BOOK REVIEWS

Calling All Stars

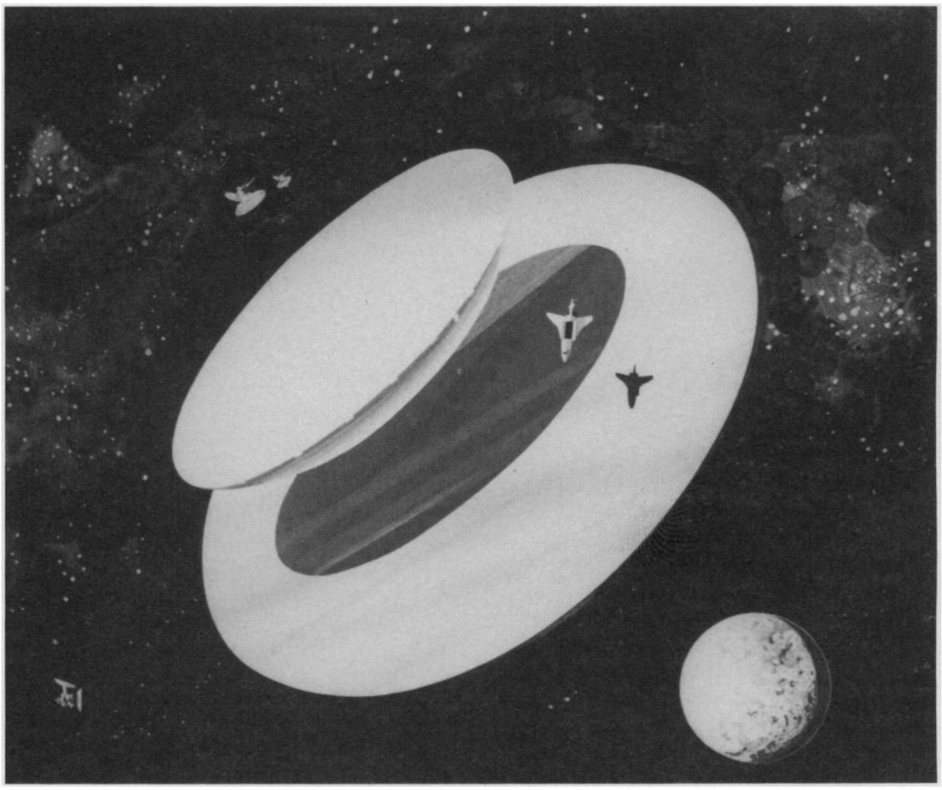
Is Anyone Out There? The Scientific Search for Extraterrestrial Intelligence. FRANK DRAKE and DAVA SOBEL. Delacorte, New York, 1992. xvi, 272 pp., illus., + plates. $22.

There is an impressive literary tradition of conjecture about the existence of other worlds, as instanced by Lucretius writing on the nature of things in the first century B.C.:

> The universe is infinitely wide.
> Its vastness holds innumerable atoms. . . .
> So it must be unthinkable that
> Our sky and our round world are precious and unique. . . .
> Out beyond our world there are, elsewhere,
> Other assemblages of matter making other worlds.
> Ours is not the only one in air's embrace.

Frank Drake unobtrusively alerts us to this thread of opinion by placing at the heads of the chapters of this book of which he is the principal author a series of epigraphs spanning the centuries from Greek times to the present. "By the late 1970s," according to Drake, "perhaps 90 percent of the scientific community shared a belief in the existence of life on other planets of the Galaxy"; he reports that recently when Cable News Network asked viewers to call in their answers to the question "Do you think there is intelligent life in space?" 86 percent of the callers said "yes." Consequently this book does not aim to persuade. Nevertheless, a firm rebuttal is provided for the 1978 Golden Fleece Award, Senator Proxmire's "own flashy way of bashing research projects and gaining publicity," directed at the effort to locate such life. NASA funding was set back a year or two by this attack, and in 1981 Proxmire successfully proposed an amendment to the appropriations bill stipulating that "none of these funds shall be used to support the definition and development of techniques to analyze extraterrestrial radio signals for patterns that may be generated by intelligent sources." Today, however, the Search for Extraterrestrial Intelligence (SETI) is alive and well at NASA, with a Targeted Search under way at Ames Research Center and a Sky Survey at the Jet Propulsion Laboratory. Despite several dozen searches already made in many countries, only a minute fraction of the search space has been scanned, and that only briefly; but the NASA-Ames initiative will generate a prodigious flow of data from 28 million channels simultaneously, amounting to millions of megabytes daily and creating the sort of technology challenge that NASA likes. Sophisticated software will peruse the incoming data stream for signs of intelligence, and Drake is clearly hopeful that success will crown the effort in his lifetime. However, long experience with negative results has taught that SETI programs need dual objectives so that positive astronomical results will sustain the attention of the investigator. Transportable equipment that can ride piggyback on a radiotelescope engaged in a normal program has been found effective and offers a means of maintaining a search into future decades in the event that contact does not occur as soon as one might hope.

