not always shed light on those aspects that are often considered most relevant. These aspects include human emotional experiences, such as feelings and value judgments. They are decisive in the realm of human decision-making. Whenever a choice is made between actions, whenever collective or personal decisions are taken, scientific reasoning can and should provide information about predictable consequences. The actual decision, however, remains outside of science, it represents a kind of reasoning which necessarily is complementary to scientific thought.

Science contains many activities of different aims and different character—the several basic sciences with all their variety of approach from cosmology to biology and the numerous applied sciences that are spreading and involving more and more aspects of human concerns. Science is like a tree in which the basic sciences make up the trunk, the older ones at the base, the newer, more esoteric ones at the top where growth into new areas takes place. The branches represent the applied activities. The lower, larger ones correspond to the applied sciences that emerged from older basic sciences; the higher, smaller ones are the outgrowth of more recent basic research. The top of the trunk, the frontier of basic research, has not yet developed any branches. Applying this picture to the physical sciences, we would locate classical physics, electrodynamics, and thermal physics at the lowest part of the trunk with broad branches representing the vast applications of these disciplines. Higher up the trunk we would put atomic physics with well-developed branches such as chemistry, materials science, electronics, and optics. Still higher we would find nuclear physics with its younger branches symbolizing radioactivity, tracer methods, geology, and astrophysical applications. At the top, without branches, so far, we would locate modern particle physics and cosmology. There was a time, only 50 years ago, when atomic physics was the branchless top.

All parts and all aspects of science belong together. Science cannot develop unless it is pursued for the sake of pure knowledge and insight. But it will not survive unless it is used intensely and wisely for the betterment of humanity and not as an instrument of domination by one group over another. There are two powerful elements in human existence: compassion and curiosity. Curiosity without compassion is inhuman; compassion without curiosity is ineffectual.

References and Notes

1. This figure is based upon an exponential increase of expenditure with a doubling time of 10 years, as it occurred during the last two decades, and a final yearly expenditure of $3 billion. The starting time is irrelevant.
2. From a contribution by H. B. G. Casimir at the Symposium on Technology and World Trade, National Bureau of Standards, U.S. Department of Commerce, 16 November 1966.
3. E. Purcell, quotation from an unpublished report to the Physics Survey Committee of the National Research Council, Washington, D.C.
4. M. Polanyi, *Personal Knowledge* (Univ. of Chicago Press, Chicago, 1958), p. 182.
5. Similar views have been expressed by T. R. Blackburn [*Science* **172**, 1003 (1971)].
6. I. I. Rabi, *Science: The Center of Culture* (World, New York, 1970), p. 92.
7. M. Mead, *Daedalus* **88**, 139 (1959).

NEWS AND COMMENT

National Environmental Policy Act: How Well Is It Working?

In a moment of jubilation, shortly after Congress passed the National Environmental Policy Act (NEPA), which he coauthored in 1969, Senator Henry M. Jackson acclaimed the new law as the "most important and far-reaching conservation measure ever enacted." It will be some time, of course, before anyone can fairly judge whether the law actually has lived up to Senator Jackson's description. But at the 2-year mark, NEPA has clearly established itself as one of the most controversial environmental measures of all time—one whose repercussions have rattled virtually every department and bureau of the federal government in a remarkably short time.

The law has two major features. One establishes the President's three-man Council on Environmental Quality (CEQ), which is partly responsible for encouraging the government to comply with NEPA and partly for advising the President on environmental affairs. The other feature is a broad statement of policy to the effect that government should seek to enhance the environment "by all practical means" consistent with other national policies, and that every citizen should help. What lends muscle to the lofty intentions of NEPA is an "action-forcing" provision that requires government administrators to prepare detailed statements of the environmental effects of any major action they propose, and to study all practical alternatives.

This "action" proviso is at the focal point of the controversy over NEPA and has led to efforts by some agencies to seek legislative exemptions from the law. These efforts, and the court rulings that led to them, were described in an article last week; this article deals with NEPA's more pervasive day-to-day effects on the government.

