Comets and the Origin of Life by Janaki Wickramasinghe, Chandra Wickramasinghe, and William Napier. New Jersey/London: World Scientific, 2010. 232 pp. $70 (hardcover, 2009). ISBN 9789812566355.

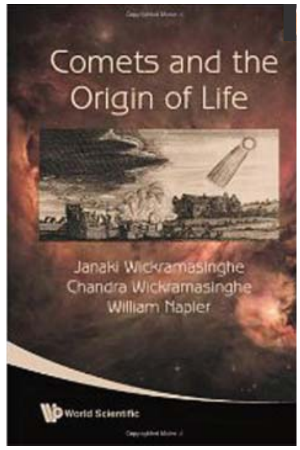
This volume is the latest in a series of books and articles stretching back more than three decades on a theme quite startling in its claims and implications: that terrestrial life did not originate on Earth but arrived in the form of cells or bacteria from outer space. The idea of "panspermia," that the seeds of life are spread from planet to planet, dates to the 19th century with the ideas of Lord Kelvin. It was championed by the Swedish physicist, chemist, and Nobelist Svante Arrhenius at the beginning of the 20th century. Once scientists recognized the difficulties of life surviving in the conditions of interplanetary and interstellar space, by the 1960s a neo-panspermia became popular: not life itself, but prebiotic chemicals were the new seeds of life, made more likely by the discovery of numerous complex organic molecules in meteorites, comets, and interstellar molecular clouds. But the difficulties of synthesizing anything more complicated than amino acids in the wake of the famous Miller-Urey experiment in 1953 kept alive the idea that life itself may be spread throughout the universe.

At the center of this work is Chandra Wickramasinghe, a research student of the maverick astronomer Fred Hoyle. In 1962 Hoyle became interested in the origin and nature of interstellar dust, in particular as found in dense molecular clouds, and he and Wickramasinghe set to work on the problem. They became convinced that dust could not form inside molecular clouds, but must have originated in the atmospheres of cool stars, protoplanetary discs, or supernova ejecta, a theory now widely accepted. It was the next steps that became increasingly controversial: that the spectroscopic signature of dust was best explained by complex biomolecules such as cellulose; that biomolecules were assembled into still more complex forms inside comets; and that the living cells and bacteria generated there were responsible for the origin of life on Earth. And not only that: Hoyle and Wickramasinghe argued that the delivery of bacteria from space continues, affecting both the origin and the ongoing evolution of life, and may even be responsible for certain diseases on Earth. These theories were not only reported in reputable scientific journals such as *Nature*, but also in popular books including *Lifecloud* (1978), *Diseases from Space* (1979), and *Evolution from Space* (1981). Biologists were not impressed; Lynn Margulis, not known for the timidity of her own theories such as endosymbiosis, called the first book "wanton, amusing, promiscuous fiction."

The current volume, based on a Ph.D. thesis at Cardiff University completed in 2007 under the supervision of William Napier, does not go so far as the disease claim, but limits itself to the latest evidence for what we might call the "microbial life panspermia hypothesis," whereby life itself is spread throughout the universe via comets. The germ of the hypothesis originates with, and is given initial credence by, two well-known facts: First, life on Earth originated shortly after the so-called "late heavy bombardment" of the planet by planetesimals about 3.8 billion years ago; and second, the Oparin–Haldane–Miller theory of the spontaneous origin of life on Earth from non-life has defied all attempts at laboratory synthesis beyond the amino acid stage—a long way from life. In the view of the authors, their hypothesis is proven by a variety of spectroscopic evidence. Their conclusion, that comets harbor primitive microbial life and are the agents for the distribution of life on a galactic scale, not only accounts for the origin of life on Earth, but also offers a sweeping vision of a universe full of life. It does not, of course, solve the problem of the original origin of life, but necessitates only one origin somewhere in the galaxy, or even the universe.

As with so many other questions, the validity of this sweeping theory comes down to the nature of evidence. And it is here that many critics find the argument wanting. Two examples will suffice to show the uncertainty of the arguments. In Chapter 2 on "cosmic dust and life," the authors discuss evidence supporting biological dust grain models, in other words dust grains with a possible biological provenance. In one case they describe the Stardust mission, which captured dust particles from the tail of comet Wild 2 in January 2004. The results included the detection of hetero-aromatic organic molecules rich in nitrogen and oxygen, which the authors conclude "could be a tell-tale sign of degraded material, biology being particularly rich in such structures" (p. 57). It could also be something else. In this sense the argument is reminiscent of those made for nanofossils in the Mars meteorite ALH84001: The magnetite in the Mars rock could be biogenic, but not necessarily. Most scientists have concluded that even with three other independent lines of evidence, it is unlikely that the rock bears evidence of past life on Mars.

In a second argument the authors discuss the capture of stratospheric dust in the Earth's atmosphere via U2 aircraft, and compare a carbonaceous structure in one of the particles to a 2-million-year-old microbial fossil found in the Gunflint cherts of Minnesota, concluding that "in view of the striking similarity seen between the two images . . . the most reasonable explanation might be that the particle . . . was a partially degraded iron-oxidising bacterium" (p. 60). The possibility of contamination aside, the words "might be" hang heavily over the claim; the particle might just as easily be something else. Such morphological arguments have a long



history of controversy, ranging from the Claus–Nagy controversy in the 1960s over "organized elements" in meteorites (still alive today in the claims of Richard Hoover et al.), to the Brasier–Schopf controversy over the 3.45-billion-year-old microfossils of the Apex chert formation in western Australia. Schopf (one of the main skeptics when the Mars rock nanofossils were announced in 1996) claimed certain structures in this formation as evidence for the oldest fossils on Earth; in 2001 Brasier and his colleagues argued that they might not be fossils at all but deposits of graphite or organic molecules produced abiotically. Many scientists now prefer the latter interpretation.

The authors also must argue for the origin of life inside comets, and for the viability of microbes under extreme conditions for long periods needed for panspermia to be effective. They reason that molecular clouds and comets can shield any interior microorganisms from ultraviolet radiation. Ionising radiation is more damaging, but they argue that only a minute number of microbes would have to survive for cometary panspermia to work. Moreover, extremophiles on Earth increasingly demonstrate how rugged life can be.

Neither biologists nor astronomers have been impressed with the Hoyle–Wichramasinghe arguments over the last 30 years, and they are unlikely to be convinced by the new evidence presented here. Molecular biologists consider the gap between non-life and bacteria to be very large even under the relatively stable conditions of Earth, reasoning that it is even less likely that it could have happened spontaneously inside comets or molecular clouds. For their part, astronomers have not been convinced by the spectroscopic evidence. While the reader will learn a great deal about comets, interstellar dust, and molecular clouds in this volume, and while the authors may be correct in their panspermic conclusions, their less-than extraordinary evidence has not convinced the scientific community of their extraordinary claims. As Carl Sagan reminded us in another of his pithy quotes, "what is called for is an exquisite balance between two conflicting needs: the most skeptical scrutiny of all hypotheses that are served up to us and at the same time a great openness to new ideas." At stake here, as in so many other areas, is maintaining that balance.

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