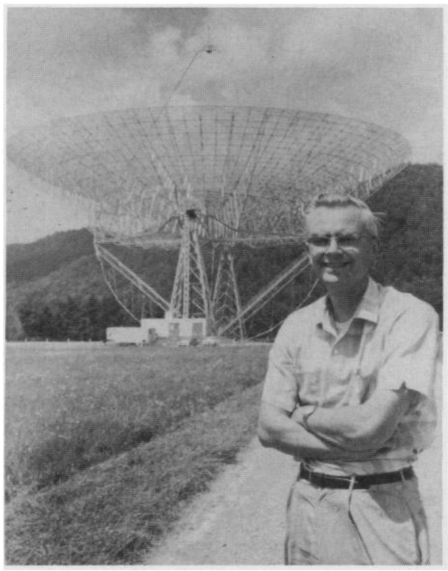
Since 1960, when Drake conducted Project Ozma, which scrutinized τ Ceti and ϵ Eridani for emission on the hydrogen-line frequency, much enthusiasm and many publications have been generated, going well beyond the simple assertions of belief in extraterrestrial life made in earlier times. The modern literature is characterized by adherence to the laws of physics and by our vastly extended familiarity with the physical universe. Drake's book, which is largely autobiographical, presents this excitement through the eyes of a principal participant. The book is not hard reading and would be enjoyed by many a high school student, especially for the bits of astronomy, physics, and engineering that are slipped in as needed, in very clear prose. How to code a message so that it is intelligible to someone who does not know your language or where you are is explained very nicely in an anecdotal context of exchanges of cryptic binary strings between Drake and Barney Oliver. The principle of transmitting a 551-bit message in the expectation that the recipient would hit upon presenting it as a raster-scanned picture of size 19 by 29 is rather beautiful, though in these



"Space-based SETI systems would surpass most earthbound telescopes because they could receive radio frequencies that are blocked by Earth's atmosphere. Here is Arecibo in space—a one-thousand-foot antenna with a huge shield guarding it from Earth-generated radio interference. You can see the space shuttle nearby, its cargo bay open and its shadow falling on the shield. Two feeds, which are free-flying spacecraft, hover just above the dish, with a relay satellite at the lower left beaming the captured signals to Earth, bottom right." [From *Is Anybody Out There?*, NASA photograph] days of laser printers with 8,000 by 10,000 pixels per page it does seem slightly out of date to imagine a significant message from another civilization in space containing only half a kilobyte. In 30 years terrestrial computer technology has advanced so astoundingly that the problem of decoding an alien message has become much less daunting; Drake now contemplates with equanimity the prospect of receiving the whole of the Encyclopedia Galactica. Nevertheless there was a time when language seemed to be an issue; television is the answer.

Does radio afford the best medium for interstellar communication and is anyone out there? Drake's answer is yes. For the reasoned technical presentations one can refer to collections of original papers edited by A. G. W. Cameron (*Interstellar Communication*, Benjamin, 1963), C. Ponnamperuma and A. G. W. Cameron (*Interstellar Communication: Scientific Perspectives*, Houghton Mifflin, 1974), and M. H. Hart and B. Zuckerman (*Extraterrestrials: Where Are They?*, Pergamon, 1982). Other historical and biographical information can be found in D. Swift's *SETI Pioneers* (University of Arizona Press, 1990). The idea of interstellar travel by intelligent beings was debunked by E. Purcell (Cameron, p. 121) and later authors years ago (albeit with less impact than Star Trek and UFO reports). However, the immense effort entailed in achieving radio contact (as distinct from the ease of radio communication over galactic distances to a known destination on an agreed-on frequency and schedule, after contact is achieved) has attracted some attention to alternatives. Drake does not like the idea of a brain-sized interstellar probe, which has been proposed for Case II ($\leq$100 light-years to the nearest neighbor), partly because of the large retrorocket that would be needed to bring the probe into orbit in the targeted planetary system; he does not discuss the proposal (Ponnamperuma and Cameron, p. 102) for launching small, cheap, unsophisticated flybys seriatim toward the thousand likely targets of Case II.

