easily be initiated by offering prizes for answers to some such question as this: What is the best way to reform our government machinery in order to improve the relationship of science to the federal government, and, by improving that relationship, to improve the total relationship of science to our whole society?

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"The story of the Crab Nebula" [N. U. Mayall, *Science* **137**, 91 (1962)] caused me to examine my old radio maps [G. Reber, *Proc. I.R.E. (Inst. Radio Engrs.)* **1948**, 1215 (1948)]. At 480 megacycles per second the most prominent feature of the winter Milky Way corresponds with the position of M1. Apparently I encountered this object without being aware of its nature. The observations were made during 1946–47.

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Science for the Humanist

The editorial "Science and the humanities" [*Science* **138**, 1367 (1962)], commenting on James H. Mathewson's excellent article on educating the nonscientist in the nature of science [*ibid.* **138**, 1375 (1962)], exhibited a parochialism and arrogance unworthy of the pages of *Science*. The editorial says that science is difficult; therefore our educational process should be geared to the teaching of science. After that, the graduate can pick up the humanities at his leisure because "after the rigors of training in science, the subject content of the humanities seems hardly more difficult than a good novel."

Are the myriad individual and social problems of a typical blighted area of a big American city (poverty, dependence, mental health, delinquency and crime) really so easy of solution? How about the economic, social, and cultural problems of developing areas? Racial conflict? War? Ethics? Can rigorously trained scientists, after a bout of easy novel-like reading, undertake to tell us how to meet these problems?

To paraphrase the comment by Kenneth E. Boulding in a review of two works on sociology in the *Scientific American* (issue of January 1963), it is very tempting for the physical scientist to conclude that, because all of us live in a society and inevitably pick up a considerable amount of folklore about it, amateur standing is all that is necessary in that area and that, if we need to solve social problems, a few Pugwash conferences of distinguished physicists will do the trick.

What the rigorously trained scientist needs to realize—especially if he is going to speak publicly as a representative of the scientific community—is that science is not the only body of learning and technique that, in the phrase of the editorial, is standing between our civilization and "chaos and starvation." A not insignificant problem of education today is how to give the scientist an appreciation of the nature of man and society.

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Mathewson's article on science for the citizen does indeed point up many of the difficulties that beset those of us who are involved in general-education science courses.

What Mathewson does not mention is our most annoying problem: time. In the typical general-education sequence, a nonscience major is required, or urged, to take a 1-year course in the physical sciences and a 1-year course in the biological sciences. In some colleges the requirement is reduced to a semester course in each of these areas. How solid a grasp of the methodologies of science can a student acquire in this amount of academic time?

In the case of the physical sciences (the area in which I teach), what effect does this time limitation have on the criteria for selecting subject matter? Should the academic year be devoted to the study of case histories in physics alone? or in chemistry? or in geology? There is certainly enough material in each of these areas for a full-year cultural course. What effect does the background and bias of the individual teacher have on decisions about what material is "relevant" and what is not? How much mathematics ought to be (or *must* be) involved in a physical science course in order for the student to understand the part played by mathematical thinking in the development of physical ideas? Can the student understand the significance of Newtonian mechanics without working problems which involve $F = ma$? What is of more worth to the nonscience major—to know that $s = \frac{1}{2}gt^2$ or to understand the second law of thermodynamics? Or is *any* emphasis on mathematical discipline a waste of time in such courses? Would the student be better off if he read C. P. Snow and discussed the impact of science on society? At any conference on general education that I have attended, these questions have always been bounced around in random Brownian motion, but the answers are usually not satisfactory.

A secondary nuisance in a physical science course is the fact that the average student in such a course has managed to forget most of the algebra and geometry of his high school years (there must be a Freudian explanation for this). Therefore, if one attempts to use the most simple mathematical logic as a necessary part of the course, part of the course time usually has to be spent on remedial work in mathematics. In other words, the teacher finds himself spending some weeks of discussion time doing over the work of the high school mathematics teacher, while more pertinent course material has to be bypassed or rushed over. It has also been my experience that a considerable number of students in such a course enter the university ill equipped to read and understand most of the books written for the layman about science.

