Letters

Virus Hunting and the Scientific Method

The suggestion in the News briefing "Virology dead, says Duesberg" (14 Dec., p. 1514) that I should be "exempt from teaching any course that relies on the scientific method" because I favor the "innocent until proven guilty" approach is perhaps the most honorable discharge I have earned so far. Unfortunately, the view that according to "the usual scientific method . . . a hypothesis remains a candidate until it is disproven" can have serious consequences, in particular, if it is a candidate for a way to confront disease.

Take the currently popular virus-AIDS hypothesis. The virus remains to be proven guilty (*1*). But the hypothesis is currently the only candidate for a way to confront AIDS (*2*). This confrontation has produced no cure, no vaccine, a highly toxic antiviral medicine, and an infectious syndrome that does not spread from behavioral or clinical risk groups [the United States has now lifted its ban on visitors who test positive for the human immunodeficiency virus (HIV)], and all that for about $3 billion a year. Lately it looks as if there is even disagreement about how to prove HIV guilty, in particular, about what kind of microbial allies are needed to cause AIDS (*3*). In view of the emerging HIV schism, I wonder which candidate hypothesis professors should be "exempt" from teaching.

Other examples demonstrate that the ever-popular germ theory has at times "remained a candidate" far too long, until finally disproved at great cost to the affected people. In the United States tens of thousands died unnecessarily in the 1920s because pellagra was considered infectious by the U.S. Public Health Service, until Joseph Goldberger proved it to be a noninfectious vitamin B deficiency (*4*). Indeed, the disease was said to be transmitted by "poor hygiene" among corn farmers in the South—the primary risk group for pellagra (*4*). In Japan, at least 10,000 suffered in the 1960s and 1970s from a drug-induced neuropathy, including blindness, that had been misdiagnosed as a viral diease for more than 10 years (*5*). The pursuit of oncogenic viruses as the causes of cancer by me and by many of my learned retrovirology colleagues provides another example. Although it has generated such academic triumphs as viral oncogenes and reverse transcriptase, it has been a total failure in terms of clinical relevance to cancer, primarily because, with a very few exceptions, cancers are not infectious. Perhaps professors should not be exempt from questioning clinically unproductive hypotheses from a generation of virus hunters who have never seen a frontier outside the laboratory.

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Radon Risk and EPA

I would like to respond to Philip H. Abelson's editorial "Uncertainties about health effects of radon" (19 Oct., p.353). The information provided here will help to clarify some of the misconceptions about the potential health risks from radon and about the Environmental Protection Agency's (EPA's) Radon Action Program.

The Indoor Radon Abatement Act of 1988 sets a national, long-term goal of achieving indoor radon levels similar to ambient outdoor levels. This is not yet technologically achievable. Consequently, EPA is not planning to lower the current action level to ambient levels at this time. The cost of reducing elevated radon levels to EPA's current action level of 4 picocuries (pCi) will range from $500 to $1500 in most cases, not $10,000 per house.

The National Academy of Science's (BEIR IV) committee extrapolated lung cancer risks derived from epidemiologic studies of miners to project lung cancer risks for U.S. males and females (*1*). EPA's central estimate of approximately 20,000 annual lung cancer deaths is derived by using the relative risk models, in conjunction with lifetable analyses, presented in the reports of the BEIR IV committee and the International Commission on Radiological Protection (ICRP 50 report)(*2*). This estimate is not based on screening data from EPA measurement studies. Rather, the estimate was calculated by assuming that the average residential exposure is about 0.25 working level month (WLM) per year (about 1.3 pCi per liter) (*3*). This estimate of exposure is consistent with the estimates by Anthony Nero (*4*) of the theoretical frequency distribution of annual radon levels in homes. EPA is currently conducting a National Radon Residential Survey that will determine the national frequency distribution of annual radon levels in residences.

EPA believes priority should be given to identifying those areas where high radon levels are highly prevalent. Over the past 5 years, EPA and the U.S. Geological Survey have been working to develop a radon potential map using residential survey data and geological indicators. The map will identify those areas of the United States that have the highest potential for elevated indoor radon levels. It will not identify individual homes with elevated radon levels.

Testing is the only method currently available that will identify individual structures with high radon levels. Different levels can be found in adjacent homes, and homes with elevated levels can be found in areas of low radon potential. Consequently, EPA recommends that most homes be tested (typical cost is $10 to $30) to determine whether they have elevated radon levels. It should also be noted that homes with high levels are not "rare." On the basis of Nero's frequency distribution, we estimate that there may be several million homes with annual radon levels above 4 pCi per liter, and more than 100,000 homes with levels above 20 pCi per liter.

