www.astrosociety.org/uitc

No. 58 - Summer 2002

Responsible Exploration: Protecting Earth and the worlds we explore from cross contamination

by Margaret Race, PhD

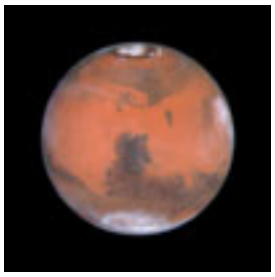
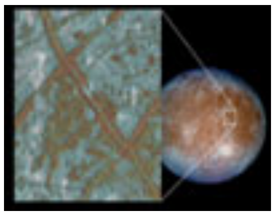
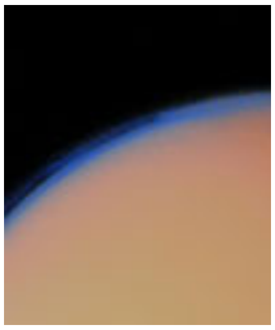
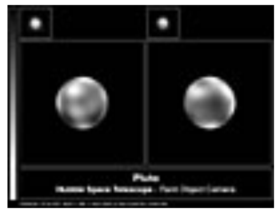
What is Planetary Protection?

Since the beginning of the space program at the time of Sputnik, there has been concern about the need for planetary protection — the prevention of human-caused biological cross-contamination between the Earth and other solar system bodies. Although the probability is low because of the harshness of space environments, it's possible that "hitchhiker" bacteria and other organisms transported on spacecraft and equipment might cause irreversible changes in the environments of other planets or interfere with scientific exploration for life (forward contamination). In addition, until we know more about the prospect of extraterrestrial (ET) life, we have to be careful that spacecraft or extraterrestrial samples returned to Earth don't contain anything that could harm Earth's inhabitants and ecosystems (back contamination).

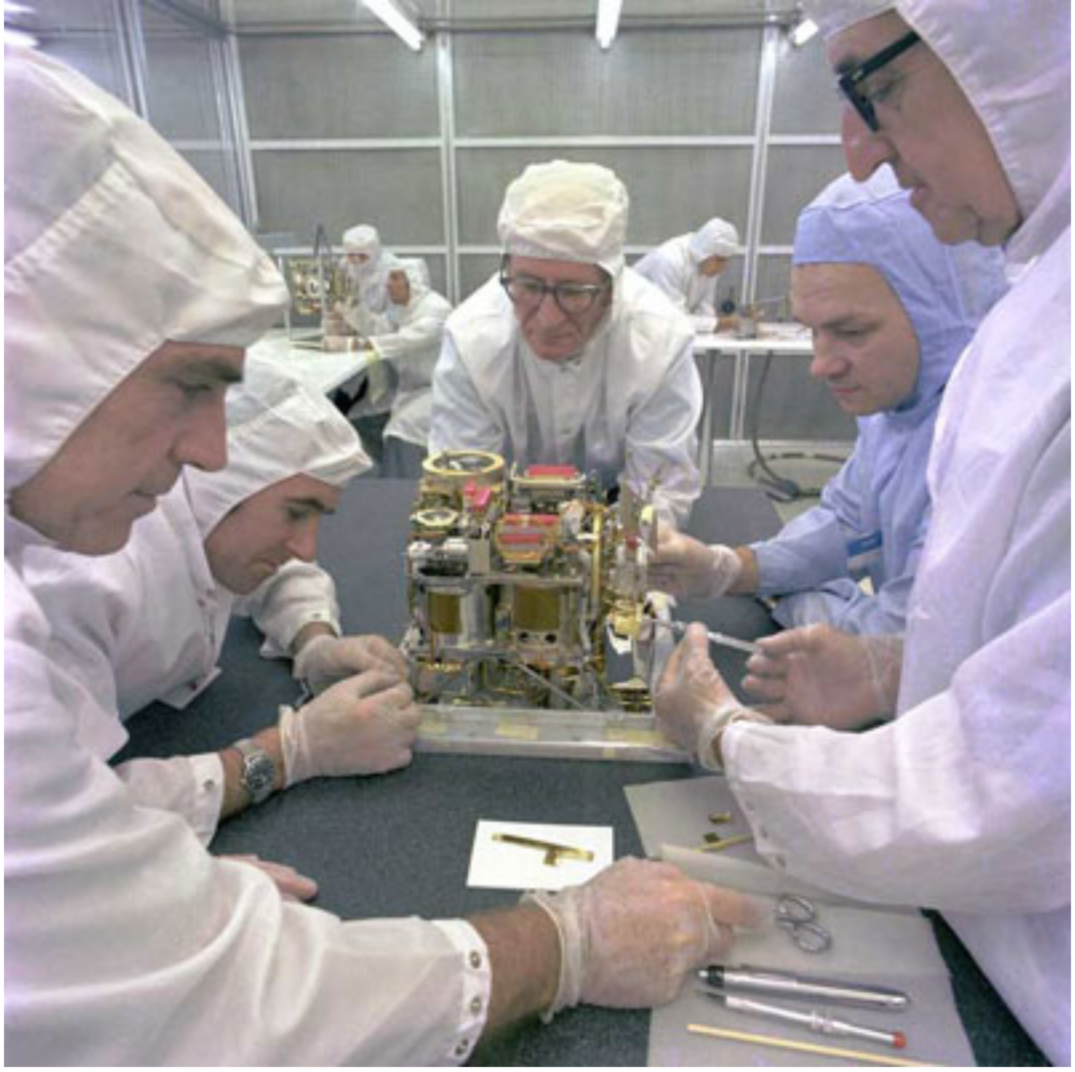
This image of Earth was taken on August 25, 1992 by NOAA GOES-7 satellite. It shows a planet teaming with life that we want to protect from contamination from alien life forms. At the same time as we explore beyond the boundaries of our home planet we must be careful not to carelessly spread even microbial life to other potentially fragile ecosystems.
Photo Credit: Image produced by F. Hasler, M. Jentoft-Nilsen, H. Pierce, K. Palaniappan, and M. Manyin. NASA Goddard Lab for Atmospheres - Data from National Oceanic and Atmospheric Administration (NOAA).