Whether anyone is out there is a matter to be approached by programs such as SETI, rather than by weighing assertions of belief. Probably many scientists do not have a belief, pro or con, but would be interested to learn. Still, it is hard to sit on the fence, and there is clear evidence that some at least of the astronomers who have chosen to devote time to SETI have made their minds up in advance. One persuasive consideration has been Drake's Equation for the number of detectable civilizations in space, assuming a conventional view of how life arose on earth. However, persuasive arguments can be given for other scenarios (Hart and Zuckerman, p. 34), including terrestrial uniqueness. Suppose life did not originate in the warm sunlit pond imagined by Darwin but resulted from chemical evolution under stable conditions inside the earth (T. Gold, *Proc. Natl. Acad. Sci. U.S.A.* **89**, 6045 [1992]), where the influences of temperature variations, solar irradiation, and meteorite impacts in the early eons were much less drastic. The probability of such a happening occurring elsewhere can only be guessed and might be very small. On the other hand, subsurface archeobacteria such as those found within the earth down to some kilometers in depth could live, and may now be living, inside several solar-system planets and satellites whose exposed surfaces are inhospitable. If the sunlight-independent bacterial life, which is found in oil wells and which on the sea floor sustains the food chain around the hot vents, is widespread in space, then safe dispersal of life over interstellar distances by impact debris needs to be thought about. Indeed, one must also reconsider the idea of



"The three-hundred-foot telescope behind me was built on the cheap at Green Bank [National Radio Astronomy Observatory] in 1963. It collapsed due to its faulty construction in 1989, fueling rumors that aliens had trashed it." [From *Is Anybody Out There?*]

Vignettes: Styles of Mentation

They are types observed often enough before in human affairs and I still believe that they are not entirely artificial. Applying them to scientific thinking, I should call the first the problem-solving type; minds which choose out of the world 'round them a certain piece of experience and drive through to an explanation. The probing, analytical and pragmatic minds, which at their best can reach the heights of Rutherford and Darwin . . . . In everyday affairs it is probably the commoner type of mind, and so the performances of its highest exponents seem familiar and easy to most of us . . . which means that we under-estimate them unduly on the principle that what is not mysterious cannot be profoundly admirable. The second type, the abstracting mind . . . gets perhaps more than its share of admiration just because it is difficult for most of us to argue with, speaking as it does a different mental language from our own. These minds do not drive through a portion of experience; they wait for experience to make itself into shapes in their minds, they assimilate and correlate, find resemblances in different things, differences in similar things. At their best, in Faraday [or] Einstein . . . , they are the great generalizers; at their worst they are infantilely fantastic and removed from all reality.

C. P. *Snow*, in *The Search* (1958), as quoted by John de la Mothe in C. P. *Snow and the Struggle of Modernity* (University of Texas Press)

Should the scientist be monological or multilogical? Should the scientist be reductionist or holist? Should the scientist be inductivist or deductivist: lateralist or verticalist? In a word: *Yes.* As a thinking person, the scientist needs to be able to draw on all of these thinking skills, or risk being little more than a technician with a lab coat. Perhaps the best metaphor is the zoom lenses used on cameras. You need a Zoom Mind that can change focal length from wide angle to long distance with, of course, a high degree of close-up macro capability (and equipped with special filters for discerning intellectual traps).

—*Joseph J. Carr*, in *The Art of Science: A Practical Guide to Experiments, Observations, and Handling Data* (HighText Publications) panspermia, which seemed doomed before the possibility of transport of organic material within comets offered a shield against sterilizing interstellar radiation.

There are some rich alternatives open in the mystery of the origin of life. SETI is a program taking action on this matter of deep interest to human beings.

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High-Pressure Physics

Frontiers of High-Pressure Research. HANS D. HOCHHEIMER and RICHARD D. ETTERS, Eds. Plenum, New York, 1992. xii, 497 pp., illus. $125. NATO Advanced Science Institutes Series B, vol. 286. From a workshop, Fort Collins, CO, July 1991.

Pressure is an important thermodynamic parameter that can be used to squeeze information from biological, chemical, geological, or physical systems. As such, it is similar in importance to temperature or electric and magnetic fields. The main advantage of high pressure is that it provides a way of changing density and interatomic distances over a wide range. This is of great use for studying the behavior of organisms of the deep sea, investigating chemical reaction rates in liquids and solids, understanding the interior of the earth, or testing theories of condensed matter, to name just a few applications.

