having novel ideas and is rewarded for having them.

This point of view has some grain of truth in it. There is evidence that children or adults who are rewarded for having novel ideas do tend to produce more of them (*4*). One experimental study of this effect showed clearly that training children to formulate new questions, to restate a given problem in their own words, and to generate ideas about it created a generalized tendency for them to do this when they were presented with entirely new and different problems (*5*). Moreover, this result could be obtained with training that lasted only a few hours. In a way this is disturbing to those who favor a "creativity" point of view; it is almost too easy. The authors of the study point out that these manifestations of "creativity" may be merely the result of "sensitization"—that is, of alerting the children to the feasibility and desirability of behaving in such a fashion (*6*).

The process approach has in it a little of both the "content" and "creativity" approaches. Though it rejects concentration on any particular science, it extends the notion of teaching generalizable ideas and skills. While it rejects the notion of "creative ability" as a highly general trait, it adopts the idea that productive thinking can be encouraged in relation to each of the processes of science—observation, inference, communication, measurement, and so on. The argument is that if transferable intellectual processes are to be developed in the child for application to continued learning in sciences, these must be separately identified, learned, and otherwise nurtured in a systematic manner. It is not enough to be creative "in general"—one must learn to carry out critical and disciplined thinking in connection with each of the processes of science. One must learn to be thoughtful and inventive in observing a variety of specific phenomena, in manipulating many different objects in space and time, in predicting a number of kinds of events, as well as in generating hypotheses.

The sixth grader who has learned science processes in this manner should be capable of studying science in the higher grades in a way which is not now possible. What is he ready for in terms of additional science instruction? This is a most important question, concerning which one can only guess at the present time. It seems probable that such a student will be able to learn about any given science, presented in accordance with its theoretical structure, in far less time than would otherwise be required. Certainly he should have a better conception of science as a way of thinking and discovering.

References and Notes

1. Commission on Science Education, *Science—A Process Approach* (AAAS, Washington, D.C., 3rd exptl. ed., 1965), pts. 1 (A and B)–7 (A and B).
2. *Sci. Educ. News* **1963**, No. 11, 1 (1963); Commission on Science Education, *Science—A Process Approach: Commentary for Teachers* (AAAS, 3rd exptl. ed., 1965); *Comm. Sci. Educ. Newsletter* **1**, No. 1 (1964).
3. In the assessment, the results of each exercise are systematically tested. The teacher (or in certain instances, another person), administers a "check list of competencies" individually to three pupils selected in accordance with a predetermined random order. The check list contains simply worded questions (to be checked "yes" or "no") designed to make possible unambiguous observations of the processes the child is able to perform shortly after he has had the exercise. The intent of these check lists is simply to obtain an answer to the question "Has the child learned what the exercise set out to teach him?" An additional test, intended for administration to individual pupils at the end of the school year, is designed to measure children's capabilities in generalizing their knowledge of science processes. Other kinds of evaluation are planned to assess the changes in attitudes and interest which are hoped for as a result of this sort of science instruction.
4. C. W. Taylor, Ed., *Creativity: Progress and Potential* (McGraw-Hill, New York, 1964); M. V. Covington and R. S. Crutchfield, *Programmed Instruction* **4**, No. 4, 3 (1965).
5. R. S. Crutchfield and M. V. Covington, "Facilitation of creative thinking and problem solving in school children," paper presented at the Annual Meeting, AAAS, 29 Dec. 1963.
6. This article is obviously not an appropriate place to deal extensively with the many and complex research questions that have been investigated in the attempt to understand cretivity. An excellent summary of educational implications derived from studies of the characteristics of creative persons is the chapter by D. W. MacKinnon, "Personality correlates of creativity," in *Productive Thinking in Education*, M. J. Aschner and C. E. Bish, Eds. (Nat. Educ. Assoc., Washington, D.C., 1965), pp. 159–171.
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NEWS AND COMMENT

Scientists and Civil Defense: Dialogue at Berkeley

Berkeley, California. Since the limited test-ban treaty went into effect in 1963, civil defense as an issue of public policy has lain practically dormant. A symposium on civil defense at the AAAS meeting last week may have anticipated the revival of debate, since a decision on deployment of antiballistic missiles is said to be imminent in Washington and an expanded civil defense program is viewed as an integral part of an ABM system.

