safely as possible and without delay; and (iii) to ensure wide participation in the analysis of the results, be they positive or negative. To this end a letter has been circulated to more than 200 involved scientists, and their answers are being analyzed.

But any exercise in the assessment of risks must include an equally careful analysis of the expected benefits. It is therefore of the utmost importance that recombinant DNA research be developed with close consideration not only to its contributions to the fundamental problems in molecular genetics but also to the conversion of their solutions into practical and beneficial applications. Explicit action toward these goals should go beyond conferences and courses to collaborative research. Results of experiments will be required to ensure that the claims of proponents of a lively continuation of research in genetic manipulation are legitimate.

Once the risks are more critically assessed, and the benefits more clearly defined, appropriate steps ought to be taken by the various national and international bodies concerned. These initiatives should lead to an improved concept of international cooperation toward safer and more productive research in this as well as other areas of biomedical science.

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Is Sweden More Energy-Efficient?

In their article "Efficient energy use and well-being: The Swedish example" (3 Dec. 1976, p. 1001), Schipper and Lichtenberg draw the conclusion that Sweden is more energy-efficient than the United States by comparing the economic output per unit of energy consumption in the two countries. They further conclude that the living standards are the same in each country. Although the study is an interesting analysis, these conclusions are a misinterpretation of the facts. Based on the simplistic criterion used in the analysis, the states of New York, Rhode Island, Vermont, Connecticut, and Hawaii are more efficient in economic productivity per unit of energy use than is Sweden. Although such studies as that of Schipper and Lichtenberg are beneficially provocative in the energy conservation debate, they may also become exhortations for unrealistic energy conservation targets.

A basic fallacy in their study is the omission of the difference in the mix of industrial, service, and agricultural activities within the two countries. An analysis of different economic activities in the United States reveals that energy use per unit of labor varies by as much as a factor of about 75 between energy-intensive operations, such as oil refineries, to such low-energy users as printing and publishing. For example, the United States refines 133 percent more oil per capita than Sweden: but Sweden produces 77 percent more newspapers and 141 percent more books per capita than the United States. Because of the differing industrial mixes among the states of the United States, there is a variation of about a factor of 5 in the economic output per unit of energy among the 50 states—even though the United States has a mobile labor market, a common economic basis, a common currency system, and common consumer product availabilities and life-style. Similarly, variations in the detailed industry mix in each nation can result in large variations in the energy used per unit of economic output and can be misinterpreted as differences in technical efficiency of energy use and in implementation of conservation.

Schipper and Lichtenberg mask the true comparison of the economic value added in manufacturing per unit of energy use as shown in their table 9 [column E_J (kwh/$)]. Manufacturing use of electricity is certainly separable from the available mix of generation sources, and this comparison should have been made on equivalent primary energy input (the gross kilowatt-hours total described in the heading of table 9). If this table is thus recalculated, then the kilowatt-hours of total energy (t) per dollar of value added would show the United States at 16.5 kwht per dollar and Sweden at 21.2 kwht per dollar. Thus, Sweden's manufacturing is only 78 percent as economically effective in the use of energy as is U.S. manufacturing. This should not be interpreted as indicating either Swedish wastefulness or a potential for conservation—rather it is undoubtedly the result of the economic optimization of the use of all the resources (capital, labor, materials) available in each country.

Further, international comparisons, as between Sweden and the United States, are distorted by the difficulty of converting monetary exchange rates into comparisons of real purchasing values. The comparison of the well-being or scale of living among nations cannot be inferred by the dollar equivalent of monetary exchanges. Total personal income per family is a better measure of economic well-

being than gross domestic product per capita because of the differences in the national savings fraction and differences in family composition.

The Swedish total family income, including government-provided social services, in 1971 was about 78 percent of that in the United States, even after adjusting the relative Swedish income upward to correct the exchange rate for higher purchasing power in Sweden. It would probably be very difficult to convince an average American family that it would not be lowering its living standards if it accepted a Swedish family income. The comparisons by Schipper and Lichtenberg of automobiles, television, food, and housing support the differences in standard of living suggested by the differences in total personal income per family.

With regard to conservation techniques, because of the relative international mobility of technologies, worldwide differences among nations in the effectiveness with which energy is used industrially are likely to become similar in a short time. There are, of course, individual national differences in resource availability, demography, and social structure which give rise to selective cases of improved efficiency of energy use to meet specific end purposes. For example, the combination of electricity generation with district heating that is fairly common in Sweden and Northern Europe represents a more efficient energy use system for these purposes. However, it is not necessarily the most efficient in terms of the total national resources that need to be applied for these same purposes. For this reason, district heating in the United States has only rarely been used, even though the technologies have been available for decades.

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We share the concern expressed by Starr and Field over misuse of simplistic measures like energy use per unit of GNP (gross national product). Unfortunately the literature is also replete with (to paraphrase Starr and Field) "exhortations toward energy supply targets" based primarily upon manipulations of that ratio (*1*). Careful reading of our work, however, shows that our conclusions were not based upon that ratio, but instead arose from consideration of energy use efficiencies and the mix of economic activities in Sweden and the United States. We compared the most important energy-using activities, and not aggregate ratios, as Starr and Field mistakenly assert.

