SETI: SHOULD EARTHLINGS TACKLE IT?

A comment on Frank Tipler's review (December 1987, page 92) of *The Search for Extraterrestrial Life: Recent Developments*, edited by Michael D. Papagiannis. Does bioastronomy resemble parapsychology, as Tipler contends? Is it fair to conclude that bioastronomy should not remain in the International Astronomical Union? I say no to both questions.

This issue of membership in the IAU could be considered in light of a comparison of the so-far-fruitless search for extraterrestrial intelligence with the so-far-fruitless search for gravitational radiation from astronomical objects. In both cases, detectors are constantly being improved. Gravitational radiation is firmly predicted to occur by a well-founded physical theory if the numerical values of astronomical parameters fall in a certain range. Although the physics of ETI signal processing and transmission is well founded, the astronomical parameters that would guarantee generation of such signals are far less certain than are those for gravitational radiation. This makes searching for ETI a much more risky enterprise than searching for gravitational radiation, but astronomers believe that the rewards of contact would have an even wider impact on science in general.

Such considerations led the National Academy of Sciences–National Research Council Astronomy Science Committee, which I led from 1978 to 1982, to "recommend an astronomical Search for Extraterrestrial Intelligence (SETI), supported at a modest level, undertaken as a long-term effort rather than as a short-term project, and open to the participation of the general scientific community."[1] I believe it is too early to give up the search on the basis of the negative evidence so far.

Reference

1. Astronomy Survey Committee, National Academy of Sciences and National Research Council, *Astronomy and Astrophysics for the 1980s*, vol. 1, Natl. Acad. P., Washington, D. C. (1982), p. 150.

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2/88

In response to Frank Tipler's review of *The Search for Extraterrestrial Life*: We know that, at one location in the universe, carbon atoms form compounds of sufficient complexity to allow intelligence. And if that phenomenon exists in one place, it is at least conceivable that it may exist elsewhere, so the proper scientific procedure is to look for it.

We are faced with two hypotheses: Intelligent life exists only here; or it exists elsewhere. Either one may be true, but the first can never be proven; the second can at least be tested. So far, we have examined far less than 1 percent of the most likely portion of the electromagnetic spectrum's multidimensional search space (of direction, frequency, polarization and so on). If, after searching more than 50 percent of this space at reasonable sensitivity, we still have no evidence for the existence of others, then perhaps we should begin to take seriously the idea that intelligent life is rare.

Let's not be like Galileo's colleagues, who refused to look into his telescope because they were certain that Venus couldn't have phases, Jupiter couldn't have moons, and the Sun couldn't have spots.

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1/88

In Frank Tipler's review, he embraces Brandon Carter's interpretation of the "weak" anthropic principle to support his view that extraterrestrial intelligence does not exist and that the search for ETI should be abandoned. However, his reasoning is no clearer than that of Carter himself (in *Philos. Trans. R. Soc. London, Ser. A*