Abelson seems to be unconvinced that the BEIR IV committee findings (which are based on studies of several cohorts of individuals) demonstrate that there is a risk from radon. He urges a cautious epidemiological approach. However, he relies on an unpublished ecological study by B. L. Cohen as the basis for questioning whether residential radon is a significant problem.

Although EPA supports the need for further epidemiologic studies of indoor radon, these studies should be designed so that they are of value for risk assessment purposes. The strongest scientific evidence of a causal relationship between exposure and risk comes from analytical epidemiologic studies. Ecologic studies are not recommended for the study of residential radon risk(*5*).

Unlike case-control or cohort studies, Cohen's work is based on descriptive ecological studies that examine groups of people and data on average radon exposures. In these studies, there is no way to relate the level of radon exposure for an individual to that individual's health status. Nor do these studies provide a way to assess other lung cancer risks, such as smoking experience, that could significantly affect cancer rates in the study region.

A number of case-control studies of lung cancer risk and residential radon show some correlation between indoor radon and lung cancer mortality (*6*).

Abelson questions whether it is appropriate to assume linearity at low doses, as the BEIR IV committee did. Epidemiologic studies of miners show that significantly increased risks of lung cancer mortality occur across a broad range of cumulative exposures to radon, including cumulative exposures at 40 WLM or lower (*8, 9*) (cumulative residential exposure from a lifetime at EPA's action level of 4 pCi per liter is in this range.) Given the evidence for linearity in these epidemiologic data, EPA considers it reasonable to assume that a similar relationship exists for cumulative radon exposures in residences.

Both the BEIR IV and ICRP 50 committees assumed a linear dose response relationship. The only evidence the BEIR IV committee found against linearity was in their analyses of the Colorado uranium miners, where the risk per unit exposure decreased at very high doses (above 2000 WLM), but not at low doses. Also studies of Colorado and Czech uranium miners, as well as animals, show an exposure-rate effect (*8*); that is, for the same cumulative radon exposure, the risk from long exposures to low radon levels was greater than the risk from short exposures to high radon levels. The implication of this for risk from residential exposures is of concern.

On the basis of abundant epidemiologic and experimental data, radon has been classified as a human carcinogen. There is some uncertainty associated with the epidemiologic studies of miners, as well as with the projection of lung cancer risk from studies of occupational exposures to residential exposures. However, despite the differences in the miner cohorts, in the measurement of radon exposures, and the different statistical approaches used, all the major epidemiologic studies of miners yield comparable estimates of lung cancer risk. In addition, most analyses indicate that extrapolation from the studies of miners to the indoor environment introduces only a relatively small degree of uncertainty, ranging up to 30%. Thus, in the face of uncertainty, radon must be considered an important public health problem (*9*). A panel of experts under the auspices of the NAS and supported by a grant from EPA is completing an investigation of the relationship between mines and indoor areas.

EPA recognizes the uncertainties associated with estimation of radon risks, as well as the uncertainties of risk assessment in general. Nevertheless, risk estimates serve as an important indicator of the potential health effects to the general population. Given the weight-of-evidence for the carcinogenicity of radon in humans and the potential for elevated radon levels in homes, EPA believes it is prudent public policy to urge the public to test their homes for radon and to reduce elevated levels.

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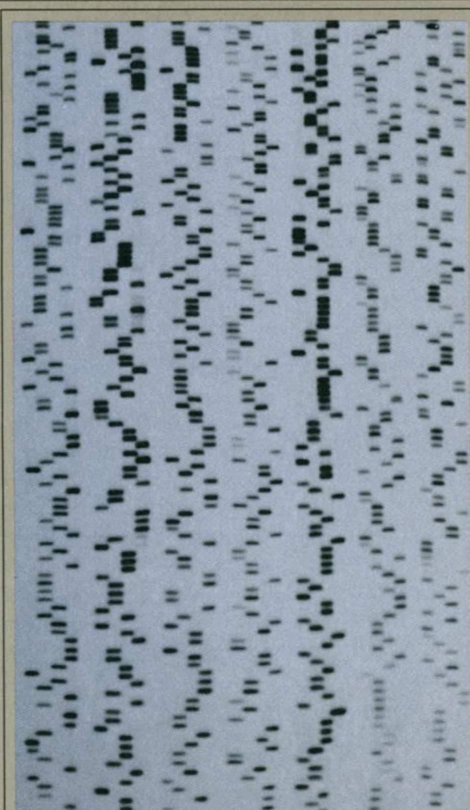

