geology and astronomy should be included. Geology is important for considerations of paleontology and evolution, while astronomy involves atomic and nuclear physics and the 'big questions' of cosmogony. These four courses, plus the four basics, would total 48 semester hours and still allow time for three half-courses or more in advanced biology. . . . The choice of courses for a 'most desirable' program is a difficult one, but it can be approached realistically in terms of the teacher's responsibilities."

In pargraph five Greenfield mischievously implies that teachers prepared according to an undergraduate program such as I outlined would "be so ignorant that no one would want them." He has, of course, missed the central point of my paper: that teaching science is an important task for which special preparation is necessary. To contend that future professional chemists need special training that differs from that of future biologists does not imply that one field of work is more important than the other; they are just different, and each requires special preparation. The same is true of science teaching in the secondary schools, which now involves over 65,000 teachers throughout the country. The past attempts to train future science teachers as single-subject majors fail on two accounts. First, they do not provide the schools with teachers adequately trained in *science*. Second, too many of the more promising potential teachers are lured out of the schools by much higher salaries currently available in industry and the government. On either basis, the schools and our children lose.

Greenfield neglects the appalling fact that, at present, only about 3000 new science teachers, qualified by whatever meager standards are set by the separate states, enter the schools each year, when some 7000 are needed. As a result, biology, which enrolls more students (1,200,000) than physics and chemistry combined, is frequently taught by individuals with far less preparation than even the two and a half to three years of biology I recommended. For example, in a recent addition to the many studies of teachers, M. O. Pella [*The Status of Science Offerings in Wisconsin in 1955–56*, Univ. of Wisconsin (1956)] found that in Wisconsin, in which state 83 percent of the 445 high schools enroll less than 500 pupils, biology was taught by 514 different individuals. Of these, 88 taught only biology. Ninety-nine others taught science (including biology) full-time, while 327 taught biology *and* other, nonscientific subjects. Of the 327, 114 also taught physical education, 77 taught social studies, and 67 taught mathematics. Probably, if the facts were available, New Jersey would present a comparable picture. These facts are not pleasant to contemplate, but they define the real problem, which academic wishful thinking will not overcome.

In the final paragraph, the emotionally loaded terms "repetitious invective" and "anti-intellectual propaganda" are not becoming a professor or *Science*. The damage to the training of teachers and the education of our youth has hardly been the result of the many proposals, which far exceed, in scope, the actual training of those who teach our children every day. The unwillingness of science professors to design effective training programs based on a knowledge of the facts has contributed materially to our present difficulties. The problem is serious, especially so now when near-panic is evoking extravagant public statements about the schools and those who teach in them. Answers to the question of what pattern of undergraduate study is most desirable for the future *science* teacher is squarely up to the collegiate departments which continue to supply most of the science teachers for secondary schools. Invectives may draw a chuckle, but they hardly constitute a thoughtful or realistic appraisal of a desperately serious problem, which must be met by the science faculties of our colleges and universities.

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Nuclear Tests and Ethics

In addition to the many social aspects of the radiation problem discussed in the AAAS symposium at the Indianapolis meetings, there is one that seems not to have been dealt with in detail, perhaps because it is obvious or because it appears unimportant. I have in mind the question whether nuclear bomb tests are in any sense permissible *from the viewpoint of science.*

There has been much talk during the last years about the formulation of a code of ethics for scientists. It should, however, be realized that much of this code already exists implicity in the actual practice of science. In particular, scientists have accepted a rather stringent code of safety precautions in their research work. The individual researcher is still at liberty to endanger his own life in pursuit of truth. Any danger to his fellow workers or to the community at large is, however, sedulously guarded against.

Nuclear bomb testing is often talked about as involving risks. Thus, Willard Libby in his letter to Albert Schweitzer has spoken of the risk from world-wide radioactive fallout. It has become clear now, from genetic and medical studies, that it is not a *risk* but a *certainty* that every nuclear weapon tested will kill a certain number of people.

Harrison Brown, California geochemist, has put it this way: "We would not dream of lining thousands of people against a wall and shooting them down in order to test a new machine gun. But this, in effect, is what the U.S., the U.S.S.R. and the U.K. do when they test these fantastic new weapons. We do not know *who* the people are who are afflicted, but we know that with little question many people are killed as a result of these actions."

Experiments of this kind should be publicly and officially condemned by the scientific community as having no place in the pursuit of science whatsoever. A similar principle was enunciated by the Nuremberg courts in sentencing the doctors who performed experiments on concentration camp victims. The knowledge obtained from nuclear tests is tainted knowledge, knowledge obtained at the price of human individuals, belligerent or neutral, friend or enemy, innocent or guilty. If science will not proclaim its condemnation of such experiments, the verdict of history will do so in the future, and science will be condemned with them. As scientists we surely have learnt that the pursuit of knowledge cannot be the ultimate goal, but must always remain subservient to human values.

If scientists condemn such tests as having no place in science, the only justification for the tests remains that of military necessity. We are told that the "risks" of radiation damage must be weighed against the risks of exposure to Communist domination. If these are in effect the only alternatives, the West is morally doomed. If the high ideals of democracy can only be defended through the indiscriminate spreading of leukemia, then it may be asked whether democracy is worth the price. But why have we so slavishly accepted the dogma that there are no alternatives?

Some months ago the British Government issued a White Paper in which it concluded that Great Britain could not be defended militarily against nuclear attack. Commander Stephen King-Hall, noted news commentator, drew attention to the obvious implication—namely, that British subjects must develop nonmilitary means of defense against Communism. Such a path will become more and more necessary in this country also as technical knowledge advances. Could the scientific community, in order to preserve its own integrity, call on our government to proceed speedily with the exploration of paths, no matter how novel, by which both Communism and genetic deterioration might be avoided?

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