INTRODUCTION

Science, Risks, and Politics

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The whole aim of practical politics is to keep the populace alarmed—and hence clamorous to be led to safety—by menacing it with a series of hobgoblins, all of them imaginary.
—H. L. Mencken

Science has changed the world profoundly, bringing great increases in life expectancies[1] and wealth. Along with desirable changes have come some unintended consequences that affect or might affect human health and the environment.

Governments, responding to concerns about such risks, have established "risk assessment and management" organizations to estimate the magnitude of the risks and to control them. The control efforts—almost always accomplished through government regulations—affect the livelihoods of individuals, communities, and industries. It is no surprise that such regulatory efforts lead to conflicts between those who see the risks as proven and

1. J. Oeppen and J. W. Vaupel, "Broken Limits to Life Expectancy." *Science* 296 (2002): 1029–31.

justifying immediate control and those who question the strength of the evidence about risk and see benefits from continuing use of the substance or process.

Ideally, the scientists or analysts who generate estimates of harm that may result from a risk would consider all the relevant facts and alternative interpretations of the data, and remain skeptical about tentative conclusions. Ideally, too, the agency officials and politicians, who have to enact a regulatory program, would consider its costs and benefits, ensure that it will do more good than harm, and remain open to options to stop or change the regulation in situations where the underlying science is tentative.

Those ideals do not exist, have never existed, and probably never will. Interest groups and government agencies succeed in raising a clamor about a purported risk that drowns out other considerations, even, in some cases, in the absence of factual support for the claims. The media, knowing that risks sell papers and draw viewers to news programs, focus on covering the people who assert the importance of the risk. In order to appear fair, a newspaper story about risk might quote a skeptic in the penultimate paragraph, or a two-to-five-minute TV segment might give a skeptic fifteen or twenty seconds at the end. But who will take the skeptic, his facts, and his opinions seriously if the reporters consider them of so little value as to make them appear as afterthoughts.

Politicians, seeing that the public treats a risk as real, often decide to "get out in front of the problem," even though they are aware that they have little or no knowledge of the science that supports the existence or importance of the risk. Scientists, aware of the political interest in risk and the public's awareness of it, will seek research funds, knowing that a result that buoys up the risk, or, at least, a result that does not sink it, is more likely to be published, to receive public attention, and to result in further funding. Or, they may elect to bypass the usual norms of science

entirely, call a press conference and try to convince the public about a risk with no scientific peer review.

The authors of the chapters in this volume describe risk assessment and risk management activities that differ from any ideal. They describe scientists masking policy decisions as "scientific," and politicians labeling politically driven decisions as scientific, attempting thereby to place them outside the realm of political discussion, debate, and compromise. But this is an illusion. All policy matters involving human health and the environment are political. The more that political considerations dominate scientific considerations, the greater the potential for policy driven by ideology and less based on strong scientific underpinnings.

Government Involvements in Science

Governments realize the importance and power of science and employ the latest scientific tools and methods to carry out their functions. Science and politics have become inseparable because of funding and regulation policies. Moreover, politicians intervene in the practice of science, sometimes diverting science and the interpretation of scientific findings away from where the evidence leads to directions deemed politically desirable. Three chapters in this volume, by William Happer, Henry I. Miller, and Joseph P. Martino describe some such political interventions.

William Happer, "Harmful Politicization of Science"

Happer, a physicist who was Director of Energy Research at the Department of Energy during George H. W. Bush's presidency, discusses three interventions of politics into science. He describes the starvation and deaths that followed Trofim Lysenko's substitution of patent nonsense for genetics and plant science in the Soviet Union (with the full backing of Joseph Stalin and in accord

with Communist scientific thought). He discusses the ultimately failed efforts of cold fusion advocates to corral the U.S. Congress into funding their "invention." He then turns to the politicization of science about environmental risks to human health and risks to the world's climate. He puts environmental risks into perspective with comments that some risks are so serious that everyone agrees that they need attention, while others are less certain because the effects of the risks, if there are any, cannot be measured. He also describes the bias in federal funding toward "research programs that reinforced messages of imminent doom: humanity and planet earth devastated by global warming, pestilence, famine, and flood."

