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# Toxicological Risk Assessment Distortions

by Jay H. Lehr, Ph.D.

"Eventually, it may dawn on the public that they are being hoodwinked by environmental zealots who aggressively promote a non-detection limit for all undesirable chemicals."

"Absolute safety is the complete absence of harm. We can never achieve this. We can only offer probabilities that there will, in fact, be no harm."

"Why are the media so eager to give us bad news? Why do the same scientists confirm each apparent disaster? Why aren't mainstream American scientists so outraged that they contact the media?"

"Neither apple polish, cow-antibiotics, gas emanating from rocks, mundane landfill leachate, leaking tanks, chemical spills, or the ubiquitous industrial degreasers pose an imminent or terminal threat to our lives or, in most cases, even to our daily health. But the public, inadequately schooled in science and totally untrained in risk assessment, is being held captive by an 'environmental industry' reaping its economic and political rewards by malicious overstatement."

## Foreword

Dr. Jay Lehr is a water scientist with strong concerns about the degradation of our environment. He first encountered ground water pollution in the employ of the U.S. Geological Survey in 1955.

He published scientific articles on ground water pollution as editor of the journal of *Ground Water* in the early 1960s. He began working strenuously for ground water protection legislation in the late 1960s.

In the 1970s, he played a major role in the successful passage of federal legislation, including the Safe Drinking Water Act, the Resource Conservation and Recovery Act, and the Surface Mining Control and Reclamation Act.

After 30 years of leadership in our nation's environmental movement, he now believes that extremists are carrying the battle too far.

This booklet is a reprint of an editorial series by Dr. Lehr that appeared in the journal of *Ground Water* from January through June 1990.

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## About Jay H. Lehr, Ph.D.

A widely known and dedicated water scientist, Dr. Jay Lehr is the most frequently quoted authority on ground water science in America. Throughout his entire career, Dr. Lehr has been an outspoken proponent of realistic ground water management and protection programs.

He has served as a consultant to government agencies and the United Nations, has been a member of and chaired federal committees (including six years on the National Drinking Water Advisory Council), and has been called upon to provide expert testimony to numerous committees and subcommittees of the U.S. Senate and House of Representatives.



He has authored several books for both the public and private sectors and has contributed more than 150 articles to scientific and technical journals.

Dr. Lehr graduated in 1957 from Princeton University with a geological engineering degree, and followed it with his doctorate, the nation's first in ground water science, from the University of Arizona in 1962.

Today, Dr. Lehr is the editor/publisher of three journals, including *Ground Water*, the source for the pages that make this booklet; the executive director of the National Water Well Association; and a trustee of The American Ground Water Trust.

# **Toxicological Risk Assessment Distortions**

**by Jay H. Lehr, Ph.D.**

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## TOXICOLOGICAL RISK ASSESSMENT DISTORTIONS: PART I

### Without Bias

Before starting on risk assessment, let me establish credibility for my subject. Over the years, I have become reasonably competent in toxicology as a result of my efforts to promote ground-water protection legislation. I was among the first to stand up in Washington and demand federal regulation of ground water. In 1968, my colleagues and I pointed out that half the water we drink is ground water, and that it was totally unprotected. We succeeded in getting only a limited amount of ground-water protection language into the amended Water Pollution Control Act that passed in 1972, but we immediately went to work on a new law, which became the Safe Drinking Water Act of 1974. Soon thereafter, I joined another group who were working on regulating surface disposal of waste and helped them develop the Resource Conservation and Recovery Act, which closed many loopholes involving activities that were polluting ground water. Later, I worked on the Surface Mining Control and Reclamation Act, the Toxic Substance Control Act, and finally, spent many years assisting in the development of Superfund. This background is important because it will soon become apparent to you that I think we have gone too far. Nearly everything that is driving the Association of Ground Water Scientists and Engineers today deals with ground-water pollution. I do not intend to undermine your careers, but I do intend to reduce the crisis mentality that is driving this system beyond any reason, common sense, or scientific knowledge.

### Common Science/Media Distortions

I recently found an excellent sample of today's distortion problems on the front page of a *Des Moines Register* (October 3, 1989). The headline read "Underweight Babies, Rural Drinking Water Linked in University's Study." In the next day's paper (October 4, 1989, on the fourth page of section 5), there appeared a rebuttal from the people who had been wounded by the aforementioned unreviewed study at the University of Iowa. Now, there isn't anything wrong with studying the relationship between birth weight and environmental factors such as water supply as long as many potential influences are considered. In this case, if you read the full article, you learned that a correlation was made using a small statistical sample with a very small effect and then correlating that effect to the water that was drunk. Dozens of other factors that might affect the birth weight of babies were ignored.

The way science is being practiced by some people today is all but scandalous. There are scientists who like to parade in front of the press with glib comments that elicit much-desired pub-

licity, and they like to avoid the peer review of their more conservative colleagues. Their studies easily find the light of day in publications of the Natural Resource Defense Council (for example, the ALAR study); The National Wildlife Federation (e.g., the Drinking Water study); and many other overzealous environmental group publications.

What is even more wrong is using the media for peer review of science. Research should first stand the test of peer review in scientific journals. There is, unfortunately, an attitude at some universities that praises people who get publicity for science done on the university campus regardless of how spurious it may be.

Many studies of ground-water pollution show that the percentage of wells exceeding maximum contaminant level is small, if not insignificant. But the news media that report these studies focus not on what can be considered good news, but rather on the percentage of wells in which a particular chemical is detected.

A 1987 Iowa Department of Natural Resource Public Water Survey that tested 853 water systems is a case in point (Fleetwood and Martin, 1989). The fact that 14.7 percent of the systems had detectable pesticides got all the publicity; the fact that only 1 percent exceeded maximum contaminant levels did not.

That we find so many chemicals in our water supply is less related to an expanded use and abuse of chemicals than it is to an ever-improving capability to perceive smaller and smaller quantities of chemicals in laboratory tests. In many cases, the presence of pesticides in ground water has evolved into a public concern that borders on outrage (Spaulding, 1989). This "chemophobia" tends to result in a loss of objectivity.

Much of this concern has evolved from quantification of compounds which, because of their constituents (many contain halogens or nitrogen), can be detected in sub-part per billion amounts. Once the part per million was the visible limit, then we improved three orders of magnitude to parts per billion, and now we commonly measure things 1/1000 of that quantity or a part per trillion basis. We will achieve common recognition of 1/1000 of that in a part per quadrillion in the next decade. One day we may recognize that there is something of everything in everything else and that a glass of water likely contains a molecule of every compound on earth.

Eventually, it may dawn on the public that they are being hoodwinked by environmental zealots who aggressively promote a nondetection limit for all undesirable chemicals. But analytical technology changes. Yesterday's zero is no longer zero, and today's zero will not be zero tomorrow.

Driving toward nondetection is unreasonable and may even be unethical. Although many chemicals are undesirable, safe standards for all chemicals based on reasonable toxicological studies can be established, and the nation's paranoia or chemophobia can be diminished.

### Reality

Environmental scares are not all bad. They often create new industries. The ground-water monitoring industry is certainly a case in point. The radon industry is another. Environmental groups would quickly go out of business were they not able to send out mailings describing the latest threat and asking for money to fight it. In other words, environmentalism has created a whole group of vested interests who fare better when there are many problems than where there are few. That tends to tilt the public debate toward solutions even when knowledgeable scientists are skeptical about the seriousness of the threats and the insistence of urgency.

There is an element of make-work involved in all of this. And it's not just our industry that is plagued with it. Scares about the food on the shelves of your own markets have shaken the food industry to its foundation. The driving force in the food scare movement consists of hundreds of organizations that bill themselves as environmentalists. In a way, they have become an industry as well. Their ability to attract foundation grants and individual contributions rests on their ability to make news, and they often have allies in the press who suspend their skepticism when these groups make claims—even wild ones. They say they represent the public interest, but they don't do so badly for their own interests either.

Do we need an environmental industry? Maybe we do but the answer would be more certain in my mind if this industry exercised more quality control over its science. And indeed there is a very bad aspect to it all, namely an unconscionable effort to distort scientific reality in order to provide a constant sense of menace for a population that is terribly deficient in scientific aptitude. I don't intend to eliminate environmental concern among my readers, but I do hope to arm you with information that will allow you to stand toe-to-toe and argue over the seriousness of many environmental threats.

### Risk

We all accept risks every day. When we accept these voluntarily, we don't worry. Problems arise when the risks are forced upon us. Many of you smoke in spite of the proven risk of lung cancer. But that is your choice. It's the involuntary risks that really scare us. We are willing to accept some involuntary risks like being struck by lightning. The chance of being struck is about one in a million, and we consider that an acceptable risk. In

the legal profession, that is called a "deminimus" risk—a negligible risk.

The chance of your contracting cancer in today's society is about one in four. Yet we regulate chemicals based on a lifetime ingestion of a maximum contaminant level that would increase our risk of getting cancer by one in a million. This is conservative, to say the least. And while that calculation is commonly based on so many parts per billion of a particular chemical, many environmental groups and some at U.S. EPA are dissatisfied. They prefer zero quantities of unwanted chemicals in our water supply.

### Risk Assessment and Management

Risk assessment has always been with us. When cavemen recognized that animals could be a source of food, they had to weigh the hazards of being mauled by that animal versus courting starvation. We actually have writings about risk assessment that date back about 3,000 years, yet our present level of concern began only in 1960 (Paustenbach, 1989a). We became aware then of radiation in our environment and decided to quantify how much we would be willing to put up with from a variety of sources.

Risk management deals with the need for risk reduction (Rodricks, 1987). Are there significant risks that can significantly reduce the length of our lives and, if so, what should we do to eliminate them? We are now reaching a point where acceptable risk is considered somewhere in the order of a one-in-a-hundred-thousand chance of dying from exposure over a lifetime. People, in fact, are willing to accept much greater risk than that, but this is the risk below which government says it will not try to regulate. After you see how it reaches those numbers, you will realize that it is likely already regulating risks that are much smaller.

The goal of risk management is to select the options that balance the benefits of an action against a real or perceived risk with the costs of eliminating that risk. Risk assessment yields critical data to risk managers and has a number of parts, including hazard identification, dose-response assessment, exposure assessment, and risk characterization.

