Scared to Death

How Chemophobia Threatens Public Health

Presented by

The American Council on Science and Health

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January 2011

American Council on Science and Health
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Acknowledgements

This paper is based on the book **Scared to Death: How Chemophobia Threatens Public Health** by Jon Entine, published by the American Council on Science and Health. The following people reviewed the original paper on which this summary is based:

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CHE•MO•PHO•BI•A:

the irrational fear of chemicals

Living in Fear

When Pamela Davis was pregnant with her daughter Meaghan, she started to worry about contamination from lead paint in her Hoboken, New Jersey home. She read stories about chemicals in baby dolls, pots, shower curtains and carpets. An article on the Internet warned that sippy cups were dangerous. A friend told her that the bright pink baby pajamas she had gotten as a gift were treated with toxic flame-retardants. Soon her entire nursery seemed to pose mysterious threats to her unborn baby. Pamela felt trapped.

If news stories and the Internet are to be believed, the dangers from chemicals are increasing, cancer stalks us at every turn and our children are vulnerable. Synthetic chemicals are essential for modern life, but our views of them are conflicted. We rely on chemicals to improve human health. Pharmaceuticals keep us healthy. Plastics are found in everything from toys to cars to medical supplies. Pesticides and herbicides boost food production and quality. It's impossible to conceive of life in the 21st century without the

materials and fuels that synthetic chemicals have made possible. But from soap to sunscreens, drugs to DDT, we are faced with an endless stream of confusing messages about the safety of chemicals we come in contact with everyday. The synthetic ingredients that make up many products suggest the unknown, and like many of us, Pamela Davis processes that as fear. "Once you're aware of one thing it just spreads and you start questioning everything," she said. "You can drive yourself absolutely crazy trying to keep your baby healthy."

Considering the conflicting narratives, the public has difficulty distinguishing between useful and benign substances in products and those that could pose dangers when misused. Highly publicized reports of environmental, chemical and pharmaceutical catastrophes––from the Exxon Valdez and BP oil spills to Bhopal to thalidomide––are mixed interchangeably with exaggerations and scare stories about chemicals found in common plastics or in our homes. Belief in the relative benefits of chemicals, trust in the industries that produce them and confidence in government regulators have never been lower. Corporations that produce chemicals are often portrayed as greedy and indifferent. Questions persist about the government's ability to exercise its oversight responsibilities.

The perceived risk posed by common chemicals has grown even as research has raised doubts about the assumed links of many chemicals to cancer. Lifestyle factors like a lack of exercise, smoking, excessive alcohol consumption and eating habits that lead to obesity contribute far more to the overwhelming majority of cancers. Yet, the chemophobia epidemic keeps gaining momentum.

How does the public adjudge hazard, safety and risk? How safe is safe? Media perceptions and government regulations are often shaped by a fervor fed by misconceptions about the widespread dangers of common chemicals. The fear extends beyond their misuse to the alleged dangers they pose as key ingredients of essential products. An illusion has developed that chemicals can be divided into categories of "safe" versus "unsafe." But any substance, even food and vitamins, can be harmful if we consume too much of it. Safety is relative, depending on the frequency, duration and magnitude of exposure. This obsession with chemicals is unhealthy. Serious health challenges need to

be forcefully confronted, but the resources devoted to challenging and removing relatively innocuous chemicals and developing substitutes—substances that have often not been scrutinized as much as the chemicals they would replace and thus confer an illusion of safety—often divert us from addressing known health risks. This chemophobia can result in the opposite of what was intended: a decrease rather than an increase in public health.

The public misunderstanding of chemicals and risk has arisen due to variety of factors: advances in analytical chemistry allowing the detection of ever smaller amounts of substances; evolution of the Internet and social media; emergence of environmental advocacy organizations staffed with committed activists but often few scientists; uncritical or outright biased reporting about claims that synthetic chemicals are inherently risky; industry capitulation to campaigns against their products; government inclination to respond to exaggerated claims in politically safe but scientifically unsound ways; and the erosion of public trust in authority, including of government, industry and the scientific community.

Chemical manufacturing is estimated to be a $3 trillion global enterprise. The U.S. Environmental Protection Agency estimates that there are 84,000 synthetic substances in use in the world today. Chemicals are used to make a wide variety of consumer goods, as well as products for the medical, agricultural, manufacturing, construction and service industries. The boom started in the early 20th century and accelerated in the 1920s and '30s with advances in technology leading to the creation of new forms of plastics, including nylon and synthetic rubber made from petrochemicals. The use of newly developed chemicals played an important role in the Allied victory in World War II.

