The 2006 Astrobiology Follies: Return of the Phantom Martian Microbes

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Centuries of speculations on the possible existence of extraterrestrial life eventually focused on microorganisms. Direct tests for the presence of living microbes on Mars by NASA's Viking Missions in 1976 gave negative results. In 1996, NASA scientists created a media frenzy by announcing evidence for the presence of microbial microfossils in a Martian meteorite. The "microfossils," however, were soon shown to be inorganic artifacts. In 2006, a new dubious claim of evidence for past microbial life on Mars appeared. NASA hype continues to publicize Mars and other celestial bodies as possible locales of microbial life in the context of "astrobiology." This article examines the meaning and validity of "astrobiology" as a scientific entity.

Mars has been a favorite site of science fiction and speculations on extraterrestrial life since 1898, when H. G. Wells published *The War of the Worlds*. In the novel, the Martians are strange creatures with heads about four feet in diameter, and they are very advanced technologically. The Martians are shot to Earth in giant cylinders that land in the English countryside, and they proceed to cause widespread destruction with "Heat Rays" and other weapons. Fortunately, for Earth's humans, the Martians begin to die rather suddenly en masse because they are susceptible to terrestrial pathogenic bacteria. The narrator of the novel explains this as the result of the "fact" that there are no bacteria on Mars. Consequently, Martians have no immunity and are "irrevocably doomed, dying and rotting even as they went to and fro. It was inevitable. By the toll of a billion deaths man has bought his birthright of the earth, and it is his against all comers; it would still be his were the Martians ten times as mighty as they are."

Wells apparently did not believe that bacteria could be early forms of life which eventually evolved to plants and animals. He says nothing about the evolution of the Martians, who require fresh blood from other creatures in order to live.

The possibility of life on Mars persisted in the minds of some scientists into the 1960's. Eventually, this led to NASA's Viking missions to Mars in 1976. Viking spacecraft landed complex instruments on the planet to make direct tests for the presence of life in any form, including microbes of diverse physiological types. The results were negative (Gest 2005b; Horowitz, 1986). Norman Horowitz, who headed the Bioscience efforts of Viking, concluded that Mars was devoid of life because it lacks "oceans of liquid water in full view of the sun" and is suffused with damaging short-wave ultraviolet radiation. These circumstances have led to "development of a highly oxidizing surface environment that is incompatible with the existence of organic molecules on the planet. Mars is not only devoid of life, but of organic matter as well." Horowitz here refers to organic matter in more than trace quantities.

1996; the ALH84001 Martian meteorite

In August 1996, a NASA report by McKay et al. (1996) announced detection of *past* microbial life on Mars as evidenced, in part, by observation of "wormlike microscopic fossils" in a Martian meteorite. These were said to resemble, in general appearance, certain kinds of terrestrial microfossils. The NASA report elicited an overwhelming response from the communications media. The news avalanche included many articles touching on philosophic and religious implications of "finding extraterrestrial life."

Steve Squyres, who later became Principal Investigator of the current Mars Exploration Rover Mission, has described the excitement generated by the 1996 "Mars Media Mayhem" as follows (Squyres 2005): "On the way from Michigan back to Ithaca, we stopped at Mary's grandparents' home in rural Ohio. I plugged in my laptop for the first time in a couple of weeks, downloaded my e-mail and stared at it, dumbfounded, Dave McKay had found fossils in a Martian meteorite?!? Dave was a researcher at NASA's Johnson Space Center, and he was a major-league meteorite expert, so this was no off-the-wall nutcase. Still, it had to be a joke, or a hoax, or something, didn't it? But there was too much e-mail traffic in front of me for it to be anything but real.

And real it was. I flipped on the TV, and everywhere I looked it seemed there were Mars bugs. CNN had Dave live in a press conference, looking wide-eyed and a little alarmed by all the fuss he had created. His story seemed hard to believe at the outset, but as he laid out his case it sounded like there might be a chance he had actually found something. President Clinton came on next, declaring that the United States was going to get to the bottom of this question. Holy shit. It was obvious to me that the only way anybody was going to get to the bottom of this question was to send a rover to Mars to collect some rock samples." Squyres quickly perceived gold in McKay's "bugs."

