Cancer Risks: People Can Be Rats, But Rats Aren't People

By Bruce N. Ames and Lois Swirsky Gold

Pollution appears to account for less than 1 percent of human cancer, yet public concern and resource allocation for chemical pollution are very high, in good part because of the use of animal cancer tests in cancer risk assessment. Animal cancer tests, which are done at near-toxic doses, are misinterpreted as meaning that low doses of synthetic chemicals and industrial pollutants are relevant to human cancer. About half of the chemicals tested, whether synthetic or natural, are carcinogenic to rodents at these high doses. A plausible explanation for the high frequency of positive results is that testing at the near-toxic dose frequently can cause chronic cell killing and consequent cell replacement, a risk factor for cancer that can be limited to high doses. Ignoring this effect greatly exaggerates risks. Scientists must determine mechanisms of carcinogenesis for each substance and revise acceptable dose levels as understanding advances.

The vast bulk of chemicals ingested by humans is natural. For example, 99.99 percent of the pesticides we eat are naturally present in plants to ward off insects and other predators. Half of these natural pesticides tested at near-toxic doses are rodent carcinogens. Reducing exposure to the 0.01 percent that are synthetic will not reduce cancer rates. On the contrary, although fruits and vegetables contain a wide variety of naturally occurring chemicals that are rodent carcinogens, inadequate consumption of fruits and vegetables doubles the human cancer risk for most types of cancer. Making these foods more expensive by reducing synthetic pesticide use is likely to increase cancer. Humans also ingest large numbers of natural chemicals from cooking food. Over a thousand chemicals have been reported in roasted coffee; more than half of those tested (nineteen of twenty-six) are rodent carcinogens. There are more rodent carcinogens in a single cup of coffee than potentially carcinogenic pesticide residues in the average American diet in a year, and there are still a thousand chemicals left to test in roasted coffee. This does not mean that coffee is dangerous but rather that animal cancer tests and worst-case risk assessment build in enormous safety factors and should not be considered true risks.

> ***"Linear extrapolation from the near-toxic dose in rodents to low-level exposure in humans for synthetic chemicals, while ignoring the enormous natural background, has led to exaggerated cancer risk estimates and an imbalance in the perception of hazard and the allocation of resources."***

The reason we humans can eat the tremendous variety of natural chemical "rodent carcinogens" is that we, like other animals, are extremely well protected by many general defense enzymes, most of which are inducible (that is, whenever a defense enzyme is in use, more of it is made). These defense enzymes are equally effective against natural and synthetic chemicals. There is no general difference between synthetic and natural chemicals in the ability to cause cancer in high-dose rodent tests....

Trends

Cancer was estimated to cause 23 percent of the person-years of premature loss of life and about 530,000 deaths in the US in 1993.[1] Four major cancers (lung, colon-rectum, breast, and prostate) account for 55 percent of the deaths. Nevertheless, cancer death rates in the US are decreasing, after adjusting for age and excluding lung cancer. According to a 1993 update from the National Cancer Institute, the age-adjusted mortality rate for all cancers combined (excluding lung and bronchus) declined from 1950 to 1990 for all individual age groups except 85 and above.[1] The decline ranged from 71 percent in the 0-4 year old group to 8 percent in the 74-85 year old group. The update notes that "if lung cancer were eliminated, then the overall cancer death rate would have declined over 14% between 1950 and 1990...."

An analysis by Professor Peto has come to the same conclusion: "The common belief that there is an epidemic of death from cancer in developed countries is a myth, except for the effects of tobacco. In many countries cancer deaths from tobacco are going up, and in some they are at last coming down. But, if we take away the cancer deaths that are attributed to smoking then the cancer death rates that remain are, if anything, declining. This is reassuringly true in Western Europe, Eastern Europe and

Excerpted from "The Causes and Prevention of Cancer: The Role of Environment" by Bruce N. Ames and Lois Swirsky Gold in *The True State of the Planet* by Ronald Bailey, editor.

6,000 Molecules of Li_2O in Every Pint of the World's Oceans...So What?

By John Allen Paulos

A little calculation illustrates how small an amount of contaminant is required to give the impression of a serious risk. Assume the earth's oceans contained pristinely pure water and that some environmental demon were to spill into them a pint of some awful chemical — say Li_2O for the sake of fantasy — and then systematically churn them up, so that the chemical was evenly distributed throughout. (A liquid pint is a bit more than the volume of a typical can of soda.) A few years later an inspector from an environmental agency removes a pint of water from an ocean somewhere and indignantly announces that there are X molecules of Li_2O in this pint of formerly pure water. What would be your guess of the approximate value of X?

Let me sketch for you how to use arithmetic, a smidgen of geometry, and a smattering of chemistry to come up with a very rough order-of-magnitude estimate of this number. (Skip this and the next two paragraphs if you abhor this kind of stuff.) Note first that the surface area of the earth is approximately $2x10^8$ square miles. (The radius, r, of the earth is about 4,000 miles, and the surface area of a sphere is $4\ r^2$.) Knowing that 75 percent of the earth's surface is covered with water at an average depth of about 2 miles, we determine that the volume of water in the world's oceans in cubic miles is $3x10^8$. Multiplying this figure by $5{,}280^3$, the number of cubic feet in a cubic mile, we find that the volume of the water in the world's oceans is, in cubic feet, about $4.4x10^{19}$. Since there are about .017 cubic feet in a pint, the volume of the ocean is approximately $2.6x10^{21}$ pints.