In the postwar years, a country on the cusp of sustained prosperity embraced scientists and industry as architects of innovation. The 1950s brought affluence to more Americans, leading to an increased demand for consumer goods, from energy and detergents to plastic, rubber and fibers. A sophisticated pharmaceutical industry arose. Agribusiness grew rapidly in response to both public concern about feeding the world—the Green Revolution was made possible by the advent of pesticides and synthetic fertilizers—and the desire for fruits and vegetables year-round. It was an era of growing

abundance and chemicals were viewed as essential components of this consumption revolution.

But the complexity of modern life gradually intervened. Dramatic growth laid bare the inadequacy of certain public protections. Corporations, the engines of progress, were also the main source of industrial pollutants that fouled our air, water and soil. Legitimate concerns emerged over the use of chemicals on farm products and in the making of consumer goods and drugs. Highly sophisticated detection techniques that measure minute levels of toxic chemicals in blood and urine helped fan anxiety. Fifty years ago, science could isolate a trace chemical from a capful dumped into a swimming pool; now we have instruments that can identify that same chemical in the parts per trillion in Lake Erie.

In response to the growing impact of chemicals, numerous federal agencies, most notably the EPA, which regulates chemicals in the environment, and the Food and Drug Administration, which regulates foods and drugs, were founded or expanded. The Centers for Disease Control and the Occupational Health and Safety Administration also evaluate potentially hazardous chemicals, particularly those that cause, or might cause, cancer. These agencies have evolved in a climate of increasing public mistrust to address the growing complexity of modern production and consumerism. Most industrial countries have comparable oversight bodies. Today there are 170 synthetic chemicals or exposure circumstances that have been classified by one such agency, the International Agency for Research on Cancer, as known or probable human carcinogens.

Numerous chemicals—natural and synthetic—have been indentified in the environment as dangerous at elevated levels of exposure and for which genuine caution is warranted. For example, significant exposure to lead can lead to neurological problems, including seizures, coma or death, which is why its use is tightly regulated. Many workers exposed for years to asbestos, another natural substance, developed lung disease and cancer because its toxic effects were not known, regulations were lax, ventilation systems were inadequate, and they did not wear protective clothing. Workers who handle almost any chemical in high enough concentrations need special protections.

But even a highly toxic chemical should not necessarily be banned outright; that decision should be based on where and how a chemical is used and at what concentrations. Its potential risks must be balanced against its demonstrated benefits.

The public controversy, however, exists over relatively common chemicals found at minute levels supposedly lurking in our foods and in everyday consumer products. Lurid headlines, such as "Alarming Body Burden Results: Tests Reveal 300 Chemical Compounds in Newborn Babies" or "89 of 116 Chemicals Detected in Americans' Blood and Urine" used alarmist language. Although advocacy groups play an important role in focusing public attention on potential environmental hazards, some NGOs (non-governmental organizations) consistently exaggerate the threats, going so far as to portray our houses, schools, hospitals and workplaces as toxic cauldrons. By their measure, questionable substances can be found in meats and fish, on fruits and vegetables. The bottled water industry, created because people feared contaminants endanger our tap water, now finds itself under scrutiny for selling water in plastic containers made with chemicals that modify our hormones. Cookware and plastic wrap, sippy cups and the cans used to package long-shelf life foods are portrayed as serious hazards. Danger looms in cosmetics, toothpaste and cleansers. Carpets, drapes and cabinetry are sources of alarm. The list goes on and on.

While scientists may scoff at this caricature of risk and the implication that chemicals are inherently dangerous, such stories are the calling card of many advocacy campaigns and are given credence in the media. Even as you read this, people are snapping up the latest scare treatise, ***No More Dirty Looks***, which, according to ***Time*** magazine, "unmasks the toxic ingredients in mainstream chemicals"—particularly in cosmetics and other personal care products.

