23–27. American Assoc. of Bioanalysts, natl., New York, N.Y. (L. D. Hertert, AAB, Suite 1049, 490 Post St., San Francisco 2, Calif.)

24–25. Eastern States Health Education Conf., New York (I. Galdston, New York Acad. of Medicine, 2 E. 103 St., New York 29.)

24–25. Nutrition Conf., 4th annual, Detroit, Mich. (J. M. Orten, Dept. of Physiological Chemistry, Wayne State Univ., College of Medicine, 1401 Rivard St., Detroit 7.)

24–26. International Scientific Radio Union, spring, Washington, D.C. (J. P. Hagen, National Acad. of Sciences, 2101 Constitution Ave., NW, Washington 25.)

24–26. West Virginia Acad. of Science, annual, Morgantown. (M. Ward, Glenville State College, Glenville, W. Va.)

24–26. Wildflower Pilgrimage, 8th annual, Gatlinburg, Tenn. (A. J. Sharp, Dept. of Botany, Univ. of Tennessee, Knoxville.)

25–26. American Assoc. of University Professors, annual, Denver, Colo. (R. K. Carr, 1785 Massachusetts Avenue, NW, Washington 6.)

25–26. Georgia Acad. of Science, annual, Emory Univ., Emory. (M. T. Clark, Chemistry Dept., Emory Univ., Emory, Ga.)

25–26. Louisiana Acad. of Sciences, annual, Shreveport. (H. B. Boudreaux, Louisiana State Univ., Baton Rouge 3.)

25–26. South Dakota Acad. of Science, annual, Rapid City. (J. M. Winter, Botany Dept., Univ. of South Dakota, Vermillion.)

27–1. American Ceramic Soc., 60th annual, Pittsburgh, Pa. (C. S. Pearce, ACS, 4055 N. High St., Columbus 14, Ohio.)

27–1. Electrochemical Soc., spring, New York. (H. B. Linford, ES, 1860 Broadway, New York 23.)

27–1. Society of American Bacteriologists, 59th annual, Chicago, Ill. (E. M. Foster, Univ. of Wisconsin, Madison 6.)

27–1. Southwestern and Rocky Mountain Div., AAAS, annual, Las Vegas, N.M. (M. G. Anderson, New Mexico A.&M. College, Las Cruces.)

28–29. Automatic Control in the Petroleum and Chemical Industries, 3rd annual conf., Norman, Okla. (M. L. Powers, Extension Div., Univ. of Oklahoma, Norman.)

28–3. Engineering Societies of Western Europe and the United States, conf. (closed), New York. (C. E. Davies, American Soc. of Mechanical Engineers, 29 W. 39 St., New York 18.)

May

1–3. American Physical Soc., Washington, D.C. (K. K. Darrow, APS, Columbia Univ., New York 27.)

1–3. Kansas Acad. of Science, annual, Ottawa. (C. T. Rogerson, Dept. of Botany, Kansas State College, Manhattan.)

1–3. Midwestern Psychological Assoc., Detroit, Mich. (D. W. Fiske, Dept. of Psychology, University of Chicago, Chicago 37).

1–8. American Soc. of Tool Engineers, 26th annual, Philadelphia, Pa. (ASTE, 10700 Puritan, Detroit 38, Mich.)

(See issue of 21 February for comprehensive list)

LETTERS

The editors take no responsibility for the content of the letters published in this section. Anonymous letters will not be considered. Letters intended for publication should be typewritten double-spaced and submitted in duplicate. A letter writer should indicate clearly whether or not his letter is submitted for publication. For additional information, see Science **124**, *249 (1956) and* **125**, *16 (4 Jan. 1957).*

Training of Science Teachers

In the December issue of *The Scientific Monthly* [**85**, 320 (1957)], Fletcher G. Watson advances a plan for the training of science teachers that may be suitable for teachers of physical science but is very inadequate for prospective teachers of biology. He proposes that the "biology teacher" have general inorganic chemistry (with qualitative laboratory), organic and quantitative chemistry, mathematics through the calculus, and introductory and atomic physics, plus geology and astronomy and probably meteorology, but only one year of introductory biology plus a semester of vertebrate physiology and one of plant physiology.

It does not seem to bother Watson that his "biology teacher" will have no intensive courses in botany and zoology and interrelated fields other than the two years mentioned. It bothers me very much. He thinks "Geology is important for considerations of paleontology and evolution, while astronomy involves atomic and nuclear physics and the 'big questions' of cosmogony." One can hardly deprecate these aims, but surely it would be more useful for our "biology teacher" to be well informed with regard to plant and animal biology and the integrating disciplines, so that he might consider the "big questions" of *biology.*

Watson thinks "genetics, cytology, and biochemistry are desirable but might be delayed to a fifth year or summer school." He seems to think that these are less relevant to the preparation of a biology teacher than astronomy, atomic physics, or geology. He does not even mention microbiology, morphology, or taxonomy.

It is not uncommon for physical scientists to lack appreciation of the scope of the biological sciences, but it seems doubtful that many would plan so scant a biology major. The de-emphasis of biological science has been so consistently practiced that, in the popular mind, the biological sciences are seldom thought of when the word *science* is used. Biologists have been especially lax in correcting the imbalance, as well as in pointing out to their colleagues in the physical sciences that the biological sciences are at least as broad in scope and as detailed in depth as the physical sciences.

There are other phases of Watson's article that seem regrettable. For example, he argues against the "good solid major" in science for the secondary school teacher, for, among other things, "Already those with a strong but narrow major are too attractive to industry and the Government." Does this mean that he wants us to have teachers so ignorant that no one else will want them?

The attack on the "good solid major" and the repetitious invective against the "narrowly trained specialist" are of course not new, but more of the anti-intellectual propaganda that we have too long tolerated, and in consequence of which great damage has been done to the training of teachers and the education of our youth. It would seem to be the urgent responsibility of those who are concerned about the improvement of American education to reject the fallacious notion that a teacher can be too well educated in his subject and to insist that our teachers be more thoroughly and intensively trained in the fields that they are required to teach. We need teachers, at all levels, who can inculcate a real love of learning and an appreciation of the nature of knowledge, and who will inspire young minds to genuine scholarly activity and exploration of science. Such teachers will need more than survey courses in their chosen fields.

SYDNEY S. GREENFIELD
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Sydney Greenfield's letter merits a reply because it illustrates the traditional position and line of argument taken for years by those in special areas of science. I had anticipated comparable complaints from the chemists, the physicists, and the earth scientists because I had proposed a training program with some balance among several fields. There seems to be an unwillingness to look realistically at the responsibilities of science teachers actually employed in the schools and at how they are to be "trained in the fields they are required to teach." Certainly it is easier to contend that the pattern of courses offered for a departmental major is *necessarily* the best possible preparation for teaching science than to look realistically at the task required of teachers (whether we like it or not) and attempt to prepare them for beginning this important work. With Greenfield's first four paragraphs I might agree, except for the obvious misquotation regarding my suggested program of study, during the four undergraduate years, for a potential teacher of biology and general science. The actual statement was: "The biology-general science major should include organic chemistry, which is essential to an understanding of modern biology. Atomic physics would also be helpful, for radioisotopes are playing an increasingly important role in biological investigations. Some instruction in

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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