Continuing, note that there are about 29 cubic inches per pint and roughly .06 cubic inches in 1 cubic centimeter; thus there are approximately (29/.06=) 480 cubic centimeters in a pint of water or, equivalently, 480 grams of water, or, using the fact that a mole of water weighs about 18 grams, about 25 moles of water in a pint. Each mole of water contains Avogadro's number ($6x10^{23}$) of molecules, so a pint of water contains $1.5x10^{25}$ molecules of water. (There are more direct routes to this number, whose size explains why it is so easy to make a mountain out of a mole spill.)

So a pint of the now polluted oceans contains how many molecules of Li_2O? The fraction of the ocean's volume that is Li_2O is $1/2.6x10^{21}$. And this is also the fraction of the chemical in a pint of ocean. Since a pint contains about $1.5x10^{25}$ molecules, we multiply these two numbers and see that almost 6,000 molecules of the vile Li_2O reside in every pint of the world's oceans.

That pint of Li_2O (a volume slightly bigger than that of a soda can, remember) dropped into pure oceans of the world and spread about uniformly resulted in almost 6,000 molecules of the stuff appearing in every pint we retrieved. The point of this tiny orgy of calculation and dimensional analysis is that it doesn't take much to come up with a frightening headline. One part out of $2.6x10^{21}$ probably doesn't sound like much even to an alarmist, but 6,000 molecules per pint would almost certainly rouse anxiety among many.

North America—and, in the 'West,' the death rates from other diseases are falling rapidly. For most non-smokers, the health benefits of modern society outweigh the new hazards. Apart from tobacco (and in places, HIV), the Western world is a remarkably healthy place to live"....[4]

Pollution

Synthetic pollutants are feared by much of the public as major causes of cancer, but this is a misconception. Even if the worst-case risk estimates for synthetic pollutants that have been made by the EPA were assumed to be true risks, the proportion of cancer that EPA could prevent by regulation would be tiny.[105] Epidemiological studies, moreover, are difficult to conduct because of inadequacies in exposure assessment and failure to account for confounding factors like smoking, diet, and geographic mobility.

Indoor air is generally of greater concern than outside air because 90 percent of people's time is spent indoors, and the concentrations of pollutants tend to be higher than outdoors. The most important carcinogenic air pollutant, however, is likely to be radon, which occurs naturally as a radioactive gas that is generated as a decay product of the radium present in trace quantities in the earth's crust. Radon enters houses primarily in air that is drawn from the underlying soil. Based on epidemiological studies of high exposures to underground miners, radon has been estimated to cause as many as 15,000 lung cancers per year in the US, mostly among smokers due to the synergistic effect with smoking.[106-8] Epidemiological studies of radon exposures in homes[109-10] have failed to demonstrate convincingly an excess risk....

Distractions: Animal Cancer Tests...

Adequate risk assessment from animal cancer tests requires more information about many aspects of toxicology, such as effects on cell division, induction of defense and repair systems, and species differences.

Linear extrapolation from the near-toxic dose in rodents to low-level exposure in humans for synthetic chemicals, while ignoring the enormous natural background, has led to exaggerated cancer risk estimates and an imbalance in the perception of hazard and the allocation of resources. Although some epidemiologic studies find an association between cancer and low levels of industrial pollutants, the studies do not correct for diet, a potentially large confounding factor, and the levels of pollutants are low and rarely seem plausible as a causal factor.[117] The idea that there is an epidemic of human cancer caused by synthetic industrial chemicals is not supported by either toxicology or epidemiology.

If the costs were minor the issue of putting hypothetical risks into perspective would not be so important, but the costs are huge.[125-6] Costs escalate as cleanliness approaches perfection. The idea of trade-offs is not adequately dealt with in most attempts to deal with pollutants; instead it is assumed that upper-bound risk assessment to one in a million protects the public. The Office of Management and Budget Report[127] and also the Harvard Center for Risk Analysis report[128] that compared costs for risk reduction among government agencies concluded that the money spent to save a life by EPA is often orders of magnitude higher than that spent by many other government agencies. EPA risk estimates are based on "risk assessment" (default, worst-case, linear extrapolations to one-in-a-million risk), unlike most other government agencies, so the actual discrepancy between EPA and many other agencies is even greater. Many scholars have pointed out that expensive regulations intended to save lives[129] may actually lead to increased deaths, in part by diverting resources from important health risks and in part because higher incomes are associated with lower mortality risks.[130-1] Worst-case assumptions in risk assessment is a policy decision, not a scientific one, and confuses attempts to allocate money effectively for risk abatement. Regulating trivial risks impedes effective risk management....[132]

Decreases in physical activity, and increases in smoking, obesity, and recreational sun exposure, have contributed importantly to increases in some cancers in the modern industrial world, whereas improvements in hygiene have reduced other cancers related to infection. There is no good reason to believe that synthetic chemicals underlie the major changes in incidence of some cancers. In the United States and other industrial countries life expectancy is steadily increasing and will increase even faster as smoking declines.

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