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Viewpoint:
**Millennial Fever, Extremophiles, NASA, Astroenvironmentalism, and
Planetary Protection**

Ryder W. Miller

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At the turn of the 21 st century, especially for those involved with The Mars Society or those who followed developments in space exploration, there was a belief that we could send people to Mars sometime soon. At the millennium, just after the 30 th anniversary of the moon landing, there were many in the astronomical community who were proposing Mars as the next manned space mission. Robert Zubrin, the president of The Mars Society, was making the argument that we could presently send people to Mars more easily than we could send people to the moon 30 years earlier. To the benefit of the possible extraterrestrial life in the solar system, history decided for a number of reasons that we were not ready to send people to Mars or go to Jupiter’s moon Europa yet.

During the 2000 election campaign, concerned parties in the astronomical community were examining the political positions of Al Gore and George W. Bush closely. There was also the interest at the Mars Society in *terraforming* Mars: altering the Martian environment to produce an atmosphere so Earth life could survive there. Kim Stanley Robinson in his 1990’s award winning science fiction tetralogy, *Red Mars*, *Green Mars*, *Blue Mars*, and *The Martians*, envisioned a future where International Space Law was ignored and most of the planet Mars is changed to support human life before a thorough search for extremophiles was conducted. Robinson envisioned preservationists on Mars, but they lose the major battles in his award-winning scenario. His was no terraforming series about some far off planet; it was a disturbing thought experiment about our closest neighbor in space in the near future. Pamela Sargent had also recently written a famous science fiction series where Venus is terraformed. Maybe it was realistic to echo a lack of concern about preservation and our search for life elsewhere. Robert Zubrin and others dream of terraforming Mars as illustrated in a recent release of a paper in the *Journal of Geophysical Research* (Marinova, et al., 2005) which postulates that the injection of “synthetic ‘super’ greenhouse gases into the Martian atmosphere could raise the planet’s temperature enough to melt its polar caps and create conditions suitable for sustaining biological life.” What about the search for extraterrestrial life on Mars first? The discovery of extraterrestrial life, even if only microscopic, could teach us things that we cannot fully predict. What about appreciating Mars as it is before we decide to drastically change it?

Recent developments in the exploration of space have included

mathematical proof of other planets, greater concern about potential asteroid collisions, a trip to Saturn and its moon Titan, the new belief that there could be oceans under the icy surfaces of some of the moons of Jupiter, string theory, dark energy and matter, the new Rose Center in New York City, the winning of the X prize, and the emergence of astrobiology and planetary protection. But astronomers have yet to find life on other planets. Discovery of extraterrestrial life could possibly challenge the tenants of biology. Maybe life elsewhere evolved due to cooperation rather than competition? On Earth, there was also the recent discovery of extremophiles, resilient life forms that live in habitats that we had once considered inhospitable. The discovery of extremophiles has revolutionized the field of exobiology, now called astrobiology.

Thinking about astronomical developments at the turn of the century, it was difficult to separate what "could be" from what "may be." Decisions about space exploration were being made that could drastically affect the future of humanity. Almost as if stepping out of a science fiction book, NASA has a Planetary Protection Officer who focuses on forward and backward contamination resulting from space exploration. The fear of backwards contamination from possible life found on Mars creating havoc here on Earth is one of the reasons that a Mars sample return missions has not yet been planned. There are also those who presently fear that space will become a new battleground, especially due to the use of nuclear powered vehicles in the near Earth orbit. But of more concern here is the not widely known NASA Stardust Mission that will bring back samples from the tail of the Wild-2 comet for examination in 2006.

The discovery of extremophiles has changed the previous paradigm that life can only be found on pleasant Earth-like planets. Astrobiologists are now reminding us that life can be found in extreme locations. We have found life in deep ocean volcanic mounts (this multi-cellular life gets its energy from chemical processes rather than sunlight), the ice fields of the North and South Poles, in the oceans under Antarctic ice, and some bone-dry deserts. Water, rather than heat, is considered the key indicator concerning where life can be found in space. Life has been judged resilient and able to survive in extreme situations. We have found microbes that survived the Apollo trips from the Earth to the moon. The desire to terraform other planets would interfere in the search for these possible extraterrestrial companions in the solar system, and provides a justification to cease space exploration until a different sentiment arises.

The new astrobiology/extremophile paradigm now argues that life may possibly be found under the icy surfaces of some of Jupiter's moons, in the volcanoes of Jupiter's moon Io, in the underground caverns of Mars, the ice

fields of the moon, in approaching comets, and in the clouds of Venus, Saturn, or Jupiter. Planetary protection is necessary so we do not interfere with or obscure the study of life that can be found there.

Exponential population growth of non-indigenous life is the key danger. Microscopic life brought back to Earth or to another planet from Earth will not necessarily have the population limiting factors that keep them in check elsewhere. Human populations due to technological development have escaped their population limiting factors and drastically affected the Earth. We see many similar examples of this with harmful non-indigenous species around the globe. When organisms are introduced they can alter ecosystems, and extraterrestrial microbes could possibly alter planets. Though these potential invaders are tiny, if their population grows beyond control they can cause damage to terrestrial populations. They may also enter the Earth's biosphere as extraterrestrial diseases.

