LETTERS

Martian life?

Are the "very small" objects found on a Martian meteorite too small to be living organisms? (Right, a tube-like structural form 0.5 micrometers long.) If traces of earlier life on that planet have really been found, then what are some of the implications for theories about the origins of life? On other matters, progress in the use of insect-resistant transgenic plants is assessed. And research on how the human immunodeficiency virus fuses to the cell is discussed.


NASA

Past Life on Mars?

Richard A. Kerr's News article about possible traces of life found on a Martian meteorite (16 Aug., p. 864) focuses primarily on the validity of the evidence. Less is said about the implications. If life existed or exists on Mars, four possibilities are raised for its origin: (i) life arose first on Earth, then was transported (presumably by a meteorite) to Mars: (ii) life arose first on Mars, then was transported to Earth; (iii) life arose first elsewhere, then was transported to both Earth and Mars; or (iv) life arose independently on Earth and Mars. From a materials-transport perspective, a Martian origin is more likely than an Earth origin because Mars is a more efficient source and Earth is a more efficient sink of planet-to-planet material. Because of the weaker gravitational field of Mars, major Martian impacts are more efficient than their Earth counterparts at propelling intact debris out of the planet's gravitational hold. Earth's stronger gravitational field—and its smaller orbit, which places it in a higher concentration of meteoric material—makes Earth more effective than Mars at sweeping up interplanetary debris. If life arose on only one of the two planets and was transported to the other, then that would be extreme evidence of the ability of organisms to live in harsh circumstances (such as on a rock bombarded by ultraviolet radiation and cosmic rays as it hurtles for thousands of years through the interplanetary vacuum). If life was transported to both planets or arose independently on both planets, then that suggests that life is ubiquitous and will occur or arise wherever conditions are slightly hospitable. Given that life on Earth thrives kilometers deep in the ocean's sea vents at hundreds of times atmospheric pressure living off hydrogen sulfides and that life thrives in boiling hot springs and far below the surface in Earth's crust, the ubiquity of life in the universe should not be surprising.

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The Research Article "Search for past life on Mars: Possible relic biogenic activity in Martian meteorite ALH84001" (16 Aug., p. 924) by D. S. McKay *et al.* presents two viewpoints that require comment.

First is the assumption that single-domain magnetite found on the meteorite is biological in origin. Particles of magnetite are characteristic of some bacteria on Earth (such as *Aquaspirillum magnetotacticum*), where the strong magnetic field invites a navigational role for permanent magnets (*1*). An ecological role for magnetite in the weak magnetic field of Mars is less persuasive.

Second, the suggestion that very small objects found on the meteorite might be cellular fossils must take into account a lower size limit for living cells imposed by atomicity (*2*). To suggest that objects on the order of 10^{-22} steres (10^{-22} cubic meters) could be cellular requires that all of the necessary biological functions of a cell could be carried out by an "organism" with less than 100 million atoms. Such an "organism" would be two orders of magnitude smaller than the smallest known one-celled organisms on Earth, mycoplasma.

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References

1. R. Blakemore, *Science* **190**, 377 (1975).
2. H. J. Morowitz, *Beginnings of Cellular Life* (Yale Univ. Press, Hew Haven, CT, 1992), p. 60.

The News article by Kerr notes that "At 20 to 100 nanometers in length, the objects [found on the meteorite with the use of an electron microscope] are 100 times smaller than the smallest microfossils of ancient bacteria ever found on Earth . . ." However, the bacterium *Coxiella* (a small, gram-negative pathogen) may be as small as 200 by 400 nanometers (0.2 by 0.4 micrometers), which would be closer to a five-fold difference in size. Thus, it is conceivable that bacteria could have evolved on Mars that were even smaller, that is, within the range of the objects found.

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Response: Single-domain magnetite can be produced external to the cell by dissimilatory Fe^{+3} reducing bacteria (*1*). Such magnetite is apparently not used by these bacteria for navigational purposes. We cannot tell whether the magnetite that was found in the meteorite (*2*) best fits a dissimilatory or assimilatory model, assuming that it was biogenetically produced. Even if this magnetite was internally produced by bacteria on Mars, a "navigational role" for it cannot be ruled out. Little is known about the past magnetic field of Mars; the field could have been much stronger during the period when volcanism was active on the planet.

We know of no widely accepted theoretical minimum size for bacteria, although we agree that one may exist on the basis of the number of molecules within a cell. Forms interpreted as fossilized nanobacteria ranging from 30 nanometers to 200 nanometers have recently been reported in terrestrial copper ores (*3*). This size range is similar to the ones described in the article (*2*). As microscope technologies improve (with, for example, sealed emission gun scanning electron microscopes), smaller and smaller bacteria may be discovered. Finally, conditions on Mars may have favored the evolution of very small microorganisms as compared with typical terrestrial ones.

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References and Notes

1. D. R. Loveley, *Microbiol. Rev.* **55**, 259 (1991).
2. D. S. McKay *et al.*, *Science* **273**, 924 (1996).
3. R. H. Sillitoe, R. L. Folk, N. Saric, *ibid.* **272**, 1153 (1996).
4. Readers can visit the WWW site of the Earth Science and Solar System Exploration Division of Johnson Space Center at http://www-sn.jsc.nasa.gov/

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Important Credit

The Research News article "Getting familiar with the top quark" by James Glanz (23 Aug., p. 1046) does a good job of explaining the