Even as the hard evidence suggest Americans have never been safer when it comes to exposure to chemicals and drugs, many people mistakenly believe we face more environmental hazards now than at any point in history. That's understandable. Over the years, the public has been traumatized by oil spills; the thousands of deaths and injuries associated with the methylmercury con-

tamination of Minamata Bay in Japan by the Chisso Corporation from 1932 to 1968; the explosion at a Union Carbide pesticide plant in Bhopal in 1984; and occupational exposures to vinyl chloride, benzene and aniline dyes. The problems caused by the drug thalidomide, which was withdrawn in 1961, left deep scars. Numerous drugs have been withdrawn in recent years because of health concerns, such as cardiovascular toxicity (e.g. Vioxx/Rofecoxib; fenfluramine, with fentermine called Fen-phen), liver damage (e.g. Trovan/Trovafloxacin) or other ill effects, some not sufficiently identified during trials.

Less clear-cut are controversies over exposure to environmental chemicals such as Agent Orange (a Vietnam-era defoliant that contained a dioxin compound), PCBs (polychlorinated biphenyls, found in industrial fluids) or the pesticide DDT (dichlorodiphenyltrichloroethane), in which scientists have modified or even reversed their assessments of toxicity. Equally problematic are reports about the purported dangers of chemicals that we encounter regularly in common products, such as BPA (bisphenol A) and phthalates used in plastics; the industrial surfactant PFOA (perfluorooctanoic acid also known as C8), PBDE (fire retardant compounds polybrominated diphenyl ethers) and atrazine, an herbicide.

There are toxic threats in our environment, and it's important to identify them and take appropriate action. But the picture painted in some quarters far overstates the actual dangers. Regulation of chemicals is stricter and more effective than it's ever been. There have been significant advances in technology and ways of handling chemicals by industry. Only a trickle of new drugs makes it to market each year. In the case of pesticides, for example, the chemical industry estimates that only one in 139,000 new compounds survive the gauntlet from the chemist's laboratory to the farmers' fields. Each potential product that makes it into production undergoes some 120 separate tests, taking 8 to 10 years at a cost of as much as $184 million.

The politics of contested science can be a messy business for everyone. The motivations of industry and self-proclaimed environmental white knights are not always transparent. Intentions are difficult to deconstruct when ideology, financial incentives, academic reputations and public attention are in play. While scientists who accept private funding, even for a study of a sub-

stance that's not at issue, risk being labeled by advocacy groups and academic scientists as "corrupt," NGOs and university scientists who endorse exaggerated assessments of chemical risk are sometimes positioning themselves for government grants or publicity.

Chemophobia is rising even while the actual danger of chemical contamination or harm from everyday exposures, particularly in the workplace, has decreased sharply over the years. The very word "chemical" has become a hot button. A recent national poll by the University of Michigan found that the public rates "chemicals in the environment" almost as big a concern as teen pregnancy, alcohol abuse and child neglect, and far more dangerous than depression or school violence. Yet, researchers have found that more than 70 percent of cancer cases can be linked to smoking and poor eating habits that lead to obesity. Perceptions about chemicals have become so distorted that many people are willing to forgo the unquestioned benefits of their use, such as in vaccines, because they believe that they could poison their children. The result is a society that is increasingly wary of chemicals and science in general, and supportive of the removal from the market of many useful and in some cases irreplaceable chemicals—even when there is no evidence that they pose serious risks and the substances that replace them are often untested.

How Chemicals Are Tested

Until the 1960s, the standards used by the government to determine safety levels and manage risk were hopelessly imprecise and subjective. To establish safe levels for substances in the air, water or soil, regulators needed to move from the black/white qualitative approach of either allowing or banning a substance to a quantitative approach of determining how much of each substance might be allowable in each environmental situation. As the health focus on cancer and the fears associated with chemicals escalated, noted University of California at Berkeley chemist Bruce Ames invented a quick, inexpensive test (now known as the Ames test) to evaluate toxicity. His test determines if any chemical of interest might cause mutations in the DNA of bacteria in vitro (in a controlled environment, such as in a test tube or Petri dish). If mutations were observed then that particular chemical was considered likely to be a carcinogen in lab animals.

The Ames test and the development of rodents modified to be cancer-prone led to an ultra-cautious toxicological evaluation system and chemical

regulatory process. Over the years, what many scientists believe is a convoluted multi-stage model has been developed to extrapolate animal risk to people:

(1) Scientists do a biological assay (the Ames test) on some pesticide, food additive, preservative or other chemical to find out if it is mutagenic. It shows whether the DNA of the bacteria is altered in a significant way.