Is NEPA, in fact, producing useful results? The law's success, to a great extent, is in the eye of the beholder. Unquestionably, the law has given both community and national environmental groups a substantial new access to the courts, and, in turn, their litigation has given NEPA a forceful clout that it might never have had otherwise. The most visible offspring of this symbiotic union has been a series of federal court rulings that have dealt some stunning setbacks to major programs of the Atomic Energy Commission (AEC), the Department of the Interior, and even the Environmental Protection Agency—all of which inspires one environmental lawyer in Washington to call NEPA "the great equalizer."

Like the pistol of the same name, NEPA has also engendered a certain amount of ill-will, particularly among congressmen from districts where public works have been held up for court-ordered environmental reviews, as well as among a growing number of government administrators whose programs have been paralyzed by similar court rulings. Several observers of the new law's evolution detect a strong undercurrent of resentment toward NEPA among such mid-level officials, who

often seem to regard it as less of an instrument of enforcement than as a weapon of malicious harassment.

So far, the highest government official to say so publicly is John A. Carver, Jr., a Democratic appointee to the Federal Power Commission (FPC). In a recent speech to a petroleum industry group, Carver said that "NEPA has minimal impact in any substantive way," and that, while it may be a laudable expression of policy, "its sole observable function has been that of furnishing a weapon of delay to those who would use it for that purpose."

Carver's remarks, however, obscure the fact that judicial rulings and consequent delays of pipelines, power plants, and dams have been based on what the courts found to be cursory, slanted, or otherwise inadequate environmental impact statements. Delays and the agencies' reactions to them also have tended to obscure a number of less sensational but nonetheless positive side effects of NEPA which—in the long run—may prove to be a more accurate and lasting measure of the law's worth than delays imposed by litigation.

The law and its requirement of impact statements has forced, perhaps not obviously, nearly every agency—over 40 in all—to conduct a sometimes agonizing reappraisal of the way it performs its business and the way its business affects the environment. As a direct result of NEPA, the federal government this year will spend thousands of man-hours and perhaps $20 million that it never spent before to anticipate the adverse effects of pest-control programs, military installations, highways, and numerous other major and minor public works worth billions of dollars.

All this activity has imposed an unfamiliar burden of introspection and public exposure on federal agencies, in addition to masses of new paperwork and considerable overtime labor. This process has also produced an unprecedented flood of information about the environmental effects of government activities and their underlying rationale.

Among others, Russell E. Train, the chairman of the CEQ, believes that NEPA has opened some important cracks in executive secrecy in that it forces government administrators to articulate the reasoning behind their activities—and to solicit and respond to comments from both the public and other agencies—before taking any major action.

NBS Loses Branscomb to IBM

The President's technology opportunities program, which was unveiled early this year, assigned a lead role to the National Bureau of Standards (NBS), marking what was probably the first time the bureau has starred in any program of national prominence. Lewis M. Branscomb, the man who aroused the low-profile and somewhat sleepy agency to such eminence after only 2½ years as its director, announced last week he is leaving to become vice-president and chief scientist of IBM. This decision, which Branscomb explains as "a personal opportunity for me that is not likely to come again," will deprive the Washington science scene of one of its rising and brighter stars.

IBM did not have to scour the length and breadth of the nation for its new executive. Emmanuel R. Piore, present chief scientist at IBM and a doyen of American statesmen of science, is a member of the NBS visiting committee. An atomic physicist, not a computer technologist by trade, Branscomb will direct IBM's research on a strategic rather than a tactical basis. IBM spends roughly $500 million a year on research and development, compared with a total budget of less than $50 million enjoyed by the NBS. Branscomb thus steps into a job that is ten times larger and, it is said, will roughly double his present salary of $36,000. Since becoming director of the NBS in June 1969, he has turned down at least two university presidencies and has been in the running for the presidency of Massachusetts Institute of Technology (which went to Jerome B. Wiesner) and the directorship of the National Science Foundation (assigned to H. Guyford Stever).

Branscomb, age 45, has been with the NBS for more than 20 years, serving first in its atomic physics section, and from 1961 as head of the Joint Institute for Laboratory Astrophysics, a cooperative venture between the NBS and the University of Colorado. The 2½ years since he succeeded Allen V. Astin as NBS director is too short a time to have turned around a federal agency that is itself part of a larger bureaucracy, the Department of Commerce. Branscomb has made few changes of substance, and his most notable achievement has probably been to foster a change in attitude toward the bureau and a recognition of its potential as the government's instrument for stimulating industrial technology.