The symposium was conceived, as AAAS president Henry Eyring said in introducing the all-day session, as a means of meeting the scientific community's "duty to provide our fellow citizens with an objective account of the technical data relevant to the grave issues of public policy on war and defense." The scientific credentials of the panelists were impressive, and their efforts to maintain the standards of scientific discourse evident. But the discussion demonstrated both the complexity of the problem and also how widely scientists may differ on matters of public policy where facts needed to support conclusions are unobtainable.

Takeoff point for the symposium may be said to be the Project Harbor report produced by a summer study group at Woods Hole in 1963. The Assistant Secretary of Defense for Civil Defense had requested that the National Academy of Sciences make a study in the field of civil defense. A group of 60 scientists and engineers headed by Nobel prize-winning physicist Eugene P. Wigner produced a report of some thousand pages.

The full report was not widely circulated, but a summary published by the Academy was made generally available. A "preliminary statement" included in the summary, which appears to have attracted more attention than anything else in it, said that the present limited civil defense program was "considered to represent a minimum level of significant protection below which a na-

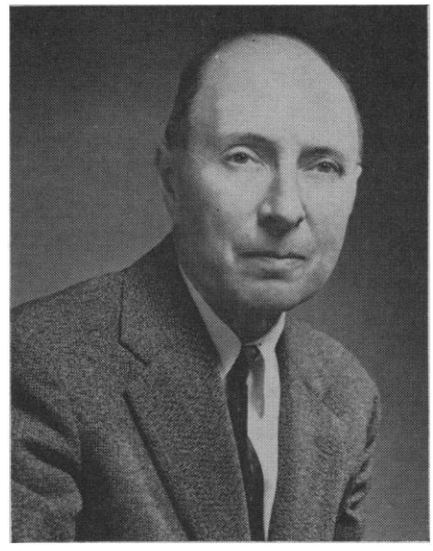
tional effort may not be justified at all. A more adequate program, which was generally favored by the participants in the study, would include (1) shelters in target areas that are capable of protecting against blast and fire, (2) stockpiling of necessary supplies and hardening of critical facilities along with intensive planning to accelerate recovery, and (3) substantially greater federal involvement in the program in an effort to improve professional competence and coordination of operations."

As a result of the study, Wigner has been working part-time as head of a small group at the Oak Ridge National Laboratory concerned primarily with problems of immediate survival in a nuclear attack. At the symposium Wigner described a type of blast shelter system feasible for use in target areas. The system represents a new concept in design and has been subjected to closer cost analysis than have many shelter proposals in the past.

(What is proposed is a "tunnel-grid system" consisting of a network of interconnecting cylindrical tunnels which themselves serve as shelters. The design meets many of the objections raised in the past to blast shelters, since any part of the system can be reached from any other, and services and facilities can be shared. Except in areas where the system was breached by nuclear cratering, occupants would be protected from blast and heat and air loss due to fire storms. The cost of such shelters in urban areas is estimated at $500 per space.)

Opponents of civil defense criticized the Project Harbor report as being an argument for blast shelters rather than an objective study of the feasibility of a civil defense program. In addition, Project Harbor was called too "optimistic" in assessing longer-term implications of a nuclear attack.

As might have been expected, the main division among the panelists at Berkeley was on the question of whether or not the United States should extend its civil defense program along lines suggested in the Project Harbor report. The symposium participants, in the order of their appearance, were Fred A. Payne, of the Marquardt Corporation, a former high-level Pentagon planner; Wolfgang K. H. Panofsky, director of the Stanford Linear Accelerator; Owen Chamberlain, University of California, Berkeley; Wigner, Princeton; Victor W. Sidel, Massachusetts General Hospital; John Howard Rust, University of Chicago; and Barry Commoner,



Eugene P. Wigner

Washington University. Payne, Wigner, and Rust were in favor of blast shelters, while Chamberlain, Sidel, and Commoner were aligned against them. Panofsky favored a strengthened professional civil defense establishment but was closer to the "anti's" on the question of an extensive system of blast shelters.