Ironically, they also ignore our sixth conclusion, in which we state that "consideration of . . . only the energy/GNP ratio . . . obscures dramatic differences in intensity (or efficiency) and economic structure." We could not have expressed our concerns over the abuse of the energy/GNP ratio more strongly.

Moreover, the comparison of the energy/GNP ratio for individual states within the United States, as attempted by Starr and Field, is of little meaning unless the data are adjusted for the energy embodied in flows of goods across state boundaries, climate, and so forth. Such adjustments were explicitly made in our article and found to be of vital importance in our comparisons. As 40 percent of U.S. energy is used in industry, ignoring the energy embodied in steel produced in Indiana and shipped to New York, for example, makes such comparisons almost useless.

We also took structure into account explicitly, another part of our work overlooked by Starr and Field in their letter. We noted differences in production and consumption mix. The figures given by Starr and Field are incomplete. Had they drawn upon the figure for oil refining given in our table 10, they would have seen in the very next line in that table that, compared to the United States, Sweden produces four times more paper and pulp per capita, far more energy-intensive products than refined oil. This activity accounts for as much energy consumption in Sweden as the combined refining and chemical sectors in the United States. These data and our explicit discussion of structure contradict the implication of Starr and Field that the United States (producing more oil and less newspapers) has a more energy-intensive manufacturing sector than Sweden. In fact, the reverse is true. One of our Swedish references (*2*) points out that if the United States produced the same product mix that Sweden does with U.S. technology, U.S. energy use would be considerably higher. As we said in our article, the higher energy/GNP ratio in manufacturing in Sweden arose because of this structural phenomenon and the vagaries of "simplistic" aggregation of the energy/GNP ratio, since virtually all important energy-intensive products in Sweden are made with modern, more energy-efficient technology than are the same products in the United States. There may be minor differences due to different kinds of steel or oil products manufactured, but the overall conclusion, that energy-intensive products in Sweden are produced more

efficiently than in the United States, largely because of higher relative fuel prices in Sweden, is supported by a large number of other American and Swedish analyses referenced in our original article and in a recent study (*3*) sponsored by the Electric Power Research Institute as well.

Our conclusions were also not very sensitive to the method of accounting for electric power, a topic we dealt with in considerable detail. In several tables we provided energy use totals that reflected both electricity use counted with and without real thermal conversion losses and imaginary losses allocated to hydropower. We also explained that allocating thermal losses to hydropower distorts the economics of energy use, both because the relatively inexpensive hydropower available in Sweden stimulates relatively higher use of electric-intensive processes and because the use of combined heat and electricity cycles makes the Swedish heat rate considerably lower than that in the United States.

We also dwelt at great length upon the subject of international comparisons of well-being and the difficulty of measuring living standards with the GNP. We are not familiar with the measure of well-being "total personal income per family" offered by Starr and Field and could find no economists who had used this. However, the difference in this index between Swedish and American incomes is almost exactly cancelled out by the difference in family size, Swedish families in 1971 being only 79 percent as large as American families. Furthermore a comparison based only upon material goods is unrealistic. The Swedish comprehensive health care and housing for the aged counts, as well as washers and dryers, in measuring well-being. In any case, the issue is not who is wealthier. Our comparison was based on "how well" energy is used, not "how much."

We share the optimism of Starr and Field over the international spread of conservation techniques. However, we do not find 12 inches of attic and wall insulation or automobiles with a fuel efficiency of 24 miles per gallon—ingredients in Swedish energy use—"unreasonable conservation targets" as Starr and Field imply. With regard to district heating, we questioned the overall effectiveness of this technique in Sweden and did not consider it a major factor in our conclusion. Elsewhere, however, the Swedes appear to share our enthusiasm for additional conservation, having embarked upon a national investment campaign that has already shown results. Thus international comparisons reveal both important techniques for using energy effectively, as well as the high degree of flexibility in long-run energy needs.

Leaders in the power industry have shown a great degree of skepticism toward suggestions that the United States could significantly improve energy-use efficiency. This skepticism is understandable if the basis for those suggestions is crude comparisons of energy/GNP ratios. The same skepticism should also be applied to industry forecasts of "needs" that use such aggressive measures [see (*1*) and articles in (*4*)]. We certainly agree that there are grounds for debate over what are "reasonable" conservation targets. The letter from Starr and Field, however, is founded primarily on generalizations, aggregations, and selective use of the available data. A careful reading of our article shows that there are indeed many promising Swedish techniques and policies that provide for more effective use of energy and other resources.

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Controversial Grant Proposal

My editorial of 11 March (p. 939) refers to a move by the House of Representatives in April 1976 to shut off funds for a controversial National Science Foundation grant proposal. This is incorrect. It was a grant proposal to the National Institute on Drug Abuse (Department of Health, Education, and Welfare), rather than one to the National Science Foundation. The congressman involved, of course, was Representative Robert Michel (R–Ill.). A report on this action appeared in the 30 April 1976 issue of *Science* (News and Comment, p. 450).

I apologize for any embarrassment this inadvertent error might have caused the National Science Foundation.

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