Keeping space missions from infecting Earth and other worlds

Spacecraft can move germs between planets, so cleanliness is key

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water streaks on Mars

This false-color image was taken by NASA's Mars Reconnaissance Orbiter, showing Hale Crater. Scientists think the dark, narrow streaks shown here might be signs of flowing water on Mars. If there’s water, there also might be a chance for life.

UNIVERSITY OF ARIZONA/JPL/NASA

BOSTON, Mass. — In the new movie Life, astronauts engage in an epic battle to protect Earth. The team is studying an organism from a sample of Martian soil. But this creature isn’t as cute as it first appears. It is strong and smart and eventually threatens to destroy the space station and take over Earth.

This is science fiction. But there may be some nugget of truth to the situation. “We don’t know what we don’t know,” explains Norine Noonan. She’s a biologist at the University of South Florida in St. Petersburg. Robots or astronauts may one day encounter organisms on other worlds. If they do, they might also bring them home to Earth — maybe not even on purpose. Like an infection or microbial weed, those alien species could have the potential to flourish on Earth. They might even displace one or more of Earth’s own species.

Noonan described what’s at stake, here, at the American Association for the Advancement of Science annual meeting on February 17.

NASA is planning for sample-return missions in the not-so-distant future. These missions would retrieve dirt, dust or other bits of a planet or moon and bring them to Earth for study. If that happens, the space agency will need a range of experts to advise it on how to handle the samples safely. For instance, they would have to look into preventing any life that may be brought back from infecting species on Earth. And because Earthly life would be aliens on Mars, NASA can’t risk infecting the Red Planet or any other worlds that its missions visit.

The issue has become a growing concern as biologists have uncovered species on our planet able to survive extreme environments. These organisms are called extremophiles (Ex-TREE-moh-fyles). Some live deep underground in caves. Others make their homes on volcanoes or in the hot waters of Yellowstone’s geyser pools.

“We know so little about extremophiles on Earth,” Noonan says. In fact, she points out, scientists have yet to identify most bacteria on our planet. So if the experts don’t know much about what is here, how can they hope to know what might be living on distant worlds or their moons? Some alien critter might be barely surviving at home — but poised to grow like gangbusters in Earth’s environment. So bringing it home could prove quite risky.

An old and increasingly costly worry

Scientists first started considering what Earth-life they might be sending into space following the 1957 launch of Russia’s Sputnik — the world’s first satellite. As missions became more advanced, scientists started calculating just how many microbes might stow away on spacecraft. The idea was to keep the numbers low so that few of these terrestrials would be available to make themselves at home on any extraterrestrial site.

In the 1970s, NASA sent two sets of orbiters and landers to Mars. These Viking missions were to search for life on the Red Planet. But NASA didn’t want to risk traveling all that way just to later “detect” some Earthly germ it had accidentally launched into space, notes Cassie Conley. She is a planetary protection officer at NASA’s headquarters in Washington D.C. Before each spacecraft launched, it was baked in an oven. The hope was that this heat would kill most germs on board.

Viking 1

This Viking 1 launch couldn’t take place until after NASA had sterilized the spacecraft it was carrying — one that would be going on to Mars.

NASA

The goal, she explains, was to keep the total to fewer than 30 viable organisms on the entire outside surfaces of the spacecraft.

It’s now Conley’s job to think about how to keep Earth’s microbes from infecting Mars and beyond. That includes places like Jupiter’s moon Europa and Saturn’s moon Enceladus.

For now, though, she is focusing on keeping Mars “clean.” After the Viking landers failed to find hints of life on Mars, NASA relaxed its requirements about sterilizing spacecraft prior to launch. But in the past few decades, there’s been growing evidence of water on Mars. And where there’s water, there could be life. Concern has been building, Conley says, that spacecraft cleanliness requirements may have been “relaxed a little too far.”

That’s led to a lot of discussion about how to clean the next round of spacecraft headed to the Red Planet. And that disinfection is no small deal. Ten percent of the total cost of a mission can be spent just to remove germs, Conley says. Justifying anything that costly “leads to tension,” she adds.

Scientists want as many instruments as possible on a spacecraft. But at 10 percent of the cost of a billion-dollar mission, germ removal alone might run to millions of dollars. That can be as much as a major science instrument. So there can be a tug-of-war between doing science and keeping the spacecraft clean, she says.

There’s also a lot of talk about what to do when astronauts go to Mars. Humans spew lots of microbes into the air around them. Figuring out how to keep those germs from infecting the Martian environment will be important, too.

Spending the money to keep extraterrestrial worlds clean is essential. “We don’t understand all of the consequences of moving organisms around,” Conley says. “We want to put protections in place before we have the chance to make mistakes.”