Hazard identification is defined here as the process of determining whether human exposure to an agent could cause an increase in the incidence of illness. It involves characterizing the nature and strength of the evidence of causation. Although the question of whether a substance causes cancer or other adverse health effects in humans is theoretically a yes-no question, there are few chemicals or physical agents on which the human data are definitive.

Dose-response assessment is the process of characterizing the relation between the dose of an agent administered or received and the incidence of an adverse health effect in exposed populations.

Exposure assessment is the process of measuring or estimating the intensity, frequency, and duration of human or animal exposure to an agent currently present in the environment or of estimating hypothetical exposures that might arise from the release of new chemicals into the environment.

Risk characterization is the process of estimating the incidence of a health effect under the various conditions of human or animal exposure described in the exposure assessment.

So far, we have studied about 600 chemicals that are carcinogenic to animals. We only know of about 25 that are definitely carcinogenic to man. The studies take many years. We can't use man as a guinea pig, so we make certain assumptions between animal studies and that of the human.

### Carcinogenicity

A carcinogen is a chemical that will cause genes and cells to duplicate themselves in an imprecise manner so that we get a repetition of incomplete cells in the body. An unhealthy environment is created in some organs or parts of the body until the whole body ceases to function properly. A mutagen is a substance that will alter genes, but not necessarily make them reproduce. A teratogen is a substance that creates birth defects. There are six factors that we consider in determining carcinogenicity of a chemical. We look at the number of animal species to which a chemical is carcinogenic. We study the number of animals affected by the chemical; the number and types of tumors that the different animals get from the chemical; what the incidence of cancer is in the animal population that is subject to it; what kind of a dose is required for the chemical to be carcinogenic; what the dose-response relationship is to those given such and such a dose and exactly what happens. In order to come out with some kind of numbers, we take an animal population and feed it x milligrams of a chemical per kilogram of weight every day. We then determine at what dose does the whole population get a tumor? We then drop down and determine at what dose does half the population get a tumor and then, perhaps, at what dose does five percent of the population get a tumor, and at what dose does none of the population get a tumor?

We use those dose-response figures to plot a curve and interpolate with mathematical models a calculation of what kind of an exposure man could withstand without having a serious risk of getting cancer. We usually define that risk as one chance in a million—very conservative—and the extrapolation is very difficult. Normally, we are feeding the animals between 100 and 10,000 times the amount that would have an impact on the human species. This kind of research was never intended to be used to define numbers that man could live with. It was intended only to determine whether a chemical was a hazard at any level at all.

We now end up with interpolations sometimes as small as a part per trillion as being the upper limit for some chemicals. A part per trillion is the same as the ratio of 1/16th of an inch to the distance to the moon. In other words, 1/16th of an inch is one-trillionth of the distance to the moon. We're chasing things that small while 400,000 people die every year from smoking and another 100,000 die from drinking alcohol. Also, the risks are based on unrealistic ingestion rates for a lifetime of 70 years. With water, we assume you drink two liters a day (approximately one-half gallon) for 70 years. You can't leave your house, go on vacation, or leave town for any reason; you must keep drinking the same water.

### Human Data

Many of the studies intended to scare us cannot be duplicated, but are never discarded. We do rat studies, feeding them tons of chemicals, then extrapolate back from a dose 10,000 times what a human would ever consume while simultaneously disregarding real human data. An example in point: EDB, a fumigant for agriculture, was determined to be a carcinogen through a rat study. Based on the maximum contaminant level established for EDB, an individual who worked eight hours a day for 40 years in a workplace exposed to 20 parts per million of EDB would have a 99.9 percent chance of getting cancer. Yet we have data on people who have worked in exactly those conditions for decades, working to manufacture EDB, and we don't have a single incident of cancer. Has the MCL for EDB been changed? Not at all.

We have similar data on dioxin. There is no proven evidence as yet that dioxin has done anything more than cause a skin rash. Yet we do not change our acceptable risk levels. In addition, the government always chooses the most conservative mathematical model to extrapolate from the animal studies. We are unnecessarily wreaking havoc on our economic system and creating anxiety-related problems for the public in general. People do not understand what risk is really about or that this 70-year exposure yields only a one-in-a-million chance of cancer.

While a few chemicals with which we deal allow a risk of one in 100,000 or even one in 10,000, one in a million is the norm. What does this really mean? Your chances of eventually contracting cancer are currently about one in four. Supposedly if you drink a water supply just above a particular chemical's maximum contaminant level for 70 years, you increase your risk of getting cancer by one in a million. This means that in a population of a million, instead of 250,000 people dying of cancer, 250,001 might die of cancer. Or, your chances of getting cancer are increased from 25 percent to 25.001 percent, an incredibly small increase in risk. To prove this statistically would require a sample larger than the earth's entire

population (Paustenbach, 1989b).

Prudence in all matters of health is certainly desirable, but we need a balance between the chemophobia that has overtaken much of our population and the high cost. We need sensible management of industrial chemicals. We don't need crazed obsession.

If you want to look at the necessity for introducing economics into the health arena, you only have to look at the debate that is going on in the medical profession regarding how much medical effort should be expended to save the life of a very elderly person. We are able to keep people alive long after the quality of life ceases to be desirable. The health care system is running out of money and it is having to ethically debate this issue. The "health care" system's argument is tangible because it's not a mathematical model that determines whether a person is allowed to die or allowed to live with the expenditure of money. It's a sure thing. We're spending similar amounts of money where it's as far from a sure thing as anything imaginable.

### Thresholds

Until the recent chemophobia scare, the main rule in toxicology has been that the dose makes the poison. We don't assume in toxicology that something is a poison, because everything is a poison given a certain dose. And yet when it comes to carcinogenicity in a water supply, we treat matters entirely differently. We have adopted the no-threshold idea that if a lot of something is bad, then a tiny amount of it is bad, also. This doesn't make sense in medical science.

We know that the carcinogenic effect is the square of the dose (Higginson, 1988). You double the dose, you square its impact. But we also know that it rises to the fourth power of time; that is to say if you double the time of exposure, that time interval has a fourth power exponential impact. If we take a 60-year-old person who has been smoking a pack of cigarettes a day for 20 years, that person actually has one-tenth the chance of getting lung cancer compared to a 60-year-old person smoking one-half pack a day for 40 years. We should also be capable, therefore, of extrapolating back to reasonable No Observable Effect Limits (NOEL).

### Cancer and Carcinogens

The population is getting older, and it was as our population aged that we really saw cancer as a major death threat. Diet looks like the key factor in cancer. The Japanese have a lot of stomach cancer (Higginson, 1983). We have little. Japanese get little colon cancer. We have a considerable amount. We are looking at what our dietary differences are. We are learning that industrial chemicals are not nearly as important as we once thought,

and that natural things are more important in the whole evolution of cancer and people's health (OTA, 1989). In America, we equate nature with benevolence. Historically, nature has not been benevolent. Nature produces more poisons than man ever thought of.

Overall, in the decade between 1974 and 1983, cancer declined. Stomach cancer was down 20 percent, cervical cancer was down 30 percent, and ovarian cancer was down 8 percent (Ames, 1986a). Only lung cancer increased, 15 percent in men and 70 percent in women. Our life expectancy has risen from 45 years in 1900 to 65 years in 1940, and 76 years in 1982. We anticipate it will be 82 at the turn of the century.

This is true because chemicals are not killing us. In fact, natural pesticides make up 5 to 10 percent of dry plant weight. We are exposed to 10,000 times as many natural carcinogens as we are to man-made carcinogens (Ames, 1986b), and thus 99.99 percent of our carcinogen-intake is natural rather than man-made. A cup of coffee has 4,000 parts per billion (ppb) of hydrogen peroxide. Our chlorinated tap water averages 83 ppb of chloroform. A cola drink has 7900 ppb of formaldehyde. Beer has 7700 ppb of formaldehyde, and 50 million ppb of the well-known carcinogen, alcohol. A peanut-butter sandwich has 75 times the risk of the maximum contaminant level of EDB. A mushroom has 200 times that risk, and yet we outlawed EDB without looking at what the long-term effects of radiation as a substitute to sterilize food will be. We also replaced TCE. TCE came along because earlier solvents were flammable and dry-cleaning plants went up in flames. So we developed TCE, but it is a carcinogen. However, the limits we are requiring on TCE use are ridiculous. You've all read about Silicon Valley, where officials shut off 35 water-supply wells. Only two of the wells had significant health risks (Ames, 1987), and it was determined that the two worst wells in Silicon Valley were 1,000 times safer than drinking two glasses of wine, and 15 times safer than breathing most indoor air (Tierney, 1988).

The wells in Woburn, Massachusetts have fewer carcinogenic substances than normal tap water, and yet they were all closed. The reasons for cancer in America are not determined scientifically. Doll and Peto (1981) explain that between 25 and 40 percent of our cancer is a result of tobacco; between 10 and 70 percent is a result of our diet; occupational cancer causes are between 2 and 8 percent; alcohol causes are between 2 and 4 percent; viruses are estimated to cause between 1 and 10 percent; and pollution causes between 1 and 5 percent.

### Improving the Atmosphere

None of this changes the law, which all of you must abide by. You have to respond to the EPA

maximum contaminant levels. We have no choice. Thus you may say that everything I've written up to this point is irrelevant to your performing your job, whether it's determining if someone can use a water supply, or determining if something needs to be cleaned up. I recognize that, and I don't expect to change that. What I'm striving for is an atmosphere in which the public can sleep better, where the public recognizes the validity of protecting our water supply and the importance of cleaning up some of the water supply without getting far sicker from anxiety-related diseases than they will ever get from environmental pollution.

I don't regret anything I've ever done in contributing to the passage of environmental protection laws. I resent, however, the ways in which those laws and imprecise science are used to rile the public into an atmosphere of unnecessary fear. Now some will say that if people don't stay scared, they won't do anything. I have a lot more confidence in my fellow man. I think we can tell people the truth, tell them what the real risk is, and be confident they are not going to walk away and forget about health risks. The public can help us make wise decisions.

Cleaning up to the public's expectation is impossible. The risk has already been distorted, and analytical techniques are too good. The public wants everything out. This was fine when we could only see a part per million. Now we are seeing a part per trillion, and a part per quadrillion is right around the corner.