Until recently, the National Science Foundation had this suddenly fashionable area all to itself with its RANN program (research applied to national needs). The new money for enhancing industrial research in this year's budget was in fact split between the National Science Foundation and the NBS, a partition that many attribute to Branscomb's powers of persuasion with White House officials, including Peter G. Peterson, who has now become Secretary of Commerce. Largely through gaining a share of the industrial technology incentives program, the new budget request for the NBS is, at $72 million, some 60 percent larger than last year's.

Branscomb's empire-building spirit has been less in evidence in consumer product testing, a field that might be expected to interest a standards bureau. The affair of the AD-X2 battery additive, which 18 years ago occasioned the firing and rehiring of the previous NBS director, has not been forgotten in the bureau. Branscomb says it would be "very unwise" for the NBS to get into consumer product testing because its sophisticated equipment can better be used in devising methodologies of testing than in assessing particular products.

Branscomb has served on several of the key advisory committees that form the backbone of the science governance system. He has been a member of the ballistic missile defense advisory committee, the president's science advisory committee (PSAC), and the defense science board. Branscomb says he will be too busy at IBM to participate in the Washington science advisory committee system. But his experience at IBM will clearly place him at no disadvantage as a candidate for the science-based posts that may become available in future.—NICHOLAS WADE

Harvard Teaching Assistants Strike

Harvard's teaching fellows, to protest a cut in their financial support, have formed a new union which has apparently succeeded in getting their support restored. However, it is too soon to tell whether the group will wither away or become a long-term force on campus.

On 28 March, some 500 union supporters picketed Harvard classes to protest a decision made by R. Victor Jones, Dean of the Graduate School of Arts and Sciences, to redirect half of Harvard's contribution to assist teaching fellows—$800,000—to academic departments' discretionary funds. The change would have affected graduate student teachers by knocking in half the tuition rebates by which, in the past, Harvard has reimbursed them on the basis of need. While not exactly a pay cut, the decision would have had an impact on approximately half of the graduate school's 2200 resident graduate students. Union spokeswoman Barbara Herman says, "this was felt to be inequitable." After the cut was made public, the Graduate Students and Teaching Fellows Union was formed and made their one-day picket of Harvard classes.

Herman estimates that the union's pickets stopped 85 percent of all Harvard teaching activities. Although the administration does not recognize the union and no negotiations were held, Jones did announce shortly after the day-long strike that the $800,000 will go to teaching fellows' tuition rebates after all. While pleased with their success, Herman says the union now plans to continue to press for recognition—either by Harvard or by the National Labor Relations Board—and will take up other issues.

The union claims to represent about 1050 graduate students, of which 500 are also teaching fellows. It has some faculty support. "After all, we were graduate students once too," commented one professor. Another, Karl W. Deutsch, professor of government, said "I am not frightened at the thought of a union. Many highly skilled people have unions." Deutsch was one of those professors who rescheduled his 28 March class rather than cross or have his students cross the union's picket lines.

The tuition rebate issue is specialized, and also appears to be resolved. But Herman claims that there is a larger issue which may help the union to last: dissatisfaction with the university's new president, Derek C. Bok, who took office only last year. Herman says that Dean Jones is Bok's "major academic appointment" in the graduate school, and that the tuition rebate cut is typical of decisions the Bok team has made. "They seem to have been making statements on the basis of financial efficiency and not heeding their educational implications." As added evidence, she cited a lowering of graduate school enrollments and a plan to have Harvard University Press publish fewer works that are purely of scholarly interest and more that will sell profitably.

If dissatisfaction with the Bok administration is widespread, the union could have fertile ground to take root permanently. One index of such dissatisfaction has come from undergraduate Garrett Epps, outgoing editor of the *Harvard Crimson*. In the editor's traditional "parting shot" editorial, Epps criticized the Bok appointees as "slick maximizers" and contrasted them unfavorably with the "zany yankees" who characterized the administration of Bok's controversial predecessor, Nathan M. Pusey. Bok, Epps wrote, makes "cosmetic concessions which divide and pacify the constituencies he must manipulate." Whether or not the student's charges are accurate, it would appear that in some quarters the new President's honeymoon is over.

