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# Six Common Errors Relating to ENVIRONMENTAL POLLUTION

by  
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## EDITOR'S NOTE:

Professor Ames is Chairman of the Department of Biochemistry, University of California, Berkeley, and was formerly on the board of directors of the National Cancer Institute (National Cancer Advisory Board). He is a member of the National Academy of Sciences. He was the recipient of the most prestigious award for cancer research, the General Motors Cancer Research Foundation Prize (1983), and of the highest award in environmental achievement, the Tyler Prize (1985). He does no consulting for the chemical, drug, or food industry, or for law firms.

### Error 1: Cancer Rates are Soaring

Overall, cancer death rates are staying steady or coming down, the major exception being smoking-related cancer. The

latest update from the National Cancer Institute (12/2/85) for the decade 1974-1983 shows that cancer of the stomach is down 20%; cancer of the cervix-uterus is down 30% (both of these have been decreasing for decades); cancer of the ovary is also down 8%. The cancer rates that are clearly increasing are male lung cancer (up 15%) and female lung cancer (up 72%), both of which are caused by smoking (as is 30% of U.S. cancer), and melanoma (up 20%), which is thought to be due to sunlight exposure.

Life expectancy is steadily increasing in the U.S. and most industrialized countries (except for the U.S.S.R., where male life expectancy has fallen to 62 years). Infant mortality is decreasing, and, though the statistics aren't good on birth defects, there is no evidence that they are increasing overall.

Conclusion: We are the healthiest we have been in human history.

### Error 2: Man-Made Chemicals are Present in Significant Amounts

I argued in an earlier article in *Water Magazine* (Vol. 27, No. 2) and in the scientific literature, that amounts of pollution that humans are ingesting from pesticide residues or pollution are trivial relative to the background of natural and traditional (e.g. from cooking food) carcinogens. For example, the possible carcinogenic hazard of drinking the TCE-contaminated well water in the 35 wells shut down by EPA in Silicon Valley is even less than that from the chloroform in ordinary chlorinated tap water, and is thousands of times less than the possible carcinogenic hazard of drinking an equal volume of beer (alcohol is a carcinogen) and 10 times less than the hazard of eating a daily peanut butter sandwich (peanut butter contains traces of aflatoxin, a mold carcinogen). These latter hazards are themselves trivial.

### **Error 3: Storks Bring Babies and Pollution Causes Cancer and Birth Defects**

The number of storks in Europe has been decreasing for decades. At the same time, the European birth rate has also been decreasing. We would be foolish to accept this correlation as evidence that storks bring babies. The science of epidemiology tries to sort out from the myriad chance correlations those meaningful ones involving cause and effect. It is important to understand, however, that epidemiological methods are inherently difficult and that it is not easy to obtain convincing evidence. There are also many sources of bias. For example, because there are so many different types of cancer or birth defects, just by chance alone one would expect one or more of them to be at a higher frequency in any particular small community. The science of toxicology provides evidence as to whether a possible correlation is credible.

There is no convincing evidence from epidemiology or toxicology that pollution is a significant source of birth defects and cancer. For example, the epidemiological studies on Love Canal, dioxin in Agent Orange, Contra Costa County refineries, Silicon Valley, Woburn, or DDT, provide no convincing evidence that in any of these well publicized exposures pollution was the cause of human harm. Even in Love Canal, where people were living next to a toxic waste dump, the epidemiological evidence for an effect on public health is equivocal. My analysis of the toxicology data on many of these cases suggests that the amounts of the chemicals were much too low relative to the background of natural and traditional carcinogens to be credible sources of increased cancer to humans.

Environmental exposure to TCE, PCE, TCA, ethylene dibromide and other pollutants is thousands of times lower than the exposure to these same agents in the workplace. If one expects to find some effect of PCE, or TCE or ethylene dibromide, the workplace is where to look. The studies on these so far do not provide any definitive evidence either way, though they vary in thoroughness. Historically, cases of cancer due to workplace exposure resulted mainly from exposures to chemicals close

to the toxic level. For example, I testified in 1981 in California that the EDB levels that workers were allowed to be exposed to were shockingly high (our calculations showed that the workers were allowed to breathe in a dose higher than the dose that gave half of the rats cancer). California then lowered the permissible worker exposure over 100-fold: by far the toughest standards in the country. Despite the fact that the epidemiology on EDB in highly exposed workers does not show any significant effect, the uncertainties of our knowledge make it important to have strict rules about workers because the doses can get extremely high.