Speaking on "the basic case for civil defense," Payne argued that nuclear war is possible—for example, through "accidents" or through "someone else's decision, not our own," and that "therefore, population shelters are a necessary part of a prudent defense program which is charged with protection of the national interest against the use of military force by others."

Noting that the civil defense program has had "stepchild" status in the government, Payne traced this to the decision made during the Eisenhower administration to follow a deterrence strategy based on a very large arsenal of nuclear weapons. He said that the Defense Department has little operational interest in civil defense and that, in the competition for budget funds, civil defense has been overshadowed, because "in a world of atom bombs it is cheaper to kill adversaries than to save friendlies."

Early in the Kennedy administration, responsibility for civil defense was moved to the Defense Department and a program of marking and stocking fallout shelter space in existing structures was begun. (Another panelist observed that about 136 million fallout shelter spaces have been identified. Some 75 million of these have been stocked with supplies, and some 50 million, with water.) The Office of Civil Defense, incidentally, has slipped in the departmental hierarchy. It is no longer headed by an assistant secretary and is now under the authority of the Secretary of the Army.

Panofsky, whose topic was "civil defense as insurance and as military strategy," favored a relatively small civil defense program, which he termed "insurance," and opposed a big one such as would be linked with an ABM system. This opposition he based on three main considerations: (i) the adverse effects on American society which he believes would result from the interweaving of civil-defense training and volunteer activities extensively into civilian life; (ii) what he feels are faulty (optimistic) assessments of the effects of nuclear war; and (iii) a probable escalation of the arms race resulting from the response of other nations to our augmented civil defense program.

An insurance-type program he defined as one which would reduce the impact of nuclear war but not affect the likelihood of its happening. He also suggested organization of an insurance-type program along the lines of a professional pattern, with a corps of shelter managers, radiation monitors, and other specialists trained and paid by both federal and local governments. Such an organization would minimize the interweaving of civilian and military activities, he said, and could also be used to deal with natural disasters and other nonnuclear emergencies.

Panofsky put a good deal of emphasis on his contention that, in a nuclear attack, the "immediate problem of survival through shelter may not be the controlling factor at all." Too much stress, he said, has been put on inventorying facilities which would be damaged in a nuclear attack and not enough on investigating what he termed the "complex systems aspect of the problem." For example, a highly developed transportation system in the United States has made possible a food-distribution system such that relatively small stocks of food are kept in cities. This transportation system depends largely on trucks, and these in turn depend on electricity to pump fuel. And, Panofsky went on to say, "the recent power failures in the Atlantic states have clearly demonstrated that all of the analysis of availability of power in post-attack areas with which I am familiar are quite meaningless."

What Panofsky called "the hardened society"—a society in which there is

Vietnam: AAAS Council Expresses Concern about Effects of Growing Conflict

The Vietnam war and its pressures on federal support for research were the subject of two resolutions adopted last week by the AAAS Council at the association's annual meeting in Berkeley. The Council, which is the parliamentary body of the AAAS, is composed of some 450 members, including the officers of the association and representatives of the association's more than 300 affiliated societies and academies. About half the Council members were present.

The first resolution was introduced by the Committee on Council Affairs, which is the steering committee of the Council; the second, which did not explicitly refer to Vietnam, was introduced by four members of the Stanford University faculty, Leonard Herzenberg, David Hogness, Halsted Holman, and Arthur Kornberg. The texts follow.

For Settlement of Vietnam War

We feel called upon to add our own to the many voices raised in concern for a continuing peace: We commend world leaders here and abroad in their increasing efforts toward negotiation and speedy settlement of the war in Vietnam.

Prolongation of the Vietnamese war, with its increasing danger of universal catastrophe, threatens not only the lives of millions, but the humanitarian values and goals which we are striving to maintain.

Besides this concern which we share with all citizens, we bear a special responsibility as scientists to point out the large costs of war for the continued vigor of scientific research. Like all scholarship, the sciences cannot fully flourish, and may be badly damaged, in a society which gives an increasing share of its resources to military purposes.

Concern for Budgetary Effects

The scientific community is deeply disturbed by the limitations in the federal budget for research in science and health that appear imminent as a result of unexpected budgetary commitments.

