Science: Self-criticism and self-defense

Is science in danger? A philosopher says yes

The AAAS's annual, year-end self-examination of science and its role in society was marked this year as much by growing concern about the health of science and the indifference or even hostility of many persons toward science and technology today as it was by questions of the social responsibility of scientists.

The theme was perhaps best elucidated by science philosopher Stephen E. Toulmin, who spoke of the fragility of science and noted similarities between trends today and those that brought the only other historical era of flourishing science to a close. Taking a somewhat different tack, Joseph F. Coates delivered a blistering attack on the American intellectual community's ignorance of science and technology, which he contends leads, among other things, to an inability to deal rationally with the problems they create. "For the intellectual to turn away from science may be the ultimate in antiintellectualism." (Exerpts from Coates' paper appear on p. 6.)

Toulmin, professor of humanities and provost of Crown College at the University of California at Santa Cruz, asked, in an invited address, "And shall we have science for ever and ever?"

"Basic science," he said, ". . . is an activity that has flourished vigorously just twice in human history, each time for some four or five hundred years." The first great burst of critical speculation about nature was in classical antiquity. It lost its self-confidence and momentum "under familiar-sounding circumstances," when its central philosophical and intellectual ambitions were abandoned, its inquiries fragmented, and the concern of the educated public fell away. Science as we have come to know of it revived only after a further 1,200 years, when Copernicus "challenged the skepticism of the Alexandrians and reinstated the older intellectual claims of scientific inquiry."

The first six articles in this issue report on issues aired at the annual meeting of the American Association for the Advancement of Science in Washington. Research notes from the meeting follow on p. 8 and p. 10. More articles from the meeting will appear in future issues.

Toulmin says the situation that ended the classical period of natural inquiry "was in some respects not unlike our own." Natural science became fragmented in a diversity of subsciences, confused in the public mind with technology and craft know-how, and divorced from the broader questions of natural philosophy that had been its source of its interest to educated men at large. He believes similar forces, both from outside and within science, are at work today.

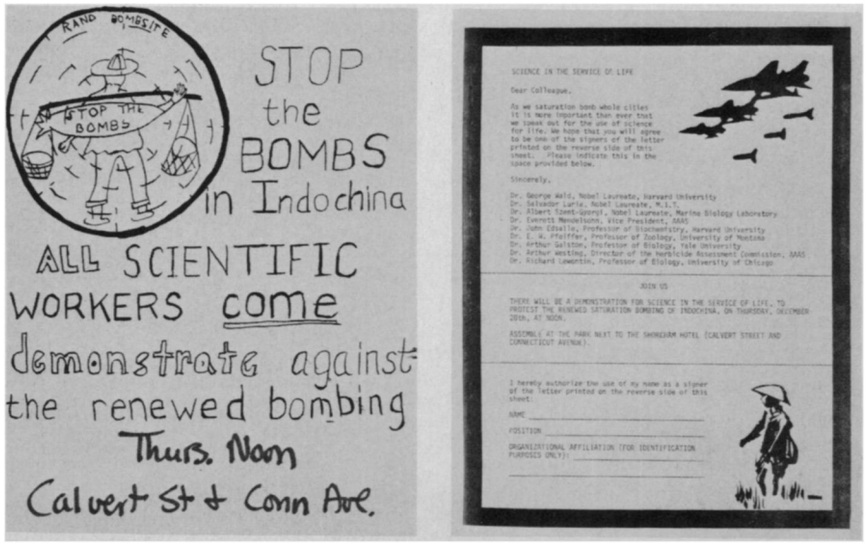
". . . I'm not interested in posing as the Prophet of Doom. But I do think that it is worth somebody's while to underline . . . the grounds for thinking that the state of science today may be more fragile than we normally assume. . . ."

Today, Toulmin notes, there is an alienation of many educated persons from science, a widespread confusion between the intellectual goals of basic science and the practical goals of technological innovation, and a turning away by the scientific profession from great unifying themes toward a more fragmented, narrow approach.

Toulmin cautions against dismissing or underrating the significance of the current reaction against science. "Behind all the exaggerations and denunciations of the antiscientists, there are some uncomfortable facts to be faced." Scientists, he says, too frequently lay themselves open to criticism for exaggerating the scope and reach of scientific understanding, failing to deal with the moral choices implicit in their choice of research topics, and blundering into ill-considered relationships with government and industry. "These criticisms can be blunted only if we show that we too are ready to consider more profoundly than before what the broader social, cultural and political affiliations of science have been, are and could be."

