tribute to the debate than the average citizen because of scientists' greater technical knowledge, but certainly not because of their greater ethical insights. It is in this arena of public participation that professional organizations of scientists could "work out ethical codes of conduct for their members." Such public participation would also help develop and maintain a positive public image of scientists by helping to ensure "responsible application of their work."

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Rotblat's idea of an oath for scientists is a good one, but the misuse of scientific knowledge cannot occur without the activity or complicity of other people—engineers, lawyers, business persons, politicians, advertisers, weapons manufacturers, historians, news writers and broadcasters, and media owners, to name a few. Scientists are certainly responsible for considering the possible and probable uses of their discoveries. However, no oath by any of us will prevent or even discourage those who pursue nonethical uses of the knowledge that our method provides. It is not only scientists' feet that should be held to the fire.

Perhaps we scientists should promise to be conscientious not only in the application of our method but also in the education of nonscientists regarding what science is, why we do it the way we do, and the tentative nature of our product—theory. Indeed, many mistakenly view science as a compendium of facts rather than the application of method. Creating opportunities for this sort of public education is a worthy challenge.

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Rotblat suggests that young scientists should "reflect on the wider consequences of their intended field of work before embarking on a career in academia or industry" and proposes that they take, upon graduation, an oath similar to the Hippocratic oath. I support Rotblat's proposal as one of the scientists who helped develop the Jerusalem Statement on Science for Peace, together with participants of the Second International Symposium on Science for Peace, held in January 1997 in Jerusalem and organized and hosted by the UNESCO–Hebrew University of Jerusalem (HUJ) International School for Molecular Biology and Microbiology (ISMBM) (*1*). It was suggested that scientists who accept the Science for Peace oath should also accept the concepts of the Jerusalem Statement: that scientific endeavors and achievements be used only for peaceful purposes, there should be free movement of members of the academic community, there should be a free flow and sharing of scientific information and knowledge, and the academic environment should remain open and dedicated to free expression (*1*).

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References

1. Y. Becker *et al.*, "The Jerusalem statement on science for peace"(*Science for Peace Series*, vol. 3, UNESCO, Venice office, 1997), pp. 13–16. Available at: www.tau.ac.il/~becker/UNESCO_HUJ/j_stat.html

While appreciating the intent of Rotblat's Editorial, I have concerns for the inference that scientific enterprise should be socially directed. The question raised is, whose morality shall prevail in the direction science will take? The scenario that presents itself includes such prohibitions as human genetic research and someone's ideas as to which questions are suitable for inquiry, perhaps based on variable moral codes, political agendas, and religious fervor. In this direction lie dangers every bit as egregious as those that concern Rotblat.

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Response

I agree with most of the correspondents, although I take exception to some of the points made by Gottlieb. I did not make the assumption that scientists are aware of all the ramifications of their research; this is obviously untrue. What I did imply was that they should desist from research when its harmful ramifications can be foreseen. Nor can I accept Gottlieb's suggestion that only *after* carrying out the research work—which may have harmful consequences—should the scientist become concerned, jointly with the public, about ways of dealing with the consequences. Surely, the whole point is to try to prevent them in the first place; this is where the need for an ethical code for scientists comes in.

Clair is quite right that many other groups are involved in any misuse of scientific knowledge. However, this does not absolve the scientist from taking the initiative. And I agree, researchers should also be teachers, educating nonscientists about the nature of science and the role it plays in modern society.

What sort of moral criteria should be adopted? asks Amacher. I share with him the agonizing on this issue. A possible answer is provided by Becker, with his Science for Peace program, although for many this may be far too general.

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Considering Manure and Carbon Sequestration

In his Policy Forum "Carbon sequestration in soils" (25 June 1999, p. 2095), William H. Schlesinger notes that manure application has been suggested as a possible mechanism for soil carbon sequestration (*1, 2*) and suggests that, although manuring has a number of practical applications, it has no value as a method for sequestering carbon in soil. Schlesinger's basis for this argument is that for every hectare of land manured, 3 hectares are required to grow silage for the livestock that produce the manure. The greater soil organic matter (SOM) concentrations in manured fields, he says, "can thus be expected to be associated with declining SOM on a proportionally larger area of off-site lands."

Schlesinger's position holds true if extra livestock are included in production systems solely to produce extra manure to then apply to land for the purposes of carbon sequestration. However, livestock are raised for the provision of agricultural products; manure is merely a by-product. We suggest that this by-product (as well as perhaps other by-products of our society, such as human sewage sludge) could be better used to increase SOM levels, thus sequestering carbon (*1, 2*).