At a time when national commitments are growing greater than available resources, there must clearly be some means of assigning priorities to the various objectives on which our resources may be expended. Some difficult choices must be made by the nation as a whole.

As scientists we bear the special responsibility of providing some of the information on which such choices must be based. Particularly relevant is information as to how different allocations of tangible and intellectual resources might affect scientific research. This information must be made available to aid the public and those who bear final responsibility for decisions regarding allocation of the nation's resources.

Be it resolved, therefore, that the Committee on Council Affairs of the AAAS establish a committee to:

1. Investigate the status and consequences of decreased federal support for training and research in the fields of science and health,
2. Inform members of the AAAS on this matter, for example, through the journal *Science*.
3. Consider means of educating the public toward the end that informed decisions on allocation of public funds can be made with an understanding of the alternatives involved and
4. Propose possible actions on this matter which might be taken by the AAAS.

"hardening" of such functions as electric power supply, water supply, and food stocks and stockpiling of medical supplies—not only would require the creation of extensively reorganized governmental apparatus to manage it but also would run counter to main trends in the economy.

In the realm of strategy, Panofsky feels that, under the present conditions of nuclear stalemate between the United States and the Soviet Union, "a large civil defense program would only raise the level of armament on both sides of the iron curtain to a higher level without an increase, and [with] possibly a decrease, in our security."

Owen Chamberlain, a Nobel laureate in physics, speaking on the effect of civil defense on strategic planning, also took the position that a major expansion of civil defense implies an acceleration of the arms race. But he noted at the outset that it would be difficult to make a scientific justification of the statement he was about to make.

With both the United States and the U.S.S.R. depending on a deterrent strategy, said Chamberlain, the citizens of each nation are hostages to the nuclear weapons of the other nation. He viewed civil defense as an attempt to "degrade" the weapons of an adversary, and stated, "anything we do to degrade its weapons, we can be sure the Soviet Union will respond to." If the Soviet Union developed a major civil defense program, he said, the United States would take action to regain its deterrent.

Chamberlain added, however, that, in view of nuclear proliferation, he could envision some kind of agreement between the Soviet Union and the United States for a limited civil defense program "to forestall nuclear blackmail."

Wigner's topic was the possible effectiveness of civil defense. While he dealt primarily with technical problems, like other panelists he spoke on other facets of civil defense. "As in all technological problems," said Wigner, "the first question which arises concerns the purpose for which we wish to provide the technology. As I see it, the purpose of civil defense is, in the first place, to preserve our peace; that is, to render a war less likely without abandoning the way of life which we usually take for granted. . . . The second purpose is to preserve as many lives and as much means of livelihood as possible, in case neither civil defense nor the other efforts to preserve peace should prove successful."

Wigner gave much of his time to a

description of the proposed tunnel-grid system. The design was heavily influenced by the original requirements that evacuation of people in shelters be made possible and that lines of communications between shelters be provided. An early conclusion was that tunnels intended to connect shelters could themselves be used as shelters.

The proposed tunnels would consist of reinforced concrete pipe 8 to 10 feet in diameter, with a wall thickness of 8 inches. While the tunnel walls could withstand pressure of 450 pounds per square inch, blast resistance would, operatively, be 100 pounds per square inch, because air-intake valves are not designed to withstand higher pressures and earth movement would be a serious factor. Bunks would swing down from the sides of the tunnel when it was not being used as a passageway. Three tiers of bunks on each side are envisioned; thus, with all spaces occupied, there would be about one person per foot length of tunnel.

Because of the interconnections, said Wigner, families could be reunited, critical personnel such as doctors would be mobile, and air and power supplies could be furnished to parts of the system where facilities were damaged. Evacuations of the entire system through peripheral tunnels would also be possible. To provide such tunnel-grid shelter systems for U.S. cities with populations of more than 250,000 would cost an estimated $38 billion. Wigner stressed that the tunnels could be adapted for such peacetime uses as parking garages, rapid transit, or underground highways. The tunnels, however, would not have to be deep underground. They would have to be placed beneath city utilities, but would require a minimum of about 3 feet of earth cover, said Wigner.

In discussing post-attack problems Wigner acknowledged that better provision for food and other necessary supplies would have to be made if the civil defense program is to be strengthened.

