that it is the cause of all our urban woes, a thesis lacking empirical support.

Humphreys is incorrect in asserting that I claimed freedom of choice now exists. I said that it is a value which should be given primacy, under the aegis of voluntaristic information and contraception programs. The work of implementing that value has hardly begun.

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Research Natural Areas

In his article "Natural areas" (4 Aug., p. 396), William Moir refers briefly to a publication that should receive more attention. *A Directory of Research Natural Areas on Federal Lands of the United States of America* (*1*) is a list of more than 300 research natural areas with their descriptions, locations, and individual information sources. It is cross-referenced by type, state, and species of note and serves as an announcement of the availability of natural areas for appropriate use by scientists and educators.

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Reference

1. Federal Commitee on Research Natural Areas, *A Directory of Research Natural Areas on Federal Lands of the United States of America* (Government Printing Office, Washington, D.C., 1968).

Safety at Rocky Flats

Donald Michels (Letters, 21 July, p. 208) takes issue with Deborah Shapley's disturbing report (News and Comment, 5 Nov. 1971, p. 569) on safety at Dow Chemical Company's Rocky Flats plutonium plant in Colorado. Michels is on the Rocky Flats staff (an affiliation not mentioned in his letter) and thus is hardly a disinterested observer.

Michels appeals to the reader to imagine that plutonium plant safety has evolved somewhat over the past 25 years and that there is no inconsistency in the claims of the Atomic Energy Commission (AEC) that the Rocky

Flats plant is safe and the AEC request for funds to make it safer. However, most improvements at Rocky Flats have been made since the nearly disastrous plutonium fire of May 1969 and the discovery of off-site plutonium contamination. Despite improvements, both plant safety and public safety remain uncertain because (i) the AEC has not complied with the request of the Environmental Protection Agency for a detailed plant-safety analysis, and (ii) neither the National Committee on Radiation Protection and Measurements nor the International Commission on Radiation Protection has recommended plutonium inhalation standards applicable to the general public, including children.

In comments on reports by me and my associates (*1*, *2*) Michels is careless with facts and makes statements out of context, based largely on unpublished sources. Michels claims that plutonium soil data must show a bimodal distribution to establish the presence of plutonium from Rocky Flats. This unsubstantiated speculation is incorrect because it is at odds with unequivocal evidence from $^{239}Pu/^{90}Sr$ ratio data for soils (*2*). Duplicate small soil samples, obtained using carefully tested procedures, have variations attributable to differences in the size and number of plutonium particles present (*2*). Without basis, Michels implies that our data are unreliable because of such variations. Our experimental methods and results have been reported (*2*). If, as Michels suggests, members of the Health and Safety Laboratory of the AEC take exception to some of our conclusions, they should publish their own views.

In January 1970, I attributed the off-site plutonium to the May 1969 fire at Rocky Flats (*1*). The possibility that the off-site plutonium resulted from a 1957 fire or a plutonium-contaminated oil spill was first admitted by Dow representatives on 10 February 1970. Subsequently it was shown (*2*, *3*) that most of the off-site plutonium was due to the oil spill.

Michels incorrectly states that only 17 percent of the winds at Rocky Flats have an easterly component. Possibly he was misled by uncritical consideration of the wind data in Figure 1 of HASL Report No. 235 (*3*), in which the wind frequency scale is incorrect. About 35 percent of the winds have an easterly component, justifying my statement that about one-third of normal stack effluent is carried to the west. Further-

more, I have never questioned the fact that the most frequent winds in Denver over the Platte River valley are southerly to southwesterly. I only question the argument that such winds somehow protect Denver from Rocky Flats plutonium contamination.

In justifying the few Rocky Flats employees on the Transuranium Registry (450 of 7700) Michels makes indefensible statements: "Studies of exposures to workers must naturally be restricted to those persons involved in incidents" and ". . . few of those [plutonium workers] collect significant exposures during their tenure." Cancer risks applicable to the maximum permissible lung burden (MPLB) for plutonium are very uncertain (*4*), and chronic effects of low level plutonium exposure are unknown. Cancer from inhaled plutonium may be due to the irradiation of cells within the short range of alpha radiation around each plutonium particle. If so, the lung cancer risk would depend on the number, size, and persistence of plutonium particles in the lung. On this basis the MPLB is a meaningless concept, and plutonium lung burdens below detectable levels would involve significant risk. Not only plutonium workers, but all others exposed to airborne plutonium at Rocky Flats and its environs, have received plutonium exposures of uncertain consequences.

If the AEC is to be allowed to pursue a plutonium fast breeder program, we must first obtain an adequately comprehensive evaluation of the chronic effects of low levels of plutonium on man. I agree with Shapley that the limited program of medical follow-up of past and present employees of Rocky Flats falls woefully short of the mark.

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References

1. "Report on the Dow Rocky Flats fire: Implications of plutonium releases to the public health and safety" (Colorado Committee for Environmental Information, Boulder, 1970).
2. S. E. Poet and E. A. Martell, *Health Phys.* **23**, 537 (1972).
3. P. W. Krey and E. P. Hardy, "Plutonium in soil around the Rocky Flats plant" (Report No. HASL-235, Health and Safety Laboratory, Atomic Energy Commission, New York, 1970).
4. A. B. Long, *Nucl. News* **14**, 69 (1971).

Understanding Science

The important effort reported in the editorial "Understanding of science" by Amitai Etzioni (4 Aug., p. 391) needs more than the membership of the AAAS to be successful. Those disenchanted with technology may view the explanations of scientists as propaganda, while similar activities by attorneys, educators, bankers, and other nonscientist professionals could be meaningful to them. A start was made in 1966, with the pamphlet "Education and the spirit of science" issued by the National Education Association (*1*). Why not work with other friendly groups?

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Reference

1. Educational Policies Commission, "Education and the spirit of science" (National Education Association, Washington, D.C., 1966), now out of print.