Luckily, there is a NASA Planetary Protection Officer, Dr. John D. Rummel, whose responsibility it is to focus on this issue. At the Fall 2004 meeting of the American Geophysical Union there was a presentation about planetary protection efforts for science writers given by Dr. Rummel, Margaret Race (The SETI Institute), Karen Buxbaum (Mars Program Planetary Protection Manager at the Jet Propulsion Laboratory and California Institute of Technology), and Roger Kern (Biotechnology and Planetary Protection Group Jet Propulsion Laboratory) called: "Planetary Protection: Keeping it Clean in Solar System Exploration" (Rummel, 2004).

Some of the basic planetary protection principles include (Rummel, 2004):

- Preserve planetary conditions for future biological and organic constituents exploration (avoid forward contamination)
- To protect Earth and its biosphere from potential extraterrestrial sources of contamination (avoid backward contamination)

Examples of mission constraints include (Rummel, 2004):

- Constraints on spacecraft operating procedures (only send probes where and when the missions have been planned)
- Spacecraft organic inventory and restrictions
- Reduction of spacecraft biological contamination
- Restrictions on the handling of returned samples
- Documentation of spacecraft trajectories and spacecraft material archiving

In relation to extremophiles, the NASA Planetary Protection Officer has

noted: "Planetary protection provisions are important, not because we expect to find these things out *there*, but because we didn't expect to find them *here!*" (Rummel, 2004).

Here being the life we found in extreme terrestrial environments.

There already are planetary protection microbial reduction methods for non-life detection missions that include wiping space probes clean with alcohol, vacuum processes, and dry heat baking sterilization (Kern, 2004).

NASA currently uses a variety of microbial-burden detection technologies. Methods include disinfection, use of solvents, wipes, rinses, hydrogen peroxide vapor, pulsed-light, ultraviolet light, radiation, and dry-heat (Kern, 2004).

The "bioburden" can be assessed based on sample collection with a cotton swab and enumeration of cultivable spore formers on petri dish as directed by *NASA Standard Procedures for the Microbiological Examination of Space Hardware* (NHB 5340.1A, 1968) (Kern, 2004).

If we sent human beings back to the moon and onwards to Mars, planetary protection will be a more challenging issue. For manned missions we would need to manage human biological processes that could alter pristine locations on the moon and Mars.

Karen Buxbaum, Mars Program Planetary Protection Manager at the Jet Propulsion Laboratory and California Institute of Technology, wrote in her presentation at the AGU meeting (Buxbaum, 2004):

Human missions to Mars: What do we know, what can we know, and when do we need to know it? Placing humans safely on Mars and bringing them back to Earth will require new knowledge, and a meaningful extension of current planetary protection policy and its requirements.

Linda Billings of the SETI Institute (who told me that she was more concerned about the use of plutonium in space missions, and is also bothered by the "frontier mentality" in space exploration) presented a paper at the conference. In the abstract (Billings, 2004) to the presentation she wrote:

The U.S. National Aeronautics and Space Administration (NASA) and the international Committee on Space Research (COSPAR)

both have planetary protection policies in place.

Because the practice of planetary protection involved many different disciplines and many different national and international and governmental and non-governmental organizations, communication has always been an important element of the practice. Thus the NASA Planetary Protection Office has a long-term communication research initiative under way, addressing legal and ethical issues relating to planetary protection, models and methods of science and risk communication, and communication strategy and planning. With the pace of solar system exploration picking up, the era of solar system sample return under way, and public concerns about biological contamination heightened, communication is an increasingly important concern in the planetary protection community.

NASA: Bang, Crash, and Scoop

NASA is currently developing long range plans to go back to the moon and then Mars using plutonium for space missions. One could argue that the use of plutonium for NASA space missions is also a planetary protection issue! NASA missions recently have involved disasters, and other violent spectacles.

The NASA Space Shuttle Columbia exploded in the skies over Texas in 2003. What if there was plutonium aboard? NASA crashed and burned the Galileo space probe into the atmosphere of Jupiter in 2003. NASA crashed a projectile into comet Temple-2 to explore the comet's core. NASA parachuted the Huygens space probe onto Saturn's moon Titan (this space probe did a slingshot maneuver around the Earth carrying plutonium). Of immediate concern is a mission to the comet Wild-2 that will include a sample return of dust from the tail of the comet. Not necessarily, but possibly, the return mission could infect Earth with extraterrestrial microbes. Panspermia is a widely publicized theory that postulates that life may have traveled through space on asteroids, comets and meteorites, seeding formerly lifeless planets like the Earth.

All these spectacular missions rattle one's nerves, and the public needs to be concerned that some of these missions may bring back microbes that can impact our Earth's biosphere in ways that we cannot anticipate. These special microbes could possibly join the ranks of biological terrors like AIDS. Many people would love to own a rock from Mars or the moon, but they may be endangering themselves by exposing themselves to extraterrestrial chemicals and life. The new paradigm of life caused by the discovery of

extremophiles should make us even more concerned about planetary protection. Mars may not be a dead rock world (DiGregorio, Levin, & Straat, 1997), but harbor microscopic pathogens that could cause uncontrolled diseases on our planet. The same may be true of Europa, Io, Venus, etc.