The confusion between science and technology, Toulmin notes, is widespread. The trouble begins when technological by-products come to be seen as science's entire public justification.

But Toulmin believes the main threat to science is to be found among the scientists themselves. "For myself, I confess, I find neither the confusion of science with technology nor the alienation of the antiscientists as potentially damaging to the long-term 'advancement' of science as the third and final sign of Alexandrianism: the turning-away of scientists themselves from the grand unifying themes of natural philosophy." He argues that the increasingly fragmented division of labor and narrow specialization in science tend to cut off scientists' minds from sources of new ideas ("if Darwin had been indoctrinated into the established methods of contemporary phys-



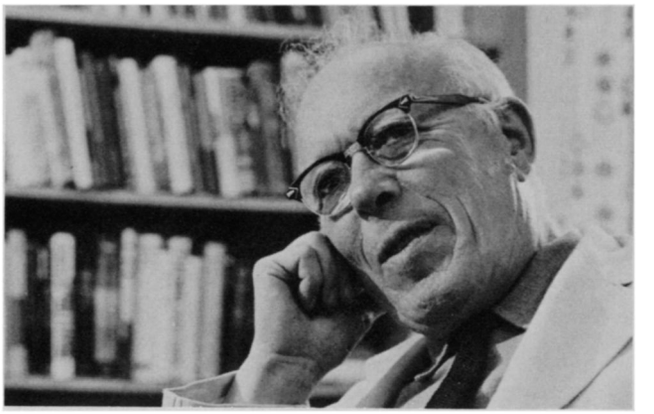
Antiwar pamphlets at AAAS meeting call on scientists to protest bombing.

Man and nature: Symbiosis

The realization that man, in his struggle to achieve civilization, has marred the earth's natural beauty and threatened its health, has made mankind seem, in some eyes, like a pestilence or parasite that sucks earth dry of its resources and upsets the balance of nature.

This view, according to René J. Dubos, is wrong: Man's relationship to the earth is not parasitic but symbiotic. Lecturing last week at the Washington meeting of the American Association for the Advancement of Science, the noted humanist elaborated on his view that man can, and does, improve on nature. "Nature is incapable, by itself, of fully expressing the diversified potentialities of the earth." Before the coming of man, he declared, earth was covered with forests and marshes. "There was grandeur in this seemingly endless green mantle, but it was a monotonous grandeur. . . ." Man, by clearing fields, erecting graceful buildings, planting gardens and parks—in short, by "humanizing" the earth—revealed the underlying diversity of the earth. "The symbiotic interplay between man and nature has often generated ecosystems more diversified and interesting than those occurring in the state of wilderness."

When it comes to solving ecological problems, he said, nature does not always know best. The periodic population crashes of lemmings, muskrats and rabbits are a clumsy way of reestablishing an equilibrium between population size and natural resources. As for the recycling processes



Dept. of Agriculture

Dubos: "The wisdom of nature is often short-sighted."

considered to be the earmarks of ecological equilibrium, the accumulation of coal and peat demonstrates that nature has failed again. In fact, Dubos pointed out that man has completed the circle by burning peat, coal and oil, making carbon and minerals once more available for plant growth. The problems arise because man is recycling too rapidly, overloading the system. Nature has "junkyards," too: "The science of paleontology is built on them."

Dubos acknowledges that "many of man's interventions into nature have, of course, been catastrophic." But he believes that with wise management "mankind can act as steward of the earth for the sake of the future."

iology he might never have gotten around to unraveling the origin of species") and reinforce the feeling among laymen that the domain of the sciences is none of their concern.

"Newton, Darwin and Freud dealt with topics that spoke to the laymen as forcibly as they did to the specialist: The specialized scientist of today often has no more communication with the outsider than an Alban Berg or a Jackson Pollock. And this is not merely a pity for the layman. It is a source of harm to the sciences, too, since it cuts them off from their natural constiuency: i.e. from all those more broadly educated laymen to whose philosophical interests science has been able to bring important insights. . . .

"Science needs to rebuild its constituency among the public at large, at a time when its social reputation has been tarnished. This is something that can be done only if the scientists concerned set aside all sense of professional superiority . . . and seek to draw a wide body of citizens into the discussion of scientific affairs on equal terms.