More important, however, for other campuses is the success, if limited, of the union tactic. As one administration official pointed out, a whole series of events, including investigations of alleged discrimination by the Department of Health, Education, and Welfare, is changing the tone of decision-making on campus. "The universities are now in the real world of economics," he said, "and this has a whole range of implications for labor regulations. It is clearly one of the issues of the 1970's."—D.S.

Still, there is no clear evidence that government officials are using this new information to a significant extent in their day-to-day decisions. It would be excessive to say that thousands of impact statements are piling up uselessly on the desks of obdurate bureaucrats; one can in fact find instances in which NEPA studies have prompted changes in a project, not the least of which is the trans-Alaska pipeline. But, on the other hand, such examples are hard to come by, and those that do exist are often complicated by overtones of judicial duress or the threat of it. It is important to note at his point that nothing in the law gives anyone veto power over any project or decision; nor is there any language which says explicitly that an agency must *use* an impact statement once it has gone to the trouble of writing one. Environmental groups hope the courts will eventually make that interpretation of the law, but so far the courts have not.

On balance, it seems as if federal agencies are still much more intent on meeting the letter of the law than on voluntarily adopting its spirit. As Robert Cahn, a member of the CEQ, puts it, "NEPA has been a very effective tool for arousing and informing the public, but it is not yet an effective tool in the decision-making process. . . . Perhaps it's too much to expect this kind of revolutionary measure to work as fast as we'd hoped, and for agencies to cancel or modify projects as a result of it this soon."

In the past 2 years, more than 4000 environmental impact statements have poured into the CEQ's small quarters near the White House. Six employees screen them for poorly done or otherwise remarkable statements, although the CEQ tries to avoid commenting on them individually; that is the job of the various agencies and it is the council's intent to make the process as self-operable as possible.

The volume of statements is deceiving in a way, since roughly half of them are brief and rather perfunctory documents concerning small highway projects and new airport construction financed through the Department of Transportation. (DOT is the leader in numbers but not quality. The Department of Housing and Urban Development and the FPC also rank near the bottom of the quality scale. Although impact statements are generally improving in sophistication and thoroughness, many, CEQ sources say, still amount to little more than post facto justifi-

cations of decisions already made.)

Each month's accumulation of statements is listed and summarized in a publication from the CEQ, the *102 Monitor,* named after section 102 of NEPA which requires them. The latest selection begins with a 48-page discussion from the Department of Agriculture on its annual fire ant spraying program and ends with a 13-page document from the DOT concerning the repaving of 4.4 miles of roadway in Lafayette County, Wisconsin. Although most of the 200 statements in between run no more than 100 pages, there are exceptions: The final impact statement on the trans-Alaska pipeline, released late last month, fills nine volumes and weighs 18 pounds. Interior Secretary Rogers C. B. Morton describes this weighty compilation as the most thorough examination of environmental effects that "any work of man has ever had." In any case it is one of the longest and, from all appearances, a great improvement over the first try—a 200-page paper so poor that even the Army Corps of Engineers found itself complaining about it last year.

As might be expected, such a massive new occupation as the writing of impact statements has brought with it some difficult learning experiences and even some organizational changes in a number of departments and bureaus. Each of more than 40 agencies has had to compose complex guidelines for writing its statements, and then has had to train hundreds of professional and clerical employees to use the guidelines. Some agencies, like the AEC, have had to start from scratch a second time, after a federal court ruling, in effect, invalidated the first set.

Throughout the Executive Branch the advent of NEPA has also fostered the appearance of new offices of environmental affairs and improved the fortunes of old ones, as agency heads have come to recognize that a deftly written impact statement can make all the difference between smooth sailing for a program and complete paralysis. Now, hardly a federal agency is without an environmental office, and those that lack one have not escaped NEPA's grasp entirely. The Securities and Exchange Commission, for example, requires corporate stock prospectuses to disclose a company's expenditures for meeting pollution control regulations and to own up to environmental lawsuits hanging over it.