### **Error 4: Regulate Without Understanding How Carcinogens Work**

The fact that high doses of a chemical cause tumors doesn't mean that small doses will. Most of the carcinogens we are worrying about in pollution may, in fact, be harmless at low levels. A list of carcinogens isn't enough. Some carcinogens damage DNA and some do not, and this makes an enormous difference in how we should deal with them at low doses. The key issue is understanding the mechanism by which carcinogens cause cancer.

The main rule in toxicology is that the "dose makes the poison," that at some level every chemical becomes toxic, but that there are safe levels below that. In dealing with carcinogens, the scientific consensus evolved that we should treat carcinogens differently and assume that even low doses could possibly cause some harm, even though we don't have the methods to measure effects at low levels. This idea evolved because most carcinogens appeared to be mutagens (agents which damage the DNA, the genetic material in cells). There was the previous precedent from research on radiation, which is both a mutagen and carcinogen, for thinking that there possibly could be effects of chemicals even at low doses.

Our own work was critical in establishing the idea that most of the classical carcinogens were mutagens damaging DNA (about 90% in our studies). However, in

recent years there has been a change in the picture. An astounding percentage of chemicals tested in animal cancer tests are being classified as carcinogens (over 50%), and most of these do not appear to be damaging DNA. The recent cancer tests are also different in that they are being done rigorously at the maximum tolerated dose of the chemical for the lifetime of the animal. Earlier tests, e.g., the Innes study, where only 10% of a series of pesticides were found to be carcinogens, were much less careful to reach the maximum tolerated dose. The question then arises why the non-DNA damaging chemicals TCE, PCE, DDT, PCBs, chloroform, dioxin, etc., are carcinogens. I, and a number of leading cancer researchers and toxicologists, believe that they are accelerating the promotional step of the cancer process at toxic doses. Cancer is a multi-step process, and any agent that accelerates any step would be expected to be a carcinogen. Two steps are of primary importance: a) *initiation*, the DNA damaging step (recent work on oncogenes supports mutation as one aspect of carcinogenesis), and b) *promotion*, which appears to involve cell proliferation. This second step can be accelerated by viruses, such as the human carcinogenic viruses hepatitis B (a major cause of liver cancer in the world) and human papilloma virus 16 (HPV16), a contributor to cancer of the cervix, both of which cause chronic cell killing and consequent cell proliferation. Promotion can also be caused by hormones and may account for much of the cause of hormonally influenced cancers such as breast cancer. The promotional step of cancer causation can also be accelerated by chemicals, such as alcohol causing cirrhosis of the liver leading to cancer. The classical chemical promoters would be expected to be, and are in fact, carcinogens when tested in thorough animal tests at the maximum tolerated dose. There is increasing evidence to show that low doses of promoters are not active. I think it is likely that a high percentage of all of the chemicals in the world, both man-made and natural, will be classified as carcinogens, when tested at the maximum tolerated dose, and that most will be acting through cell killing, causing chronic irritation and cell proliferation.

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## POLLUTION, *continued*

Thus, the common water pollutants, such as TCE and PCE, are unlikely to be of public health significance because a) the amounts we are exposed to in pollution are trivial relative to the background of natural carcinogens, even if we assume that they are as dangerous as DNA damaging carcinogens; and b) the evidence is that they are not DNA damaging carcinogens and are just those we should ignore at low concentrations.

Evidence is also accumulating that extrapolating linearly from the enormous doses of rat tests to low-dose human exposure may be much too pessimistic even for those carcinogens which are mutagens.

Agents causing birth defects that are not mutagens would also be expected to be harmless at low doses. Important risk-factors for birth defects in humans include: age of mother, alcohol, smoking, and rubella virus. The trace amounts of chemicals being found in the occasional polluted well are, in my opinion, much too low to be credible causes of birth defects.