We need to let the public know that we have been doing a magnificent job in the area of prevention. Our ground-water pollution threats are landfills, agricultural chemicals and industrial waste lagoons, underground storage tanks and leaking pipelines, septic tanks and highway salting, and on and on. There isn't one activity threatening ground water that we have not addressed competently in the last five years. We've probably already reduced by 80 percent emissions into the ground water from activities that are initiated today. That will not make your job any less important, because we've been making a mess for 40 years in many different ways. We have to at least assess the mess. We have to monitor it. We have to clean up some of it. And we will. But in the area of prevention, we are doing a good job. What's driving the crisis mentality now are largely environmental organizations that have been overzealous in describing the magnitude of the problem. They are made up of two kinds of people: those who want to save the world, and those who simply hate capitalism. Barry Commoner, one of the latter, said that MCLs of any kind are no good because basically they create a channel through which industry can pollute. He says you have to go to zero. What do you do when you go up into the North Woods, a great, beautiful unspoiled area where there is no industry for miles? You inhale the pine odor and you find out

that pine odor is made up of polycyclic aromatics, carcinogens, in the cleanest air we have in the country.

You've read about one scientist who helped create the scare and is now trying to undo what he did—Bruce Ames. He's the fellow who developed the test for carcinogenicity with bacteria which indicated that so many things are carcinogenic, and he was the one who first alerted people to not have anything to do with these things. Then he began to realize that the levels we were ingesting were not a problem, and he started to look at nature and came up with many of the numbers that I've quoted in this article.

These two men have two different views toward society and water pollution. Barry Commoner concludes that there are natural alternatives to all man-made chemicals and, therefore, he wants to dismantle the chemical industry. Bruce Ames sees no need for organically grown food, but he has no interest in shutting down the health food markets, because that's the American way. We don't need to drink bottled water in most places in this nation, but there's nothing wrong with an entrepreneur's convincing people that bottled water is a good drink.

The environmental movement is the third wave in our redemptive struggle in western society. The first was Christianity, the second was Socialism, and the third is Environmentalism. All, obviously, have good ideas to offer. But carried to extreme, they become negative. I believe that we, as ground-water scientists or engineers, health officers, or regulators involved in the environment, owe it to the people we serve to be honest and straightforward in dealing with risk assessment.

In "Toxicological Risk Assessment Distortions: Part II," which will be in the March-April 1990 issue, I will deal in greater length about the no-threshold controversy and the still relevant concept that the dose does, indeed, make the poison.

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## PART II — THE DOSE MAKES THE POISON

### The Toxicological Problem

The toxicology testing laboratory dates back into the 1930s, but the science of toxicology in the United States can be traced realistically to the formation of the Society of Toxicology in 1961 (Kamrin, 1988). This Society institutionalized the growing number of scientists involved in testing the effects of environmental pollutants, food additives, drugs, and other chemicals. In the late 1970s and the 1980s, academic departments of toxicology began at many universities. Thus, toxicology is a very young discipline. Many scientists we call toxicologists have become such through experience rather than formal training. Differing levels of toxicological expertise have contributed to the conflict and uncertainty in the scientific community regarding the toxic effects of a number of chemicals.

Toxicology is a discipline with basically one goal: to understand how chemicals can adversely affect living organisms. However, due to the multiplicity of chemicals and our limited understanding of how the human organism works, there are often questions as to whether or not an adverse effect has occurred, even if some biological change can be detected. Toxicology can provide answers to many questions we wish to address, but these answers must be looked at cautiously. We should not use these data to develop a false sense of what we know and unrealistic expectations for what our actions can accomplish.

We have been taught that science produces certainty. As a result, the public is impatient with scientists who express uncertainty and tend to believe scientists who express their views without reservations.

In toxicology, the certainty that most of us seek is that a particular chemical is safe. Unfortunately, there is no such thing as an absolutely safe chemical, since all chemicals can cause toxic effects in large enough amounts. When faced with this reality, most people look for a different certainty—a "safe" amount. They want to know the exact level at which a chemical changes from nontoxic to toxic. Again, this is not a scientifically realistic goal. People vary tremendously in their responses to their environment, including the chemicals in it, so what is "safe" for one person may not be "safe" for another.

While the government sets levels for many chemicals, the rationale behind these standards is not entirely scientific. Most people would like to entirely eliminate chemicals which have been labeled as highly toxic, but the ubiquitous distribution of many such chemicals makes their elimination unrealistic. In the minds of the public, however, a single number becomes a dividing line between "safe" and "unsafe." The amount and quality of scientific evidence behind this number vary from case to case and change over time much

to the consternation and almost total lack of understanding on the part of the public.

### Toxicity

The *acute toxicity* of a chemical refers to its ability to do harm as a result of a one-time exposure to the chemical. This exposure is sudden and commonly produces a health emergency. *Chronic toxicity* refers to the ability of a chemical to do systematic damage as a result of repeated exposures to small quantities of low concentrations of a chemical over long periods of time. Reactions produced by these two different types of exposure bear no resemblance to one another. Chronic toxic effects are not predictable from knowledge of acute exposure effects of the same chemical.

Some chemicals have a high acute toxicity but no chronic toxicity. That is to say, small quantities over a long period of time are harmless and, in fact in some cases, are beneficial. Vitamin D would serve as one such example; sodium fluoride is another. We require small quantities of vitamin D daily for good health, and we know that fluoride is essential for good dental health. The same can be said of sodium chloride, common table salt.

In contrast to chemicals that are acutely toxic and chronically nontoxic, there are some that are just the reverse. Metallic mercury is one example. A large ingestion of a single dose of metallic mercury will pass through the body without causing significant damage, but a buildup of mercury in small amounts over a lifetime can be lethal. Although there is little correlation between acute and chronic toxicity, both in their own way are dose-related. The greater the dose, either in small continuous quantities or a single large quantity, the greater the effect will be.

We ingest many "lethal" doses of a wide variety of compounds which have no effect on us because we spread the dose out over a lifetime. Caffeine in coffee, oxalic acid in spinach, ethanol in scotch, and acetylsalicylic acid in aspirin are just a few examples. In spite of this, the concept that exposure to trace quantities of foreign chemicals may actually produce beneficial effects is unacceptable to many people who have an anti-chemical bias.

The poor health of people who worked at certain trades was noted by early Greek and Roman physicians. The first monograph on occupational diseases was published in 1567, 26 years after the death of its author, the Swiss physician, Paracelsus (Ottoboni, 1984). He set forth one of the basic tenets of modern toxicology when he wrote: "What is it that is not poison? All things are poison and nothing is without poison. It is the dose only that makes a thing not a poison."

### Thresholds

The term "threshold" is used in toxicology to

describe the dividing line between no-effect and effect levels of exposure. It may be considered as a maximum quantity of a chemical that produces no effect or the minimum quantity that does produce an effect. It is common for the threshold to vary with the species involved and even with individuals within each species. For purposes of extrapolating animal data to humans, the highest level of exposure that produces no detectable adverse effect of any kind in any test animal is used by toxicologists as the threshold.

A margin of safety is an arbitrarily established separation between the threshold of a chemical found by animal experimentation and the level of exposure estimated to be safe for humans. The FDA adopted the convention of a hundredfold margin of safety years ago when it began setting standards for acceptable quantities of food additives. The assumptions behind the hundredfold margin are that humans are ten times more sensitive to adverse effects of chemicals than the test animals are and that the weak in the human population are ten times more sensitive than the healthy and thus compounding the tens, we get a hundredfold margin (Ottoboni, 1984). So, we end up extrapolating the no-effect level for animals back to a no-effect level for humans, then reducing the quantity by two orders of magnitude for additional safety. In recent years, there has even been a demand to adopt a thousandfold margin, although no more scientific justification for that exists than for the hundredfold margin.

No matter how large the experiment or the margin of safety, one can never prove that any environmental factor is totally harmless. Absolute safety is the complete absence of harm. We can never achieve this. We can only offer probabilities that there will, in fact, be no harm.

## Cancer

While there are many diseases as life-threatening as cancer, there are few as widely dreaded. Cancer-causing chemicals are set apart from other chemicals and made the subject of special regulations. Cancer is now recognized as a generic term for a whole host of malignant growths in the body that ultimately destroy functions upon which they are imposed. Their causes are not yet well-known, but variations among different populations of the world are beginning to focus attention on dramatic dietary differences. The hypothesis that differences in cancer incidence are due to environmental factors was first announced by Dr. John Higginson in the early 1950s (Maugh, 1979). Dr. Higginson's hypothesis was based upon an extensive study of cancer among African black populations as compared with black populations in other parts of the world. He concluded that 80-90 percent of all cancers were caused by environmental factors. With the growing concern about environmental contamination during the 1960s, it was only a short time

before the term "environmental factors" became transformed into "environmental chemicals." Thus, by the mid-70s, statements to the effect that a majority of human cancers could be attributed to carcinogenic chemicals in the environment became commonplace even though that was not at all the point of view held then or now by Dr. Higginson (1988).

## Occupational Risk

The people at greatest risk of developing cancer from exposure to chemical carcinogens are those exposed to the highest concentrations—generally in the workplace. Unfortunately, far more public attention has been given to trace compounds in our environment than to carcinogenic chemicals in the workplace. Distinct patterns of cancer do arise among workers in specific occupational groups.

The incidence of cancer is clearly dose-related: the higher the dose of a chemical carcinogen, the greater the number of individuals who will develop the cancer. Thus, a more moderate approach to carcinogenicity testing would be the use of doses comparable to those received during occupational exposure to chemicals. Working populations, as a rule, do not include young children, senior citizens, or people who are ill or debilitated. But their lack of representation in occupational groups is compensated for by the fact that occupational exposures to chemicals are usually several thousands to millions of times greater than those encountered by the general public. Occupational exposures are sufficiently high to provide valid data using numbers of animals that reasonably can be accommodated in a toxicology laboratory. That is to say, we could actually work backwards from exposures in the workplace to extrapolating those exposures to animals and testing them above and below those ranges. The use of exposure levels that reflect those found in occupational settings is most appropriate; a chemical that does not cause cancer in occupationally exposed people is not likely to cause cancer in the general public, particularly at dose levels that are thousands of times lower than those found in occupational settings.