(2) If the chemical is confirmed as mutagenic, studies are then undertaken to determine what is called the "maximum tolerated dose" (MTD) of this chemical in rats or mice. The MTD is the amount of the chemical that almost kills a rodent (or almost achieves another parameter, such as suppressing body weight.) It is a dose that, depending on the particular chemical, can be thousands to millions of times higher than a human could ever ingest in a lifetime.

(3) Next, the rodents are fed just 10 percent less than the maximum tolerated dose daily for their entire one- to two-year lifetime.

(4) However, many chemicals cannot be fed to rodents because the substances are so noxious at the dosages given. So scientists often use gavage (forced feeding into the animal's gut every day, often by injection), which is not how humans are exposed to the chemical, compromising the meaningfulness of the test.

(5) After a year or two, the rodents are sacrificed and scientists count up the tumors the animals accumulated in various organs. Most of the rodents in the control group, fed a normal diet, will have tumors anyway because they have been bred to be cancer prone. So, if the test group of rodents fed—or more likely injected with—some chemical at the highest dose has an average of, say, four tumors per animal in a particular organ, and the control group has an average of only one tumor per animal, then the chemical being tested is said to increase cancer incidence by 300 percent. This does not mean that such a study proves a chemical will cause adverse effects in rats, let alone in humans exposed under more realistic conditions. Yet, this finding, designed as a first step in testing a hypothesis, often ends up in a headline or in a media release from one advocacy group or another attempting to use preliminary research to support a cause or movement.

(6) Next, and often under pressure from the energized media and envi-

ronmental NGOs, a political body, such as the European Parliament or the U.S. Congress, or a regulatory body, such as the EPA, will classify and/or confirm this chemical as a likely human carcinogen, as if rodents were nothing more than miniature humans.

(7) These agencies then establish an "acceptable" level of the chemical—the EPA calls it "an upper estimate of the risk"—using what's known as the "dose-response curve," which includes a large margin-of-safety factor based on mathematical models. In moving to this new quantitative approach, government scientists began employing high-dose rodent studies, equating these studies to estimates of what might happen to humans exposed to the same chemicals at low doses. But there are no validated biological models that quantify the relationship between the high-dose animal results and low exposure levels experienced by humans.

Underscoring the relative arbitrariness of this process, the cutoff level is set differently by different agencies from country to country and even sometimes within a country. As in the case of the pesticide atrazine, these levels can vary by as much as 100 times. (The European safety cutoff level is 1 part per billion, while the World Health Organization sets it at 100 ppb.)

The result is that the scientific convention of setting one number to represent risk exaggerates the media and public perception of risk. Because only one number results from the assessment process, it is not surprising that, ignoring cautionary guidance by regulators, NGOs and the media select the country or agency with the tightest cutoff and then portray this number as exact, as the best estimate of risk and as predictive of cancer incidence. But that misstates what a cutoff number means. As the EPA notes, "The actual risk [from exposure to a chemical] may be significantly lower and may indeed actually be zero. It is important to recognize that the use of this model results in risk estimates that are protective, but not predictive of cancer incidence."

Employing this model, a range of chemicals, including aminotriazole, DDT, cyclamates and Alar, at one time or another, have been in the crosshairs of environmental groups because of supposed cancer-causing effects on humans. Toxicology studies are important in public health because epidemiology is not very sensitive as you cannot conduct experiments on humans. They

serve as a basis for potency estimates and offer the opportunity to compare risks. However, the advantages of these studies must be balanced with their potential to exaggerate risk. High-dose effects do not necessarily occur at low doses and effects that occur in test species do not necessarily occur in humans exposed to the same agents. Fear of the unknown and exaggerated precautions shouldn't be invoked to impede scientific progress.

Common Myths and Facts About Chemicals

Myth #1: A chemical-free world would be safer and healthier.

A chemical-free world is not possible. Everything—people, plants, animals, rocks, cars, air—is made up of chemicals. Some of these chemicals occur in their natural state and others are produced by combining naturally occurring chemicals.

Chemicals are everywhere—in living things, in inanimate parts of the environment and in the products vital to our health and quality of life. The natural world operates through the interactions of a vast array of chemicals. For example, humans need the chemical oxygen to survive. Plants, on the other hand, need carbon dioxide to grow and flourish. Thus, the chemical waste product of one form of life is the raw material for another. Even beneficial chemicals are dangerous at high levels. We need some 20 percent oxygen in air, but humans exposed to 100 percent oxygen for more than 24 hours will suffer massive lung damage.