Henry I. Miller, "The Corrosive Effects of Politicized Regulation of Science and Technology"

Miller, a former official of the Food and Drug Administration, describes the confluence of interests that can be arrayed to oppose a particular technology. Bureaucrats, whose power expands with their ability to regulate, and large companies that welcome regulatory hurdles because they have the legal and technical resources to jump them, leaving smaller, less affluent competitors little choice but to merge or to be bought out, can be found in league with activists openly antagonistic to a new technology. He is especially critical of some of the policy decisions about bioengineered products, including food, that arose during the Clinton administration. Miller concludes on a gloomy note, "There is no important constituency for sound science policy. On the contrary, politicization often represents little more than pandering to the [public's] fears, which sometimes verge on superstition."

Joseph P. Martino, "Science and Public Policy"

Martino, an engineer and retired U.S. Air Force colonel, discusses some of the most publicized environmental issues of the last de-

cade or so—spotted owls, lynxes, the reintroduction (or, perhaps, more accurately, the introduction) of wolves into Yellowstone National Park, and attempts to resolve conflicting claims on the water in the Klamath Basin. In all those issues, there is evidence that government officials intentionally selected results, misinterpreted observations, and interfered with experiments in order to advance their goals.

Happer and Miller's chapters to some extent reflect the normal working of politics. New administrations replace the senior officials of federal agencies with appointees who share their political orientations. This is expected and customary, but as Happer and Miller describe, replacements made without consideration of maintaining a solid science base for making technical decisions can lead to mistakes.

Martino's examples should not to be taken to indicate that government scientists are to be mistrusted. There is no more justification for that than wholesale rejection of the results reported by industry scientists because of their funding or dismissing environmental organization scientists because of the pressures their organizations face in raising money. In all cases, skepticism, one of the hallmarks of science, is appropriate.

Science, Risks, Images, and Assertions

In his 1961 book, *The Image*,[2] Daniel J. Boorstin, the former Librarian of Congress, lamented that citizens were losing their skepticism and were too willing to accept what they were told by the media, which he called "news makers." The nomenclature is important. At some time in the past, news makers were the people who made discoveries and decisions, built dams and businesses,

2. D. J. Boorstin, *The Image: A Guide to Pseudo-Events in America* (1961; reprint, New York: Vintage Books, 1992).

educated and informed students and others about science; they were the people who did things. Now, they are the people who package stories for the media and the people in the media who decide what news to report. They know that they are competing for the public's attention. They are not so much interested in sifting through information to identify what is right and what is wrong—except in egregious cases, of course—as in attracting and holding an audience.

Government agencies, businesses, and environmental organizations burnish images to reach the public, and agencies' and environmental organizations' images of risk can lead immediately to calls for government action to control the risks. For instance, beginning in the early 1990s, a small group of scientist-activists asserted that tiny amounts of plastics and other industrial chemicals in the environment act as "endocrine disruptors" or "environmental estrogens" that disrupt the normal functioning of hormones and affect almost every aspect of growth and development in humans and animals.

Some media outlets trumpeted the 1996 book *Our Stolen Future*,[3] a compilation of mostly unverified observations and speculations, and a paper published in *Science*[4] that presented startling results purportedly showing that tiny concentrations of some chemicals behaved as endocrine disruptors. Congress rushed legislation that requires billions of dollars to be spent to test chemicals that were regarded as safe except for the alleged estrogenic effects.[5]

Many scientists reported they were unable to repeat the ob-

3. T. Colborn, D. Dumanoski, and J. P. Myers, *Our Stolen Future* (New York: Dutton, 1996).

4. S. F. Arnold et al., "Synergistic Activation of Estrogen Receptor with Combinations of Environmental Chemicals," *Science* 272 (1996): 1489–92 (subsequently retracted).

5. D. Byrd, "Goodbye Pesticides?" *Regulation* 20, no. 4 (1997): 57–62.

servations published in *Our Stolen Future*, and the results in the *Science* paper turned out to be fraudulent.[6] It made no difference to the law that requires chemical testing. Industry is doing the tests and passing the costs on to its customers. When it's all done (if it ever is), money that could have been used to benefit health and the environment will have been spent without great prospect of improving anyone's health. The unintended consequences of the forced misallocation of society's resources are rarely given any attention. But decisions have consequences, and ultimately the costs, whether or not they "buy" anything, are borne by workers or shareholders or society at large.