M. Alice Ottoboni, in her outstanding book *The Dose Makes the Poison*, offers some wonderful analogies for the distortions offered by using high doses in animal tests. In one, she describes a team of sports physicians interested in investigating the adverse effects that may occur to the ankles, knees, and hip joints of pole vaulters. The problem is that it would take thousands of pole vaulters making daily jumps for years to obtain the necessary data to produce statistically significant results. Thus, the physicians decide that instead of a thousand people making a 20-foot jump each day for many years, they could study a hundred people making a 200-foot jump ten times a day for one year. But since no athlete could vault 200 feet, and

since the trip up is of no importance to the experiment, a nearby 200-foot cliff is suggested as a jumping-off place.

This analogy grossly exaggerates the indifference to the obvious biological limitations of the test organism but, nevertheless, the effect of indifference is the same as it is in high-dose carcinogenicity testing.

### Large Dose/Any Dose

Supporters of the use of large doses justify their position by claiming that if a chemical will cause cancer in high doses, it will also cause cancer in low doses. While this can neither be proved nor disproved, knowledge of biochemical mechanisms and data provided by studying the metabolism of carcinogens belie its accuracy. Clearly, the use of high doses in animal studies does provide valuable information that should not be ignored, but the acceptance of results from high-dosage exposures while rejecting data from moderate dose studies and studies of mechanisms of action, metabolic fate, etc., represents an attitude that is foreign to objective scientific inquiry.

There is no controversy about the existence of threshold doses for chronic toxic effect, but there is a relatively large segment of the scientific community that denies the existence of thresholds for chemical carcinogens. It can be argued that one molecule of a carcinogen can cause a change in a nucleic acid which may result in an altered gene, which in the right environment and with the right cofactors, will result in a cancer (Crone, 1986). Therefore, no concentration level of a carcinogen can be entirely safe. This is true. But one chemical change which occurs among all the other changes caused by natural and artificial means is not going to add much to the risk of the individual getting a cancer.

There are no absolutes in the study of toxicity; all risks are statistical relating to the dose of chemical received. If we are to understand the significance of chemicals in our world, we must stop seeing toxicity as an absolute and appreciate the shades of grey. We must also cast aside any tendency to superficial generalizations and examine each question of toxicity freshly and with reference to all the information available.

### Risk Assessment

Most laboratory experiments are performed at dose levels of the chemicals that produce clear, easily measured responses in the test animals (U.S. EPA, 1987). However, exposure to chemicals in the environment often occurs at dose levels low enough that adverse effects are not immediate or obvious. Thus, it is necessary to extrapolate results obtained in high doses to results expected at low doses.

This is especially difficult in the case of carcinogens. Extrapolation must span a very large

change in dose levels (four to six orders of magnitude). Carcinogenic risk assessments are generally done by exposing the laboratory animals to the same dose every day for a lifetime. This type of exposure rarely occurs in humans. Even in the workplace, exposure is frequently interrupted by vacations, sick days, and job changes.

Regardless of the threshold debate, the public should be aware that there are at least practical thresholds for all carcinogens. The incidence of carcinogenic effects and the lengths of their induction periods are definitely dose-related. If exposure to a carcinogen is sufficiently small enough as to reduce its cancer incidence to one in a billion or less or to increase its induction time to 200 years, of what practical significance would that be to the human population (Ottoboni, 1984)? The chances of winning your state's lottery would be far greater!

So, having first assumed that animal studies directly translate to humans, the cancer risk models used by regulatory agencies then assume that one molecule of a carcinogen is capable of initiating a cancer process, and that a constant exposure to the carcinogen will occur over a 70-year lifetime. Estimates derived from these models are extremely conservative as a result of these assumptions. While it is appropriate for our government to err on the side of safety in matters of public health, if the assumptions used are incorrect, the errors can be too safe by several orders of magnitude.

Society has a right to know the cost of excess safety and decide if it is worth that cost. In order for the public to make valid judgments, they should be informed of the uncertainties inherent in the risk assessment process. They should know that risk estimates are only an expression of how great or small the chances are that exposure to a given carcinogen will cause cancer and that current methods for assessing risk are extremely conservative. No one questions that those charged with protecting the public need methods to make estimates for safe exposure levels. In the process of estimating risk, however, mathematical models should be an adjunct to and not a substitute for scientific judgment. In addition, as Miss Ottoboni states clearly, "Regulatory agencies must be free from special interest pressures so that the standards they promulgate are based on concern for the public good, not political expediency."

### Mathematical Models

It is important to recognize that since direct estimates of risk at low levels of exposure would require the expensive testing of prohibitively large numbers of animals (Neal, 1983), models must be used to help account for this shortcoming. One of the major problems with risk assessment today, however, is the extreme oversimplification resulting from the use of quantitative mathematical models for extrapolating from high doses to low doses. The purpose of so-called cancer models is to

estimate a safe dose, more recently termed "a risk specific dose," (Paustenbach, 1989) based on the extrapolation of experimental results well outside the dose range used in animal tests; usually three to four orders of magnitude below the no-observable effect level (NOEL). Statistical procedures for estimating the low-dose response involve a mathematical model relating the probability of the specific response at a very low dose. Because of the statistical and biological problems inherent in the identification of true no-effect levels, most mathematical models for carcinogens have eliminated the concept of threshold dose where no response would be expected. The major failing of the widespread use of low-dose extrapolation models is that they often reduce the decision process that requires thoughtful and critical analysis of complex, and often conflicting data, to one driven by a computer analysis of four or more data points on a dose-response curve.

Although every regulatory agency that deals with carcinogens advocates the necessity for careful evaluation of all available data, most regulatory decisions have been overly responsive to the results of these models at the expense of the biological information. The greatest problem in relying so heavily on modeling rodent bioassay data is that it gives decision-makers the mistaken impression that not only is the analysis routine, but that a high degree of certainty is achieved in the analysis.

Human risk assessment is a very inexact exercise based largely upon theoretical assumptions concerning interspecies extrapolations. The uncertainties involved should be fully recognized by the scientific community and society. The mathematical models used attempt to predict how many test animals would respond at low-exposure levels based upon observed responses of a few animals at high-dose levels. The models tell us little about predicted human responses at any exposure level.

#### Upper-Bound Estimates

Mathematical models give a range of risk estimates. The upper-bound estimate is the worst case estimate of risk. By its derivation, it is unlikely that the number represents the true risk. Dr. Fred Hoerger, at a seminar in 1985, illustrated the upper-bound estimate and its inherent distortion in the following manner.

"It can be said that the upper-bound estimate of rainfall for the United States is 15,000 inches per year. Since yearly rainfall in the United States averages from a few inches to perhaps 50 or 60 inches per year in Miami, Florida, my estimate of 15,000 inches per year sounds outlandish. For a moment, let me justify my estimate on the basis of 'prudent' predicting principles. Historical record shows the highest single-day rainfall was 43 inches in Alvin, Texas in 1979. Simply multiplying this number by the number of days in a year and extending it to the entire United States gives my estimate of 15,000 inches."

Of course, such extreme rain occurs only rarely in the United States. But in risk assessment terminol-

ogy, it is just such a worst case assumption that once linearized and extrapolated can result in equally outlandish answers. The faults in the aforementioned logic are that 43 inches of rainfall is obviously an extreme case, and that dramatic climate differences across the United States preclude its being considered a homogeneous area for extrapolation purposes.

Conditions of risk assessments with such extreme conservative biases do not provide decision-makers with the information they need to formulate an efficient and cost-effective regulatory strategy. A perverse and unfortunate outcome of using absurd, upper-bound estimates based on compounded conservative assumptions is that it leads us to regulate insignificant risks while ignoring more serious ones.

The increasing tendency of assessors in regulatory agencies to adopt conservative assumptions in their calculations has become a serious problem which few have dared to address. The rationale, of course, is to ensure that the true risk to everyone will be less than that predicted. While this may look like an admirable goal, it has a number of shortcomings. The repeated use of exceedingly unlikely exposure scenarios makes it difficult to compare assessments by different scientists because they incorporate widely varying levels of conservatism in their assumptions. Furthermore, many exposure scenarios are called "worst case," implying that they are feasible when, in fact, they are distantly remote.

#### The Bottom Line

There are many scientists from a host of disciplines who, along with toxicologists, expound on the toxic properties of chemicals. Molecular biochemists and microbiologists, for example, may well have great expertise in the effects of chemicals at the molecular or cellular levels. But unless they understand the principles that govern the more complex organisms such as man, they have no basis for making judgments, much less public statements, on the significance for man of the effects they find in their test systems. In addition to miscellaneous scientists and physicians who render toxicological opinions, recent years have seen the emergence of a new breed of toxicologist, the environmentalist lawyer who knows the vocabulary but not the substance of toxicology. Finally, there are the high priests—scientists who have taken up the cause of protecting the environment and all God's lesser creatures against the machinations of our industrial society. They believe we should eliminate nearly all synthetic chemicals. Their gospel includes stories of the damaging effects of synthetic chemicals, and they preach it with religious zeal and passion. Unfortunately, the public has no way of distinguishing between self-proclaimed and legitimate experts. Attempts by anyone, no matter how objective, to indicate who is expert and who is not only causes

further controversy and worsens the problem. The public must eventually rely on their own good judgment in deciding whom to heed.

### Dismantling the Chemical Industry

It has become common for environmental consumer groups to demand that chemicals they consider detrimental to their special interests be banned. The banning of chemicals in the words of M. Alice Ottoboni (1984), is "... a simplistic solution to a very complex problem and often produces greater problems than those sought to be remedied by the ban. In some cases, it requires the elimination of a chemical whose toxic properties and hazards are quite well-known and the substitution of a chemical or chemicals about which there is much less information." Furthermore, the banning of chemicals denies man's ingenuity to develop methods of use that will be protective of the health of the public and of the environment. Proponents of bans either do not accept that the chemicals in question can be used safely or contend that the malevolence and greed of the petrochemical industry will not permit safe use. In "Toxicological Risk Assessment Distortions: Part III," I will take "A Different Look at Environmentalism."