### **Error 5: Only a Small Number of Chemicals Are Carcinogens and Reproductive Toxins, and We Can Eliminate Them**

This is a total fallacy. Over 50% of all chemicals tested to date have been found to be carcinogens in high doses. I have just discussed why I think this proportion will continue and that a high percentage of all chemicals we test in the future, both natural and man made, will prove to be carcinogens. Many hundreds of chemicals are believed to cause reproductive effects in large doses. If we ever start systematic testing of reproductive toxins at high doses, I expect a sizeable percentage of both natural and man-made chemicals will be on the list. We must understand that our world is full of carcinogens and reproductive toxins and always has been. The issue is the dose in which they are present. Fortunately, almost all of these are present in tiny doses which pose no real danger.

Natural carcinogens are everywhere: they are present in mushrooms, parsley, basil, celery, cola, wine, mustard, beer, peanut butter, and many more remain to be discovered. Bread, cola, and beer all contain

formaldehyde, a natural carcinogen. We make carcinogens when we cook our food or bake our bread. We make carcinogens in our normal metabolism, so that human blood contains many natural carcinogens. Every complex mixture has carcinogens: car exhaust, gasoline, smoke from your chimney, urine, feces, dirt. Many of the chemical elements are carcinogens. Millions of tons of natural carcinogens are dropped on the ground when bracken fern and other plants die. Even the campfires and the cars of Sierra Club members are spewing carcinogens into the air. Given the uncertainties of our knowledge, it is impossible to prove that any of these many carcinogens are completely safe at low doses. If everyone is guilty until they prove themselves innocent for producing any amount of carcinogen, even parts per billion (one part per billion is one person in all of China), we will divert our wealth to fighting lawsuits over trivia. Though some people do benefit from lawsuits, the public health will not.

The fact that scientists can now measure parts per billion of carcinogens and are learning to measure parts per trillion (one-sixteenth of an inch is about one-trillionth of the distance to the moon), doesn't mean we should think that important pollution is increasing or that it is of great concern.

### **Error 6: Technology Is Doing Us In**

Modern technologies are almost always replacing older, more hazardous technologies. The reason billions of pounds of the solvents TCE and PCE (the main dry-cleaning solvent in the U.S.) are used is because of their low toxicity and the fact that they are not flammable. Is it advisable to go back to the age when dry cleaners or industry used flammable solvents and were going up in flames frequently, or dry cleaners used the much more toxic and hazardous solvent, carbon tetrachloride? Eliminating a carcinogen is not always a good thing. Ethylene dibromide (EDB), the main fumigant in the U.S. before it was banned, was present in trivial amounts in our food: the average daily intake was about one-tenth of the possible carcinogenic hazard of the aflatoxin in the average daily peanut butter sandwich, a trivial risk

in itself. If we don't fumigate, there will be insect infestation and subsequent mold carcinogen contamination of grain. This would be a regression in public health, not an advance, not to speak of the greatly increased costs. I suspect that the coming alternatives, such as irradiating food, might be more hazardous than EDB, as well as being more expensive.

Modern pesticides replaced more hazardous substances such as lead arsenate, one of the major pesticides before the modern era. Lead and arsenic are both natural, highly toxic, and carcinogenic. Pesticides have increased yields and brought down the price of foods, a major public health advance. The total amount of possible carcinogenic pesticides we eat in a day, on average, is both trivial and about 20 times less in amount than the known natural carcinogens in a cup of coffee, a minimal risk in itself.

Every living thing and every industry "pollutes" to some extent. We can eliminate all industrial pollution by eliminating all economic activity. It is all a question of how much we wish to spend to get rid of the last part per billion of TCE out of Silicon Valley, or PCE out of dry-cleaning plants. It may also influence the economic incentives for industry to move overseas if essential solvents are eliminated.

Everyone knows that if you spend all of your time on trivia and don't focus on important problems, it is completely counterproductive. If we divert too much of our attention to traces of pollution and away from important public health concerns such as smoking (400,000 deaths per year), alcohol (100,000 deaths per year), eating unbalanced diets and high cholesterol, AIDS, radioactive radon coming up from the soil into our homes, and high-dose occupational exposure, we do not improve public health, and the important hazards are lost in the confusion. Clearly, we don't want to ignore pollution, even if it is only a minor hazard. California already has among the strictest rules in the world, and sensible standards and penalties hasten the process of minimizing whatever hazards there are. In addition, the inexorable progress of scientific research will, I am sure, continue to provide the knowledge that will result in steady progress to decrease cancer and birth defects and lengthen lifespan. ♠