to labor and work: "Action, the only activity that goes on directly between men . . . corresponds to the human condition of plurality, to the fact that men not Man, live on the earth and inhabit the world. While all aspects of the human condition are somehow related to politics, this plurality is specifically *the* condition . . . of all political life." To act is to set something into motion in the context of human plurality, and because of this plurality every action is a beginning whose process is irreversible and whose outcome is unpredictable.

51. H. Arendt, *The Human Condition* (Univ. of Chicago Press, Chicago, 1958).
52. The future is by definition uncertain. Attempts to find a substitute for action and avoid the frustration of unpredictable outcomes must lead to either the suppression of human plurality through tyrannical control or the insistence that one's activity is "worldly" or self-contained, rather than political and interactive. The former reflects the refusal to allow consequences, the latter the refusal to acknowledge them. See Arendt (*51*, chap. 5).
53. Imperfections in human knowledge and the fundamental uncertainties associated with the probabilistic distribution of the frequency and severity of cataclysmic events can be somewhat compensated for by the provision of secondary barriers that ensure slow diffusion and return of the wastes to the environment even if the primary containment is breached.
54. This much, at least, is within the scope of mathematical risk analysis.
55. A good example of such mixed irreversibility is dropping a cracker spread with peanut butter and jelly face down on a sandy beach. In principle, the effects can be reversed. In practice, both social and physical costs are *usually* too high. I thank R. Budnitz for this example.
56. In fact, the continued existence of intelligent life requires it.
57. See, for example, H. Kaufman, *Are Government Organizations Immortal?* (Brookings Institution, Washington, D.C., 1976).
58. Note that only the perceived quality of life is referred to. This makes clear the political nature of the assertion. Translated into economic terms, this is equivalent to the price elasticity of demand being greater for falling prices than for rising prices. At times of great stress, such as during major wars, perceived quality of life may be sacrificed willingly. At other times, changes in perception are simpler.
59. This argument could be extended as follows: Knowing what we do of the dangers of nuclear weapons, we should not leave any fissionable materials for the future, on the assumption that we have been lucky and they could easily do far worse. This presents an ethical problem of even greater complexity than those set out in this article.
60. A. J. Evans excavated the first of the Mycenaean tablets inscribed in Linear B at Knossos in the year 1900. More than 50 years elapsed before they were deciphered. See J. Chadwick, *The Decipherment of Linear B* (Cambridge Univ. Press, Cambridge, 1970). The 3500 years that have elapsed since the inscriptions were made is only about one-seventh of the half-life of plutonium-239. Yet, almost all the information about the culture and language of Minos had been lost.
61. If we depleted existing beds of uranium ores, a future society would, in all probability, develop to a fairly advanced industrial stage before discovering the existence of natural radioactivity.
62. One of the advantages of seabed disposal in the center of the North Pacific plate is that the site is not only geologically stable, but barren of resources and scientifically boring (W. Bishop and C. Hollister, private communication).
63. E. A. Martell, *Actinides in the Environment and Their Uptake by Man* (Publ. NCAR-TN/STR-110, National Center for Atmospheric Research, Boulder, Colo., 1975).
64. M. Landau, *Public Admin. Rev.* **29**, 346 (1969).
65. More detailed method-specific analysis is needed to examine this somewhat intuitive conclusion.
66. That is, by other than informed and sophisticated actors who know just what it is they are seeking and for what purpose it is to be used. Under these conditions, we can be fairly certain that they would be aware of the risks.
67. Technical irreversibility and site multiplicity are taken to be independent variables. It is assumed that for each method of waste disposal there is what amounts to a functional equation that expresses the interrelationship of the variables for that specific method.
68. In the absence of contrary information, a priori equal probability of gross failure is assumed.
69. It should be kept in mind that Fig. 3 is a conceptual and heuristic device, not a quantitative map. The significant information is the relative, not the absolute, position of any given option.
70. This is, of course, only one of the possible ways to select an option. The major point here is the bounding of a region that contains the unacceptable methods, so that they may be discarded.
71. D. E. Boeyink, "Finitude and irreversibility: The duty to avoid irreversible consequences," paper presented at a regional meeting of the American Academy of Religion, April 1975. Irreversible consequences are to be distinguished from irreparable harm. The former involves uncertainty as to the harm or good of our actions in the face of imperfect knowledge and a moral finitude. Note that it is the irreversibility of consequence that is suggested as being avoidable. All action is inherently irreversible. But see Arendt (*51*).
72. Waste disposal methods have been deliberately omitted from Fig. 4 to avoid even the appearance of preempting social choice. The placement of the indicated regions relative to the various options is not purely a technical problem.
73. That is, 0.2 percent uranium concentrations in sandstone.
74. Let us assume that all methods chosen have equal rates of failure. If two options were selected, and the probability of a certain release during the required storage time were ½ for each of the methods, the probability that both would have such a release would be ¼. For three methods, the probability would be ⅛. This would be advantageous only if the procedure resulted in effective damage limitation. But suppose that this release could result in a catastrophe. In that case, the selection of three methods at the stated probabilities would result in a ⅞ assurance that at least one such catastrophe would occur. For two methods, the probability would decrease to ¾, and for only one method to ½. For any combination of methods there would be a distribution of failures in time and a distribution of radionuclide inventory. It would be instructive to have some strategies played out by mathematical analysis to examine over what period the hazards entailed would actually be increased by diverse options in the absence of remedial action. For long times, damage limitation would be expected to dominate.
75. The information needed for monitoring the sites and locating them would not compromise the requirement of technical irreversibility if properly done. The original design consideration should provide for the storage and handling of emplacement data, and the monitoring of disposal areas, in such a way as to provide inaccessibility of both sites and information to a naive actor.
76. This would be particularly true if remedial action could be rapidly effected, since a thorough program to develop a new method from scratch would take a minimum of several years.
77. For example, potential leakage from corroding carbon steel tanks at the Hanford reservation was prevented by solidifying the contained wastes into salt cake. There is no existing method for removing the solidified wastes without risking a potentially serious spill, because the tanks can no longer be checked for integrity. As ERDA itself put it, in *Creating Energy Choices for the Future* [(Publ. ERDA-48, Government Printing Office, Washington, D.C., 1975), vol. 2, p. 119]: "If it is determined that the salt cake must be removed from these tanks before the level of radiation decays substantially (several hundred years), unique fully remote techniques for removing the salt cake from the storage tanks will have to be developed."
78. To the extent that one holds the contrary belief that social stability is more assured than present technological aptitude, it would be better to store the wastes in a small number of accessible sites so that performance could be monitored and errors corrected. Of course, this assumes that future technologies will be an improvement and that operational errors such as that discussed in (*77*) will be avoided.
79. A. Weinberg, *Science* **177**, 27 (1972).
80. The comments of T. Bradshaw, D. Metlay, B. Schiff, K. Smith, and P. Windham are gratefully acknowledged. I thank T. La Porte and A. Middleton for their advice and support.