In my opinion, the answer to many of the questions raised by Mathewson does not lie only in the re-evaluation of general-education courses. I am in agreement with the author of the editorial when he states that much of the fault lies in the structure (or lack of it) of science teaching all the way down the educational line to kindergarten. There is now some excellent work going on in the restructuring of science teaching in the elementary and secondary schools. If these new approaches to science teaching seem to provide the kind of exposure to science we think proper for our children, then the next step involves the preparation of teachers to teach such courses. It seems to me that with the admission to the university of students better prepared to understand scientific thinking, solutions to many of the problems in the teaching of general-education science courses will become obvious.

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I take exception to, but do not completely oppose, some remarks in Mathewson's valuable article.

First, Mathewson writes, "The purpose of our schools is the development of free, capable, and responsible individuals aware of something beyond their desks. . . ." Although I do not claim to know, with certainty, the purpose of our schools, it seems to me that an ideal purpose, which subsumes that stated by Mathewson, is the providing of a forum for independent and original *inquiry* upon any matter still open to investigation that presents itself to the intellect. Such inquiry would be the basis of the awareness about which Mathewson writes.

Second, I, for one, do not believe that we have at present the capacity to outdo the Soviets in matters of technological improvisation; certainly our engineering schools are not training people along such lines. Unless I am mistaken, our superiority rests in the realm of creative pure science, which does not have immediate technological import. Since the technology of tomorrow is determined in no small part by the science of today, our technological marathon with the Russians may well be decided on the basis of the creative scientific endeavors of this decade and past ones.

Third, Mathewson writes, "The scientist can no longer feel that the essential amorality of science absolves him from responsibility for the uses of technological power." But what could be more moral than science (truth), which assumes a commitment of mental behavior (by an agent) to a self-correcting method—namely, the scientific method? In order to engage in scientific inquiry one must be involved in a form of deliberate mental conduct for which the agent is responsible. The logical methodology of science presupposes an ethical norm, and one cannot be scientific except upon an ethical and esthetical basis. In the context of science, amorality appears in the form of amoral activity passing for science.

Finally, it seems to me that if one has been trained thoroughly as a specialist, then, out of habit, one would not endeavor to broaden oneself when one's formal training ends.

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I don't know when I have agreed more heartily with another man's point of view than I did while reading Mathewson's "Science for the citizen: an educational problem."

There was, however, an assumption stated as a truism, with all its implications for educational and political systems, that must not go unchallenged. This is the notion—and that's all it is—that the Russian people "are coerced and apathetic citizens."

Where do we see this coercion and apathy? Do Russian films, ballet, opera, poetry, and art reflect this? Have returning tourists and scholars conveyed this impression? Are such mannerisms exhibited by Russian teachers and politicians? What of Russian athletes—can they be labeled apathetic?

The "facts," as I interpret them, incline me toward the opposite view—one that is not lulling in its simplicity. As we seek to strengthen our own society, let us not measure another's with imperfect yardsticks. To paraphrase one of the Soviet saints, self-deception can be the opiate of the people.

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The problem expounded by Mathewson is one that the journalist has recognized for a longer time, perhaps, than the scientist or even Admiral Rickover. Most of us would agree that "the scientist and the nonscientist must learn to understand each other and to act on . . . common goals and values."

I would like to share an experience that raises doubts that Mathewson's proposed science survey courses or the editorial proposal of "almost continuous exposure to science, beginning in the primary grades," lead to viable solutions. It may be that neither goes far enough; the trouble may be too deep-seated to be correctable through tinkering with the curriculum.