Humans depend on many other types of chemicals including proteins,

carbohydrates, fats, metals and vitamins. These are supplied by food. The chemicals in the food we eat are utilized as raw materials for our growth and functioning. However, because humans are so complex, some of the chemical processes needed for these activities can malfunction. As a result, humans are subject to a variety of diseases that reflect excesses or deficiencies in these essential chemicals. For example, diabetes can result from the lack of production of the chemical insulin. Fortunately, it is now possible to make insulin synthetically and add this chemical to humans to counteract the effects of diabetes.

Thus, we are dependent on synthetic, as well as natural, chemicals for treating disease and improving both longevity and the quality of life. Both natural and synthetic chemicals are integral to all aspects of modern life. For example, natural chemicals in petroleum power cars, trucks and other vehicles, providing us with mobility and access to foods and goods from faraway places. Synthetic chemicals are critical to the functioning of the cornucopia of electronic devices, including computers and cell phones, giving us the ability to communicate around the globe instantaneously. There is no such thing as a chemical-free product and, indeed, chemicals are essential to human life and to our standard of living. Not only is a chemical-free world unachievable, it would be undesirable if it were possible.

Myth #2: Synthetic chemicals are dangerous; natural chemicals are safe.

All chemicals, whether synthetic or natural, have the potential to cause harm to people under the right circumstances. There are no nontoxic chemicals. Chemicals differ only in the types of toxicity they can cause and the exposure level at which these effects occur.

Many natural chemicals are toxic at high doses, including those in the food we eat and the water we drink. For example, a number of chemicals that occur naturally in our diet have been shown to be carcinogenic to rodents at high doses. Others, such as compounds found in soy products, can cause effects similar to those of human hormones. Thus, natural chemicals that are

critical for life may also cause harm if humans are exposed to them under certain conditions. Similarly, other natural chemicals, such as arsenic, have been shown to cause adverse effects in humans when found in high levels in drinking water. The toxicology literature is rich with stories of "endemic diseases" caused by natural food ingredients.

The same types of effects that are produced by exposure to natural chemicals, such as carcinogenicity and hormonal effects, also can occur from exposure to synthetic chemicals. In almost all cases, these effects occur only at high doses and so, as a group, synthetic chemicals are no more toxic than natural ones. The potency of a chemical does not depend on whether it is natural or synthetic; some of the most toxic chemicals are natural and some of the least toxic are synthetic. Indeed, there are a number of natural chemicals that are very highly toxic; these include the toxins that cause botulism and tetanus.

Both synthetic and natural chemicals can be toxic and present risks. Whether a chemical should or should not be used should be based on its risks and benefits, and how or if it should be used. For example, a synthetic chemical used as a pesticide may be very important for destroying insects that carry dangerous diseases but may also cause toxicity at high doses. Chemicals naturally occurring in gasoline, a product critical for transportation, may also cause toxicity if exposures are high. In both cases, these chemicals are valuable because their benefits outweigh their risks.

Myth #3: Synthetic chemicals are the cause for the rising incidence of many serious diseases, including cancer.

First, over the past few decades there has been a decrease, not an increase, in the rate at which new cancers are diagnosed and the rate at which people die from cancer. Second, while there have been reported increases in the incidence of other diseases, the causes for such increases are not known.

Cancer is a disease that causes dread because of the toll it takes on victims and their families. Because cancer is a disease that becomes more common as

we age, the number of cancers has been increasing as we live longer. This increase in number gives the perception that cancer is becoming more common at all ages. However, when the incidence and death rates for cancers are calculated for each age group, it can be seen that they are decreasing. For example, if we looked at the rate of cancer in 80 year olds today, we would find that it is lower than it was in 80 year olds 10 years ago.

Cancer is not the only health problem that is of serious concern. Diseases that affect children, such as autism and asthma, also have been in the public eye because of reported increases in the numbers of cases of these illnesses. Careful studies of the reasons for these increases suggest that in many cases they are apparent, not real. This can occur due to changes in diagnostic practices, greater availability of diagnostic and treatment services, earlier age at diagnosis and greater public awareness. The scientific evidence does not support claims that these diseases are due to chemical exposures.