NEWS AND COMMENT

Search for a Science Adviser: The Names on the List

In Tibet, when the Dalai Lama died, the monks used to choose his successor by scouring the nation far and wide for the newborn into whom his soul had transmigrated.

In Washington, in what may or may not be a better method, the aides of the President-elect draw up a list of names which is read over the telephone to people expected to be knowledgeable about how each might perform in the office in question.

Jimmy Carter's aides are giving what is perhaps surprisingly high priority to the search for the President's science adviser.

The list of names for science adviser includes the following candidates. It has been put together from those being asked their opinions, not those doing the asking, and so may not be inclusive, let alone indicative of the final selection.

Apparently at the top of the list are Lewis Branscomb, Jerome Wiesner, and Wolfgang Panofsky. Branscomb, a former head of the National Bureau of Standards and now IBM's vice-president for research, is chairman of Carter's science policy task force. Wiesner, the president of MIT, was science adviser under Kennedy, and Panofsky is director of the Stanford Linear Accelerator Center.

It is not known whether any of these three would be able and willing to take the job. If none is, the guessing is that the choice would be made from the second rank of candidates, which is said to include John Baldeschwieler of Caltech, and three Harvard men, engineer Har-

Paris and Bonn Alter Nuclear Stand

In the face of growing international concern over the proliferation of nuclear weapons and the advocacy of an incoming American president pledged to strong antiproliferation measures, both France and West Germany have indicated that they will forego further exports of nuclear fuel reprocessing plants that could be used to acquire plutonium for atomic weapons.

The separate announcements did not apply to existing contracts, and therefore left uncertain the status of France's agreement to sell a reprocessing plant to Pakistan and West Germany's agreement to sell fuel reprocessing as well as enrichment technologies to Brazil. These two deals have been the subject of much criticism in the last 18 months, and were singled out by President-elect Carter when he called for a voluntary moratorium on the sale or purchase of sensitive nuclear technologies during his election campaign. Although France and West Germany indicate publicly that they will honor their existing contracts, the European press reports that France would not be sad if Pakistan bowed out and that Germany is reluctantly investigating ways to strike the sensitive technologies from its Brazilian nuclear package, while preserving the lucrative reactor contracts.