I inquired of a class of senior journalism students why they so strenuously resisted the idea of taking courses in natural science, particularly physics and chemistry. Several years of academic counseling had given evidence of such resistance on the part of students in the social sciences and the humanities. Didn't they realize that, living in the atomic and space age, and being journalists, they had better expose themselves to its key sciences? The replies, from students from half a dozen different secondary-school backgrounds, were all the same, and disconcerting. Remember, these seniors of the class of 1963 were high school sophomores when the first sputnik was launched, and they had encountered the scholastic belt-tightening that followed. Sure, they'd like to take physics and chemistry, rather than the easier zoology-botany or astronomy-geology sequences they chose to fulfill distribution requirements. But they couldn't. Why not? Because in high school they had had to make the decision to go the science-mathematics route or the humanities-social sciences route. And quite definitely, they testified, they couldn't sample or straddle—not if they expected to make the grades and get the credits needed for admission to college.

Is this division of the flock at the secondary-school level general, and is it contributing to Sir Charles Percy Snow's frightening dichotomy of "the two cultures"?

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I find it distressing that the recent editorial "Science and the humanities" should perpetuate C. P. Snow's gap between the two cultures in a manner so blatant and, indeed, Victorian. With the phrase "After the rigors of training in science, the subject content of the humanities seems hardly more difficult than a good novel," one wipes away as trivial all the nonscientific scholarship of our civilization in general and our universities in particular.

Any reasonable acquaintance with the recommended study of scientists (rather than of science itself) as a subject for humanists shows that it is not a necessary condition that there exist a type specimen or standard sample from which to proceed. One can proceed to study science from the outside (historically or philosophically), just as one can study political history without being trained as a politician, or economics without becoming a successful businessman. Indeed, one may criticize Mathewson's proposal from the other direction; he seems to be ignorant of the fact that much of what he proposes (and more) is already in being, and in process of rapid and effective extension.

There are at least nine graduate schools now offering doctorates in the history and philosophy of science (including the sociology, economics, and politics of science) and more than 30 colleges offering undergraduate instruction in this field. At Yale, courses in the history of science have become valuable supplementary fare for scientists and humanists, and history of science has a sizable research program in its own right. At Oak Ridge during June and July 1963 there will be a summer institute designed to give nonscience college teachers an opportunity to discuss these aspects of science, in the expectation that they will introduce such discussion into their own teaching programs. In these ways, it is hoped, we may at one and the same time solve the problem stated by Mathewson and help prevent the rise of another generation of scientists that can hold such an absurdly derogatory view of humanistic scholarship as that expressed in the editorial.

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Effects of Penicillin on Bacteria

The interesting and constructive paper by J. Ciak and F. E. Hahn dealing with the antimicrobial action of penicillin [*Science* **137**, 982 (1962)] states, "Lysis of *S. aureus* under the influence of penicillin has rarely been mentioned," presumably as a mode of action of penicillin or as a consequence thereof. A reference from 1957 and another from 1959 are cited.

Actually, such effects were reported, and considered a mode of action, early in the penicillin story. Bonét-Maury and Pérault [*Nature* **155**, 701 (1945)] reported that when cultures of *S. aureus* are exposed to appropriate concentrations of penicillin, "proliferation stops almost immediately, followed by slow lysis of the bacteria," and that penicillin exerts a "very powerful lytic action." A year earlier, Nitti *et al.* [*Ann. Inst. Pasteur* **70**, 80 (1944)] made a similar observation. In 1947 Dufrenoy and Pratt referred to "bacteriostatic, bacteriocidal [*sic*], and bacteriolytic concentrations" of penicillin [*J. Bacteriol.* **53**, 657 (1947)], and Pratt and Dufrenoy offered an explanation for the "extensive bacteriolysis" of *S. aureus* exposed to the antibiotic [*ibid.* **54**, 127 (1947)].

In 1949 it was suggested that one fundamental effect of penicillin is qualitatively similar in Gram-positive and Gram-negative bacteria, but quantitatively different. "The evidence indicates that penicillin affects aerobic Gram-positive and Gram-negative organisms by blocking the catabolism of nucleotides. The threshold concentra-