Three chapters in this volume describe expensive and extensive research efforts devoted to images of risk. Stephen Safe assesses the research that fails to find any health from endocrine disruptors in the environment. Bruce Ames and Lois Swirsky Gold review the collapse of the scientific underpinnings for the assertion that environmental chemicals are a major cause of cancer. Bernard L. Cohen contrasts the absence of data to show that nuclear power plants have caused death and disease with the near-total demise of the nuclear power industry because of assertions about cancer risks from the plants.

Stephen Safe, "Endocrine Disruptors"

The claims that tiny amounts of chemicals with estrogenic (hormonal) activity caused a multitude of health effects have some plausibility. Hormones, present in the body at very low concentrations, affect many biochemical reactions, and it's possible that environmental chemicals that mimic them would affect humans.

6. Office of the Secretary, Department of Health and Human Services. "Handling Misconduct: Case Summaries." http://ori.dhhs.gov/html/misconduct/arnold.asp. The only penalty levied on the guilty scientist was an order that he not apply for federal research funding for five years. It made no difference to the scientist, who decided to go to law school.

Safe, a well-respected biochemist, reviews the extensive scientific literature and finds no convincing data about the putative effects of trace amounts of plastics and other chemicals on human beings. He concludes that too much effort was expended on the research because there is great reluctance on their (our) part to say "enough is enough." With limited funding available, this can seriously impede research that addresses more pressing environmental and human health issues.

Bruce Ames and Lois Swirsky Gold, "Cancer Prevention and the Environmental Chemical Distraction"

Bruce Ames, elected to the National Academy of Sciences in recognition of his research in genetics and genetic control, and his colleague, Lois Swirsky Gold, who has published and continuously updates a compendium of the results of laboratory tests for possibly carcinogenic chemicals, are convinced that those tests have, at most, a questionable bearing on human health. They argue that the high doses of chemicals used in the tests cause toxic effects that are rarely—probably never—seen at the far lower exposures experienced by humans. In the absence of those toxic effects, the chemicals are not a cancer risk. Despite the limited, and perhaps zero, risk from those chemicals, federal regulatory agencies that are interested in preventing cancer have focused their efforts on reducing exposures to them.

So what? Where's the harm in overregulation of chemicals? (1) No, or tiny at best, health gain can be expected from regulations. (2) The focus on "environmental carcinogens" diverts attention from research that is likely to make a difference in health.

To the extent that Ames and Gold are right, and they probably are right to a large extent, the fascination of politicians, regulators, the media, and the public with environment carcinogens will eventually be seen as more than a diversion of resources. It will

also be seen as a fascination that retarded improvements in health.

Bernard L. Cohen, "Nuclear Power"

Cohen, a physicist, was a participant in the battle for acceptance of nuclear power that was waged between nuclear scientists and engineers on one side and political activists, aided by a few scientists and endorsed by the gullible media, on the other. The media embraced the activists' claims of great risks and failed to put the (far smaller than the activists claimed) risks from nuclear power into perspective, by, for instance, comparing a person's exposure to natural radiation to his possible exposure to radiation from a nuclear power plant. Nor were comparisons made between the risks of ordinary life—motor and industrial and home accidents that kill thousands—to radiation risks from nuclear power that have killed no one. Cohen speculates that the growing recognition that fossil fuel power plants are a major source of pollution and other problems, including problems arising from foreign sources of supply, will lead to a revival of interest in nuclear power.

The Persistence and Importance of Assertions

Careful research has weakened assertions that environmental chemicals are endocrine disruptors and major causes of cancer. Environmental organizations still tout the risks to raise the public's awareness—they say—and to solicit contributions. Government officials, in charge of programs to investigate the risks, continue to provide funds to scientists who look for evidence to support the assertions and to programs that test chemicals for effects that have little, at best, and more likely, no, relationship to human health. Environmental organizations' publicity and gov-

ernment spending programs can keep assertions alive despite mounting scientific evidence that they are wrong.

Cohen's chapter illuminates a dangerous component of risk assertions. Those who make assertions focus only on risks. They ignore any benefits that come from the substance or process and the possibility that elimination of their targeted risk may increase another risk. In the 1960s and 1970s, during the battle over nuclear power, there was no room in the antinuclear forces' world for any trade-offs. They acted as if shutting down nuclear plants involved no risks, having only the one effect of eliminating the cancer risk that they associated with the plants. In fact, there are few decisions to reduce risks that don't bring other risks, such as, in this case, more emissions of gases that may contribute to global warming.

