Scooping Up a Chunk of Mars

Fresh samples from the Red Planet

By RON COWEN

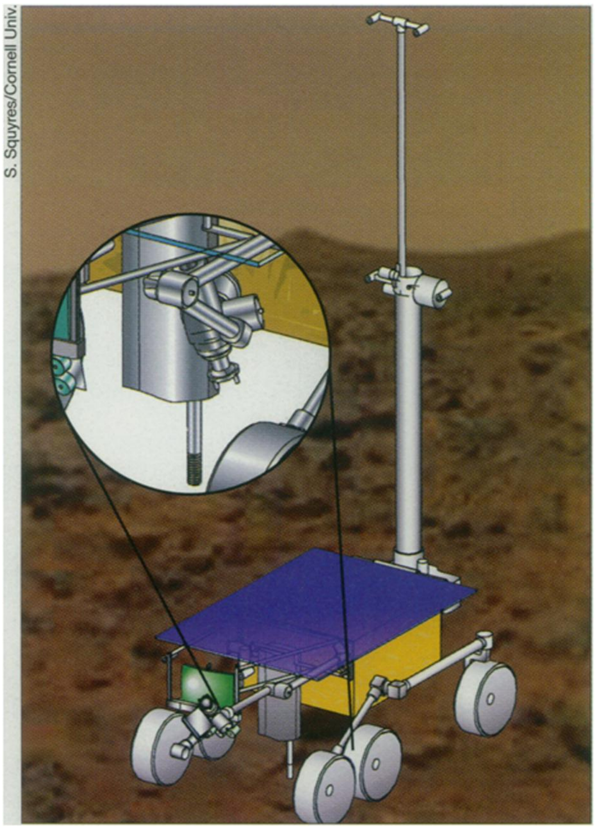
Except for a gentle wind that whined softly through the empty houses, it was deathly silent. Bodies lay everywhere, heaped and flung across the ground in frozen surprise.

In Michael Crichton's 1969 novel *The Andromeda Strain*, an unmanned government spacecraft returns to Earth, contaminated by an alien organism that destroys an entire town.

NASA is striving to ensure that fact won't collide with fiction a decade from now, when a small capsule containing a canister the size of a soda can, packed with soil and rock fragments from Mars, is scheduled to parachute onto Earth.

Even if the container carries living material from the Red Planet—a possibility scientists consider remote—the organisms aren't likely to survive in Earth's environment. Nonetheless, researchers plan to handle the canister as gingerly as if it contained the Ebola virus.

"You must assume that what you bring back is hazardous until proven otherwise," says planetary ecologist Margaret S. Race of the Search for Extraterrestrial Intelligence (SETI) Institute in Mountain View, Calif.



S. Squyres/Cornell Univ.

Illustration of Athena, the first rover planned to gather and store bits of the Martian surface. Inset: Set to leave for Mars in 2001, Athena features a tiny drill that will take cores of Martian rocks.

Race and other scientists outlined plans for gathering and retrieving Martian samples at the annual meeting of the American Association for the Advancement of Science in Philadelphia in February and at a conference on astrobiology at George Washington University in Washington, D.C., in March.

Contaminating Earth with critters from Mars is one concern, but scientists also want to make sure that any samples scooped up from the Red Planet are pristine, unsullied by stray organisms from our own planet. Dead or alive, terrestrial life could hitch a round-trip ride on the two robotic missions, now scheduled for launch in 2001 and 2003, that will be the first to gather and cache material from Mars. If organic compounds from Earth found their way into a storage canister, they could confound analysis of the samples.

"You have to be extremely careful not to carry along your own evidence of life," says Doug Blanchard of NASA's Johnson Space Center in Houston. In other words, you don't want to send a craft to Mars, only to discover life from New Jersey.

Arguments over the origins of amino acids and other organic compounds in the famous Martian meteorite ALH84001 highlight the problems faced in analyzing fresh samples from Mars, notes Michael H. Carr of the U.S. Geological Survey in Menlo Park, Calif. "So much of the debate about ALH84001 has been about what's terrestrial—what has come from the ice in Antarctica—and what is intrinsically Martian," says Carr (SN: 1/24/98, p. 54). Planetary scientists want to avoid a repeat of these arguments when spacecraft bring back samples from Mars.

To minimize such debate, engineers and scientists are contemplating several ways of sterilizing the rovers on the 2001 and 2003 missions. Crude, but highly effective methods of sterilization were once applied to entire craft traveling to Mars. Before their launch in 1976, every component of the twin Viking missions was heated to temperatures above the boiling point of water. Then each craft was baked in a giant oven for 36 hours. "The sensitive electronic equipment we have now could never withstand that kind of heat sterilization," says Race.