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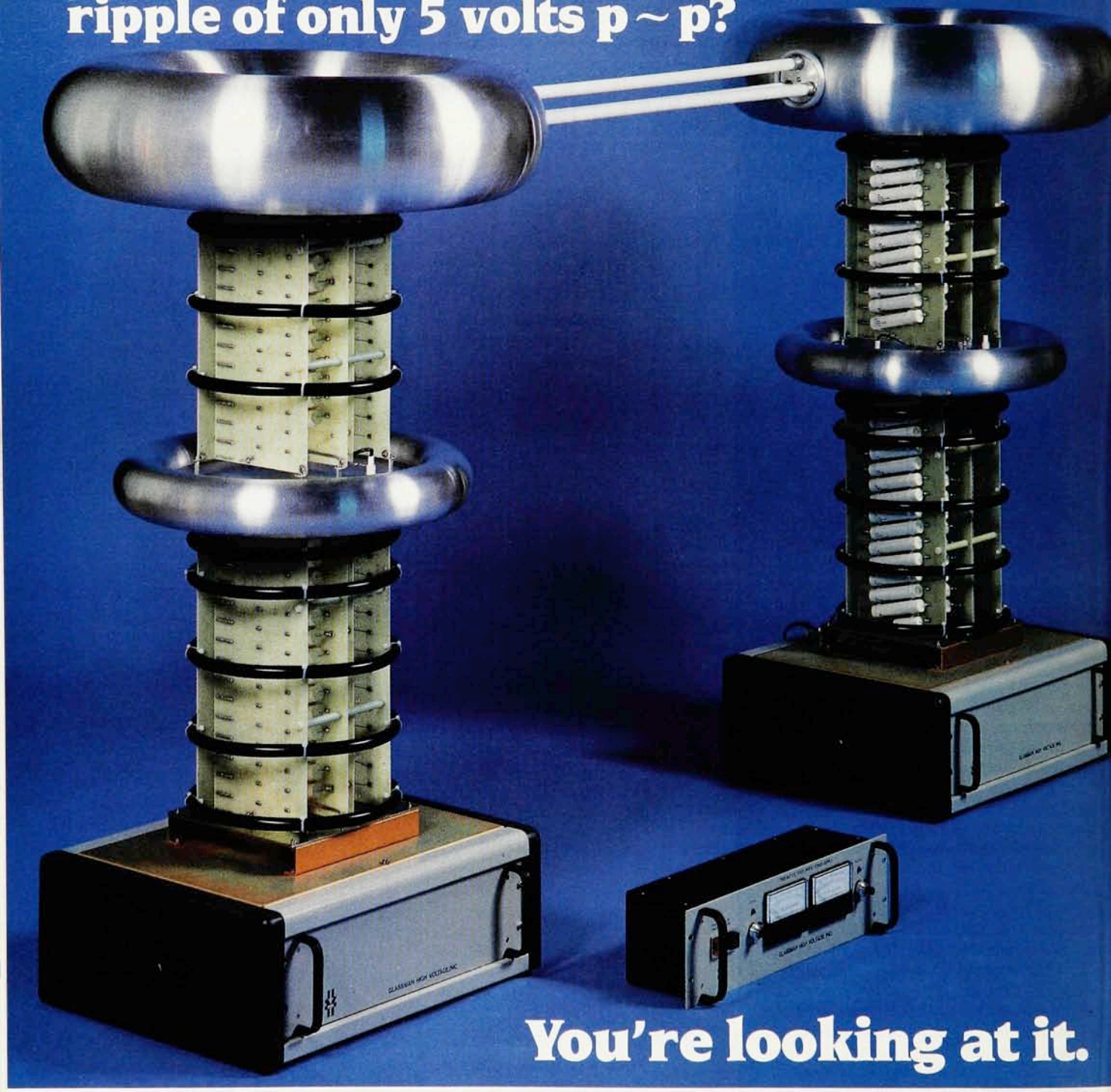

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310, 347, 1983). A summary is as follows:

▷ The time it took for intelligent life to evolve on Earth is about half the main-sequence lifetime of the Sun; that is, they are of the same order of magnitude.

▷ The former time scale, being biological, should be expected to be of a quite different order of magnitude from an astrophysical time scale.

▷ Therefore the time needed for an Earth-like planet to evolve ETI is *much longer* than the main-sequence lifetime of a G2 star! Therefore intelligent life on Earth is a fluke.

The reader might be puzzled as to why the third point should follow from the first and the second, or why the second should necessarily be the expectation. He or she may consider the above a good example of highly biased, or forced, reasoning by a non-ETI-believer. It may be contrasted with the logical view that a spectrum of ETI evolution times around 4.5×10^9 years is to be expected, ranging from perhaps 1×10^9 to 12×10^9 years. This view is supported by the fact that the first life on Earth was initiated relatively quickly, after only some 7 percent of a G2 star's lifetime. Espousal of a weak anthropic principle does not mean that relevant information like this must be ignored.

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12/87

The book review by Frank Tipler is actually a list of Tipler's objections to a search for extraterrestrial intelligence.

First, says Tipler, he would have emphasized "Brandon Carter's new 'weak' anthropic principle argument for the nonexistence of ETI," which is of "revolutionary significance." Carter's lengthy treatise (*Philos. Trans. R. Soc. London, Ser. A* **310**, 347, 1983) points out that "biological theorists run the risk of error in the interpretation of the evolutionary record unless they take due heed of the astrophysical restraints under which evolution took place." This seems self-evident. Carter, an astrophysicist, then presents "a new application" of "the ordinary ('weak') anthropic principle to the problem of the evolution of terrestrial life," showing evidence suggesting that the evolutionary chain included at least one but probably not more than two links that were highly improbable in the available time interval. Examples of such steps are the original establishment of the genetic code and the final breakthrough in cerebral development. Carter's final message is that "one should steer a moderate course between the Scylla of anthropomorphism and the Charybdis of unjustifiable neglect of anthropic selection effects."