In criticizing the Environmental Protection Agency's (EPA's) proposed implementation of the 1988 Indoor Radon Abatement Act, Abelson seems to ignore the fact that the EPA's response is in full accord with repeated recommendations by prestigious scientific panels. These panels have stated in unmistakable terms that, for purposes of establishing public policy, it is prudent to assume that any incremental exposure to ionizing radiation is potentially harmful to human health. The regulatory structure growing out of these largely uncontested recommendations includes "as low as reasonably achievable" criteria that require industry to reduce public exposure to ionizing radiation whenever the cost is less than $1000 per avoided person-rem. The associated cost to society is on the order of $2 million per imputed life saved. And in contexts such as the sealing up of uranium tailing piles to prevent the escape of radon, cleaning up radioactive contamination in defense establishments, redesigning or abandoning nuclear power plants to reduce the consequences of hypothesized accidents, and establishing criteria for the management of low- and high-level radioactive wastes the cost per imputed life saved is enormously greater.

The estimated cost of $10,000 per home to achieve the objectives of the Indoor Radon Abatement Act is thus well within the range of costs now being incurred by society to remediate small imputed risks to the public. Furthermore, despite remaining scientific uncertainties, the possibility of an actual risk to the public from indoor radon is considerably less far fetched than the possibility of significant risks from other imputed hazards that have occasioned great public alarm. In this sense the EPA is to be commended for seeking to reduce the egregious inconsistencies between indoor radon guidelines and the far more strict regulatory mandates for dealing with other sources of potential public exposure to radiation.

Nevertheless, Abelson's contention that national priorities should focus on the elimination of large, well-documented risks rather than on the remediation of small conjectured risks seems entirely reasonable. But the scientific community itself has tended to be tolerant of those members who cater to rampant public misconceptions concerning the magnitude and plausibility of a large variety of hypothesized risks. It is therefore to be hoped that the indoor radon problem will dramatize the urgent need for the scientific community to become more actively involved in seeking to establish a rational and consistent national attitude toward dealing with the increasingly expensive problem of risk aversion.

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Abelson correctly points out the uncertainties about the health effects of radon. Equal uncertainties (largely due to a lack of information) surround the availability of methods for correcting this problem. Because the solid airborne decay products of radon are electrically charged, simply circulating the air within a room (by using, for example, an overhead ceiling fan) will reduce their concentrations through plate-out by 50 to 60%. Since the decay products are not a health hazard external to the body, this represents an effective method of control. If a positive ion generator is combined with the fan, reductions of 90 to 95% are readily accomplished. Although it may require upward of $10,000 to correct the problem in homes with high radon concentrations, corrective action in the vast majority of homes can be accomplished for only a few hundred dollars.

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Abelson's editorial discusses the uncertainties about health effects from exposure to low levels of radon and criticizes the Environmental Protection Agency (EPA) for taking action before these uncertainties are cleared up. The editorial does not, however, point out that these same uncertainties apply at least equally to ***all*** low level radiation, including that from (i) radioactive waste, (ii) reactor accidents (more than 95% of all health effects are due to ***low*** level radiation), (iii) bomb test fallout, and (iv) diagnostic x-rays, and we are certainly acting on those. In fact, we are spending several billion dollars a year protecting the public from them, 100 times what is spent in the public and private sectors combined on protection from radon; whereas the radiation exposure the average American receives from radon is a thousand times more than he or she can ever expect to get from items (i) and (ii), 100 times more than from (iii), and 10 times more than from (iv).

Clearly, programs for reducing exposure to radon are many orders of magnitude more cost effective. Confirming this, my analyses (*1*) indicate that the cost per life saved with present programs is roughly $200,000 for protection from radon, $200 million for protection from radioactive waste, and $2 billion in protection from reactor accidents.

Science has published many pieces about the problems and dangers from radioactive waste and reactor accidents, thus contributing to public concern about them. How then can it now complain about EPA contributing to concern about radon? Why pick on radon?

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Ubiquitous Neuroscientists

The *Science* cover of 4 January suggests that someone has tested the Gaia hypothesis by patch-clamping the troposphere. I am eager to know how they obtained a gigaohm seal that large. I am also concerned that they do not attempt to excise the patch; that might put a hole in the ozone layer!

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Erratum: In the title of the report "ACh receptor–rich membrane domains organized in fibroblasts by recombinant 43-kilodalton protein" by W. J. Phillips *et al.* (1 Feb., p. 568), the word "kilodalton" was misspelled.