Instead, each rover may be suffused with hydrogen peroxide gas before launch. A powerful oxidizer, the gas kills living material clinging to the vehicle and degrades biological molecules and membranes. After the peroxide bath, the rover might be sheathed in a protective skin, or bioshield, that it would shed only after landing on the Red Planet.

To ensure that the craft is sterile, biologists will take swabs of different parts of the craft and let any cells propagate into colonies in a laboratory. In addition, they will search for signs of individual microbes or fragments of microbes that might not grow in culture, says microbiologist Roger Kern of NASA's Jet Propulsion Laboratory in Pasadena, Calif. He notes that such testing will need to take place before the launch of the Mars-bound mission, as well as after its return.

To gain a better assessment of earthly contamination, scientists may install small slides, known as witness plates, on various components of the craft, including the canister that will hold the Martian samples. After the craft returns to Earth, scientists will compare the material accumulated on those plates with the composition of the samples, as well as any matter deposited on a set of archived plates that never left Earth.

"This should give plenty of control to determine whether biological entities are the real Martian enchilada or merely contaminants that originated on Earth," says Race.

By the time the Mars-bound slides return to Earth, instruments for detecting compounds will undoubtedly be more sensitive, and standards for contamination may be more stringent.

"The techniques for detecting proteins and little pieces of DNA and so on are just unbelievable compared to what they were 5 years ago," says Carr. "Surely there is going to be a similar evolution over the next decade or so. This presents a challenge for us: The sample won't be back on Earth until 2008, so how do we make a set of requirements in the face of this rapidly changing capability?"

The first expedition takes off in 2001. It will feature a vehicle five times the size of tiny Sojourner, the six-wheeled rover on Mars Pathfinder that became a staple on the nightly news last July. Roaming a few tens of kilometers from its mother ship—Sojourner traveled only a few meters—the rover will use a pencil-thin drill to dig a centimeter or so into a selection of boulders lying on the Martian surface.

After analyzing the composition of each sample, the rover will transfer the nugget to a tiny treasure chest—a box with enough cubbyholes to hold 91 samples of rock and 13 of soil, amounting to about half a kilogram of material. Two years later, according to current plans, the 2003 rover will fill a similar treasure chest on another part of the Red Planet.

In 2007, another lander and rover will arrive to pick up the booty. In a set of carefully choreographed moves, the new rover will retrieve one of the two boxes—from whichever site seems have a more intriguing set of samples—and deposit it in the lander. In the current strategy, the lander will blast off from the planet but will not return to Earth. To break the chain of possible contamination, the lander will rendezvous with a waiting craft, in orbit about Mars, that had never touched the surface. The lander will hand over its precious cargo, and the orbiting craft will begin its journey back to Earth.

While the samples are in transit, scientists hope to maintain them at chilly temperatures and low pressures similar to those on Mars. The canister will also be carefully monitored: A drop in pressure inside the container may indicate that Martian material is leaking out. Under such circumstances, ground controllers will redirect the craft so that it whizzes past Earth instead of landing.

If monitoring reveals no problems, however, the canister will break loose from its return vehicle as it nears Earth and parachute onto solid ground. A team of scientists—it's not yet known whether the initial handlers will be from NASA, the Centers for Disease Control and Prevention, the military, or some other group—will transport the canister to a designated research facility.

In a report issued last year, the National Research Council recommended that the facility be up and running for several years before the Martian cargo arrives. "It's not just a matter of it being a check-out stand at the supermarket," says John D. Rummel, planetary protection officer for NASA. "We need to be ready to deal with whatever cards we're dealt."

Because the samples will be tiny, they may be best analyzed inside a small, closed compartment known as a biosafety cabinet, or glove box, says Race. Researchers

Lessons from Apollo

Between October 1968 and December 1972, astronauts in the Apollo program landed on the moon six times, gathering 380 kilograms of lunar rocks and soil. In all, notes John R. Bagby, former deputy director of the Centers for Disease Control and Prevention in Atlanta, 18 astronauts and six Apollo command vehicles were in contact with lunar material.

The effort to quarantine the astronauts and isolate the moon rocks was elaborate but erratic. "It was a sham," says Michael H. Carr of the U.S. Geological Survey in Menlo Park, Calif.

Just before their craft splashed down in the Pacific Ocean, the crew of Apollo 11 got permission to equalize pressure in the landing vehicle by opening a vent, allowing air within the craft to escape into Earth's atmosphere. Shortly after the vehicle landed, divers popped opened the hatch to the craft and tossed in isolation suits, marking a second breach in quarantine, Bagby notes.

Strict isolation would have prohibited any such maneuvers, he says, until after the craft had been lifted to the deck of the recovery ship and connected by a tunnel to the isolation vehicle, known as the Mobile Quarantine Facility.