Tipler writes that "Carter observes that the time it took to evolve intelligence on Earth is within a factor of two of the main-sequence lifetime of the Sun," which is well known. Tipler than says, "Now, the former is a biological time scale, and *a priori* we would expect it to be quite different from the latter, which is an astrophysical time scale." There is no basis for Tipler's assumption. Both time scales embrace events that are measured in minutes or days—the explosion of a supernova, the rhythm of a Cepheid variable, the budding of a yeast cell, the pregnancy of a mouse—and also events that span eons—the formation of a galaxy or a planetary system, the evolution of hemoglobin or thymidylate synthase. Sadly, he fails to perceive that the story of our planet is a commingling and succession of various forms of evolution: astrophysical, planetary and geological evolution, the existence of the hadean Earth, followed by slow cooling, great rains, boiling oceans, the early atmosphere, the beginnings of life and its protracted march through billions of years of increasing complexity. This was what Charles Darwin, building on James Hutton and Charles Lyell, began to see as a replacement for the old superstition of a 6000-year-old universe. Is Tipler a creationist?

Tipler then says that the "average length of time needed to evolve intelligence on an Earth-like planet is actually much longer than the main-sequence lifetime of a G2 star," so that "we would expect approximate equality between the Sun's lifetime and the time needed to evolve intelligence." But intelligence *has* evolved on the Earth, and the Sun has another 5 billion years of "lifetime." So, say the searchers for ETI, since this all has happened, it can happen again elsewhere.

The Fermi paradox is explained, apparently, by Tipler when he says that Ben Finney's "picture of Polynesian evolution is exactly what I predicted would be the behavior of colonizing ETI," namely, that various moral objections or social mechanisms would prevent interstellar travel. He then says, correctly, that "we have one extremely significant experimental result: They aren't here." But if "they" were here, we wouldn't need to search elsewhere for them! Tipler complains of the expense of SETI, and likens bioastron-

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omy to parapsychology. He says that more money is being spent on ESP research than ever before. The same is true of expenditures on most human activities. He also says that "bioastronomy resembles nothing so much as parapsychology." This is quite untrue. SETI uses scientifically sound methods in an attempt to detect radio signals. Radio waves are authentic natural phenomena. Parapsychology looks for unnatural events by dubious methods such as dowsing, spoon-bending and levitation.

George Gaylord Simpson (*Science* **143**, 769, 1964), as quoted by Tipler, was referring to exobiology, not to "bioastronomy." It is true that Simpson argued against the possibility of two-way space communication and against the possibility of extraterrestrial humanoids. Simpson said that we can "learn more about possible extraterrestrial life by studying the systematics and evolution of earthly organisms.... my plea is that we invest just a bit more of our money and manpower, say, one-tenth of that now being gambled on the expanding space program, for this sure profit." NASA's planetary biology program provides significant support for the study of evolution.

Against SETI is that its success is only remotely likely, but for SETI is that it seeks to cast light on one of the greatest challenges of the unknown: Are we alone in the universe?

THOMAS H. JUKES
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Until the December 1987 issue of PHYSICS TODAY, I did not realize that the Books department of the magazine was an approved forum for presenting late conference papers under the guise of a book review. What PHYSICS TODAY chose to publish as a review of *The Search for Extraterrestrial Life* had absolutely nothing to do with the merits or faults of the volume and, with the exception of two short direct quotes, could have been written whether or not the book itself existed!

In addition, Frank Tipler is misinformed. There is no "present NASA-funded radio search," only a SETI R&D program that is trying to develop the technology to conduct a *comprehensive* search of the available microwave spectrum, something that has never before been attempted. I for one am hopeful that NASA will receive fiscal year 1989 funding to initiate such a systematic search. Following an extended search effort, it may be necessary to interpret negative results—always a tricky business. Interpreting those results before the data are even collected is preposterous!

