forbids their being true, science becomes indistinguishable from superstition.

One final comment should be made about the danger of heuristic arguments about heuristics in science. Wiener objects to von Neumann's theory of games, which depends upon stating the complete formal rules of a game, and suggests that we substitute tentative play modified by experience. He justifies this suggestion by pointing out that this is the way human beings play chess, in particular, or run their affairs, in general. He points out that certainly Napoleon won his victories by modifying his strategies in terms of the different abilities and responses of his opponents. He seems not to recognize that this strategy also led Napoleon to Russia and Elba.

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Science and Human Affairs

The AAAS Committee on Science in the Promotion of Human Welfare should be congratulated on its statement [*Science* **132**, 68 (8 July 1960)]. Most of us will agree that the problem discussed is real and urgent. No one should oppose the suggested preparation and dissemination of reports for the general public.

The "development of liaison between scientists and the public on a local basis," however, raises some prickly problems and should stir up a continuing debate. The scientist who tries to take part in political and economic activities as a scientist, instead of merely as a citizen, comes face to face with the fact that all important decisions in business, politics, and war are made on the basis of inadequate information and unproved theory; in an embarrassingly large number of cases, the scientist can only point out the depth and breadth of human ignorance—and shut up. But in many cases the border line between personal prejudice and scientific theory is pretty dim, and the man who sets out to explain the facts about radioactive fallout or increasing birth rates is apt to find himself defending a political philosophy or religious dogma.

Unfortunately, it is a general rule that men tend to be radicals in fields which they know well and conservatives in areas where their knowledge is superficial. Physical scientists and engineers are usually classed as reactionaries by the more original theorists of politics and economics. It would be unfortunate if our efforts to serve humanity merely resulted in identifying science with the most archaic,

unimaginative, and sterile approaches to social problems. (Note: I am a physical scientist.)

We can avoid such traps if—and only if—we emphasize the fact that the real contribution which science can make to problems of human relationships is *not* "facts" or "answers." The real contribution is an attitude and a set of values. Science did not gain its present power and influence simply by being an orderly accumulation of data; a large telephone directory may contain a million facts, in perfect order, and an infinite number of telephone directories would contain an infinity of factual information—and be of no value whatever for solving our major problems. Science, as we now know it and value it, exists because there have been men with a passion for ideas, whose first loyalty was to intellectual honesty—men who valued an increase in understanding more than they valued the comfort and safety of accepted authority. They have created a tradition of objectivity, tolerance, free speculation, patient analysis, and open communication. They have fought, when necessary, for the right to consider alternatives to established dogma and the freedom to discuss ideas, including the ideas of other men in other countries.

There is little doubt that such an attitude, if widely understood and generally accepted, could be a major step toward the better ordering of human affairs. I recognize the fact that there are many who will argue that the application of the scientific attitude to social relationships is impossible—that the human animal simply has to have some outlet for the irrational and psychopathic forces which are within us all. It is obvious that we all seek someone to blame for our frustrations and inadequacies. There is something irresistibly attractive in the thought that we can please God and solve all problems by simply burning heretics and despoiling unbelievers. War, politics, and religion have traditionally satisfied these needs, and it may be argued that they always will. We can only say that, if this is so, "always" may be a very short period of time. But we have good reason to hope that there are unexplored potentialities in human psychology. Books like Ruth Benedict's *Patterns of Culture* tell us that there are alternatives to most of the sources of satisfaction which we take for granted, and that enduring societies can be based on these alternatives. It is not absurd to try to create a world in which scientific discovery will give as much emotional satisfaction—and bring as much prestige—as killing large numbers of strangers, or one in which intellectual integrity will be as powerful as fanaticism.