Still, after transport to a state-of-the-art receiving laboratory at NASA's Johnson Space Center in Houston, the astronauts, lunar samples, and equipment remained in isolation. Scientists who examined the samples did so only through glove boxes. To determine whether the lunar material might prove harmful to life on Earth, scientists fed moon dust to some 70 species of animals. Alas, the Japanese quail managed to peck through the glove boxes.

After showing no ill effects for 21 days, the Apollo 11 crew was released. At that time, a decade before researchers knew about the AIDS virus and other slow-acting pathogens, a 3-week quarantine seemed adequate, says Margaret S. Race of the SETI Institute. But public and political pressure to honor the crew—the first to walk on the moon—was also a factor in limiting their time in isolation.

Some of the snafus, notes Race, came about because scientists coordinating the quarantine had not been working together long enough. In addition, many researchers never thought the moon could support life—a view that has only been reinforced since the early 1970s—and some were hard-pressed to take the threat of lunar contamination seriously.

NASA/Johnson Space Center

Apollo 11 astronaut Neil Armstrong (left) talks to his family by telephone from a quarantine facility. The Apollo astronauts remained in isolation for 21 days after the mission.

"I would be loath to have the public think that NASA was going to handle the Martian samples in the way that the lunar samples were handled," says J. William Schopf of the University of California, Los Angeles, a member of the team that first examined the lunar samples. He adds that the agency has sought recommendations from panels of life scientists and is working with biologists to develop procedures for handling the Mars samples.

"NASA is essentially an engineering outfit . . . and they do an excellent job at that, but they're not as active in biology," Schopf notes. "NASA's feet have to be held to the fire." —R.C.

A sampler of other sampling missions

Earthlings won't have to wait until 2008, when a canister of Martian rock and soil is scheduled to arrive, to receive the first delivery of extraterrestrial material by spacecraft since the Apollo missions brought rocks back from the moon. Two years earlier, robotic spacecraft are scheduled to bring back a variety of far-flung pieces of the solar system.

These samples are not expected to contain signs of past or present life, but they may speak volumes about the solar system's formation and evolution.

For 2 years, beginning in 2001, a mission called Genesis will collect material from the solar wind, the stream of charged particles blown by the sun into the far reaches of space. In 2006, the craft is expected to bring a milligram of solar material to Earth.

That same year, astronomers are expecting to receive their first sample of material from a comet. Set for launch in 1999, the Stardust mission will fly close enough to Comet Wild 2 in 2004 to collect dust and gas from the shroud cloaking the body's icy nucleus. During its 7-year journey, Stardust will also gather grains of dust from the interstellar medium. A mission called Deep Space 4 (DS4) will pay an even closer visit to another comet, Temple 1. Drilling as deep as 1 meter beneath the surface, DS4 is expected to scoop up about 100 cubic centimeters of material, about the volume of a tennis ball. Its mother ship is set to carry the samples to Earth in 2010.

One year after its launch, scheduled for 2002, a U.S.-Japanese mission known as MUSES-C will rendezvous with a near-Earth asteroid called 4660 Nereus. Firing three pellets into the asteroid at point-blank range, MUSES-C will generate clouds of debris, some of which it will funnel into the craft expected to arrive back on Earth in 2006. —*R.C.*

NASA/Jet Propulsion Laboratory

Artist's depiction of the Deep Space 4 lander-return module lifting off from the nucleus of Comet Temple 1 and heading toward its mother craft (upper left). The module will carry with it a canister of samples of the comet's icy core. Remaining behind, at the center of the image, is a lander anchored to the comet's surface with a telescoping spike.

manipulate material by inserting their hands into gloves that are sealed tightly to the compartment.

"The Centers for Disease Control and Prevention has a great deal of experience in dealing with known pathogens," says Kern. "We just have to make sure that NASA follows those procedures and has experience in that."

"There's nothing about what we know on Mars so far that would lead us to believe that we're going to find anything weird," says Race. "We are not finding anything physical or chemical that is different than on Earth."

She adds, however, that the search for life in the Martian samples won't be restricted to seeking familiar molecules like DNA. On Earth, she notes, living materials "are little bags of chemical reactions that require a vessel" such as a membrane or a cell wall. Finding some similar sort of structure would be one indicator of life in the Martian samples.

"They'll slice and dice and chop it up and look at it in all different ways," says Race. Even if they find nothing, they still plan to see if the Martian material affects cells growing in the laboratory.

"We had better go the most cautious route, even though there's not a lot of people around who think we'll find little green men inside when we open the canister."

"There's always the potential that you'll find there's life on Mars but that it's so wimpy that it gets eaten by anything that runs into it," says Rummel. It would be difficult to detect organisms that are destroyed by common microbes or chemicals native to Earth.

Visions of some malevolent alien organism, like the rubber-eating microbe in *The Andromeda Strain*, are "not something I'm going to be losing any sleep over," says Kern. □