The so-called "wormlike fossils" in ALH84001, however, proved to be very much smaller than typical terrestrial bacteria. So, it was immediately questionable that structures of such small dimensions could have contained the minimum essentials for independent life. The NASA report listed several other kinds of indirect evidence to support their claim of "evidence for primitive life on early Mars." Within months, a number of knowledgeable scientists expressed skepticism of the NASA claims (Gest 1997), and experimental tests in independent laboratories soon made it clear that the "wormlike fossils" were simply bits of inorganic debris (Kerr 1997). A 2006 report from the Carnegie Institution's Geophysical Laboratory confirmed that carbon complexes present in ALH84001 were probably formed by "non-biological processing on Mars" (Steele et al. 2006).

March 2006; Phantom microbes in the news again

At a recent Lunar and Planetary Science Conference, McKay et al. presented new evidence of organic remains of life in another Martian meteorite, designated Nakhla. This meteorite fell to Earth in 1911 in Egypt, where it collided with a hairy dog. According to an account in *Science* (Kerr 2006), the McKay group believes: "The putative organics [*in the meteorite*] are in veins whose walls are peppered by tiny tubules extending into the adjacent mineral, olivine….They (have) argued that microbes acid-etched the tubules in the hunt for nutrients." Andrew Steele [Carnegie Geophysical Laboratory] commented: "McKay has so many contaminants he has to eliminate. We do know Nakhla is

contaminated with a lot of organics." The Science account continues: "They include organic matter produced by abiotic means on Mars, organisms that invaded Nakhla after it fell to Earth in Egypt killing a dog, and organic agents used in the preparations of thin sections. Steele would take another tack: 'In Nakhla, I assume it's contamination. Prove me wrong.'"

In support of their past contentions, McKay et al. have cited publications by geologist Dr. Robert L. Folk, who maintains he discovered very small "mineral-making" bacteria that he calls "nannobacteria"….organisms 50-200 nanometers in length. Letters published in *Science* (see Maniloff and others 1997) by several scientists argued that objects in this size range could not have the information storage capacity and replication processes needed for a living system. Folk's reply to the letters is somewhat bizarre: "I have cultured nannobacteria on stubs of metallic aluminum in tap water, and I recently found that the mucus-like nannobacterial globs fluoresce strongly in ultraviolet light, signifying that they contain organic molecules. No fluorescence is observed on bare parts of the stub or on the container, so they seem to be metabolizing the aluminum." The possible existence of nannobacteria remains controversial. Folk's adventures bring to mind remarks by the eminent paleobiologist/biogeochemist Preston Cloud about a common hazard: "It is bad enough that nature lays traps for us. More vexing to deal with is the fact that fantasy can all too often rule the judgment even of those who at other times practice science. It is amazing that apparently competent physical geologists, who would be unlikely to tolerate a similar lack of rigor in their own fields, are nevertheless willing, without benefit of biological experience or advice, to express far-reaching judgments about objects of the most dubious biological nature or ancient provenance" (Cloud 1983).

Earth's microbes in the wasteland of NASA's "astrobiology"

As the phantom "Martian microfossil" story faded into the sunset in 1997, a new doctrine emerged from NASA's managers, "astrobiology." It surfaced in the form of a virtual Astrobiology Institute, which described "astrobiology" as "study of the origin, evolution, distribution, and destiny of life in the universe. Astrobiology represents a synthesis of disciplines from astronomy to zoology, from ecology to molecular biology, and from geology to genomics" [see Goldin (undated)]. Suddenly, life on Earth…the only locale known…became a subfield of Life in the Cosmos, with Charles Darwin as an early practitioner! I have identified the word "astrobiology" as an oxymoron which simply expresses a *hope* that life will be found beyond Earth (Gest 2005a; 2006).

Astrobiology at Ten is the title of a recent editorial in *Nature* (2006; vol. 440, p. 581), which must compound the confusion emanating from "astrobiology" publicity. The editorial notes that "the field [*astrobiology*] was cooked up, in part, out of political necessity, as a means of bundling together research programmes on exobiology, other life sciences, and planetary science." The editors believe that "many microbiologists with an interest in extremophile microbes have suddenly become astrobiologists because astrobiology is--or was—where the money is….Some second-rate research may have been funded on occasion, thanks to the astrobiology moniker's modishness." Their view of "microbiologists becoming astrobiologists" is certainly inverted. Many "astrobiologists" have become amateur microbiologists, focusing on terrestrial extremophile ecology and related matters for obvious reasons. The existence of such

bacteria is exploited by NASA to fuel the tacit hope that there may have been organisms that once could have lived under the very hostile conditions on Mars (e.g., at an average temperature of minus 55 C).