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### Editor's Note

*The author has done extensive research into the field of toxicology and risk assessment in recent years leading to the crafting of this series of editorials. This research has led to the conclusion that there are two unusually outstanding resources on this topic. One is the comprehensive text, "The Risk Assessment of Environmental Hazards," edited by Dennis J. Paustenbach of McLaren Environmental Engineering. This 1,155-page book, published by Wiley Interscience in 1989, contains contributions from 60 authors including a Foreword by past-EPA Administrator, William D. Ruckelshaus. The other is "The Dose Makes the Poison," by M. Alice Ottoboni, published by Vincente Books, Berkeley, California, 1984. This 222-page paperback book makes a bold and creditable statement on the science of toxicology.*

*Part I of this editorial series was adapted for publication in the Water Well Journal January 1990 issue under the title, "Ground Water: Still Our Most Healthful Water Supply." Part II of the series appearing above has been similarly adapted and appears in the March 1990 issue of Water Well Journal under the title, "The Dose Makes the Poison."*

## PART III — A DIFFERENT LOOK AT ENVIRONMENTALISM

### First Things First

I'd like to start this article by making a few things abundantly clear. I am an environmentalist. By virtue of your jobs, you are all environmentalists. None of us see redeeming qualities in contaminating air, water, or soil. We all want pollution reduced and eventually eliminated in a cost-efficient manner. No water professional could see any value in allowing chemical contaminants to be foolishly, unwittingly, or maliciously placed in our atmosphere or biosphere. Through education and regulation, we will all work to curtail these activities. We all want to methodically clean up what can be reasonably cleaned up; in fact, most of us will earn our livings in this endeavor for the better part of our professional lives. The smarter among us will guide our children into similar career pursuits.

Having said this, and with no desire to waffle on the issue or be disingenuous, it is time to stop scaring the !?#!?! out of the American public with fraudulent, malicious, and totally inaccurate risk assessments of the latest environmental screwups. Neither apple polish, cow-antibiotics, gas emanating from rocks, mundane landfill leachate, leaking tanks, chemical spills, or the ubiquitous industrial degreasers pose an imminent or terminal threat to our lives or, in most cases, even to our daily health. But the public, inadequately schooled in science and totally untrained in risk assessment, is being held captive by an "environmental industry" reaping its economic and political rewards by malicious overstatement. The American media's sales and rating-point incentives encourage many reporters to walk in lock-step with those who would enslave our population in needless fear.

We have just witnessed a miracle in our lifetime as the people of eastern Europe have thrown off the yoke of tyranny and tasted the fresh air of freedom. Do not take lightly our own subtle enslavement by an overzealous environmental industry that would have us return to a life of cowering under one environmental threat after another.

Today, the environmental industry employs tens of thousands of talented people making excellent salaries, no longer in the mold of their once spartan, stoic leader Ralph Nader. They have the support of 20 million U.S. citizens (up from only four million a decade ago), most of us being counted among them, who contribute to their various causes. They have a business strategy as clear as any Fortune 500 company and major financial support from many of those same companies.

Of course, access to big money doesn't discredit global environmentalism. In fact, it ought to make the movement more honest. Environmentalists pretend—and much of the media promote the pretense—that they are somehow above financial self-interest and possess an inherent moral super-

iority to those who fail to share their vision. They are, however, an interest group who, like any other interest group, work hard to promote their perquisites and politics. Motherhood and apple pie just happen to appear to color their every move.

On the surface, the goals of the environmental industry are very reasonable: who could be against them? All of us desire to live in clean surroundings, breathe uncontaminated air, drink potable water—it would be difficult to fault their objectives. But it is just these objectives that "successfully conceal the underlying trend toward an all-encompassing political dictatorship wherein the individual's desires are subordinated to the state to the point where his freedom of choice will be reduced almost to zero" (Kazmann, in press). It is time to throw off our naivete about those who profess to be acting in our best interests.

With all the good—no!—fantastic news coming from the world in matters of politics, the media, ever believing that ultimately only the worst news sells, are redoubling their efforts to show gloom, doom, and outrage at industry's manhandling of our water, air, and food. A day rarely passes that a dour newscaster does not attempt to scare the wits out of viewers with the latest "possible carcinogen" found in *trace* amounts somewhere in our environment.

After an intensive study of the first decade of cancer prevention in this country, Edith Efron, in her book, *The Apocalyptic* (1984), concluded that the antiscience and antitechnology trends in our liberal society have distorted environmental cancer research and saturated society with theories of cancer causation and prevention that are pure myths. Her book contains explosive information about scientific misrepresentation as well as manipulation of the press.

Efron points out that for more than 20 years, apocalyptic scientists have focused on predictions that the modern industrial system will ultimately bring about the destruction of life on earth. A major form of that destruction will be cancer, they say, and proceed to make their case by ignoring data (some from as far back as the early 1960s) which contradict their prophecies.

The American press has been nourished on bad science since the inception of our cancer prevention program. It was trained, as one trains a circus dog, to view doomsayers in and out of government as fountainheads of scientific truth. The media has shown a consummate credulity in the face of arbitrary edicts brandished by the policymakers as the voice of science; it has been taught by scientists seeking the spotlight to treat secretive or baseless assertions from scientific sources like scoops. The press doesn't seem to know that science does not operate by assertions, by leaks, by off-the-record briefings, by Xerox machines spit-

ting out documents with release dates geared to the evening news, or by documents with no authors' names at all. No one has taught the press that the appearance of such phenomena means that what one is hearing is not science at all.

Undoubtedly, some journalists have been ideologically receptive to the "apocalyptic axioms." Some have enjoyed the excitement of a new kind of war between good and evil. Some have unquestionably seen themselves as righteous adjuncts of the regulatory process while most have never known the meaning of the scientific words they were so eagerly transmitting to the public. I cannot, however, indict the press for failing to understand what it takes years to learn. To write this series of editorials, I had to review over 200 papers and a dozen books. Reporters must write swiftly; they often cover the daily news and may have insufficient time to do their "homework." The inadequacy of the media coverage is more correctly the inadequacy of their informants. Above all, it is the inadequacy of thousands of scientists who have been fully aware that this country has been fed politically corrupt science but have remained silent in the face of the cultural malpractice of their colleagues—perhaps out of self-interest but, unquestionably, out of fear and helplessness.

### The Media

Nationally renowned author Ben Wattenberg offers valuable insight about the popular environmental movement in his book, *The Good News Is The Bad News Is Wrong* (Wattenberg, 1984):

"In terms of specifics, the environmental viewpoint is often valuable as a comprehensive vision of our time; however, it is in my judgment, typically both wrong and damaging . . . No sane people are antienvironmental; we are all for improving the quality of life. No one proposes to swim in polluted waters; no one gobbles carcinogens just for the hell of it; and surely, some of the alarm bells that have sounded point to real problems.

"But that is not the point. The point is that the environmental movement has argued that the overall quality of our lives is poor and getting worse. Such a view is incorrect."

Why are the media so eager to give us bad news? Why do the same scientists confirm each apparent disaster? Why aren't mainstream American scientists so outraged that they contact the media? There are no simple answers to any of these questions. Sensationalized bad news is apparently what the media think the public wants. George Will, *Newsweek* columnist, once said "Only man is perverse enough to feel most alive when the news is most lurid."

The news media thrive on conflict. Never mind if the fight is between a Nobel Laureate in geophysics and the president of the Flat Earth Society; credentials mean little to the media. A fight is a fight. Environmental reporters are often in too much of a hurry to listen to the pros and cons of an issue. The journalists, under pressure, want the scientists who can offer the best one-liners, regardless of the fact that ethical scientists describing serious work will rarely risk oversimplification or quick summaries.

Furthermore, environmental alarmists appear to be experts on everything, willing to pontificate on nearly any subject while most scientists are specialists, rarely willing to speak authoritatively outside their field.

Our best role models are the men and women of the U.S. Centers for Disease Control (CDC) in Atlanta, Georgia—arguably this country's most reliable and accreditable scientific agency. As scientists, we should get in the habit of accepting cancer analyses and related statistics only when they are determined by the Center for Disease Control. The CDC staff, some 5200 strong, are remarkably dedicated and known widely for their lack of turf battles and budget fights which so often disrupt the work of many other federal agencies. A CDC official recently described his agency as a place which allows one to keep his or her idealism well into middle age. State and local health officials who assist the CDC through cooperative grants also revere the agency and their fair and comprehensive efforts. Unfortunately, their thorough studies that so frequently diffuse environmental crises take years to complete, and ultimately receive page 19 coverage from the press. Such has been the treatment of their information concerning compounds like EDB, PCB, dioxin, and many other targeted, terrifying substances. Their pronouncements of the scant or absent evidence supporting the public terror is invariably buried where few readers go.

### Risk and Fear

When presented in dramatic form with skilled, passionate rhetoric, risks from hazardous wastes, chemical pesticides, and other environmental dangers can certainly generate outrage. Once the outrage is created, the objective facts—the actual dangers under alternative policies become much less important. Extreme measures to protect the public from a single danger seem justified.

To be sure, we recognize that environmentalists do ask important questions about the ethical, economic, and social implications of new technologies. The problem is that because they commonly present their case in such a shrill and, at times, unscrupulous manner, the debates they encourage are filled with fear and anger rather than information and reasoned judgment.

Increasingly, regulation of chemicals is being governed by political responses to public fear and hysteria rather than by careful, objective evaluations of the actual risks and benefits posed by the chemicals.

"Risk" is often interpreted as bad—a thing to be avoided. Yet all economic and technological progress requires that human beings take risks. It is precisely because our ancestors took risks that we enjoy healthier, longer lives than they did. Aaron Wildavsky in his book, *Searching for Safety*, persuasively argued that "there can be no safety without risk" (1988).

Immunization against childhood diseases is a good example. Each year, three and one-half mil-

lion children receive vaccines against whooping cough, diphtheria, and tetanus. Twenty-five thousand of these children come down with high fevers; 9,000 of them become seriously ill; 50 are brain-damaged, and as many as 20 may die (Wildavsky, 1988). And yet, quite correctly, our public health services find these risks preferable to the frequent incidents of disease and death that would occur were these vaccines not administered.

Frightened people truly suffer due to distorted information. For the most part, they do not know what to do about their situation other than to modify their lifestyles to the extent possible. They can live without smoking, for example, but they cannot live without breathing—no matter how great they are told the imminent threat of air pollution may be.