"Perhaps if the threads had not been allowed to become so frayed—if scientists had acted earlier to encourage that feeling for the broader significance of science in the life and thought of our whole species that so many laymen have recently come to lack—the political and cultural situation of science might not, even now, have deteriorated as far as it has." □

Science dissenters and social policy makers

Science for the people means using technological advances to enhance the quality of life. Science for the people means using social science in the formulation of workable social policies. Science for the People is also the name of a small but vocal group of scientists, engineers and students who speak up whenever they think science might be used against the people. By speaking up they hope to keep the public as well as their fellow-scientists aware of the possible misuses of science.

In the past, the group's activist warnings against passivity have sometimes stifled rather than stimulated rational discussion. So this year, when Science for the People people attempted to set up a table for distribution of their literature last week at the AAAS meeting in Washington, they ran into trouble. Without the necessary permission, they set up and began leafleting on the first day of the meeting. The police were called in, a struggle ensued and eight persons were arrested. This action and reaction focused some attention on the group and they were eventually allowed to pursue their goals.

One of these goals was to question some of the makers of government social policy. They got their chance when James S. Coleman of Johns Hopkins University spoke at the AAAS session on public policy and social sciences. The announced chairman of the session was Daniel P. Moynihan. Science for the People distributed leaflets advertising the session and accused Coleman and Moynihan of fostering racist policies. So many persons showed up that the session was delayed for a half hour while more space was found.

When Coleman, author of the now famous or infamous) Coleman Report, finally spoke, he did not talk about the policies that grew out of his research. Instead, he attempted to develop a set of principles to govern policy research. Among them were:

- Partial information at the time an action must be taken is better than complete information too late. In other words, a steady accumulation and input of research results should be used to aid policy decisions.
- A variety of approaches is more likely to hit the target than one elegant but possibly misfired solution.
- The existence of competing or conflicting interests requires special self-corrective devices such as the commissioning of more than one research group under the auspices of different interested parties and independent review of research results using an adversary or dialectical process.
- If policy research results are transmitted back without open publication, the results will ordinarily not be acted upon nor will they be openly

Intellectuals and technology: A point of view

The following remarks are excerpted from a paper, "Antiintellectualism and Other Obstacles to the Control of Technology," by Joseph F. Coates, delivered last week at a AAAS session on Government Control of Technology. The author is with the Office of Exploratory Research and Problem Assessment of the National Science Foundation.

Traditionally an intellectual is a person committed to the use of reason as a means to understanding and hence as a means to control nature and guide human behavior.

At every stage in the movement from magic to science some thought and some thinkers are arrested in their development and become fixed in the sterile categories of an earlier period. The contemporary intelligentsia, by and large, is in an intellectual cul-de-sac. Rather than remaining *au courant* with the new development in human thought, a large number of them, influential in the communications media, are arrested in the categories, concepts and perspectives of another century. They misunderstand the conceptual categories and manipulative tools essential to the analysis and control of society.

In the contemporary world, science and its derivative technologies are the leading edge of intellectual development. Yet many of the intelligentsia either limit themselves to social, political categories reflecting 18th- and 19th-century conceptual frameworks or are beguiled by the social-political-artistic ephemera of the recent past.

Many of the intelligentsia seem bent on excluding any understanding of science and technology from their cerebrations. Consequently basic forces in our world are treated as magical, awesome, or demonic. The present situation among the intellectuals is illustrated in a survey by Kadushin et al. The purpose of that study was "to identify journals which are influential among intellectuals on issues concerning national policy (or more specifically, social problems) and literature (or more specifically reviews of books dealing with social issues) and thus locate the chief gatekeepers of public opinion among intellectuals." The top 10 candidates elected were The New York Review of Books, New Republic, Commentary, New York Times Book Review, New Yorker, Saturday Review, Partisan Review, Harper's, Nation and Atlantic. Newsweek was eleventh. Where is Science, The Scientific American, The New Scientist, the American Scientist, Society, The Annals of the American Academy of Political and Social Science?

The least one could expect is that those intellectuals concerned with the super-structural elements of art, literature, religion, history, economics and government would be paying closer attention to the science and technology which now determine and define those production modes. The intellectual cannot guide the world if he does not know how it works. What is schist, or for that matter, what are schistosomes? The latter cause the fifth most important health problem in the world. What are the fundamentals of micro and macro economics? What are the half dozen inventions that make the contemporary city possible?

To claim to be an intellectual and not to be able to speak with knowledge about organic chemistry is incredible. Not only does it in its more practical aspects permeate every aspect of our lives, our health, our food, our garments, our housing, it also is one of the finest intellectual achievements of the Western world.

To be oblivious of the "central dogma" (of genetics) is to be unprepared to understand a major determinant of the future or enter the discussion of genetic engineering.

