Where is everybody? Some new answers

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Are We Alone? The Possibility of Extraterrestrial Civilizations. By Robert T. Rood and James S. Trefil. Pp.262. ISBN 0-684-16826-X. (Charles Scribner's Sons: 1981.) $14.95.

Is the origin of life so extraordinarily improbable an event that it has occurred but once in the history of our galaxy, or do star-systems other than our own teem with intelligent life, able to communicate with us? Surely this question, raised almost 40 years ago by Enrico Fermi, is one of the most profound that we can imagine.

In an engaging and readable book, Rood and Trefil outline an emerging modern view of the answer. Their style is informal and unpretentious, and the level is suitable for interested non-scientists, but they offer tid-bits of detail for specialists. Given the provocative and necessarily speculative nature of their subject-matter, it seems a happy choice on their part, as well as an honest one, that they include a chapter listing their own divergences of opinion and the arguments made on either side of the issues.

They begin with the seminal paper, "Searching for Interstellar Communications", by Giuseppe Cocconi and Philip Morrison, which appeared in *Nature* in 1959 (**184**, 844–846). There the authors pointed out that sensitive radio receivers could detect signals from transmitters of moderate power over interstellar distances. Frank Drake, already thinking along similar lines, was further stimulated by Cocconi and Morrison's paper and carried out Project Ozma, using a radiotelescope to listen for possible artificial signals emitted from the nearby, solar-type Tau Ceti and Epsilon Eridani systems. Although no recognizably artificial interstellar signals were ever detected, then or in searches over the succeeding decades, there grew in the early 1960s something of a consensus among those scientists interested in the question. It was based on the assumptions they made of probabilities: that a star will have planets, that life will develop on one such planet, that it will develop technological expertise and that a culture capable of communication will survive long enough to be heard. Those probabilities and a few other factors, simply multiplied together, form what is variously called the Sagan–Drake, the Drake or the Green Bank Equation. Rood and Trefil choose the last version, as a memorial to the first scientific conference (1961) on interstellar communication. The participants at the Green Bank conference concluded that intelligent life was abundant in our galaxy, that physical space-travel over interstellar distances would be forever impractical and that communication could occur only by radio transmissions; the only problem was to find the right frequency and the signal code.

One definite signal, unmistakably intelligent and extraterrestrial, could end the argument at any time, but until that happens everyone can speculate. Most of *Are We Alone?* is devoted to the fascinating skein of logic woven over the past ten years by a younger generation of scientists, who have reached a fairly general agreement among themselves that the Green Bank participants were both too sanguine on their probabilities and too short-sighted on technical progress. In the modern view, life is a far more unlikely phenomenon than had once been thought, and there is a strong possibility that it is unique to our planet.

Michael Hart stimulated much of the new research on the Fermi question, and the authors discuss Hart's work in considerable detail. Dr Hart, now at Trinity College in Texas, set up a mathematical model of the Earth's atmosphere, and in 1978 traced the evolution of that atmosphere by computer over geological time, from its formation by volcano emissions to its complete transformation through biochemical processes once life had formed. Hart found that the survival and evolution of life depended on an extraordinarily lucky series of accidents, by which the temperature of the Earth remained remarkably constant for most of the age of our planet. Had we not been so fortunate as to be located at precisely the right distance from the Sun, within margins of no more than one or two per cent, Earth would now be as lifeless as Mars or Venus, according to Hart's calculations.

The young revolutionaries further conclude that their elders were badly misled by (in my phrase) "temporal chauvinism", a lack of appreciation of the probable development of technology beyond our era. If there is a civilization more advanced than our own, it will be ahead not just by decades but by millenia — and with technology to match. The authors conclude that the modern concept of space colonies, not published until more than a decade after the Green Bank conference, logically confounds many of the assumptions made at the time. Space colonies, they estimate, are certainly feasible technically, do not require a particularly high level of technology, and have such extraordinarily high survival value for any civilization reaching its nuclear age that they will inevitably be developed by any long-lived civilization capable of interstellar radio communication. Given the certainty of space colonies, virtually every star-system is a hospitable target for colonization by any species, no matter what its point of origin or requirements of temperature, gravity and atmosphere.

The development of space colonies therefore means, in the opinion of the young scientists of the modern school, that physical interstellar travel, first by robot probes and then by living colonists, is a natural and not particularly difficult stage in the development of any intelligent civilization. That conclusion is made quantitative by computer simulations carried out by Eric M. Jones at the Los Alamos Scientific Laboratory. Dr Jones comes to a single conclusion, remarkably insensitive to assumptions about ship speeds, the gestation time for a civilization around a star before it spawns colonies to move on to other stars, and other variables. He finds that the spread of a civilization outward across the entire galaxy takes no more than at most a few thousandths of the galactic age — that is, the expansion is explosive. My own calculations confirm that conclusion, and suggest an even shorter expansion time, less than one ten-thousandth of the galactic age. I argue that the outward movement of self-replicating robot probes is more certain than that of life, but Jones may well be right in his assertion that, in our own case, "The human migrants will not be far behind the probes".

In the view of the young revolutionaries, based on that chain of logic, if there had ever been an intelligent race prior to our own its descendants would be here already. And as we seem to have evolved locally, we are not they. Hence, there's a strong probability that we are in fact alone in our galaxy. It is thought-provoking that Enrico Fermi, by his famous question "Where is everybody?" appears to have arrived at the same conclusion 40 years earlier. □

The opening lines of the seminal paper by Cocconi and Morrison (1959) which stimulated others to listen for signals from space.

No theories yet exist which enable a reliable estimate of the probabilities of (1) planet formation; (2) origin of life; (3) evolution of societies possessing advanced scientific capabilities. In the absence of such theories, our environment suggests that stars of the main sequence with a lifetime of many billions of years can possess planets, that of a small set of such planets two (Earth and very probably Mars) support life, that life on one such planet includes a society recently capable of considerable scientific investigation. The lifetime of such societies is not known; but it seems unwarranted to deny that among such societies some might maintain themselves for times very long compared to the time of human history, perhaps for times comparable with geological time. It follows, then, that near some star rather like the Sun there are civilizations with scientific interests and with technical possibilities much greater than those now available to us.

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