To explain, apply, and defend our scientific values is neither easy nor safe, however—especially when we try to apply them to controversial policies. The committee report ably, but too briefly, points out the pressures which are being applied to make science an instrument of national policy, and to make it sacrifice its best traditions in the hope of transforming it into a dependable military weapon. The committee might well have added some comment on the informal social pressures, which can be equally strong and equally deadly. The fact is that most laymen regard the application of scientific objectivity, tolerance, and logic to problems which touch on religion, patriotism, politics, or sex as blasphemous, subversive, and immoral. And a surprising number of scientists feel the same way. Few of us are any more judicious or restrained, outside our laboratories, than the average layman. On the whole, we cooperate enthusiastically with the efforts which our nonscientific friends are making to run the world by tradition, prejudice, and simple inertia.

A program somewhat along the lines recommended by the committee is probably essential if science, as we

know it, is to survive. Otherwise, we may expect an ever-increasing blanket of secrecy to cover the progressive degradation of science to the status of a weapon for cold war or hot, and ever-increasing suspicion, hostility, and misunderstanding to divide scientists from nonscientists. Such a program, though, will call for more courage, more action, and more conscious resistance to mass hysteria than most of us have been willing to contribute to date. During the recent years which were dominated by Joe McCarthy, the real point at issue was not the guilt or innocence of his victims. The real question was whether the American citizen could be punished for opinions as well as for acts—whether our traditional freedom of thought, freedom of association, freedom of movement, and freedom of speech were absolute or subject to the whim of any official who claimed to act in the national interest. The question was obviously of vital importance to scientists, yet scientific and technical societies took remarkably little part in the debate, and scientists as individuals applauded the witch-hunt about as often as they condemned it. We shall have to do better in the future if science is to have either the respect or the understanding of future generations.

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The suggested approach of the AAAS Committee on Science in the Promotion of Human Welfare is a fine beginning for restoring balance in the relationships between the scientist and the general public. As the committee comments, the problem is an acute one, becoming more so, and some sort of crash program is needed in these frightening times. In this light, I think the four-point program proposed—(i) stimulation of discussion among scientists, (ii) gathering of facts relevant to an issue, (iii) dissemination of reports to the public, and (iv) development of local liaison—is a good one.

However, with regard to points (iii) and (iv), I think an approach on a more vertical front than that proposed is required. The adult public as it now exists has little if any background in science and scientific thought. It has had schooling in which the study of science was largely avoided. This is true even of the political and economic leaders of our society. Many of those with college educations have had business or liberal arts training in which the science requirement has been at a minimum. Those with high school educations have had even less science.

There is therefore a poor foundation on which to build a structure of scientific awareness in our lay population. A man who has had no physics is not likely to grasp fully the implications of the nuclear revolution. A man with no biology or mathematics cannot really understand the problems of the population explosion. Although I do think we should attempt to reach the adult public according to the proposals advanced by the committee, I also think we have considerably more to gain by an expanded program directed toward our student population.

There is much talk of increased science teaching in our schools. However, it must be remembered that these curricula are still being run by the same administrators who were in charge before and who were dedicated to making school as easy as possible. They are the least well educated people in our educational system and are hardly qualified to administer a meatier program without guidance and support from scientists themselves. It appears to me that those schools which had strong science curricula before have them still and that those which had weak programs still have weak ones.

This is not to say we should educate all to be scientists. I am saying we can do a lot more to see that our students are taught enough science and scientific method of thought to enable them to consider the problems created by scientific advance and have some hope of solving them intelligently.

To be specific, I think we should (i) participate more, as individual scientists and in groups, in the educational affairs of our communities; (ii) create committees, if they do not already exist, to consult with state and national educational organizations and with state education commissions to impress upon them the importance of expanded science teaching in the schools; the committees should be prepared to present suggested curricula, textbooks, and teaching methods to these organizations. (iii) these activities should be conducted on a broad scientific front rather than by individual groups representing biology or chemistry or mathematics.

We are forced now to take almost defensive measures as scientists against a relatively ignorant and sometimes hostile public. By making greater efforts on behalf of our students, we should be able to look forward to a time when the general public will be aware of the peculiar methods and needs of science and of the problems created by scientific advance; will understand the difference between science and technology; will not exert the pressures which undermine scientific integrity; and will not have to be forced-fed a diet of science in order to gain some dim understanding of the tremendous changes occurring in the world.

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