Physician Victor W. Sidel, who spoke on the medical aspects of civil defense, expressed a sentiment held uniformly by opponents of a bigger civil defense program, saying "preparedness for an attack might cause intensification of the attack."

Sidel's remarks were, in general, an argument that the magnitude of medical and public health problems in a nuclear attack and its aftermath were not being squarely faced by scientists, government planners, or the public. "Thermonuclear war," he said, "would lead to medical problems quantitatively greater and qualitatively different from any faced before." Not only would the injured overwhelm remaining medical facilities and survivors be highly vulnerable to epidemics, but it is likely that a shelter program might cause an enemy to modify his form of attack and resort to chemical and biological warfare against civilians.

Rust, who discussed the agricultural problems of civil defense, concentrated mainly on the effects of nuclear attack on animals, particularly farm animals. He assumed the "rational conduct of war," in the sense that no combatant would resort to nuclear "scorched earth" tactics which would cause the extinction of animal as well as human life. Arguing from these assumptions, he said that damage to agricultural areas from fire and blast would be limited. Fallout would be the major problem, particularly for farmers and their families. He cited studies which have showed that domestic animals, with the exception of sheep, can withstand single and accumulated doses of radiation much higher than doses humans can withstand, and he concluded that, in the event of a nuclear attack, "more animals will survive than men to eat them." Rust said that, in most animals, fertility has been shown not to be impaired by radiation at the levels he was discussing.

Exploring the "feasibility of biological recovery from nuclear attack," Commoner urged that more serious attention be given to the evaluation of chances of recovery from nuclear war. He said it was necessary to consider the possibility that the nation would never recover, and he stressed the effect of such a war on the environment and on the fabric of society.

The sort of nuclear-war-produced upset in the environment which might be disastrous for man could arise, he said, from the relatively high resistance of insects to radiation. Insects destroy food crops, but birds normally control the insect population. Birds, however, are much more sensitive to radiation than insects, and the consequence of thermonuclear war could be an incursion of insects on the food supply.

If people were badly demoralized and the social machinery shattered by a nuclear episode, those who survived blast, fire, and irradiation might well succumb to epidemics through failure to take necessary countermeasures.

Beyond the immediate devastation and the less direct effects of a nuclear attack, Commoner suggested, such an attack might cause a permanent change in the weather of the continental United States. He cited a Hudson Institute "scenario" prepared for the Defense Department which postulates a 20,000-megaton strike against the United States mainly in the form of groundbursts designed to destroy hardened missile sites and underground installations. The debris injected into the atmosphere would reduce solar heat to such an extent that a new ice age might be triggered, the scenario suggests.

Commoner believes that there is inadequate understanding of the process of recovery from nuclear attack and that it is not known whether the United States could survive a nuclear war. He charged that Defense Secretary Robert McNamara had presented evidence which was "woefully incomplete" and "misleading" in testimony on how many lives could be saved by particular civil defense programs. He stressed that, to the question of whether the nation could survive a nuclear war, scientists are obliged to answer, "We do not know."

A question period following the panel discussion was presided over by Anatol Rapaport, professor of mathematical biology at Michigan—an appropriate choice, since his interests include theories and techniques of conflict resolution. The question period produced a few concessions but no conversions.

Rapaport noted that all the panelists were concerned with how lives can be saved, and remarked on "the value-oriented nature of the discussion" despite the fact that scientists were involved.

Without presuming to have insights into the psychology of the pro-civil-defense or anti-civil-defense communities, Rapaport asked these questions: To what extent are the critics of civil defense influenced by antipathy toward the military or a dread of the warfare state? To what extent are advocates of civil defense attracted by the technical complexity of the problem, or to what extent are they so appalled by the thought of a world under Communist influence that they will defend American values whatever the cost?

While there was disagreement in the panel over increasing civil defense, no plea was made for less. The specter of

China as a nuclear power hovered over the session, and such strong opponents of a big civil defense program as Chamberlain and Sidel favored a modest one—presumably useful in cases of nuclear blackmail—especially if the emphasis was on general disaster planning rather than civil defense.