On 16 December, the French government's nuclear export council announced that it would halt future sales of reprocessing plants, saying that "France does not intend to contribute to the terrible threat of nuclear arms proliferation." The council is headed by President Valery Giscard d'Estaing and was set up just 3 months ago to reconsider French nuclear policy, after the departure of Prime Minister Jacques Chirac who was said to have been responsible not only for the reprocessing sale to Pakistan but also for the controversial sales of power reactors to Iraq, Libya, and South Africa.

The shift in the French position immediately put additional pressure on West Germany to reconsider its policy, particularly its $4 billion package deal to supply Brazil with eight commercial power reactors plus the peripheral technology for a complete nuclear fuel cycle (*Science*, 30 May, 1975). Four days after the French announcement, a spokesman for the West German foreign ministry, Klaus Terfloth, said that his country would go along with the position taken by France, except in the case of Brazil. Terfloth's remarks did not constitute a formal policy statement, but were made in response to reporters' questions. Renegotiation of the Brazilian sale would be politically risky for Chancellor Helmut Schmidt's shaky coalition government, since the sale was the largest export contract in German history. Nevertheless, the German press reports that the government is responding to American pressure, especially the prospect of more duress from Carter.

Reconsidering the Brazilian Deal

In a December article, the newsmagazine *Der Spiegel* says that there is widespread resignation in Bonn to the idea that reprocessing and enrichment technologies can no longer be used as sweeteners for large nuclear sales. At the most recent nuclear supplier's conference this fall, the Ford Administration reportedly pointed out that U.S. shipments of nuclear fuel to West Germany were not necessarily guaranteed, and in the face of such threats the Bonn government may be backing down.

Der Spiegel reports that "Chancellor Schmidt himself gave the order to check how West Germany may be able to wind herself out of the Brazil deal elegantly and without endangering the contract for exporting the [eight power] reactors." The newsmagazine further reports that the German state department is searching for precedents for unilateral cancellation of parts of the contracts.

Thus, even before Carter assumes office, his strong stance on nuclear exports is apparently bringing France and Germany into line with a more conservative policy, and there is some evidence that the Carter position may eventually be effective in reversing the two trade agreements that presently loom as the most likely vehicles for further weapons proliferation.—WILLIAM D. METZ

vey Brooks, chemist Paul Doty, and physicist Edward Purcell. Also on some lists is Ivan Bennett, provost of the medical center at New York University.

Speculators are paying particular attention to Baldeschwieler because of what is said to be his closeness to Harold Brown, the president of Caltech and Secretary of Defense-designate. Some say that Brown will promote Baldeschwieler as the President's science adviser, while others think that Brown will want him as Director of Defense Research and Engineering. A third post being mentioned for him is that of director of the National Science Foundation, although the guess is that the present acting director, Richard Atkinson, will probably also have a chance for the job. Baldeschwieler, a chemist, was deputy director of the Office of Science and Technology during the Nixon Administration.

The Carter staff do not yet seem to have turned their attention to the NSF, although they already have lists of names for the science positions at assistant secretary level in the departments of State and Commerce. In some instances the names for these posts are the same as those for the science adviser, which perhaps points to a certain naïveté by the list makers in thinking the same people would be suitable for either job.

Carter's personnel search is being handled by his aide Hamilton Jordan and by another group called the Talent Inventory Program. The two groups are "cross-talking," explained an aide in a third group.

There are two other such bodies whose activities affect scientific matters—a group studying reorganization of the federal government, and a policy analysis group under Carter's issues man Stewart Eizenstadt. Alfred Stern, a mathematics professor at Wayne State University, Detroit, and Eizenstadt's deputy, is the staff member responsible for science. Stern has working for him liaison officers to the NSF and the Office of Science and Technology Policy (no liaison officers have been appointed for NIH). The two-person team assigned to the NSF has gone through several changes and at one time included a 22-year-old Yale graduate fresh out of college. It now consists of Leonard Roellig, a physics professor friend of Stern's from Wayne State University, and Janet Brown, a political scientist delegated for 3 weeks from the Opportunities in Science program of the AAAS. According to Brown the team's job is to identify the policy issues on which the President or NSF director might have to make decisions within the next 6 months. The team has also been

asked to look at any budget changes that might be necessary (although the rumor is that the Ford Administration is requesting a high budget for the NSF) and to identify any organizational changes that may be needed (none have so far leaped to attention). "We are to outline options, not make policy," Brown says.