Fear can be a healthy response when the danger is real and when fear prompts us to proper action. But at least in relation to chemical technology, fear is often of the irrational, phobic variety. It is the outcome of information that is inaccurate, exaggerated, or presented in a way that is calculated to alarm.

A magazine showing an artist's fanciful rendition of a human head sinking into a cesspool and losing his skin on the way down does not serve the public well. It is easy to understand, however, that reporters want their stories to be as close to the front page or the beginning of the newscast as possible. These reporters have a vested interest in catastrophes and seem to find them with ease when chemicals are involved. But the role of the reporter should be comparable to that of the person assigned to inform people of a fire in a theater. Jackson Browning described it well when he said, "That person becomes a risk communicator with all the responsibility that the phrase should imply" (1987). If the person fails to inform people of the danger, he fails in his role. If he goes into the theater and frightens people by screaming at the top of his lungs, he also fails. The objective should be to achieve an orderly withdrawal from the fire in a method that suits the situation. Excited, sensational reporting has no place when people's safety and welfare are concerned.

In general terms, chemical companies who may be guilty of contamination tend to err by saying too little, while the media err by saying too much. Most people are intelligent and perceptive individuals who, even without scientific education, are completely capable of understanding scientific facts relating to subjects that are vital to their health and well-being.

Bruce Ames (1987) has labored intelligently to translate the relative meaning of risk in a myriad of substances ingested on a regular basis by the human population. He developed a simple, yet undisputed analytical system abbreviated HERP for daily HUMAN EXPOSURE dose/RODENT POTENCY dose. He takes the estimated daily dose of a chemical that will cause cancer in one-half of a group of test animals and compares it with the estimated daily dose that humans would receive of a given chemical. The result is a percentage that gives

the carcinogenic danger of the chemical. Table 1 in the Appendix to this editorial offers a significant list of comparative HERP indices using one liter of chlorinated tap water as the base of one against which all other substances are compared. Table 2 compares the relative trivial risk of a number of everyday activities, and Table 3 describes those activities in which a serious number of lives are lost each year.

The data and evidence cited in these tables are not secret. They are available to everyone in the scientific literature, but the legislative process at both federal and state levels seems to have given little weight to these facts. Instead, R. L. Stroup and J. C. Goodwin of the National Center for Policy Analysis (1989) described it thus: "The outrage of citizens, uninformed about toxicology and swayed by articulate and passionate rhetoric condemning each potential danger—usually without regard to the problems of alternative courses of action—has led from the Love Canal tragedy to the Superfund fiasco, and from largely phantom carcinogenic chemical threats in California to Proposition 65."

### Public Interest

The alliance of attention-hungry, public-interest groups and sensation-seeking media is a very powerful one. As consumer groups have become more adept at manipulation, the media have become more willing accomplices in publicizing the latest scare. The newsmen and women who consider themselves skeptics when dealing with almost all other sources of information, and particularly when dealing with big business, appear to accept the pronouncements of "public interest" groups and "experts" with the flimsiest of qualifications as though they were written on tablets of stone. No better example can be found than actress Meryl Streep. Sadly, if one person in one million dies from the ingestion of a product, or even increases their risk of contracting cancer because of something in the product, that one person becomes a news story. The other 999,999 who use the product safely are not bad news. This simple truth almost inevitably leads to an exaggeration of the problem, both by the media and thus in the minds of the public.

Fifty-one years ago, a radio play about giant, slimey, lizard-like creatures from Mars sent the U.S. into a panic. Churches all over the country filled with people praying. Cars jammed highways in a desperate race to get out of the towns. Looters appeared from nowhere. Men took out their shotguns and lined up to protect their homes. The radio play was Orson Welles' famous *War of the Worlds*. The show was completely outrageous, but because it was presented like a news broadcast, the public believed every word. Fortunately, Mr. Wells and CBS were back on the air offering apologies before too much damage was done. The great disaster became a great joke, something people would tell their grandchildren.

This story is relevant today because it so closely parallels the action on another Sunday night CBS broadcast which invaded our public con-

consciousness. I refer to the "60 Minutes" broadcast that set off the Alar debacle. Unfortunately, by the time our leading scientific agencies got together to assure people that our world wasn't coming to an end, it was too late. The concerns about children, apple juice, cancer, and pesticides had gained a momentum that still has not entirely subsided. It is unfortunate how single-mindedly the American people tend to believe what they see on television and hear on the radio, no matter how much it goes against common sense or their personal experience.

### Alar and the NRDC

The NRDC (Natural Resources Defense Council), a New York based group with a multimillion dollar budget and a long record of lobbying and litigation on subjects ranging from air pollution to nuclear energy wrote, produced, and directed our nation's epic Alar scare. With the help of a public relations agency the NRDC had, for months, been orchestrating a big publicity program for its report "Intolerable Risk: Pesticides in Our Children's Food," (Sewell and Whyatt, 1989) which was released early last year.

The NRDC gave CBS an exclusive on the report which was not released until the day after "60 Minutes" aired. That served two purposes: (1) it kept the report out of the hands of scientists and medical experts who later found stunning flaws and misrepresentations in it; and (2) it made reporters anxious to get the report and do a story on it as soon as it was released following the broadcast. The media totally lost sight of basic journalistic standards in an effort to produce their stories. While CBS gave great play to the NRDC report, it did not give independent scientists an opportunity to either examine or evaluate it.

The hysteria created by NRDC and "60 Minutes" had authorities pulling apple products from schools around the country and brought the sale of apples to a virtual standstill.

What makes all this more nauseating is the fact that to reach the exposure level that produced an ill-effect in laboratory animals, a person would have to consume thousands of pounds of Alar-treated apples every day for 70 years! Yet it took three federal agencies—EPA, FDA, and USDA—to calm the panic over apples and apple products, only to have it fueled again a month later by cover stories in both *Time* and *Newsweek*.

The report allegedly contains scientific proof that the use of eight common pesticides on fruit and vegetable crops was responsible for causing cancer in the nation's preschool population. Not surprisingly, the national news media reacted with an almost religious fervor to this dire prediction. Unfortunately, what was overlooked in the media hype was the lack of scientific evidence in the report itself. When toxicologists and pharmacologists began to take a close look at the NRDC report, their response was virtually unanimous. The report contained serious scientific flaws and factual errors that made it difficult to take its conclusions seriously.

One of the strongest allegations against the report is that it was not adequately peer-reviewed. The lack of proper peer-review led to basic inaccuracies making it impossible for scientists to reconstruct or fairly evaluate NRDC's risk assessment model. The numbers used in the NRDC's report were very poorly referenced, says former EPA official, Dr. Christine Chason (personal communication, 1989): "If they had submitted this report to any peer-review group, they would have gotten slapped on the wrist for not being able to track back to the numbers used," she said. NRDC also assumed that the chemicals were genotoxic (capable of causing genetic damage). It turned out that most of the pesticides they studied were, in fact, not genotoxic. This was a serious flaw in their whole risk assessment procedure and led to a gross overestimation of risk.

### A Look at Serious Science

About the time Ms. Streep and her friends had school superintendents throwing apples in dumpsters all across the country, other scientists were publishing reports and studies on the same subject. The National Research Council, an arm of the National Academy of Sciences, released an exhaustive study (1989) of the available data on disease risk and the American diet. It recommended that to cut the occurrence of cancer and heart disease, Americans ought to eat more fruits and vegetables. As to the chemicals that obsess the NRDC, the report said, "Exposure to nonnutritive chemicals individually in the minute quantities normally present in the average diet is unlikely to make a major contribution to the overall cancer risk to humans in the United States."

Somewhat earlier, the science magazine *Nature* published an article by researchers from Carnegie Mellon, Case Western Reserve, and the University of Washington raising questions about the usefulness of rodent bioassay studies. "Extrapolating from one series to another," they wrote, "is fraught with uncertainty" (Lave et al., 1988). However, none of these serious scientific revelations slowed the NRDC in their race to the press. Evidently, today, the end justifies the means.

I have reprinted here some of the equations used in the NRDC report to attempt to extrapolate cancer risk in humans from cancer risk in rodents. "The risk in humans will be equal to that in rats if their exposure in MG/KG<sup>2/3</sup> equals the rat exposure in mg/kg<sup>2/3</sup>. Thus, for these circumstances:

$$R(\text{human}) = R(\text{rodent}) =$$

$$q_1 * (\text{rodent}) \times \text{MG/KG}^{2/3} \times 1/\text{kg}^{1/3}$$

or:

$$R(\text{human}) = q_1 * (\text{rodent}) \times \text{MG/KG} \times$$

$$\text{KG}^{1/3}/\text{kg}^{1/3} = q_1 * (\text{human}) \times \text{MG/KG}$$

if

$$q_1 * (\text{human}) = q_1 * (\text{rodent}) \times \text{K/G}^{1/3}/\text{kg}^{1/3}."$$

These equations appear in the NRDC's report as part of their Appendix 3, "Methodology for Estimating Pre-School or Cancer Risk from Carcinogenic Pesticides in Food." Appendix 3 didn't get much mention when the public, nodding off in front of televisions all across America, first learned from TV news about the problem with apples ("Cancer in Apples?—More at 11"). It's probably asking too much to expect news anchors to take an extra 20 seconds to also discuss the fact that the study is based on something known as a "lifetime rodent bioassay." It wouldn't be too much, however, to ask everyone who conveys the results of these food-cancer studies to put the rats equals humans arguments into some perspective. In other words, maybe public policy would be better served if the public were given the actual facts to consider, rather than conclusions that encourage panic.

### What Can You Do?

The point of all this is that most of the information on risk assessment is funneled through the media, local news sources more than national ones. Most local reporters have little knowledge of, or background in, technical matters. Most of them tend to parrot things they are told. They primarily look for victims. They look for the smoking gun, the body count, the rockets red glare. You have seen it all a hundred times, and likely you will see it a hundred more. Therefore, YOU have to educate the media. YOU have a responsibility to become a participant. The media must not view the environmental groups any differently than they would an industrial group. They don't accept press releases from industry as being the gospel, and they shouldn't accept reports from the NRDC, EDF, NWF, the Sierra Club, or the Audubon Society any differently.

