In my review I did not mean to imply that those who seek a broader base for the explanation of phenomena are therefore ill-advised; on the contrary I was myself suggesting that the scientific community clearly needs a broader conception of deception. But of course, I also think that anyone who tries to move away from accepted patterns of research is apt to appear ridiculous; this in itself is a fascinating aspect of the humor of science. However, there is nothing "wrong" in appearing ridiculous, just as there is nothing really "wrong" in being deceived.

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Studies of Nonrandom Groups

In his letter (21 Oct.) Walberg does not make clear that hypothesis testing in studies involving nonrandomly chosen "grab groups" is feasible. If it were not, the results of many comparative experiments in the behavioral sciences would be difficult to interpret statistically, because any differences whatsoever might be attributed to chance fluctuations. The great Sir Ronald Fisher's work on statistical inference must be supplemented by that of Wilk and Kempthorne, Cornfield and Tukey, Collier and Baker, and many other statisticians whose extensions of randomization and permutation theory Fisher himself anticipated.

Generalization of the conclusions of such an experiment to units other than those in the grab group cannot be made probabilistically, however. This generalization depends on empirical evidence, secured outside the experiment, that no characteristics of the nonrandomly obtained units interact with the treatments so that the effects would probably be different in another group.

For example, one might grab the first 100 students passing one's door, assign 50 of them randomly to one treatment and the remaining 50 to the other, and conduct a controlled experiment. Suppose the "treatments" consist of having 50 students read a short story printed in German Gothic type and the other 50 read the same story in ordinary typewriter type of the same size, one might find comprehension better for the Gothic type if the grab group consisted chiefly of students majoring in German, but better for ordinary typewriter type if one had happened upon a sight-saving class.

Thus, if the difference between the two styles depends greatly on erudition, visual acuity, or other characteristics of the experimental subjects, the particular grab group used may lead to an ungeneralizable conclusion. Note, though, that such interactions may be infrequent or small enough not to restrict greatly the generalization of conclusions about *differences* obtained from experiments conducted with nonrandomly chosen groups (*1*). On the other hand, errors in estimating group parameters (such as, in the foregoing example, the mean reading-comprehension score) from the scores of a nonrandom sample of persons subjected to only one of the treatments seem likely to be great.

For example, if the height of a student does not interact with the style of printing type, it will make no difference whether one's grab group consists chiefly of atypically tall (or short) persons if one is trying to estimate the differential effect of the two styles on reading comprehension. If, however, one wishes to estimate the average height of male students on the campus from a sample of such men, bias will occur unless the sample is representative—and drawing a sample in a probabilistic fashion is the usual way to secure representatives within the known limits of sampling fluctuations. Walberg stressed the latter point. The former needs emphasis, too.

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Reference

1. For further discussion of the internal and external validity of experiments, see D. T. Campbell and J. C. Stanley, *Experimental and Quasi-experimental Designs for Research* (Rand McNally, Chicago, 1966).

Astronomy's Crucial Requirements

If United States astronomers were asked to draw up a list of the most exciting problems today in astronomy, we would include the following: (i) the nature of quasars; (ii) the identification and interpretation of x-ray, γ-ray, and nonthermal sources and the nature of the far ultraviolet and infrared emissions from various celestial sources; (iii) the establishment of distance scales and the large-scale distribution of matter in the universe; (iv) the origin and evolution of the stars and solar system and eventually that of the stellar system itself; and (v) the solar magnetic cycle and phenomenology-solar-terrestrial relationships.

Many of these problems require observations secured from above the earth's atmosphere. Therefore we should impress upon NASA that astronomy has a greater stake in the space effort than any other science. As with radio and x-ray astronomy, we can anticipate important results when space and ground-based observations are combined. The complementarity of optical radio, rocket, and satellite observations cannot be overemphasized. Equally indispensable is the large ground-based optical telescope located at a suitable dark-sky site. These are in grievously short supply.

