the minds of the intellectual leaders to whom the public looks for guidance, I find it significant that among the leading scientific policy makers we still have the quality, insight, and range of concerns of such men as Rabi, Szillard, Oppenheimer, Bronk, Wiesner, Stratton, Kistiakowski, Beadle, Harrison Brown, and Glen Seaborg, to name only a few at random.

Perhaps, however, this hopeful aspect of present scientific leadership is only transitory. These men received their training in the days before the "new science." If the concerns of the new generation of scientists fit those expressed in Dr. Eiduson's sample, one may indeed wonder what will happen when the men and women she studied take the place of our present spokesmen for science.

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Computers and Game-Playing

Since *Science* is intended not only for scientists in general but also for intelligent and interested laymen, it seems unfortunate that Norbert Wiener [*Science* **131**, 1355 (1960)] should have permitted himself to use the jargon of computer specialists without any explanation of the special meanings which accompany this jargon. Wiener discusses checker-playing machines, chess-playing machines, and learning machines, and this may give the impression that these are actual physical embodiments of such abilities. Actually, no such machines exist. Wiener has here followed the practice of discussing a program on a general-purpose computer as though it represented a special-purpose machine which would operate in the manner set forth in the program.

A program is a set of numbers in a certain order, and without human interpretation it remains only that. Undoubtedly a machine could be built which could move checkers and chessmen, but it could only operate on standard-size pieces and could not recognize as chessmen the innumerable pieces of different design which the human player recognizes and moves around quite simply.

It is also possible to play abstract chess, like games in a book, without moving pieces physically; but there are analog relationships in real chess—for example, the emptiness of a line, which is the requirement for movement or castling—which cannot be directly handled by any digital machine. These analog relationships can be approximated digitally by remembering and recalculating the moves of all other

pieces in order to determine whether a given line is empty and, hence, that a certain move is possible. But such a set of calculations is not identical to the visual recognition that the space between two pieces is empty. A large part of the enjoyment of chess—for example, its relationship to war games—derives from its deployment or topological character, which a machine cannot handle except by elimination. Wiener recognizes this problem by noting that different programs would be required for opening, middle, and end games. If *game* is used in the usual sense—that is, as it was used before the word was redefined by computer enthusiasts with nothing more serious to do—it is possible to state categorically that machines cannot *play* games. They cannot *play* chess any more than they can play football.

In Wiener's earlier work, *Cybernetics*, he was able to make a case for learning machines only by equating learning with conditioned reflexes. As a matter of fact, the doctrine of conditioned reflexes as an explanation of human habits and human learning is certainly questionable, if not false. Sherrington can be accepted as an authority in stating that although the behavior of living organisms can be modified by subjecting them to certain patterns of experience, reflexes in the physiological sense of that term are not conditionable or modifiable. In short, the expression *conditioned reflex* is a contradiction, because physiologists distinguish reflex activity from other types of nervous activity on the basis of the fact that reflexes cannot be conditioned. There is nothing more strange or mysterious in this fact than there is in the denial of the Lamarckian doctrine of the inheritance of acquired characteristics. Sherrington explicitly and categorically distinguishes reflex behavior from habitual behavior on the grounds that habitual behavior is acquired and modifiable, whereas reflex behavior is not.

Having described the feedback operations of computers in *Cybernetics*, Wiener goes on to say: "I wish to emphasize that I do not say that the process of the conditioned reflex operates according to the mechanism I have given; I merely say that it *could* so operate. If, however, we assume this or any similar mechanism, there are a good many things we can say concerning it. One is that this mechanism is capable of learning. It has already been recognized that the conditioned reflex is a learning mechanism. . . . There is nothing in the nature of the computing machine which forbids it to show conditioned reflexes."

When reputable scientists begin to accept explanations merely on the basis that they *could* be true and that nothing

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,