When the chemical industry spokespeople talk openly about risk and elaborate their outstanding safety record, or the program they have in place to deal with emergency situations, everyone views such communications with skepticism. People wonder what ulterior motive or hidden agenda they have in communicating this type of information. And to be sure, they have reasons beyond serving the public interest for effectively communicating risk. But so does everyone else in the risk communication arena—whether the objectives are to sell more products, secure additional research funding, draw public attention, attract more readers or viewers, acquire additional political clout, or merely beat the competition to the punch. Everyone who communicates risk is serving more than just the public interest by doing so.

Tom Vacor recommended "that the press should look more to the middle. What tends to be missing in media coverage," he said, "is enough attention to sources who are saying 'Well, the chemical is dangerous but not as dangerous as some other things,' and give a reasoned view," (1987). This is the kind of viewpoint most of you, the readers of *Ground Water*, would give. But people with such views are least likely to want to appear in the media; they (YOU) are the most reclusive sources.

Yet the recommendation I would make to the media is to seek you out and give the middle as much attention as the two extremes. And the recommendation I would give YOU is to seek out the media.

### Uncertainty

It is important to understand that uncertainties are not unique to matters of risk. Uncertainty drives all of science! If there were certainty, there would be no science. Science is an endlessly changing series of approximations. Science is about testable conclusions based on often disputable facts. It is about a community of professionals coming to reasonable agreements on matters riddled with uncertainties and incomplete data. It is in that context, underlain by an absence of prejudice, that science has a critical role in both the perception and the communication of risk.

If our goal is to convey useful information about risk, a better warning would be one which relates the risk involved to risks associated with everyday activities such as those I have included in the Appendix. This type of warning would underscore, for example, the silliness of such things as the requirements of California's Proposition 65. In most cases, the risk of consuming a product is lower than the risk of driving to the store to buy it. If, as is required in Proposition 65, everything must contain a basic warning—especially the same warning—then warning labels lose their value. A warning will affect behavior only if consumers can distinguish the few especially dangerous risks from the thousands of minor risks they take every day. California's Proposition 65 has the potential to misdirect our attention away from noncarcinogenic risks and dangers that we should be concerned about, and toward trivial risks that are no greater than that which we experience from increased exposure to natural radiation when we travel on an airplane (Wilson, 1979) which itself has been unbelievably dramatized in the press despite the fact that the concern is for those of us who travel twice weekly across a continent for 20 years.

To the most radical supporters of California's Proposition 65, posting warnings is just an intermediate step. The long-range goal is clearly to ban carcinogenic substances altogether. At a workshop sponsored by the Environmental Defense Fund, Sierra Club, and the NRDC, Tom Hayden, a California legislator, said that he hoped the state would "lead other states down the path that will ultimately lead to legislation that will eliminate all carcinogens and toxic substances that the American people are subjected to" (Heckman, 1988).

We must honestly inform the public that we do not fully understand what risk many situations carry, and that we are still collecting exposure data. Unfortunately, when we admit this, we create problems of social distrust. People want to believe that experts have the information and understand the danger. Thus, the more we admit we don't know, the greater will be the perception that we are not in control. This is not an easily solvable dilemma, especially in light of the public's propensity for irra-

tionality. While people stopped buying apples because of Alar, they continue to oppose gun control. They worry about radon but clamor for the return of the 65-mile-an-hour speed limit. Let's face it, Americans are not rational about risks.

### **Truly Serious Problems**

No one questions that environmental pollution in some places is egregious. Behind the old iron curtain, we are provided with ample examples. The USSR is full of them. In the Ukrainian town of Zaporozhye, plants emit 400,000 tons a year of toxic emissions such as benzol, phenol, formaldehyde, fluoride, nitrogen dioxide, and lead. Zaporozhye is an ecological disaster zone according to Anatoly Nesterenko, the Deputy Mayor, who said the pollution there is about 10 times higher than Soviet norms (*Wall Street Journal*, October 1989).

Official statistics show that cancer, bronchitis, and other diseases are much more common in Zaporozhye than in other parts of the Soviet Union. The infant mortality rate and the number of miscarriages are also way above average. Ukrainian health experts recently warned that life expectancies will fall by several years in the near future unless urgent measures are taken to clean up the environment.

Mr. Gorbachev has set out to attack the pollution problem, but like so many of his initiatives, this one hasn't been forceful enough. He set up a State Committee for nature protection to monitor and enforce standards, but it has little political or economic clout and hasn't had any impact. Perestroika has thus far failed to clean up what comes out of Zaporozhye's factories.

The story is much the same in Rumania where frenzied industrialization ran roughshod over the landscape, transforming many rural towns into slag heaps with foul-smelling smokestacks. An ink factory near the city of Sideu has so polluted the atmosphere that surrounding trees and houses are black. In a town called Turda, a cement works expels a beige mist from a forest of smokestacks. Strip mining has destroyed much of the rural landscape and polluted waterways. There is scant hope for quick improvement. The environment there is a disgrace.

The total environmental cleanup of all of eastern Europe will be one of many economic burdens the West must share. While now out from the cloud of secrecy, eastern Europe is still deep under the cloud of air, water, and soil heavily laden with contaminants—an order of magnitude worse than anything Americans can imagine. Could we but harness the well-meaning energies of American environmentalist armies, we could help our new-found European friends clean up their surroundings in about a decade. It will take nothing less.

Environmental groups would make a far greater contribution to society if they would concentrate more on helping these parts of the world achieve the success we in America already enjoy instead of continuing to chase the smaller and smaller amounts

of less and less important substances in our own environment. The very same groups that needlessly rattle our chains today are, indeed, largely responsible for our current dedication to the environment—the strides we have already made and the advances we are yet destined to make. Now they should address more attention to portions of society in much greater need.

### **Truly Unserious Problems**

#### **EDB**

The EDB crisis of the early 80s was not a public health crisis. It was, in fact, a crisis of communication. The message that the U.S. EPA regulators tried to convey was that the food contamination risk from EDB was a long-term rather than a short-term risk. They were frustrated because they could not induce the media to accept and disseminate that message. Instead, public perception was dominated by images of squad cars rushing with their sirens wailing to remove contaminated muffin mixes from supermarket shelves, and of chemical workers being carried off to hospitals. The media transformed the EDB incident from a general quality issue into a national crisis.

#### **Asbestos**

Yale medical professor, Dr. Bernard Gee, in a recent article in the *New England Journal of Medicine* (Gee and Mossman, 1989) concluded that there is no evidence that environmental exposure to asbestos is a public health hazard. "A friend," he says, "calls it paratoxicology," referring to the type of evidence used by the anti-asbestos crowd.

#### **Greenhouse**

NASA scientist James Hansen is widely credited with launching the highly politicized crisis atmosphere around the greenhouse question. Hansen went before a Congressional committee and said he was 99 percent sure that the earth was getting warmer, and that he had a high degree of confidence that the warming was caused by the greenhouse effect. This, of course, got the desired response—tremendous press play. But some of Hansen's scientific colleagues were dismayed. In an article entitled "Hansen vs. the World on the Greenhouse Threat" (Kerr, 1989), the journal *Science* reported that Hansen's colleagues found his greenhouse assertions unforgivable, largely because of their absolutist certitude. It seems unfortunate that absolutism is a commandment of modern environmentalism.

#### **Global Warming**

Three MIT scientists, Reginald Newell, Jane Shiung, and Woo Zhongxiang recently processed ocean temperature data taken all over the world by merchant mariners since the mid-19th century. Their results were summarized in *Technology Review* (1989). One of the most striking results suggested by the data is that there appears to have been

little or no global warming over the past century. The computer models that foretell a greenhouse effect indicate that there already should have been about a 1.8 degree rise in global temperature, but that hasn't happened. Unfortunately, the no-nonsense MIT report has been virtually ignored. Science may still be about surveying all the available facts but, increasingly, public policy is not. Of course, the global warming controversy will have some very positive fallout. The joint efforts of the American Society of Civil Engineers, the American Water Works Association, the American Water Resources Association, and the National Water Well Association in convening CONSERV 90, a national conference focusing on national water-supply solutions this August in Phoenix, might at last offer the nation the tools it needs to face our water-supply requirements for the next many decades without fear of running out of water even if global warming were to become a reality.

### **Today's Activists**

The Animal Rights Movement is a textbook example of how activist groups press their agendas into today's political system. It hardly matters, for instance, that an American Medical Association poll (Harvey and Shubat, 1989) found that 77 percent of adults think that using animals in medical research is necessary, since few people want to volunteer to replace the critters. Those people answered the phone and went back to their daily lives, working at real jobs and raising families. Meanwhile the professional activists—animal rights, antinukers, fringe environmentalists, Hollywood actresses—descend on the people to create issues in America. They elicit sympathetic free publicity from newspapers and magazines. They do Donahue and Oprah. They beat on the politicians and bureaucrats. They create a kind of nonstop, twilight zone of issues about which most American voters are barely aware. They do this because these tactics have succeeded so many times before.

If we in the U.S. are forced to work under the constant burden of all these varieties of public issue nonsense, we can never hope to realize continued gains in either human welfare or our international competitiveness.

Today, much public policy practiced by many environmental advocates is mainly about making doubters or opponents reluctant to challenge the consensus. Strobe Talbot of *Time* magazine, for example, recently announced that "no respectable scientist denies the greenhouse phenomenon." Do you have the nerve to deny it?

There is no doubt that participants of all stripes in the policy game these days have become frustrated at their inability to enact their agendas. What seems sometimes to work, though, is whipping up a kind of mass media fervor behind one's ideas. The danger in this is that it may cause the public to think that science is now primarily about politics, and in politics about half the people usually think that you

are not telling the truth.

An example of the environmental industry's desire to shut off scientific debate and keep the world focused on fear appears in a statement delivered by Ellen Silbergeld (1987), a senior scientist with the Environmental Defense Fund, at the 1986 National Conference on Risk Communication in Washington, D.C. "I am not sure how I feel about this well-attended conference," she said, "because to a certain extent I look upon the subject that we are here to talk about as a result of the destruction of consensus on environmental and other risk areas, which has occurred over the last decade in this country. In fact, I would describe the topic as a shield for inaction." In other words, groups like EDF don't want educated people discussing proper communications or education about the meaning of risk; rather, they want to keep everyone in a state of fear, interested only in eliminating all risk.