Science and Risk Assessment

"Risk assessment" is the process for examining links between risks and possible harms—for instance, chemicals in the environment and cancer; increasing concentrations of atmospheric CO_2 and global warming. Risk assessment is often called "science-based" because part of the process—establishing that a chemical causes cancer in laboratory rats or that there is a correlation between CO_2 and atmospheric temperatures—is scientific.

From there on risk assessment is dependent on policy decisions and professional judgments. In the case of the animal studies, a policy decision is necessary about how to extrapolate from the number of cancers seen in rats exposed to high levels of a chemical to estimated numbers of cancers that might occur in people exposed to levels of the same chemical thousands of times lower. We will never be sure of the accuracy of the extrapolation because the expected number of cancers in the human population is too small to be detected.

In the case of global warming, many factors in addition to CO_2

—water vapor and aerosols, fluctuations in the sun's energy output—have been identified as playing a role in surface temperatures.[7] In recognition of the limited knowledge about the effects of those factors as well as uncertainty about the role of CO_2, policy decisions are required to decide which climate models are to be used to predict future temperature changes. Those models, based on uncertain science and policy decisions, may be used to set limits on emission rates and levels for decades into the future, with profound effects upon population, technology, economic growth, and energy systems. It is impossible to know how well the models' predictions will fit with reality until time passes, and, in the meantime, we cannot determine their accuracy, making the predictions unscientific because they cannot be checked by measurements.

Because of the prominence of policy judgments in the interpretations of risk assessments, it is more accurate to say only that risk assessment has some (limited) scientific component. To call it "science-based" is an overstatement because it differs radically from science.

Hypothesis and Science

Karl Popper, generally accepted as the leading twentieth-century philosopher of science,[8] divided science into two basic steps: the formation of a hypothesis (called variously an idea, a hypothesis, or a theory), followed by the testing of the hypothesis. The physicist Paul Davies and the biologist Peter Medawar, both admirers

7. *A Guide to Global Warming* (Washington, D.C.: George C. Marshall Institute, 2000).

8. K. Popper, *The Logic of Scientific Discovery* (New York: Basic Books, 1959). See also D. Miller, ed., *Popper Selections* (Princeton, N.J.: Princeton University Press, 1985). This paperback collection contains some of Popper's essays on science at pp. 133–206.

of Popper, have compared the formation of a hypothesis to a composer imagining the notes of a symphony or an artist mentally combining the colors and shapes that emerge as a painting.[9] Hypotheses can be imagined that require the intervention of God or magic or a specialized skill, but those are not scientific. To be scientific, a hypothesis must describe events in the physical world, and it can be tested in many detailed and specific ways. If the theory passes those tests, our confidence in the theory is reinforced. A theory that is too vague or general, or makes predictions concerning circumstances beyond our ability to test, is of little value.

Predictions of human cancer risks based on results of tests in rats cannot be tested; predictions from climate-change models cannot be tested. In science the capacity to test is the capacity to falsify or confirm a hypothesis.

Assertion and Risk Assessment

Assertions of risk, which in risk assessment are analogous to a hypothesis in science, do not have to withstand tests. Theo Colborn, an author of *Our Stolen Future*, stated, "Just because we don't have the evidence doesn't mean there are no effects."[10] Exactly: we may have overlooked something in our search for evidence. But, in context, Colborn's statement went much further. It was made after several years of scientific research had failed to support her assertions about endocrine disruptors. Her statement brushed the evidence aside. No matter how much information is

9. P. Davies, *The Mind of God: The Scientific Basis for a Rational World* (New York: Simon & Schuster, 1992); P. Medawar, "The Philosophy of Karl Popper," in P. Medawar, *The Threat and the Glory* (Oxford: Oxford University Press, 1991), pp. 91–101.

10. Theo Colborn, quoted in G. Easterbrook, "Science Fiction," *New Republic*, August 30, 1999, pp. 18–22.

piled up against an assertion, there is no reason for its proponents to drop it.

Once an agency or politician accepts an assertion—and acceptance may come easily when a new program can be established or voters' favor curried—the agency or politician can demand evidence to set the assertion aside, no matter how flimsy the evidence for it. The demand cannot be met because it involves proving a negative.

Scientists' Roles in Risk Assessment

The fact that science may play only a limited role in risk assessment makes it that much more important "to get the science right." In addition to their central role in designing studies and collecting the data that go into risk assessments, scientists play a central role in devising models for estimating health risks and climate change and in selecting the models to be used.