JILL TARTER
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TIPLER REPLIES: Both James W. Deardorff and Thomas H. Jukes seriously misunderstand Brandon Carter's argument. It involves a very subtle and ingenious use of probability theory, and I could not provide a derivation of Carter's inequality, together with a discussion of how it depends crucially on modern evolutionary theory, in a short book review. Therefore, in the review I referenced my book with John Barrow,[1] which discusses the points raised by Deardorff and Jukes at length in section 8.7. In brief: Because, as Jukes says, biological and astrophysical time scales each embrace a huge range of numbers, there is no reason to expect two numbers taken at random from each set to be equal to within a factor of 2. (Random selection is justified in my book with Barrow.) In fact, Carter shows mathematically that if intelligence were selected for from the very beginning, we would expect the evolutionary time scale to be much less than the main-sequence lifetime (details in the book). Therefore, says Carter, let us account for the approximate equality by two assumptions: first, that the time scale for evolution of intelligence is Gaussian, distributed over Earth-like planets with the peak much larger than the main-sequence lifetime and with the Earth's age lying many standard deviations away from the peak; and second—this is the crucial assumption omitted by Deardorff and misunderstood by Jukes—that there is a *least* upper bound to the length of time evolution can proceed on an Earth-like planet. One can then calculate[1] that it is *probable* (*how* probable can also be calculated[1]) that we evolved near this least upper bound. How near depends on n, the number of highly improbable links. Two important points: Carter's argument computes a *least* upper bound, while the 5 billion years of additional lifetime cited by Jukes provides merely an upper bound; and the actual remaining lifetime will be much less than this upper bound if $n \gg 2$. Carter was actually unhappy with the $n \approx 2$ value. He adopted it only because he assumed the least upper bound to equal the Sun's lifetime. But there is no real evidence for this equality.[1] The fact, emphasized by Deardorff, that life on Earth was initiated relatively quickly *may* itself be an example of weak anthropic selection: Perhaps only on those planets where life

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begins early does intelligence have time to evolve before the least upper bound. It is not known[1] if the start of life is one of the highly improbable links counted by n. Steven Weinberg has recently used essentially the same logic as that of Carter's argument to obtain an upper bound on the cosmological constant.[2]

The Fermi paradox is *not* explained by Ben Finney's contention that, in Jukes's words, "various moral objections or social mechanisms would prevent interstellar travel." I claim, on the contrary, that Finney has misinterpreted his own data, which indicate that motivation flagged only after the other three barriers (ecological, technical and opposition of those in the way) made further expansion difficult. But I pointed out in my review that those three barriers don't exist in interstellar travel. Finney's picture is exactly what I predicted[1,3] would be the behavior of colonizing ETI: An *r*-strategy, characterized by rapid expansion, would be typical of those on the frontier; while a *K*-strategy, characterized by fluctuations around an equilibrium, would be typical of those in the interior. (*K*-strategy and *r*-strategy are technical terms in evolutionary biology, and refer to the two most basic reproductive strategies a species can adopt. The *r*-strategy emphasizes *rapid* reproduction. It is used, for instance, in environments where it is crucial to exclude competitors by occupying niches as quickly as possible. The *K*-strategy, by contrast, emphasizes *quality* reproduction: fewer descendants, but more resources spent per descendant. It is used, for example, in environments where niches are already occupied by members of the same species and there is competition within the species for the occupied niches.)

The crucial point, emphasized in my review, is ignored by the above authors: *Virtually any motivation we can imagine that would lead ETI to engage in interstellar radio communication with us would also motivate them to engage in interstellar travel.* In particular, radio communication is colonization of other inhabited star systems by memes (idea complexes) from alien star systems. If one opposed on moral grounds colonization by genes (via interstellar travel), one would also oppose colonization by memes (via radio). Interstellar colonization either by genes or by memes necessarily implies biological evolution on an interstellar scale: The first intelligent species to originate will occupy all ecological niches available to it, a behavior pattern adopted by all

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species that ever existed on the Earth. If Deardorff's distribution were correct, many intelligent species would have arisen billions of years ago in our Galaxy. What have they been doing these billions of years? In the view of Jukes and Deardorff, evolution apparently stops when it reaches intelligent life; theirs is the creationist view, which envisages stasis. The most solid experimental fact we have—they aren't here—is flippantly dismissed, or repeatedly ignored.

Also explained away are the 120 000 hours of radio searches for ETI. I have, so to speak, looked through the telescope, and the ETI simply aren't there. Thomas R. McDonough's explanation is that "we have examined far less than 1 percent of the *most likely* portion . . . of the search space. . . . If, after searching . . . this space at *reasonable sensitivity*, we still have no evidence . . . then *perhaps* we should begin to take seriously the idea that intelligent life is rare" (my italics). What exactly are "most likely" and "reasonable sensitivity"? Thirty years ago we were told that the searches that have since been conducted (with negative results) met those standards. As the above letters indicate, the ETI believers are already prepared to explain away any negative results of any comprehensive search. McDonough's response to possible negative results is loaded with weasel words (for example, "perhaps"), and Jill Tarter puts it thus: "It may be necessary to *interpret* negative results—always a tricky business" (my italics). One "interpretation" I predict will be used is the "zoo hypothesis": Advanced civilizations talk only to themselves; they don't want to interfere with the cultural development of primitives like us. How does this differ from a favorite excuse of parapsychologists, that paranormal phenomena like ghosts will not manifest themselves to nonbelievers? True, contact would have a wide impact on science in general, as George Field says. But the same could be said for ESP detection. In both cases, there are good theoretical and experimental reasons for believing that the phenomena—ESP and *intelligently generated* radio signals (not merely radio signals, as Jukes claims)—don't exist.