Planetary protection policies for space exploration are like environmental, health or safety policies on Earth. We want to prevent the transport of potentially harmful organisms or microbes from one place to another (either accidentally or deliberately) for two main reasons: 1) they could be infectious or pathogenic, or 2) they could cause ecological or environmental disruption. On Earth, there are regulations and control measures intended to prevent the spread of serious disease-causing microbes (for example, anthrax, HIV/AIDS, hoof and mouth disease, tuberculosis, or Dutch Elm disease), or to limit the movement of invasive pest species (for example, fire ants, gypsy moths, zebra mussels, kudzu vine or water hyacinth). In space exploration, the issues are basically the same, except for one important thing — we don't know if extraterrestrial life even exists, never mind whether it might harm Earth. Until we know for sure, we must follow strict domestic and international policies that apply to spacecraft and missions, prior to launch, on the planet during exploration, and upon return to Earth.

The task of planning effective planetary protection measures involves a combination of the latest scientific knowledge and some sophisticated guesswork. Even before a spacecraft arrives on a planet, there will have been tremendous thought about what kind of life might be there, how we would recognize it, and what kind of biohazard, if any, it might pose to Earth if it were returned in samples. Looking further into the future, we need to think about what precautions will be needed for human astronauts both when they visit new locations and when they return to our home planet. Planetary protection policies must take into account all these uncertainties — even while exploration continues to determine whether life exists elsewhere. Until we know for sure, we must be conservative to prevent the very act of exploring from disrupting or interfering with life, whether in extraterrestrial locations or on Earth.

				
Mars has long captured our imaginations and remains a serious target for human exploration. With evidence of water once being plentiful on this planet, we take the maximum precautions when exploring this world. Many of the new protocols being developed are for the near future as we plan sample return missions.	Europa is a moon of Jupiter. Its frozen surface is believed to have an ocean of liquid water beneath it heated by tidal forces. Water and heat make it another candidate for a possible abode of life.	Titan, Saturn's largest moon has a smoggy nitrogen atmosphere. Its make-up is similar to our own atmosphere, but much colder. Cassini will drop a probe through the smog to give us more detailed information about curious moon.	Eros, was the first asteroid to have a spacecraft put in orbit around it. Given its size and location, it is not a likely candidate to have life on it. Even though the spacecraft was eventually landed on the surface, the precautions to sanitize the spacecraft were much less rigorous than they are for a destination like Mars.	Pluto is the most distant planet in the solar system and is more like a comet than a planet. Because it always lurks at the frozen edges of the solar system, it is not a likely candidate for life. Any future spacecraft that may explore this distant icy world, will still be assembled in clean rooms but will not have to go through the same level of sanitizing that Mars rovers are subject to.
Click here to see larger versions of images with captions.				