Politicians and others interested in the best use of the science that goes into risk assessments should ensure that the scientists who participate in model selection represent the range of opinions about models. They should not leave this task up to the same group of people—scientists or policymakers—who selected the currently used models. New ideas and new perspectives are essential for designing experiments and models and for testing new ideas.

Weighing the Evidence

Scientific studies about a hypothesis, whether supportive of it ("positive") or not supportive ("negative") probably have equal chance of being published because scientists want to be as sure as they can about the hypotheses that they accept as accurate descriptions of the physical world. It is different in risk assess-

ment.[11] Many scientists are convinced that "negative results" about a risk are less likely to be published than "positive results."

Despite that bias, government agencies sometimes confront conflicting data about a risk issue, and someone or some organization is given the responsibility of judging and weighing the data. Ideally, he or she would weigh the evidence in an even-handed fashion. That may be difficult for a regulator considering the effects of saying that a risk no longer requires regulation, or for a research administration that realizes that concluding that enough information has been done requires that no more research funding will be provided.

Consensus Science

When a risk is politically important and the science is uncertain, policymakers who want to appear to be doing something rather than waiting for more certain results can turn to committees of scientists for a review of the available information. The outcome from most such committees is a consensus report.

Consensus panels about risks almost always include people who made the assertion, and they usually steer a careful, centrist path through the scientific information. It is not unusual for them to conclude that the risk is not as big as some asserted, but that it can't be rejected, and that more research is needed. How different from science. Scientists strive to find evidence that supports one conclusion over another. "Splitting the difference" or "finding a consensus" is not science. Robert A. Pielke Jr., of the University

11. M. Gough, "Antagonism—No Synergism—in Pairwise Tests of Carcinogens in Rats," *Regulatory Toxicology and Pharmacology* 35 (2002): 383–92, is an analysis of a study that showed that mixtures of two carcinogens do not cause more cancers than either carcinogen by itself. The study, completed in 1978, was never published by its sponsor, the National Cancer Institute.

of Colorado, wrote, "Consensus science can provide only an illusion of certainty. When consensus is substituted for a diversity of perspectives, it may in fact unnecessarily constrain decision makers' options."[12] In practice, decision makers will never hear some perspectives.

Two chapters in this volume discuss the workings and results of consensus panels. Both provide suggestions about how the panels might work better.

Patrick J. Michaels, "Science or Political Science? An Assessment of the U.S. National Assessment of the Potential Consequences of Climate Variability and Change*"*

Michaels, the State Climatologist for Virginia, criticizes the work and conclusions of a United States consensus panel, the National Assessment Synthesis Team, which was created to investigate the possible effects of warming on the United States. The team based all its projections on two climate change models that predicted the greatest changes in temperature and rainfall, ignoring other models—compatible with all that is known—that predict smaller changes. Michaels urges that the synthesis team be reconstituted with different members who will take the uncertainty of the models into account.

Michael Gough, "The Political Science of Agent Orange and Dioxin"

By 1990, panels at the EPA, in the Department of Health and Human Services, and the congressional Office of Technology Assessment (OTA), had decided that there was no convincing evidence that Agent Orange had harmed veterans of the war in Vietnam. Members of Congress, who had long before accepted the veterans' claims about harms, directed the Institute of Medi-

12. R. A. Pielke Jr., "Room for Doubt," *Nature* 410 (2001): 151.

cine (IOM) to review the same evidence. The IOM did not review the data as scientists typically do, but matched it against some other criteria (never specified), leaving it unclear about what criteria the committee used. Gough also criticizes the composition of the IOM committee, which was set up to exclude scientists who had taken a stand of any kind in discussions about Agent Orange, dioxin, or related substances. That action, he says, eliminated the most knowledgeable scientists from the panel.

Consensus and Policy

The recommendations of consensus panels should be treated with caution because they are based on far-from-certain science and are driven by social dynamics that can substitute the value of cohesion—"group think"—for independent, critical thinking. Instead they serve as the basis for guiding funding decisions, planning responses to changes that may or may not take place (Michaels's chapter), or providing compensation for diseases that occur no more commonly in an "exposed" population than in the population as a whole (Gough's chapter). For the public and the media, consensus panel recommendations that establish and sustain research programs, response programs, or compensation programs are a strong message that "there must be something there."