The potential of pressure for such purposes is becoming more widely recognized. This is not surprising, since, for example, the handling of a diamond anvil cell, the workhorse of the modern high-pressure laboratory, is so simple that an undergraduate can easily use it. Also, high-pressure experiments can be combined with a wide range of techniques to cover the other parameters mentioned above and make the phenomena of interest accessible to a wide range of probes. Furthermore, high pressure provides ways of synthesizing materials that are unattainable with other techniques. Though there are some instances when high-pressure experiments seem to be done just for the sake of the pressure itself, most high-pressure papers are published in journals of general scope, which is a favorable situation, since it indicates that high-pressure scientists are involved in problems of broad interest and draws the attention of others to the use of high pressure. At the same time journals and meetings devoted especially to high-pressure studies offer the opportunity to exchange technical tricks or hear about subjects one might otherwise ignore.

The publication of *Frontiers of High-Pressure Research* should provide a stimulus for further interaction among fields. As the editors write in the introduction, the workshop of which it is the proceedings was motivated by the role of high-pressure experiments in the discovery of high-T_c superconductors, in the tailoring of materials for optoelectronic devices, in advances toward producing metallic hydrogen, and in polymer research. This is an interesting mix of fundamental and applied subjects of physics, although it may disappoint biologists, chemists, and geophysicists who might be attracted by the broad title. Unfortunately, the meeting was a little too early to capture the excitement over fullerenes.

The workshop was also intended as a forum for young scientists, and this goal was achieved, judging from the editors' report and the authorship of the papers. It is a good sign that in addition to familiar names in high-pressure physics, many other researchers were present. However, the number of theoretical papers is unfortunately low, especially compared to the contents of a meeting held in 1981 to which the editors compare this more recent one. Nevertheless, the experimental papers in the volume illustrate to an outsider the wide range of techniques applicable under different thermodynamic conditions at high pressure, among them NMR, resistivity measurements, AC susceptibility, and Mössbauer, Brillouin, Raman, photoluminescence, and nonlinear optical spectroscopy at high magnetic field and at low or high temperatures.

The contents have been subdivided according to four subjects: polymers and low-dimensional systems, molecular systems, quantum wells and semiconductors, and high-T_c superconductors. At the end of each section, the highlights of roundtable discussions are presented. Two papers in the volume are particularly outstanding.

A description of the behavior of organic metals is given by I. Marsden *et al.* They start out with an overview of the organometallic molecules and proceed by giving a simple explanation of Peierls distortions and charge- and spin-density waves. Subsequently, they describe the high-pressure behavior of $Cs[Pd(dmit)_2]_2$. This substance shows a metal-insulator transition at low temperature, but with increasing pressure the conductivity of the low-temperature phase increases, maybe owing to a transition to a semimetallic phase. Even though the insulating phase does not seem to be a simple Peierls distortion of the metallic phase, the experimental results provide a clear illustration of the theoretical points discussed in the introduction of this paper.

N. W. Ashcroft discusses the influence of ordering on the stability of the phases of hydrogen in the megabar pressure regime, where metallization and dissociation are expected. It is explained in a didactic way that orientation of the protons is important, since neither a Mott model with fixed protons on a Bravais lattice nor a uniform proton distribution gives very realistic metallization pressures. But this is a formidable complication, since it is quite possible that the molecules could have fixed but random orientations. Ashcroft discusses the highly interesting possibility that in the state where band overlap occurs (and this is predicted to happen for spherically averaged configurations), the randomness could preclude the diffusion of electrons, or, in other words, Anderson localization. This in turn would prevent the observation of a Drude absorption or reflectivity edge, which is one of the most important experimental probes.

The roundtable discussions should certainly be of interest to a broad audience, since the panel members give brief overviews of their work and discuss future directions. The discussions of molecular solids and superconductors are especially enjoyable, since the chairmen have managed to clearly abstract the lively discussions. The discussion sections are probably useful reading before one makes a selection of papers to read.

I would recommend *Frontiers of High-Pressure Research* for the overview it gives of an exciting field of condensed matter science. The description of interesting and new techniques is important for specialists, and most of the papers are clear enough, apart from some jargon, that graduate students should be able to understand them.

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Other Books of Interest

Muscular Contraction. ROBERT M. SIMMONS, Ed. Cambridge University Press, New York, 1992. xii, 299 pp., illus. $69.95. Based on a meeting, Cambridge, U.K., June 1989.

By the time Andrew Huxley was awarded the Nobel Prize for his work on nerve conduction his research interests had turned to muscle contraction, and when his associates undertook to honor him at a conference in 1989, that was the subject he