The failure of the intellectual to understand science may cause it to be seen as mysterious, unworthy, or demonic, which in turn may lead to it being rejected, ignored, condemned, demeaned, or misused. For the intellectual to turn away from an understanding of science may be the ultimate in antiintellectualism.

Closely related to the antiintellectualism of the intelligentsia stemming from an ignorance of science is an equally general ignorance of technology. If one cannot speak with some knowledge and understanding of how cloth is woven or machines diecast or television operates, how plastic is formed, nuclear reactors, the telephone, accordion, glue, or the computer works, one is in the relative position of the savage in his first confrontation with civilization, alienated. The central feature of our society must perforce be reduced to misunderstanding, misjudgment, and ultimately to magical ritualistical mismanagement based on fear and awe.

disclosed to others unless it benefits the interests of whoever commissioned the study. An evaluation of Project Head Start by Westinghouse Learning Corp. that showed the project's relative ineffectiveness for teaching cognitive skills is an example. The report, said Coleman, was kept inaccessible by the Department of Health, Education and Welfare until it was reported by the mass media. Research results, he says, may be buried in departmental files if there is not a prior specification of open publication to all interested parties.

Discussing these proposed principles, Harold Orlans of the Brookings Institution said, "I do not dispute that much useful policy research can be conducted as Coleman indicates: because amidst abysmal ignorance, even faulty information can be useful; because research is often directed at humdrum administrative tasks, more clerical than intellectual; and because there is almost no way for projects which are political or intellectual exercises or diversions to fail."

Coleman's suggestion of conducting several independent studies rather than a single massive one, said Orlans, may compound the confusion because several studies are more likely to generate diverse findings, whereas a single large study is more impressive and, being less reproducible, is less challengeable. Orlans also noted that with many social problems "we do not know exactly what the target is and hence cannot say when it has been hit." Finally he said, "Coleman's social science is very tidy: Too tidy to be convincing. . . . The nation is no longer an obedient schoolroom for social scientists, as it may have been in days of greater conformity, dutifulness and common trust."

Orlans' discussion was lively, but a debate on theory was not exactly what Science for the People had hoped for. So, on one level, the activists seem to have failed. When they tried to get down to the specific issue of racist policies, they were voted down or shouted down by the rest of the audience. When they finally did get some questions across, Coleman neatly side-stepped most hot issues. (He did admit that there is a lot of social research that is shoddy and that some racist statements, in the guise of research, are actually nothing but statements of theory.) Moynihan—the real target of the radicals' attack—did not even show up to defend the policies he helped formulate.

But on another level, Science for the People made its basic point. Twice the number of persons expected showed up, and rather than a one-sided presentation of ideas from the podium, the session was a dialogue, open for more than two hours to discussion of science for the people. □

Air pollution and forests: A study still in its infancy

Despite widespread concern over the effects of pollution on living systems, one area, according to William H. Smith of Yale University, has been sadly neglected: the forest. The earth's forests play a major role in the hydrologic cycle, contribute many of the atmosphere's constituents, prevent soil erosion, harbor a large proportion of the wildlife and even regulate climate. Smith concludes that in spite of the acknowledged importance of the forest, little research has been done on the effects of air pollution on the forest ecosystem, and what research there is, he told the AAAS, is concentrated in the wrong places.

Smith divides the potential effects of pollution on trees into three categories. At low pollution levels, trees undergo no detectable change. Instead, the forest acts as a sink for contaminants. At higher pollution levels, individual plants may suffer subtle damage in the form of reduced growth, impaired reproduction, or greater susceptibility to disease. In the final, extreme case, trees are actually killed, and soil erosion, climate change or changes in the hydrologic cycle may ensue.

What little can be inferred about the forest's role as a pollutant sink, says Smith, is based largely on calculation. It has been suggested that vegetation is an important sink for ammonia, hydrogen fluoride, sulfur dioxide and ozone. A square mile of alfalfa, for example, can theoretically remove over 3,600 tons of sulfur dioxide from the atmosphere each year. The implications of a sink role for forests are even more speculative. Nitrogen gases could stimulate growth, says Smith. Chloride, fluoride and heavy metals may harm insects that feed on leaves or twigs. But they can also harm pollinators. It is impossible even to tell from present information whether a pollutant may be harmful or beneficial, he concludes.