The Precautionary Principle

Science and risk assessment, with all their flaws, take time, cost money, and leave some participants unsatisfied. The precautionary principle, which originated among German Greens in the 1970s, is offered as an alternative. It has no definitive definition. At least twenty can be found in treaties, laws, journal articles and books, and Cass Sunstein has placed them on a scale from weak

to strong.[13] The "weak" ones, if implemented in the U.S., would result in few changes from the current scheme of risk assessment and managment. Stronger definitions would toss science aside. For instance, one definition says, "action should be taken to correct a problem as soon as there is evidence that harm *may occur*, not after the harm has already occurred" (emphasis added; "may occur" is a low hurdle; any assertion should be able to leap it).

In the United States, the president of Friends of the Earth, testifying before a House of Representatives committee in 2002, said:

> . . . the precautionary principle mandates that when there is a risk of significant health or environmental damage to others or to future generations, and when there is scientific uncertainty as to the nature of that damage or the likelihood of the risk, then decisions should be made so as to prevent such activities from being conducted unless and until scientific evidence shows that the damage will not occur.[14]

Sunstein says that the strong statements mean "that regulation is required whenever there is a possible risk to health, safety, or the environment, even if the supporting evidence is speculative and even if the economic costs of regulation are high."[15] John Graham, administrator of the Office of Information and Regulatory Affairs in the Office of Management and Budget, speaking about the precautionary principle, presented a number of illustrations to show

13. C. R. Sunstein, "Beyond the Precautionary Principle," John M. Olin Law and Economics Working Paper no. 149 (2d series), The Law School, University of Chicago. Available at http://www.law.uchicago.edu/Lawecon/WkngPprs_126-150/149.CRS.Precaution.pdf.

14. B. Blackwelder, testimony before the Senate Appropriations Committee, Subcommittee on Labor, Health, and Human Services, January 24, 2002. Quoted in Sunstein, 2002.

15. Sunstein, p. 7.

that "precaution," by itself, is not a reliable guide for action.[16] (Sunstein argues that it is no guide at all.)

Two chapters in this volume discuss the precautionary principle. For rich countries, application of the principle may result only in some minor irritations and higher prices as products are taken off the market; in poor countries, it can mean death.

Robert Nilsson, "Science and Politics in the Regulation of Chemicals in Sweden"

Sweden is a fervent proponent of the precautionary principle, and Swedish government reviews of risk information place emphasis on studies that suggest a risk, largely exclude consideration of other results, and preclude consideration of benefits. Sweden has imposed restrictions on the use of chemicals that have been approved for use in the European Union (EU), bringing Sweden into conflict with the EU's principles of free trade. Robert Nilsson, until recently a senior scientist in the agency of the Swedish government that regulates exposures to chemicals, sees two possible futures for Sweden's chemical regulations. Sweden's membership in the EU may force it to bring its chemical regulations in line with the rest of Europe's. Alternatively, and chemical regulation plays only a tiny role in deliberations about it, Sweden may leave the EU.

Roger Bate, "How Precaution Kills: The Demise of DDT and the Resurgence of Malaria"

The widespread use of DDT, along with other measures, eliminated malaria from many countries in the world in the 1940s

16. J. D. Graham, "The Role of Precaution in Risk Management," speech delivered at the International Society of Regulatory Toxicology and Pharmacology "Precautionary Principle Workshop," Crystal City, Va., June 20, 2002, available at http://www.whitehouse.gov/omb/inforeg/risk_mgmt_speech062002.html.

through the 1960s by controlling the mosquitoes that spread the microbe that causes the disease. After Rachel Carson's *Silent Spring* indicted DDT as the cause of decreasing bird populations in the United States and the publication of some never-replicated tests that showed DDT to be a carcinogen in laboratory animals, the United States and other rich countries reduced, then eliminated, the use of DDT, substituting more expensive insecticides for it. Bate, director of the International Policy Network, traces the sad history as poor countries adopted the environmental policies of the rich world and phased out DDT. Malaria rates rose, and the disease became, once again, a major killer. Bate considers the DDT saga as an example of the likely outcome of increased reliance on the precautionary principle as a guide for international environmental decision making.