The Kyoto Protocol sets a baseline condition (1990) against which all changes in carbon emissions and offsets are measured. Changes in manure management must, therefore, be assessed relative to this baseline. In Europe, for example, we estimate (using 1990 figures) that 820 million metric tons of manure are produced each year (*3*). Only 54% is applied to arable land (*4*), with the remainder applied to nonarable agricultural land (such as grassland). Large applications of manure to grassland over many decades do not change SOM levels appreciably (*5*) and so do not contribute to long-term carbon sequestration, because the SOM content of grassland soils is already high and the manure is not incorporated into the mineral soil. As a result, the SOM content of grassland increases proportionately less than does the SOM content of arable land when receiving the same amount of manure.

Carbon can be sequestered in soil relative to the 1990 baseline if all manure produced is incorporated into arable land. Using a relation between manure application rate and yearly increase in SOM (*1, 2*), we estimate that if all manure were incorporated into arable land in the European Union, there would be a net sequestration of 6.8 teragrams of carbon per

year, which is equivalent to 0.8% of the 1990 CO_2-C emissions from the same geographical area. The net carbon sequestration is modest compared with other scenarios such as woodland regeneration (*1*, *2*), reestablishing pasture (*6*), or no-till (*7*, *8*) but is, nevertheless, positive relative to the 1990 baseline.

Schlesinger's plea for full carbon accounting when assessing carbon mitigation options is well made, but his comment that manuring has no application for net carbon sequestration does not hold if one considers manure as an agricultural by-product and assesses changes in manuring practice relative to a Kyoto baseline.

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References and Notes

1. P. Smith *et al.*. *Global Change Biol.* **3**, 67 (1997).
2. P. Smith *et al.*, in *Management of Carbon Sequestration in Soil*, R. Lal *et al.*, Eds. (CRC Press, Boca Raton, FL, 1998), pp. 143–152.
3. Total manure production was calculated from 1990 figures for the total number of cattle and pigs from *Eurostat, Agriculture Statistics Yearbook, 1995, Theme 5, Series A* (Commission of the European Communities, Luxembourg, 1995), and per capita manure production figures were calculated from the Ministry of Agriculture, Fisheries, and Food, *Fertilizer Recommendations for Agricultural and Horticultural Crops* (RB209, HMSO, ed. 6, London, 1994).
4. Assuming an even distribution of manure to arable and nonarable agricultural land.
5. P. Poulton, in *Evaluation of Soil Organic Matter Models Using Existing, Long-Term Datasets*, D. S. Powlson *et al.*, Eds. (Springer-Verlag, Berlin, 1996), pp. 376–384.
6. P. Smith *et al.*, *Nature* **381**, 15 (1996).
7. P. Smith *et al.*, *Global Change Biol.* **4**, 679 (1998).
8. R. Lal *et al.*, *The Potential of U.S. Cropland to Sequester Carbon and Mitigate the Greenhouse Effect* (Ann Arbor Press, Chelsea, MI, 1998).

Response

Smith and Powlson maintain that increases in SOM on manured arable land should count as a net sequestration of carbon in terms of the Kyoto Protocol. I would also support this view, if manuring led to an increase in the total carbon inventory in the soils of a nation between 1990—the Kyoto baseline year—and some point in the future. There is no doubt that arable soils receiving manure will gain SOM, but a full accounting must also consider the continuing losses of SOM from the lands used to produce silage for livestock. As long as cattle are heterotrophic, it seems unlikely that they will increase the net storage of carbon in the landscape.

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CORRECTIONS AND CLARIFICATIONS

In the News Focus article "The elusive causes of childhood cancer" by Jocelyn Kaiser (3 Dec., p. 1833), the mutation in the gene *MLL-AF4* occurs in adult and child cancer patients who have received treatment with chemotherapy drugs that inhibit topoisomerase II, not in infants whose mothers were treated with such drugs during pregnancy. In the fourth paragraph, the triggered mutation in an "unidentified gene" is a deletion in the other copy of the *TEL* gene. And the unchallenged immune system of young children should have been described as "naïve," not as weakened or frail. In the fifth paragraph, the immunological benefits to infants of long-term breast feeding may be due to antibodies during the first month, but thereafter seem to be due to transfer of other factors such as antibacterial proteins, immune cells, and microbial organisms. It is not known, however, which of these factors is important in the context of protection from leukemia. Lastly, Frederica Perera's first name was misspelled.