Intermediate pollution levels might depress growth in a number of ways. Decomposition of forest litter is a source of nutrients, and there is evidence that heavy metal pollution depresses decomposition rates. Studies of agricultural plants have shown that ozone and nitrogen oxides suppress photosynthesis.

Other pollutants impair reproduction. Photochemical oxidants have reduced fruit yield of citrus trees. Ozone tends to reduce pollen germination in tobacco and corn. There has been little research on pollution's effects on growth and reproduction in forest trees, but Smith infers similar results.

Smith says evidence has accumulated to show that atmospheric contaminants predispose ponderosa pine to infestation by bark beetles. Sulfur dioxide causes the pores in the leaves to expand, admitting disease-causing microbes.

Finally, he lists a number of cases where pollution became so intense that great expanses of forest were wiped out. At the turn of the century, smelters at Copper Hill in Tennessee destroyed 7,000 acres of deciduous forest. Pines in the San Bernardino National Forest are now threatened by oxidants from nearby Los Angeles basin, and Smith predicts that if pollution continues unabated, ponderosa pine may be all but eliminated as a species.

Smith believes study of low and intermediate pollution levels should have highest priority as these levels are already at work on forests. □

Off the record . . .

Notably conspicuous by their absence from the AAAS meeting were some of the most prominent public officials of American science. Presidential Science Adviser Edward E. David Jr., National Science Foundation Director H. Guyford Stever, and National Academy of Sciences President Philip Handler, for example, were nowhere to be seen, even though the meeting was in Washington only a few miles from their offices.

There are several views on the subject. One is that these scientific-political illuminaries find little of use to them at such a meeting. Another reason advanced, probably a more important factor, is that the demonstrations and disruptions that have marked previous AAAS meetings have produced an unfriendly climate for heads of governmental and quasi-governmental institutions potentially the target of anti-establishment critics. One holder of such a view suggests that although the organization heads would be more than a match for the dissidents in an intellectual debate, they have no inclination to be the subject of tactics of disruption.

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Several attendees took note that Philip Handler shunned a reception for science writers covering the AAAS meeting, even though his Academy was one of 10 science institutions sponsoring the reception and it was held in the Academy's Great Hall.

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Of a panel of meteorologists speaking at AAAS on weather modification, none knew, or would venture an estimate, how much the Department of Defense is spending on weather modification or whether weather modification is being used in Vietnam. When asked whether they ever get together with fellow meteorologists in the Defense Department, the response was "yes, but. . . ." □

The orange glass and the lunar highlands

That "orange" soil collected at Taurus-Littrow by astronauts Eugene Cernan and Harrison Schmitt (SN: 12/23/72, p. 404) is characteristically lunar at first glance: It's a puzzle.

Last week, scientists at NASA's Manned Spacecraft Center in Houston got their first look at the material (SN: 12/30/72, p. 420). "My first impression, to be honest, was that it wasn't orange," said William Phinney, head of the Preliminary Examination Team. "It's more of a brownish-ochre shade, but with a distinctly orange cast to it."

Physically, the soil is the finest-grained material ever examined from the moon. The grain size is about 40 microns; the average for lunar material is more like 70 to 80 microns. There are numerous clods about three to four centimeters in diameter in the material, and the clods themselves have color zones ranging from the gray to the brownish-orange. The soil is 90 percent glass. "It looks like you have a layer of orange glass laid in a band horizontally around the crater—like a marble cake structure," says Paul Gast, also of MSC. The soil is not rich in water or sulfur but it has the highest zinc content of any lunar material so far. "I think we can throw out the hypothesis that this was the result of hydrous alteration [as might be the case in volcanic fumarole alterations on earth]," Gast says. But this does not rule out the possibility that the glass was formed by a volcanic process, Gast stressed. The glass doesn't appear to have been formed by an impact event. "But how do you get orange glass on the moon?" he asks. The answer, Gast says, may also help answer the question of the green glass of Apollo 15 (SN: 1/29/72, p. 73) and the reddish glass in the Apollo 11 samples.

Radiation counting of one rock from the massif suggests that the highland material at the Apollo 17 site is fairly high in radioactive materials. The radioactive content is higher than what is found in typical anorthosites, but not as high as the Apollo 12 material dubbed KREEP. "When you tie the material from the North Massif to the Apollo 16 and Luna 20 results," Gast says, "you have an increasing suspicion that the highlands were formed by processes considerably more complex than we originally thought." The original explanation was that the highlands formed by melting and floating of the light material such as plagioclase (high in aluminum) to the top. Now it appears as though after this original crust was formed, other volcanic material was intruded on top of that crust. □