Rough estimates of what complying with NEPA has cost the government in manpower and dollars are impressive but nonetheless small compared with overall budgets and employment. The AEC, for example, has 200 employees doing nothing but writing its own impact statements and reviewing scores of them from other agencies. (Any given statement generates anywhere from 5 to 35 sets of comments from sister agencies.) Atomic Energy Commission chairman James R. Schlesinger estimates that this effort will cost the commission about $6 million in fiscal 1973, or less than 1 percent of the AEC budget.

The Agriculture Department estimates that impact studies and statements for the Forest Service, pesticide programs, flood-control projects, and a wide assortment of other projects will cost $2 million this year. The Interior Department predicts an outlay of $8 million and the diversion of 400 to 600 man-years to NEPA activities. An added expense for the Interior Department is a new computer system to keep track of hundreds of NEPA documents circulating through its Washington headquarters and field offices scattered across the country.

There is a widespread feeling in Washington, and not just among environmentalists, that all this prodigious labor must have had a salutory effect on the federal bureaucracy, that it has been or will be something of a consciousness-raising experience. As Russell Train told a recent Senate hearing, the result of the mandatory analyses and the interagency consultations "can only be more informed decision-making." Despite some complaints about the assiduousness with which the courts have been enforcing NEPA, Interior Secretary Morton and AEC Chairman Schlesinger have voiced similar thoughts. Roger Cramton, the chairman of an

Court Affirms AEC Authority

The Supreme Court on 3 April said no to states that want to set radioactive effluent standards for nuclear power plants that are more restrictive than those of the Atomic Energy Commission (AEC).

The seven to two decision culminated a suit brought by the Northern States Power Company of Minnesota. The company sought to invalidate state regulations that set allowable radioactive emissions at about 2 percent of those permitted by the AEC. The brief, unsigned order affirmed the argument of lower courts that it was the intention of Congress to make power plant radiation standards the "exclusive responsibility" of the AEC.

Several states have been inducing utilities to conform with standards that go beyond those of the AEC, but Minnesota is the only one in which a company has brought the matter to court.

The AEC announced last June that it planned to lower the ceiling for radioactive emissions to about 1 percent of what is presently allowed, which would bring them roughly in conformity with the tighter state standards. Nonetheless, many state officials are upset by the court decision. A spokesman for the Minnesota Pollution Control Agency said that the state and the AEC still differ over permissible emissions for various isotopes. Further, he says, the court decision runs against the state's approach, which is to work with each company individually to bring emissions down to the lowest practicable level.

A lawyer for Pennsylvania's Office of Radiological Health, which also has its own emission standards for nuclear power plants, says that the decision has seriously undercut states' potential to exert pressure on the AEC to improve its standards.

Power companies have generally shown a willingness to cooperate with state guidelines while the authority of states in this area awaited clarification. Continued voluntary compliance is in doubt now that states have no legal recourse.

Several members of Congress have introduced bills that would give states clear authority to lay on restrictions for radioactive emissions above and beyond those of the AEC. These are now sitting in the Joint Committee on Atomic Energy, and there is no evidence that the recent Supreme Court decision will hasten action.—C.H.

obscure but elite group called the Administrative Conference of the United States, an efficiency-promoting arm of the Executive Branch, predicts that the initial anger and resentment that mid-level bureaucrats have felt toward NEPA will give way to "an institutional viewpoint more sympathetic to environmental, as opposed to purely programmatic, values."

"Admittedly this is largely a prediction rather than an accomplished fact," Cramton adds; and he goes on to warn that it's entirely possible that NEPA may give rise to a new form of "bureaucratic gamesmanship," in which an agency's expertise is used to shape impact reports to fit preconceived decisions rather than the other way around. Representative John Dingell (D–Mich.) the other coauthor of NEPA, worries about this possibility too. The law's requirements, he said in a recent speech, are often complied with grudgingly, "behind a facade of false enthusiasm," and a risk exists that the law may do no more than spawn a race of adept memo artists "totally lacking in vision and concerned only with robotlike compliance. . . ."