There was no agreement at all on what was perhaps the central question of the discussion: whether an extended civil defense program would precipitate a new round in the arms race and thereby decrease rather than increase national security.

The opponents of a bigger civil defense program seem to feel essentially that such a program might bring war nearer and probably would not help much if war came.

In oversimplified form, the case for a bigger program was made by Edward Teller, who, in a statement during the question period, said, "The absence of civil defense will guarantee that we will not survive nuclear war."

The symposium produced no consensus except for agreement that the public should make the big decision on civil defense and should be better informed in order to make the right one. And in providing some of that information, the symposium served as a rehearsal for the ABM-civil defense debate which may soon ignite.

—JOHN WALSH

Nuclear Weapons: Nonproliferation and Test-Ban Talks To Be Resumed

When the Eighteen-Nation Committee on Disarmament reconvenes at Geneva on 27 January, the problem of arresting the spread of nuclear weapons again will be the most pressing item on the agenda. The United Nations General Assembly has asked the Geneva conference to give urgent consideration to the negotiation of a nonproliferation treaty and a treaty extending the 1963 test-ban agreement to underground tests. The nonproliferation treaty would pledge nuclear powers not to assist nonnuclear countries in obtaining nuclear weapons, and would pledge the nonnuclear nations not to manufacture or acquire such weapons.

The feeling of urgency has been growing ever since Communist China exploded its first nuclear device in October 1964. The United States presented a draft treaty on nonproliferation at Geneva in August. In a statement from the White House, President Johnson said: "The time is now. The hour is late. The fate of generations yet unborn is in our hands. And 'humanity with all its fears, with all the hopes of future years is hanging breathless' on that fate."

A few weeks later the Soviet Union submitted a draft treaty similar in many respects to the U.S. draft but different in one seemingly critical particular. The American draft would permit allies to enter into such proposed nuclear-sharing arrangements as the much-debated Multilateral Force (MLF), which now seems dead, or the Atlantic Nuclear Force (ANF), an idea which may still have some life in it. MLF would be a force of missile-launching surface ships with crews of mixed nationality. ANF, though never precisely defined, might be made up of Polaris submarines contributed by the United States and the United Kingdom, with perhaps some form of participation by West Germany and other allies. Whatever the command and control arrangements for either a MLF or an ANF, the United States would retain a veto over decisions to launch an attack.

The U.S. draft treaty carries the proviso that nuclear-sharing arrangements of this kind must not increase the total number of states or other organizations having independent power to use nuclear weapons. The Soviet draft, by stipulating that nonnuclear states shall not participate—even through an alliance—in the "ownership, control, or use of nuclear weapons," would prohibit a MLF or an ANF.

Resolving such a fundamental difference in U.S. and Soviet positions would not be easy at any time. Now, with the Vietnam war exacerbating East-West relations, the problem is all the harder. For the Soviets to compromise with the West on a basic issue and enter a nonproliferation agreement would inspire a new wave of denunciations from Communist China. The Russians would be accused of cooperating with U.S. imperialists at the very time Communists were dying in order to liberate Vietnam from American forces.

However, the waves of denunciation from China seem to continue unabated in any event, and relations between the Soviets and the Chinese have reached such a low point that some high U.S. officials suspect the Russians have developed a thick skin and no longer worry very much about what the Chinese will say. Moreover, Communist parties abroad are by no means all at one with the Chinese in opposing the Russians' policy of coexistence with the West.

Many of them, in Europe and in the underdeveloped world, support coexistence, although some parties either support the Chinese position or are sharply divided. The 1963 test-ban treaty, banning nuclear tests in all environments except underground, was signed by the Russians over Chinese protests and the heavens did not fall. On the contrary, by agreeing to the test-ban treaty the Russians gained at least a small advantage over the Chinese by forcing them—when they began their weapons tests—to defy the world consensus.

So considered in terms of the politics of international communism, the reaction to Soviet adherence to a nonproliferation treaty would not seem to pose for the Russians an unmanageable problem. Nevertheless, negotiating agreements with a capitalist adversary against whom one's friends are struggling in Southeast Asia would demand of the Soviets a *sang froid* and sophistication in diplomacy perhaps greater than any they have shown to date. Failure of efforts to arrange a settle-