald says there will be another benefit of such models as access to space grows allowing for greater numbers of the general public the chance to make that trip .

"One of the reasons we have had very few medical problems in space is that the space agencies only choose people who are very healthy. When space tourism gets underway, without carefully planned management practices, the probability of medical emergencies in orbit will grow because the general population will be flying."

The Role of SpaceCom

Both Satcher and McDonald find SpaceCom to be a valuable venue for sharing what they have learned and hearing about the latest developments in the burgeoning space business area.

Satcher says, "It's a great vehicle for increasing awareness of what is happening in space and I am looking forward to the conference this year."

McDonald says, "SpaceCom represents an excellent opportunity for us to showcase our capabilities to local constitutents and to demonstrate crossover applications to other industries, like maritime, energy, and agriculture."

Robert Satcher, Vernon McDonald, and many others from the field of medicine will be attending SpaceCom 2017 in December. Will you?

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