The AAAS seems at this juncture to be playing a more prominent role than usual in the nation's affairs. A Carter aide called AAAS executive officer William Carey 2 weeks ago—when only the first few cabinet members had been announced—saying he had heard the scientific community was unhappy that the science area was being ignored by the transition staff. To make amends for this neglect, the aide said, would the AAAS detail two people to work with the transition staff. "I told him that the scientific community was not at all indignant and that my advice was for them to take their fingers off the panic button," says Carey. The two people requested by the aide, Brown and Irene Tinker of the AAAS International Office, were both members of the science policy task force that aided the Carter campaign.

Ellis Mottur, a Kennedy science policy adviser who has been consulted by the Carter staff, believes the search for the science adviser is being well handled and reflects Carter's "tremendous personal commitment to the potential of science and technology. The scientific community ought to be delighted that at least we got the law passed [reestablishing the science adviser's postion] and that the Carter people have recognized this," says Mottur.

But Carter's aim of reducing the White House staff may crimp the style of the science adviser's reincarnation.

—NICHOLAS WADE

Science in Europe: British Ponder Reprocessing Plans

British plans to become a major world center for the reprocessing of spent fuel from nuclear power plants have been halted at the last possible minute. Officially, the reason given for the delay is to allow more time to examine the plans; but a more likely explanation is that the British Government wanted to avoid offending President-elect Carter by going ahead with reprocessing while the American position on reprocessing is still undecided.

The plans involve an expansion of reprocessing facilities at the Windscale works of British Nuclear Fuels Ltd. (BNFL) in northwest England. Part of the expansion would consist of a plant for reprocessing oxide fuel of the type used in British advanced gas cooled reactors (AGR's) and in light water reactors (LWR's). Although Windscale has functioned since the earliest days of nuclear power, it has little experience of oxide fuel reprocessing because earlier British reactors did not use this type of fuel.

The controversial part of the plan was that in addition to reprocessing AGR fuel, the oxide plant at Windscale would undertake to reprocess fuel from abroad. Contracts with Japan are already drafted and all but signed, and together with work from other European countries are expected to produce business worth £500* million. The capital cost of the expansion, to which Japan would have contributed, is £600 million.

Criticism of the plans first surfaced 12 months ago, and centered on the claim that Britain was allowing itself to be used as a "nuclear dust-bin" for Japanese nuclear waste. BNFL countered by saying that all high-level wastes extracted from spent Japanese fuel would be returned to Japan and not stored in Britain. In March this year BNFL appeared to have won the battle when the Secretary of State for Energy, Anthony Benn, told the House of Commons that the Government had decided that BNFL could take on the overseas work.

Early in November the planning committee of the County Council in which Windscale falls gave its approval for the expansion. Under Britain's complex planning regulations, this left 21 days for the Secretary of State for the Environment, Peter Shore, to intervene if he wanted to call a full-scale public inquiry into the plans. On the last possible day, he did intervene, not to call a public inquiry but simply to allow more time for consideration. The most recent development in the debate over the plans was the announcement on 22 December by Shore that his department would hold a public inquiry into the part of the Windscale plan involving oxide fuel reprocessing. Such inquiries often take 6 months or more to produce a recommendation, but indications are that the government intends to move more rapidly toward a decision.

This leaves Britain in very much the same position as the United States on the question of reprocessing, which has emerged in the past 2 years as one of the most crucial issues in the nuclear debate. President Ford's decision 5 days before the election to put reprocessing on ice has now been followed by an almost identical decision in Britain. The expectation that President Carter will be even more cautious on the issue than President Ford reinforces the view that a major international reconsideration of reprocessing is under way.

Reports which leaked out from a meeting of the London Nuclear Suppliers Club held in the middle of November lend some support to this view. The club, which first met in the summer of 1975, now has 14 members (United States, United Kingdom, France, Soviet Union, West Germany, Japan, Canada, Belgium, Czechoslovakia, East Germany, Holland, Poland, Italy, and Sweden) and is beginning to suffer from the same internal stresses and strains as other international organizations.

At the most recent meeting several member states are understood to have complained about pressures brought to bear on two contracts which involve the transfer of reprocessing technology—a contract between West Germany and Brazil, and one between France and Pakistan. Ever since these contracts were agreed on, extensive diplomatic pressure has been brought to bear on France and West Germany to cancel or modify them. The major source of such pressure has, of course, been the United States. Apparently as a result of this pressure, both West Germany and France indicated in mid-December that they would foreswear exports of reprocessing technologies in the future. The similar announcements, coming only days apart, seemed to signal a shift of policy, but left the status of the existing contracts with Brazil and Pakistan uncertain (see box, page 32).

What the United States has been trying to do, according to the leaked version of the club's last meeting, is to force

*The current exchange rate is about £1 = $1.69.