Political Throttling of Science

S. Fred Singer is a retired university professor and the president of a nonprofit policy research organization. In the final chapter in this volume, he describes an attempt by a politically affiliated scientist to silence him, by an attack on his honesty. The attack failed, but a court case was necessary to stop it. The chapter also includes a description of a subsequent attempt by Vice President Al Gore to belittle Singer's reputation because of his accepting funds from industry. A TV newsperson stopped that attempt.

S. Fred Singer, "The Revelle-Gore Story: Attempted Political Suppression of Science"

In 1991, three scientists, S. Fred Singer, Chauncey Starr, and Roger Revelle, published a paper about global warming in a small-circulation journal, *Cosmos*. In the paper, they concluded that there was no need to take immediate action to counter global warming. Later, after Dr. Revelle had died, Singer was contacted about pre-

paring a paper for a collection of essays on climate change, and he asked the editor of the collection to republish the *Cosmos* paper. The editor agreed.

At about the same time, a journalist quoted then-Senator Al Gore as having credited Dr. Revelle with introducing him to the idea of climate change and contrasted Dr. Revelle's statement in the *Cosmos* paper with Mr. Gore's calls for immediate action to counter global warming. Subsequently, a scientist involved in the preparation of the collection of essays demanded that Singer remove Revelle's name from the paper before it was republished. Singer refused. That scientist, in close contact with Senator Gore's staff, began a campaign saying that Singer had coerced Revelle, described as having been sick and enfeebled, to attach his name to a paper that he had not written. A suit was brought on Singer's behalf that was settled when the accusing scientist retracted his accusations and apologized for making them. The retraction specifically acknowledged that there was no evidence that Dr. Revelle had been coerced.

Later, Vice President Gore made a more direct assault on Singer. He called Ted Koppel, the TV news anchor, and asked him to investigate Singer's sources of funding. The attempt blew up in Gore's face. On his February 24, 1994, program, Koppel asked, "Is this a case of industry supporting scientists who happen to hold sympathetic views, or scientists adapting their views to accommodate industry?" And he chastised Gore.

There is some irony in the fact that former Vice President Gore, one of the most scientifically literate men to sit in the White House in this century, resorted to political means to achieve what should ultimately be resolved on a purely scientific basis.

"The Acid of Truth"

In his response to Vice President Gore, Ted Koppel characterized science in no uncertain terms: "The measure of good science is

neither the politics of the scientist nor the people with whom the scientist associates. It is the immersion of hypotheses into the acid of truth. That's the hard way to do it, but it's the only way that works." Koppel's ringing defense of scientists and the importance of looking at their work and not at their funding was the most significant stop to Vice President Gore's attempts to discredit Dr. Singer and other scientists with whom he disagreed. It is remarkable, however, that in a country that prides itself on a scientific base a TV newsman was the vocal defender of science.

Congress and members of the administration, of any administration, can demonstrate their commitment to sound science by deflecting attacks based on funding or association, whether the attacks are directed at industry scientists, government scientists, or environmental organization scientists. Yet they rarely do. To find errors in a scientist's data or interpretations is a legitimate task for a scientist or a nonscientist, but besmirching his reputation instead of examining his work is not.

To ask for consideration of science on its merits is a bit like a plea based on Mom and apple pie. It's actually worse because it's relatively easy to dismiss a scientist on the basis of "What do you expect? Look where she gets her money." It's more difficult to examine her research and find out if it's good or bad. In fact, that's usually well beyond the ability of a nonscientist, but it's not beyond his or her ability to ask that the examination be made.

Recommendations

From the contents of the chapters in this book, it is apparent that better policy decisions and better use of society's resources will come from an examination of all available science carried out in ways to encourage critical thinking by scientists and policymakers. The three recommendations that follow are directed at Congress and the Executive Branch. They are equally applicable to

other citizens interested in improving the usefulness of science in risk management decisions.

1. Demand Transparency

Congress recognized the importance of review of the science that goes into agency decisions when it included the "data quality section" (sometimes called "data quality act") in the FY 1999 Omnibus Appropriations Act (P.L. 105–277). Commencing October 1, 2000, federal agencies are required to provide all information produced under a federal award to interested parties. Such data will be of value to those who want to understand and to support or challenge the scientific bases for an agency decision.

As agencies receive requests, Congress and the Office of Information and Regulatory Affairs (OIRA) in the Office of Management and Budget should monitor the adequacy of agency responses. As information about agency responses is acquired, OIRA, which administers the "data quality act," can alter guidelines for its implementation as needed.

