How NASA's struggle with radiation-resistant microbe could help us understand infections

It's something out of a Star Trek plot line. An invincible life form finds its way onto the robots and satellites sent to explore other planets — resulting in the possibility of contamination. The dilemma: What should the starship captain do to protect the biological integrity of those worlds being studied?

But it's not science fiction. It's a problem NASA is dealing with, as it struggles to cope with the fact that all of its "clean rooms" are plagued by a single species of bacteria (SAFR-032) that's evaded all sterilization techniques. From the Atlantic:

> SAFR-032 is a radiation-resistant bacterial spore found only in spacecraft cleanrooms. Indeed, it takes its very name from its peculiar habitat: SAFR stands for: Spacecraft Assembly Facility,(the R is for the medium in which it's cultured.) SAFR-032 has been found in all of NASA's cleanrooms, from California all the way to Kennedy Space Center in Florida. Its spores have evolved a unique survival tactic where they can build up layers of cells to use as shields that in turn protect their DNA.
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> Bacteria inside four canisters on NASA's E-MIST mission are exposed to the stratosphere.

And we're soon to send these stowaways to Mars. So, NASA astrobiologists need to learn how to eliminate the spores on equipment. The first test, called the E-MIST experiment, aimed to measure how much SAFR-032 would survive the brutal cold and radiation of outer space. David Smith at the NASA Ames Research Center sent 40 million bacterial spores into the stratosphere for 8 hours. When they returned, more than 99 percent of them had been killed, which relieved scientists. But 267 could still reactive themselves. And they had acquired unpredictable genetic mutations. From the Atlantic:

> A large number of the surviving 267 spores showed evidence of a very common genetic change called a single nucleotide polymorphism, or a SNP (snip). A SNP is a kind of genetic do-si-do between base pairs when an A changes to a T and so on. It may not result in any change of gene expression, or it may serve to be a benefit, or even cause disease, they aren't exactly sure.

A 2008 experiment on the International Space Station exposed SAFR-032 to less intense conditions than the E-MIST experiment. The amount of radiation they were exposed to increased the chances of genetic mutation. But in the ISS experiment samples, the mutations led to increased antibiotic resistance. SAFR-032 doesn't seem to make humans or animals ill. But it's important to be able to control the bacteria, especially if natural conditions of space aren't going to kill them off.

Space exposures make bacteria do wonky things, like drive genetic mutations that make viruses more virulent or develop antibiotic bacteria. Scientists have been studying space's affects on known Earth-bacteria for years. In 2006, Cheryl Nicerkson, now at Arizona State University, discovered that space makes e.coli bacteria kill mice faster and at lower doses than E.coli that stayed home. From the Washington Post:

> It has been known for decades that something happens to microbes that leave planet Earth. Sometimes they grow faster and get better at causing disease. Just as often they do the opposite; slowing down and becoming less harmful. The biggest risk, experts say, is that the behavior is unpredictable. And when you send people to space — people who are teeming with microbes — there's little room for surprise.

Biophysicists have hypothesized that the reason bacterial cells start behaving so differently is change in forces against their membranes. Mucus, blood cells and other fluids press against bacteria and tell them something about their environment. In the micro-gravity of space, those forces all change. The cells aren't pressing against each other in the same way. So, David Klaus at the University of Colorado at Boulder suggests, it's no wonder the bacteria change their behavior to adapt to this new environment.

Understanding those changes may only be directly important to a few dozen astronauts' health right now, but the research is unlocking bacterial behavior mechanisms that we never get to see on Earth. Targeting those mechanisms could lead to potential treatments for bacterial infection and colonization. From the Washington Post:

> For Nickerson, the most tantalizing thing about all this research actually has little to do with space or a trip to Mars. By seeing how bacteria, fungi and viruses respond to microgravity, they may learn new ways to combat them on Earth…. Earth-based infectious disease research rarely pays attention to the physical forces on bacteria, Nickerson said, even though it could play a role in how pathogens cause disease. Bacteria, like all biological beings, evolved to live in gravity. It's been one of the few constants since they emerged billions of years ago. Remove that, and some interesting things are bound to be happen.

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