Publicity from the Astrobiology Institute strongly implies the extremophiles were discovered only recently. In fact, microbiologists have been isolating and characterizing pure cultures of prokaryotes from extreme environments on Earth for at least 100 years. [extreme in respect to temperature, pH, salinity, and hydrostatic pressure]. For example, Benjamin Volcani discovered extreme halophiles (e.g., *Halobacterium*) in the Dead Sea in the 1940's. Early "modern" research on extremophiles dating to the 1960's and 1970's has been reviewed by Thomas Brock (1978), who made many important contributions on the ecology of such organisms. I expect that "astrobiologists" with limited microbiological expertise will be rediscovering activities of such organisms in mixed cultures.

The Astrobiology Institute has awarded research grants to thirteen consortia at American universities and research centers. These projects typically deal with a wide gamut of standard problems in *terrestrial* biology research, e.g., gene expression, evolution, biological complexity, biogeochemistry, microbial ecology etc. In other words, research of the kind traditionally supported by the U. S. National Science Foundation and National Institutes of Health. Projects with a microbiological flavor are, of course, focused on bacteria in extreme environments. Needless to say, the "astrobiology" project descriptions are liberally sprinkled with "space jargon" plus plans for "Education and Public Outreach." It is noteworthy that the publicity machine of NASA consists of a battalion of 350 people responsible for "media relations and public outreach."

Significance of the 1976 Viking experiments

Horowitz's 1986 book is a classic scholarly work that details knowledge of the basic characteristics of life, theories on its origin, criteria for habitable planets, and the remarkable Viking experiments designed to detect microbial life on Mars. The final paragraphs of his book, which follow, should be required reading of all aspiring "astrobiologists."

"For some, Mars will always be inhabited, no matter what the data say. Occasionally one hears the opinion that somewhere on the planet there may exist a wet, warm place—a Martian Garden of Eden—where Martian life forms are thriving. Or, alternatively, that the Viking instruments did in fact find life—that the Viking data can be interpreted to mean that there are organisms living in the soil at a population density below the GCMS [*gas chromatograph mass spectrometer*] limit.

These contradictory views –one assuming that Martian life is like our own in its need for water, the other that it is not—are daydreams. The Garden of Eden would identify itself in photographs by a permanent water cloud above it and, probably, by snow on the ground. These signs have not been seen, and it is extremely unlikely that any such place exists on Mars. The Utopia landing site, where frost covers the ground for long periods of each year, is very watery by Martian standards, so it is not correct to say that the Viking mission sampled only the most desiccated areas. The second idea, that microorganisms are even now living in the Martian soil, is just another form of the blue unicorn theory. According to this theory, a blue unicorn is living in a cave on the moon, an assertion that is impossible to disprove because the unicorn is endowed by its inventor

with whatever attributes are found necessary to allow it to survive on the moon. In the case of organisms on Mars, these would include the ability to live without water or any other solvent and immunity from the processes that destroy all other forms of organic matter on the planet.

The failure to find life on Mars was a disappointment, but it was also a revelation. Since Mars offered by far the most promising habitat for extraterrestrial life in the solar system, it is now virtually certain that the earth is the only life-bearing planet in our region of the galaxy. We have awakened from a dream. We are alone, we and other species, actually our relatives, with whom we share the earth. If the explorations of the solar system in our time bring home to us a realization of the uniqueness of our small planet and thereby increase our resolve to avoid self-destruction, they will have contributed more than just science to the human future."

The importance of definitions in science

As science advances, definitions of phenomena or entities change in order to incorporate new research findings. Examples of how evolution of knowledge becomes encapsulated in improved scientific definitions are given by Gest (2001). Because the term "astrobiology" has become a vague and misleading buzzword with grandiose aspirations, I suggest that it should be abandoned and replaced with the older word "exobiology," with the simple provisional definition: "the search for extraterrestrial life." If valid evidence for past microbial life on Mars (or other celestial bodies) is ever found, the word "astrobiology" can be resurrected and redefined. There is plenty of time.

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