Congress and the Executive Branch can also use the Supreme Court's decisions about the admission of expert testimony in courts as a starting point for establishing standards for consideration of experts and their opinions. In the 1993 "Daubert Case,"[17] the U.S. Supreme Court set down some guidelines for courts to use to decide whether an expert and his or her testimony is ad-

17. *Daubert v. Merrell Dow Pharmaceuticals, Inc.*, 509 U.S. 579 (1993). Subsequently in "the Kumho Tire case" (*Khumo Tire Co. v. Charmichael*, 526 U.S. 137 (1999)), the Supreme Court extended the rules laid down in Daubert for admission of scientific evidence to testimony based on "technical" and "other specialized knowledge" such as that of mechanics or economists. The Kumho case ended the practice of some lawyers of putting experts on the stand to testify that the witness wasn't subject to Daubert because the testimony wasn't, strictly, scientific.

missible in Federal Courts.[18] Federal advisory committees could establish requirements that have to be met—say, publication of results in a peer-reviewed journal or access to the underlying data that go into a calculation—before the data or opinions will be heard.

2. Establish Advisory Panels and Get Rid of Consensus Committees

Almost every decision in our society comes from resolving disagreements: labor/management; prosecutors/defense attorneys; even sports events. Why should the resolution of scientific controversies that are important enough to warrant governmental attention be among the few settled by consensus?

Democracy can suffer from decisions based on "scientific consensus," which usually means that, though the science is not clear, some group of people has chosen a path through the controversies to a resolution of fewest regrets or maximum funding for research. Those decisions, cloaked in the authority of science, are too often removed from the checks and balances of politics. Politicians who like the consensus can deflect criticism by saying, "It's a scientific decision, well beyond my understanding and out of my hands." Those who dislike it may find it difficult and inappropriate to question or to argue about "the science." Thus politicians who benefit from a consensus decision are able to evade responsibility for their actions; it takes authority away from those who disagree; it politicizes science.

Currently, Congress and the Executive Branch depend on committees of the National Academy of Sciences for advice. They

18. D. Goodstein, "How Science Works," *Reference Manual on Scientific Evidence*, 2d ed. (Washington, D.C.: Federal Judicial Center, 2000) pp. 67–82. Available at http://air.fjc.gov/public/pdf.nsf/lookup/sciman00.pdf/$file/sciman00.pdf.

could improve the quality of advice by insisting that the committees include knowledgeable partisans about the issue under review and that the committees place a high priority on vigorous debate rather than focus on consensus. Reports should, of course, draw attention to issues on which there is genuine consensus, but they should also include minority and divergent views on issues for which there is a range of credible scientific views. "Group think" is not a good route to resolving complex science based policy issues.

3. Continue U.S. Policies About Science, Risk, and the Environment

Making decisions about risks to health and the environment is difficult for Congress, for regulatory agency administrators, for officials of industry, and for the public that awaits the decisions. Questions about science, economics, trade-offs, and uncertainty seldom have clear-cut answers. Many countries, many international treaties, and many environmental organizations have offered the precautionary principle as a shibboleth, a near-magic principle, to guide decisions about risks.

The many definitions of the precautionary principle do no more than provide comfort to those who think that the science and economics and politics that go into risk decisions can be put aside in favor of a magic bullet. There is no magic bullet. The precautionary principle(s) is (are) the product of philosophers considering the fate of the earth, and it is supposed to provide direction for decision making, including the use of science. With that in mind, it is worthwhile to recall the statement of the physicist Richard Feynman, "Philosophers say a great deal about what is absolutely necessary for science, and it is always, so far as one can see, rather naive, and probably wrong."

The U.S. Congress has established science-based regulatory

agencies and has written specific laws to deal with risks to health and the environment. The agencies and various government-appointed committees have accumulated the world's knowledge about risks and established procedures for considering the nuances of the information. As is apparent to readers of this book, improvements can be made.

Improvement will not come from policies based on the precautionary principle or any similar principle, which ignores the specifics of different risks and the benefits that accompany the substance or process that is being examined. Good policy cannot be derived by skipping over the fact that we live in a world of trade-offs and that actions have consequences. A regulatory and policy system that produces greater value for society must have a foundation of credibility. Far better to emphasize science in the risk assessment process and to examine the process and evaluate how well it works than to chase after lofty aspirations embodied in a principle without definition.