Some scientists might argue that missions to Mars have already polluted the planet, so why worry about doing better now, she notes. But her response: “That’s like stopping brushing your teeth after you’ve eaten your first candy bar.” It doesn’t happen. You just brush again, she says — and maybe better — “because it’s a good idea.”

Planetary protection, she adds, requires the same constant attention to germ-control.

Power Words

(for more about Power Words, click here)

alien A non-native organism. (in astronomy) Life on or from a distant world.

annual Adjective for something that happens in every year.

astronaut Someone trained to travel into space for research and exploration.

constant Continuous or uninterrupted.

Enceladus The sixth largest of Saturn’s more than 50 moons. Enceladus is bright white and covered with a thick shell of ice. Deep beneath that ice sits what appears to be a global ocean of salty liquid water. Enceladus is a round sphere, 500 kilometers (310 miles) across. It is a little less than one-third the width of Earth's moon.

environment The sum of all of the things that exist around some organism or some device and the condition those things create for that organism or device. Environment may refer to the weather and ecosystem in which some animal lives, or, perhaps, the temperature, humidity and placement of components in some electronics system or product.

Europa One of the moons of Jupiter and the sixth-closest satellite to the planet. Europa, 1,951 miles across, has a network of dark lines on a bright, icy surface.

extraterrestrial (ET) Anything of or from regions beyond Earth.

extremophile A microorganism that lives in conditions of extreme temperature, acidity, alkalinity or concentrations of chemicals.

germ Any one-celled microorganism, such as a bacterium, fungal species or virus particle. Some germs cause disease. Others can promote the health of higher-order organisms, including birds and mammals. The health effects of most germs, however, remain unknown.

geyser A vent (opening) in Earth’s surface that intermittently sends up a tall spray of steam or hot water. The sometimes explosive discharge of water and steam is propelled by the geothermal heating of water below ground.

Jupiter (in astronomy) The solar system’s largest planet, it has the shortest day length (10 hours). A gas giant, its low density indicates that this planet is composed of light elements, such as hydrogen and helium. This planet also releases more heat than it receives from the sun as gravity compresses its mass (and slowly shrinks the planet).

lander A special, small vehicle designed to ferry humans or scientific equipment between a spacecraft and the celestial body they will explore.

Mars The fourth planet from the sun, just one planet out from Earth. Like Earth, it has seasons and moisture. But its diameter is only about half as big as Earth’s.

microbe Short for microorganism. A living thing that is too small to see with the unaided eye, including bacteria, some fungi and many other organisms such as amoebas. Most consist of a single cell.

NASA Short for the National Aeronautics and Space Administration. Created in 1958, this U.S. agency has become a leader in space research and in stimulating public interest in space exploration. It was through NASA that the United States sent people into orbit and ultimately to the moon. It also has sent research craft to study planets and other celestial objects in our solar system.

orbiter A spacecraft designed to go into orbit, especially one not intended to land.

organism Any living thing, from elephants and plants to bacteria and other types of single-celled life.

planet A celestial object that orbits a star, is big enough for gravity to have squashed it into a roundish ball and has cleared other objects out of the way in its orbital neighborhood. To accomplish the third feat, the object must be big enough to have pulled neighboring objects into the planet itself or to have slung them around the planet and off into outer space. Astronomers of the International Astronomical Union (IAU) created this three-part scientific definition of a planet in August 2006 to determine Pluto’s status. Based on that definition, IAU ruled that Pluto did not qualify. The solar system now includes eight planets: Mercury, Venus, Earth, Mars, Jupiter, Saturn, Uranus and Neptune.

robot A machine that can sense its environment, process information and respond with specific actions. Some robots can act without any human input, while others are guided by a human.

satellite A moon orbiting a planet or a vehicle or other manufactured object that orbits some celestial body in space.

Saturn The sixth planet out from the sun in our solar system. One of the four gas giants, this planet takes 10.7 hours to rotate (completing a day) and 29 Earth years to complete one orbit of the sun. It has at least 53 known moons and 9 more candidates awaiting confirmation. But what most distinguishes this planet is the broad and flat plane of seven rings that orbit it.

science fiction A field of literary or filmed stories that take place against a backdrop of fantasy, usually based on speculations about how science and engineering will direct developments in the distant future. The plots in many of these stories focus on space travel, exaggerated changes attributed to evolution or life in (or on) alien worlds.

terrestrial Having to do with planet Earth, especially its land. Terra is Latin for Earth.

viable Able to live and survive. (in biology) Able to survive and/or live a normal lifespan.

weed (in botany) A plant growing wild in, around — and sometimes smothering over — valued plants, such as crops or landscape species (including lawn grasses, flowers and shrubs). Often a plant becomes such a botanical bully when it enters a new environment with no natural predators or controlling conditions, such as hard frosts. (in biology, generally) Any organism may be referred to as a “weed” if it enters an environment and begins to overwhelm the local ecosystem.