The hallmark of a true scientific discipline is its willingness to consider criticism. When doubts were recently expressed about the validity of the quadrupole formula, the gravitational radiation researchers immediately organized debates between the believers and the critics at conferences. Why was there no debate on the likelihood of ETI evolution at the Boston conference? Only evolutionists who believed in ETI were present; disbelievers like the famous evolutionists George Gaylord Simpson and Ernst Mayr were not invited. (My Simpson quote was from *Communication with Extraterrestrial Intelligence*, C. Sagan, ed., MIT P., Cambridge, Mass., 1973, page 362. Simpson agrees with me that the current work referred to by Tarter is a waste of funds; he refused to sign the famous *Science* letter written by Sagan, which was instrumental in getting money for the current project.[4]) Why was Michael Hart not invited to debate the Fermi paradox and to criticize Finney's interpretation? I was told by a member of the conference's Scientific Organizing Committee that the committee felt debates on the question of the very existence of ETI might attract too much media attention; this would interfere with the acceptance of "bioastronomy" as a true scientific discipline. ETI critics like Simpson, Mayr, Hart and myself are not welcome at ETI conferences, just as ESP critics like James Randi are not welcome at ESP conferences. Any discipline that puts public relations ahead of getting at the truth is not a science; should a pseudoscience remain in the International Astronomical Union?

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1. J. D. Barrow, F. J. Tipler, *The Anthropic Cosmological Principle*, Oxford U. P., New York (1986).
2. S. Weinberg, Phys. Rev. Lett. **59**, 2607 (1987). See especially the first paragraph in the second column on p. 2609.
3. F. J. Tipler, Q. J. R. Astron. Soc. **21**, 267 (1980).
4. G. G. Simpson, letter to F. J. Tipler.

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How Low Will Particle Beams Go?

In the debate in PHYSICS TODAY on the APS Directed Energy Weapons Study (November 1987, page 48), Gregory Canavan, quoting an earlier publication of his, said, " 'The early Soviet and Union of Concerned Scientists reports on SDI erroneously concluded that neutral particle beams could not propagate below 200–300 km,' an observation no one challenges."

The early UCS report[1] Canavan refers to stated, "We estimate that the beam would start to become appreciably ionized at an altitude of 140 km." This issue of the extent of downward beam propagation from a space-based weapon is a crucial one for boost-phase kill, as the advent of fast-burn boosters may allow burnout to occur while the booster is still shielded by the atmosphere. A too high estimate of the altitude will unfairly bias an assessment of neutral particle beam effectiveness.

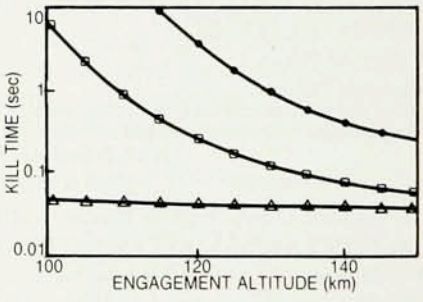
The physicists on the UCS panel that prepared the report—all members of The American Physical Society and including two former APS presidents—have learned to endure such repeated misrepresentations. My colleagues and I find it regrettable that the society itself is now being subjected to the same treatment.

Reference

1. *Space-Based Missile Defense*, Union of Concerned Scientists, Cambridge, Mass. (March 1984).

HENRY W. KENDALL
Union of Concerned Scientists
1/88 *Cambridge, Massachusetts*

CANAVAN REPLIES: The early Soviet report said neutral particle beams "are effective only at altitudes of more than 250–300 km"; the latest, "only at altitudes equal to or higher than 200–250 km."[1] Neither report was challenged, though the air densities for interaction corresponding to these altitudes differ by several orders of magnitude from the UCS's value, which in turn differs significantly from the value in reference 2.



The figure above shows penetration for typical constellations and parameters.[3] The top curve is for a constellation of 25 neutral particle beam platforms; the middle curve, for a constellation of 100; and the bottom curve, for a constellation of 100, ignoring atmospheric attenuation of the beam. Losses are small at 140 km; the time to kill electronics is 0.1 sec. Enough beam penetrates to 110 km to kill in 1 sec, so the issue debated is unaltered: Neutral particle beams can reach boost phase, in contrast to UCS statements. Buses