Terraforming is also a major issue in that some wish to alter planets before we have the chance to explore them thoroughly for life. Evidence of water and former water channels on Mars has evoked an image of the planet's past with hospitable skies and oceans, but if we returned Mars to its previous state we would be interfering with what life may presently exist there. This dreamlike hospitable Mars of the past may never have existed.

Astrogeologists for the meantime would probably prefer a pristine Mars without introduced life smeared all over the rocks and fascinating geological formations. The discovery of life on another planet, something which some astrobiologists have written is not necessarily that far away, could be the biggest scientific discovery of our lifetime! Such a discovery could teach us new things about life processes. Our solar systems, the rest of which seems inhospitable, may be the home to tenacious extremophile ecologies. We need to explore with care. Life in general may be resilient, but individual species may be limited to specific environmental conditions.

Making the argument for the importance of extremophiles puts an environmental writer in an awkward situation. Some would argue that extremophiles should not stand in the way of our future in the solar system. Critics can question your ability or knowledge of the field.

Astroenvironmentalism or the argument that space exploration, commercialization, and militarization are an environmental issue does not fit comfortably in either of the fields of environmentalism or astronomy.

Environmentalism is usually more concerned with the immediate problems on Earth like endangered species, habitat destruction, global warming, pollution, etc. Astronomy is science and not always concerned with political activism or political expediency. Luckily, there have been a number of concerned writers who have written about biological contamination, space militarization, and plutonium dangers. Notable contributors on these issues include Karl Grossman, the author of *The Wrong Stuff* which detailed NASA's use of plutonium (Grossman, 1997), Barry E. DiGregorio, who has been alerting the public to the dangers of biological contamination inherent in space exploration for years (DiGregorio, 1997; <http://www.icamsr.org/>), Gar Smith, former editor of *The Earth Island Journal* who has published environmental articles about space exploration (Smith, 1987), Eugene Hargrove, who edited *Beyond Spaceship Earth* (1986), John Rummel, NASA Planetary Protection Officer (Rummel, 2004), others, myself, and a number of science fiction writers.

The entire public has yet to be convinced that these extraterrestrial places have their own inherent worth and wonders to protect. A character aboard a space ship in C.S. Lewis's famous Space Trilogy may have said it best:

He had read of "Space": at the back of his thinking for years had lurked the dismal fancy of the black, cold vacuity, the utter deadness, which was supposed to separate the worlds. He had not known how much it affected him till now - now that they very name "Space" seemed a blasphemous libel for this empyrean ocean of radiance in which they swam. He could not call it "dead"; he felt life pouring into him from it every moment... No: Space was the wrong name. Older thinkers had been wiser when they named it simply the heavens.

We have learned recently that space is not necessarily sterile and we need to proceed with caution into this new wilderness. We should also acknowledge environmentalism as a scientific revolution of our time and proceed into the future and space accordingly. When we save other worlds we are also helping save the planet Earth.

Planetary protection that has been strongly influenced by scientific fervor, mission cost benefit analysis, national politics, etc. has been *okay*. The blame for an entire agency (and also Federal Government) cannot be put on the shoulders of a single hired planetary protection officer.

We crashed the Galileo space probe into Jupiter rather than sending it to Europa to safeguard against biological contamination, but there could have been an outcry about possible biological contamination of the planet Jupiter. We have yet to bring back rock samples from Mars because some believe they may harbor extremophiles, but some argue that extremophiles may also exist on the moon. Sending space probes rather than people has made biological contamination less of an issue in that space missions do not need to manage human biological processes, but we are planning to send people into space again. Cassini, which recently arrived at Saturn, was a concern because it could have blown up in the atmosphere releasing plutonium into the Earth's atmosphere. The recent Columbia shuttle disaster reminds us to be careful about what we send through the Earth's atmosphere. The plan to crash a probe into the comet Temple-2 to explore its internal structure rattles one's nerves, but potentially worse is the plan to return a cometary's dust sample from Wild-2 in early 2006. Precautions will be taken, but this sample return mission can be the prelude to more risky missions.

Much of the fault can be attributed to the widespread adoption of a "frontier space" mentality. If we see space as a wilderness rather than a frontier we

are more likely to treat it with concern. Treating it as such will also help us discover life elsewhere, which may deeply impact our understanding of our place in the universe. The warlike "frontier" futures that science fiction like Star Trek and Star Wars presents need to be exciting, and they are, but they are likely also jaundice. In an astronomical sense, we are all responsible for the future. We all need to help safeguard against interplanetary contamination. We will be saving these pristine places for our descendants to visit. The Planetary Protection motto is environmental and should be more widely known: "Planetary Protection: All of the Planets, All of the Time..." The acknowledgement of the possible existence of extremophiles forces us to proceed into space more cautiously than we have in the past. The interest in terraforming Mars suggests we are losing sight of our scientific and environmental priorities.

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