Such fears are not without substance. In actuality, the main objective of most agencies appears to be one of writing defensible impact statements while minimizing changes and consequent delays in their work—most of which was under way when NEPA became law. There is some feeling at the CEQ that the machinery for producing NEPA reports, while becoming larger and more adept, has not begun to mesh satisfactorily with the machinery for making decisions. Added support for this view comes from an investigation by the Government Accounting Office of seven agencies' activities under NEPA. The study, made at Representative Dingell's request, has concentrated almost exclusively on procedural details for preparing statements, but some of the GAO investigators nevertheless came away with the personal impression that the law's identifiable effects on agency decisions have been less than monumental. "NEPA is more than just a papermill," one GAO man said, "but one concern is that impact studies are not being done soon enough to really affect the decision process. Agencies tend to wait until after it's decided that a power plant or a highway is needed, and after the site is selected, before thinking about the impact."

The CEQ has tried to compile a list of exemplary accomplishments under NEPA, but so far the list is conspicuously short. For one, the CEQ justifiably credits itself with convincing President Nixon to kill the Cross-Florida barge canal, and after all, NEPA created the council, which the President initially had thought unnecessary. As another example, the Interior Department says that NEPA studies have led it to tighten design requirements for the trans-Alaska pipeline, and that if the line is built it will be less detrimental to the Alaskan tundra than it might have been before.

Further inquiries reveal some evidence that NEPA has forced federal highway authorities to pay more attention to known prehistoric Indian sites rather than blithely paving them over because they were not officially listed in the Federal Register. The Interior Department's Bureau of Reclamation can also proudly claim that it will dig a borrow pit for gravel behind a small earthen dam in southeastern Idaho as a result of NEPA studies, rather than in front, where the pit would remain as a visible scar on the landscape for decades. (This has by no means become standard practice, however. Nor has the need for the dam itself been seriously questioned.) Further, in the Department of Agriculture, the annual acreage to be sprayed for gypsy moths this year has been sharply reduced, partly, but only partly, as a result of reappraisals forced by NEPA.

"This is a very hard thing to document," Train concludes. The problem, he explains, is that one never hears about the decisions that aren't made or about projects that were modified early in the game as a result of NEPA studies. Precisely why is unclear. It may be that government administrators are reluctant to admit where they had gone astray and that a nettlesome law has shown them the light. To some observers however, the notion of unsung environmental heroes in the depths of federal agencies seems implausible. At any event, modesty of this sort is an unfamiliar virtue.

Certainly NEPA has had some beneficial spinoff that weighs heavily against its drawbacks. The public exposure it provides to formerly closed administrative procedures represents an important new restraint on executive arrogance. In creating the CEQ, the law placed a vigorous, though not always successful, advocate for environmental interests within the sanctum of the White House.

But before the law goes much further toward lifting the scales from the eyes of the builders and diggers in the federal government, the courts will probably have to take a second bold step in reading NEPA's lofty language —and require that agency administrators make a reasonable showing that their decisions do in fact take account of all the new environmental information that it generates.

—ROBERT GILLETTE

OECD: Report Sees Closer Links between Research, Social Objectives

For its industrialized member countries, the Organization for Economic Cooperation and Development (OECD)* has proved to be the most useful of international forums for consultation and mutual criticism on economic matters. At the time of the flap over the technology gap, for example, the organization provided a meeting ground for OECD science ministers and much of the analysis that enabled them to put the issues into perspective. Since OECD was created as a spinoff of the Marshall Plan, it has treated education and scientific research as essential social and economic factors and, through a competent secretariat, has generated solid data and some enterprising studies in these areas. OECD's series of reviews of national science policy, including an extramural one on the Soviet Union, has contributed a good deal to defining the goals and describing the mechanisms of science policy. And this month, OECD is scheduled to take the science policy reviews a step further with publication of a comparative study of the or-

*OECD member countries are Austria, Belgium, Canada, Denmark, Finland, France, the Federal Republic of Germany, Australia, Greece, Iceland, Ireland, Italy, Japan, Luxembourg, the Netherlands, Norway, Portugal, Spain, Sweden, Switzerland, Turkey, the United Kingdom and the United States.