All of us will agree that astronomy is a unique science. One of its unique features is that as late as A.D. 1967, its most productive research tool, the 200-inch (508-centimeter) telescope was provided by private funds made available 40 years ago! The second largest instrument, the 120-inch (305-centimeter) telescope was supplied by the California taxpayers to the University of California. Some 3 years ago, the federal government, through the National Science Foundation, initiated preliminary work on a 150-inch (381-centimeter) telescope for the Kitt Peak National Observatory.

The solution of the quasar problem may be delayed because it requires extensive use of large telescope time. As for stellar evolution and cosmological problems, nature has provided us with a celestial Rosetta stone in the Magellanic Clouds. The most urgent requirement for astronomy today is a number of large instruments in the southern hemisphere. This urgency was emphasized in the Whitford report (*1*) and reemphasized in the Physics Survey committee report (*2*). Whether American scientific policy-makers also appreciate this great need is not clear. Three well-documented proposals for telescopes with apertures of 150 to 200 inches for the Southern Hemisphere have been presented to various agencies by responsible and experienced groups of United States astronomers. The most recent one included an offer of equal cost-sharing by a southern hemisphere country and involved only the very moderate expenditure of $5

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million over a period of 5 or 6 years. None of these proposals has found support.

Meanwhile, a joint project sponsored by West European countries to build a 140-inch (356-centimeter) telescope in Chile is well along, and it seems likely a 150-inch telescope in Australia will soon be started with joint British-Australian support. In the northern hemisphere the Canadians are building a 150-inch telescope in British Columbia.

Thus, it appears, the great American contribution to observational astronomy —the large reflecting telescope at an excellent mountain site—is being taken over by alert scientists in other parts of the world with support from their governments. A significant shift in leadership may result in this area of astronomy. Similarly no progress must be reported with respect to support for the plans of American radio astronomers for large paraboloids and arrays.

We can look ahead to exciting discoveries from the orbiting observatories that are to be provided by the space program. But when it comes to equally exciting follow-up—the sort of cream that went to the optical astronomers who used the radio clues to make the identifications and astounding discoveries of the quasars—we have to record with considerable sadness, especially for the younger astronomers, that when these discoveries are in the southern hemisphere (and we can guarantee that many will be made there) we may be limited to congratulating our fortunate colleagues in other lands.

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References

1. *Ground-Based Astronomy, A Ten-Year Program* (National Academy of Sciences, Washington, D.C., 1964).
2. *Physics, Survey and Outlook* (National Academy of Sciences, Washington, D.C., 1966).

Freight Train Entries

I was amused by Miller's proposal (Letters, 6 Jan.) for a "Freight Train Award," and am grateful to Peoples for the provision of a name by which this construction may be known and ridiculed. I submit a few examples which the readers of *The Physical Review* have narrowly escaped in the last 2 years:

". . . the Bloch function modulated effective mass envelope wave functions.

A distorted-wave single-particle excitation with charge exchange calculation. . . .

. . . the constant pressure heat capacity temperature maxima and minima. . . .

. . . the rare-earth local moment-free electron-like conduction electron exchange integral coupling. . . ."

The hyphens, if any, are the author's. Hyphens are generally avoided in the freight train construction except where they add significantly to the confusion.

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A Biblical Tornado

Add to the early sightings of luminous tornadoes (Letters, 6 Jan.) the report of Ezekiel (1:4):

"And I looked, and, behold, a whirlwind came out of the north, a great cloud, and a fire infolding itself, and a brightness was about it, and out of the midst thereof as the colour of amber, out of the midst of the fire."

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Write a Book!

In commenting upon Abelson's editorial (11 Nov., p. 727), van Bavel (Letters, 6 Jan.) alludes to additional ways of circumventing the editorial review process, namely, publication of "transactions" in bound form. He fails to mention, however, an even sneakier gambit employed by those who wish to present findings or theories that are repugnant to the highest arbiters of scientific thought: Write a book! The crafty entrepreneurs of commercial publishing firms are seldom disposed to seek the critical review necessary to ensure that data and interpretations are acceptable to the various editorial panels in the author's field. Choice of this medium not only permits expression of heresies, but also adds ill-gotten financial gain to the considerable number of brownie points accruing to the malefactor.

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