Depending on where in the solar system a spacecraft is going, a variety of different planetary protection procedures and controls may be used. If the environment is one where scientists think life could exist (for example Mars or Europa), strict controls are imposed, while missions to places with little or no potential for life require few, if any, special measures (for example Venus, Saturn, or our Moon). Planetary protection starts even before launch. For example, spacecraft are assembled in cleanrooms, and scientific instruments may be heat treated or specially packaged to further reduce the 'bioload' or the number of microbes before launch (similar to scrubbing and sterilizing equipment before surgery).



The TRW-built Mars viking biology experiment was prepared in a clean room. The equivalent of a university biology lab, it contained more than 40,000 components crammed into a space no larger than a car battery. Both Viking landers carried these devices. CREDIT: TRW Space & Electronics

If samples are returned from a place like Mars where scientists hope to find evidence of past or present life, sample materials will need to be sealed remotely inside special containers and monitored to ensure they don't leak during the return flight. If containment cannot be verified during the return flight to Earth, the sample and any spacecraft components that have been exposed to the extraterrestrial environment would either be sterilized in space or not returned to Earth. In addition, when they arrive on Earth, the returned samples will be transported to a special facility for testing and handling inside a quarantine laboratory equipped with biocontainment gloveboxes designed to simultaneously protect both workers and the samples from harmful contamination. No samples will be removed from containment until they are either sterilized or certified as non-hazardous, using a rigorous battery of life detection and biohazard tests. Although scientists agree that the likelihood of releasing and spreading a contained living organism is low, special equipment, personnel, and handling are warranted to minimize possible harmful effects, should a life form be discovered.

A similar approach to planetary protection and extraterrestrial quarantine was used during the Apollo Program when Moon rocks were returned to Earth. The rocks, along with lunar-exposed astronauts and the spacecraft itself, were quarantined at a special Lunar Receiving Laboratory until a comprehensive battery of tests proved there were no biohazards.

Until samples returned from other worlds can be determined to be free of biohazards they will not be touched by humans but will be handled carefully in sealed glove boxes and with robotic assistance.

After removing the isolation garments and freshening up, the three members of the Apollo 11 crew (Armstrong, Collins, and Aldrin, left to right) are greeted by President Nixon. Before we understood how sterile the lunar environment is, they were treated with the same care as the moon rocks to make sure they did not return with microbes that might have come from the Moon.

Future round-trip missions to Mars or other extraterrestrial locations will differ from Apollo in several ways. Because no astronauts will be involved in the initial sample-return missions, and because sample amounts are expected to be limited (less than 1 kilogram of rocks and soils from Mars compared to hundreds of kilograms of lunar rocks), quarantine procedures and flight operations will be less complex. Because of the distances involved, however, the missions will still be quite challenging. In addition, advances in microbiological and chemical techniques since Apollo have greatly increased our knowledge of life in extreme environments on Earth, while expanding abilities to detect life or life-related molecules in samples. Similarly, a heightened awareness has been developed about microbial capabilities and microbe-caused diseases — with corresponding public concerns about the potential risks of sample return missions.

As solar system exploration continues, so too will planetary protection policies. Revisions to those policies will depend on an improved understanding of extraterrestrial environments and our growing awareness of the tenacity of life in extreme environments on Earth. Increasingly, it appears likely there are extraterrestrial environments that could support Earth organisms. As importantly, future missions may find distant environments that support their own extraterrestrial life as well. Planetary protection provisions will be essential to the study and conservation of such environments. The Astrobiology Web has a section "Laws, Regulations, and Treaties Pertaining to Planetary Protection" if you'd like to study this more in depth.