Another example of contorted environmental concern was provided by Jane Hathaway, an attorney for the NRDC who said, "Allowing the EPA to condone continued use of a chemical whenever the benefits outweigh the risks is absolutely an anathema to the environmental community" (*Wall Street Journal*, November 7, 1989). Some environmentalists have violently opposed using cost-benefit analysis to weigh any regulatory program. For them, this sort of thing is the thin edge of the wedge. Cost-benefit analysis directly threatens some of their most treasured policies. The people might start asking: "Is this worth it?" when it comes to pesticide policy, for instance. Then, they soon might ask the same cost questions of urban smog policy or ozone. Instead of cost-benefit judgments, some environmentalists would rather rely on the pseudoreligious exhortations that have carried the day for them so far and kept the Congress virtually hostage to their threat of the month.

In areas of science and technology, efforts by the Congress to protect the public have been singularly futile. We have, in past decades, had a plethora of unfounded environmental scares including cranberries, mercury, flammable nightgowns, nonflammable nightgowns, BIS, Alar, and asbestos to name but a few. They were a result of bureaucratic action, apparently mandated by federal health directives. They proved to be unjustified by the evidence but forced large expenditures on great numbers of people with no discernible benefits. In the words of Ray Kazmann (in press),

"Police protection may break down, fire departments be eliminated, education neglected, roads turned into pothole trails, but the latest unproven environmental concern must be dealt with even if the tax base erodes and the citizens suffer. The new idol must be supported even if civilized life collapses. An abstraction called 'environment' must be protected. As in the middle ages, we have a holy grail to pursue."

### **The Harshest View of Environmental Extremism** Let me emphasize that many environmentalists

are not alarmists. I'm referring only to people who make claims with no basis in science.

Alarmists fancy themselves defenders of the public interest while constantly predicting the end of the world through technological disaster. It appears they are not representing the interests of most Americans.

Listening to overzealous environmentalist rhetoric and observing their targets proves that these individuals are antagonistic toward American industry. If there were ever a way of solving a problem without economically penalizing an industry, they show no interest in that alternative. Ron Arnold, author of *At the Eye of the Storm: James Watt and the Environmentalists* (1982), minces no words when he charges extreme environmentalism with the "desire to drastically reduce or dismantle industrial civilization and to impose a fundamentally coercive form of government on America through the implementation of a wide range of environmental laws and controls."

We must, therefore, consider that to environmental agitators environmentalism is a means to an end. Their primary interest may not be preserving health and the quality of life, but rather changing our political and economic system by reducing corporate influence and substituting greater governmental control in order to redistribute the country's wealth. What is so amazing is how easy it is to achieve these ends. If you picket a nuclear power plant, condemn a pesticide, or charge the chemical industry with polluting air and water, your views are quickly accepted by the media and the public as honest expressions of a sensitive individual.

If, however, after examining the facts as I have, one concludes that nuclear power plants are safe, food additives and pesticides are necessary, and our drinking water is of good quality, you are in trouble.

One so outspoken will quickly be accused of being a paid mouthpiece with a vested interest. But I am not, and have none, and in truth much of the aforementioned malicious foolishness has feathered the bed of all of us working in ground-water science.

The truly concerned public health specialist works to build a world without illnesses and unnecessary deaths. Drug abuse, suicide, heart disease, and tobacco-induced mortality are the primary agents of human misery affecting our lives. These, not parts per billion of pesticide residues, are the real causes of human pain and suffering.

We can all be proud of the strides we have made in improving our environment. The technological breakthroughs of the 20th century have produced the healthiest population ever to live on this planet. Advances have not come without risks, but the benefits have vastly outweighed the costs.

It's time for knowledgeable scientists to speak out against the steady diet of misinformation espoused by the holier-than-thou activists and lobbyists who would have us believe that technology is destroying our health and well-being. Dr. Phillip Handler, former president of the National Academy

of Science, once observed, "if the scientific community will not unfrock the charlatans, the public will not discern the difference—science and the nation will suffer." (1980).

Environmental health problems do exist. Many have been addressed and others warrant strong commitments to the future. No one is in favor of pollution. The public health must be protected from harm, and it is reasonable that we should expect to pay for this benefit. However, we should know what we are paying for with our regulatory dollars and the true health benefits we are getting in return.

By tightening environmental standards, would we be paying for the reduction of real or hypothetical risks? Is it desirable to pay a great deal of money for very strict regulations based on the most cautious interpretations of ambiguous or flawed data?

There are no simple solutions to these problems. Some of us feel that it is worthwhile to protect against any possible health effects, regardless of the cost. Others will decide that the cost must be justified by some evidence of benefits. The economic consequences of these regulations are real. We must be sure that the benefits of regulations intended to protect human health are equally real.

Perhaps it is time for environmental regulations to reflect both the economic and the health needs of our population. I do not advocate the protection of the public pocketbook at the expense of the public's health. But the toxic terrorists have overreacted to a frightening extent.

You, the scientists and engineers, educated in ways which the general public is not, must begin to help your friends, neighbors, and clients understand. In a world where toxic chemicals are essential, and extremists a reality, the government, the media, and all of us will have to learn how to evaluate risks more accurately to avoid either overreacting or underreacting, and to better determine which is which.

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## Appendix

**Table 1. Risk of Getting Cancer (Relative to Drinking Tap Water)**

Relative risk <sup>1</sup>	Source/daily human exposure	Carcinogen
<i>Water</i>		
1.0	Tap water, 1 liter	Chloroform
4.0	Well water, 1 liter (worst well in Silicon Valley)	Trichloroethylene
<i>Risks Created by Mother Nature</i>		
30.0	Peanut butter, 1 sandwich	Aflatoxin
100.0	Mushroom, 1, raw	Hydrazines, etc.
2,800.0	Beer, 12 oz.	Ethyl alcohol
4,700.0	Wine, 1 glass	Ethyl alcohol
0.3	Coffee, 1 cup	Hydrogen peroxide
30.0	Comfrey herbal tea, 1 cup	Symphytine
400.0	Bread, 2 slices	Formaldehyde
2,700.0	Cola, 1	Formaldehyde
90.0	Shrimp, 100 g	Formaldehyde
9.0	Cooked bacon, 100 g	Dimethylnitrosamine, diethylnitrosamine
60.0	Cooked fish or squid, broiled in a gas oven, 54 g	Dimethylnitrosamine
70.0	Brown mustard, 5 g	Allyl isothiocyanate
100.0	Basil, 1 g of dried leaf	Estragole
20.0	All cooked food, average U.S. diet	Heterocyclic amines
200.0	Natural root beer, 12 oz. (now banned)	Safrole
<i>Food Additives and Pesticides</i>		
60.0	Diet cola, 12 oz.	Saccharin
0.4	Bread and grain products, average U.S. diet	Ethylene dibromide
0.5	Other food with pesticides, average U.S. diet	PCBs, DDE/DDT
<i>Risks Around the Home</i>		
604.0	Breathing air in a conventional home, 14 hrs	Formaldehyde, Benzene
2,100.0	Breathing air in a mobile home, 14 hrs	Formaldehyde
8.0	Swimming pool, 1 hr (for a child)	Chloroform
<i>Risks at Work</i>		
5,800.0	Breathing air at work, U.S. average	Formaldehyde
<i>Commonly Used Drugs</i>		
16,000.0	Sleeping pill (Phenobarbital), 60 mg	Phenobarbital
300.0	Pain relief pill (Phenacetin), 300 mg	Phenacetin

Source: Bruce N. Ames, Renae Magaw, Lois Swirsky Gold, "Ranking Possible Carcinogenic Hazards," *Science*, Vol. 236, April 17, 1987, pp. 271-236.

<sup>1</sup>The underlying measure of risk used here is a HERP value: Human Exposure dose divided by Rodent Potency dose. The measure of rodent potency is the milligrams of substance per kilogram of rodent body weight necessary to produce cancer in one-half the rodents, given daily exposure over the rodents' lifetime. Human exposure is measured by the daily consumption indicated in the table per kilogram of human body weight. In the table above, the HERP values have been normalized with respect to the HERP value for water.

**Table 2. Risks Which Increase the Chance of Death by One in One Million**

<i>Activity</i>	<i>Cause of death</i>
Smoking 1.4 cigarettes	Cancer, heart disease
Drinking ½ liter of wine	Cirrhosis of the liver
Living 2 days in New York or Boston	Air pollution
Living 2 months in Denver on vacation from NY	Cancer caused by cosmic radiation
Living 2 months in average stone or brick building	Cancer caused by natural radioactivity
Traveling 6 minutes by canoe	Accident
Traveling 10 miles by bicycle	Accident
Traveling 300 miles by car	Accident
Flying 1000 miles by jet	Accident
Flying 8000 miles by jet	Cancer caused by cosmic radiation
One chest x-ray	Cancer caused by radiation
Eating 40 tablespoons of peanut butter	Liver cancer caused by aflatoxin B
Drinking Miami drinking water for 1 year	Cancer caused by chloroform
Drinking 30 12-oz. cans of diet soda	Cancer caused by saccharin
Eating 100 charcoal-broiled steaks	Cancer from benzopyrene

Source: Richard Wilson, "Analyzing the Daily Risks of Life," *Technology Review*, February, 1979, p. 45.

**Table 3. Annual Fatality Rates per 100,000 Persons at Risk**

<i>Activity/event</i>	<i>Death rate</i>
Motorcycling	2,000
Aerial acrobatics (planes)	500
Smoking (all causes)	300
Sport parachuting	200
Smoking (cancer)	120
Fire fighting	80
Hang gliding	80
Coal mining	63
Farming	63
Motor vehicles	24
Police work (nonclerical)	22
Boating	5
Rodeo performer	3
Hunting	3
Fires	2.8
1 diet drink per day (saccharin)	1.0
4 tbs. peanut butter per day (aflatoxin)	0.8
Floods	0.06
Lightning	0.05
Meteorite	0.000006

Source: Adapted from E. L. Crouch and R. Wilson, *Risk/Benefit Analysis* (Cambridge: Balinger, 1982). Reported in Paul Slovic, "Informing and Educating the Public About Risk," *Risk Analysis*, Vol. 6, No. 4, 1986, Table 1, p. 407.