Further, when overall health indicators—rather than the incidence of individual diseases—are examined, it is clear that the health of the American population has been continually improving. Longevity has increased significantly during the last 50 years, a period marked by a tremendous increase in the types and amounts of chemicals in everyday use. In addition, people are staying healthy longer, so that the quality of life as well as our average lifespan has improved in recent generations.

Thus, the myth that there has been a rising incidence of serious illnesses and that these are due to the increased use of synthetic chemicals does not stand up to scrutiny. It is very clear that public health has improved significantly over the recent past, due in large part to the contributions of synthetic chemicals to the diagnosis and treatment of a wide variety of diseases. Careful analysis reveals that many claimed increases in diseases are not real. In addition, in-depth assessments of the causes of existing cases of these illnesses do not demonstrate a connection between the diseases and environmental chemicals.

Myth #4: Detection of a chemical in the environment or a sample of blood or urine means that people are in danger of adverse effects.

People are exposed to thousands of natural and synthetic chemicals each day without evidence of harm. Thus, the detection of a chemical in the environment or in a sample of blood does not imply that toxic effects are occurring.

Because natural and synthetic chemicals occur in the environment around us, people are exposed to these agents each day in the air they breathe, the water they drink and the food they eat. Therefore, it is not surprising that these chemicals can be found in samples of human blood and/or urine. Indeed, reports about the variety of chemicals found in such samples are common in the media. In some cases, reporters have written stories on analyses of their own blood or urine to dramatize the findings. In other instances, reports feature the results of large-scale government studies on the blood and/or urine levels of environmental chemicals.

What does the discovery of these chemicals in human fluids mean? First, human blood and urine normally contain a wide variety of natural chemicals. Blood contains nutrients that are carried throughout the body, but it also transports unwanted waste products resulting from normal body processing of these nutrients. These products go to the kidneys where they are excreted in urine. Many of these waste compounds can cause serious effects in people if they build up to high levels as can happen when the kidneys do not function properly.

Similarly, a number of environmental chemicals, both natural and synthetic, can be found in the blood and urine. The human body has the ability to excrete these just as it excretes its own unwanted waste products. The presence of such chemicals does not imply that any adverse effects are occurring, just as the presence of the body's waste products does not mean that the humans carrying them are suffering toxicity. Only if these environmental chemicals build up to high levels is there a likelihood of harm.

Careful analysis by government scientists of the levels of these environmental chemicals in blood and/or urine demonstrates that they are almost always present at very low levels, often called trace levels. These levels are not high enough to cause any harm; just because they are present does not mean that there is a risk involved. These analyses tell us only if people have been exposed to the chemicals studied — not if any effects are likely. Additional information, such as how often exposure has occurred, for how long and at what levels, is necessary to determine the possibility of toxic effects.

Myth #5: Chemicals used in food, consumer products and agriculture have not been shown to be safe.

Since all chemicals, natural or synthetic, can cause toxicity at some dose, none of them are absolutely safe. Indeed, there is no way to show that any chemical is absolutely safe at any dose since you can always imagine other tests that could be performed to look for more and more obscure and unlikely effects.

Since absolute safety is not a possibility, the question is whether these food, consumer and agricultural chemicals have undergone enough testing so there is a reasonable likelihood that they will cause no harm when used properly. While it has been claimed that adequate testing and evaluation have not been performed — and thus that our food and consumer products are unsafe — a careful analysis shows that this is not the case.

The claims of insufficient testing are of two types. The first is based on the idea that the current toxicity tests are not appropriate in the light of new knowledge. A good example of this is the assertion that chemicals can show no effects at high doses but still produce significant toxicity at much lower doses. Those who espouse this view say it demonstrates that traditional testing done at high doses may miss toxic effects. That's a controversial hypothesis that has, as yet, limited support among scientists.

The second type of claim is that not enough testing has been done or

that it has been performed and/or evaluated in a biased way. Generally, the incomplete or biased testing results are linked to industry. While it is true that much of the toxicity testing of products in commerce is performed by industry, this is because the federal regulatory system requires such evaluations. This approach has been very successful in almost all cases, as evidenced by the overall safety of the food supply and the very small number of chemicals in consumer products that have been shown to cause any toxicity, even in sensitive individuals, when used as intended.

Thus, the belief that chemicals have not been adequately tested before the public is exposed to them does not hold up under careful scrutiny. It is based on two assertions, neither of which is supported by the evidence. The first, that current test methods are inadequate, is based on assertions of scientists who do not represent the scientific consensus and the second, that industry testing is insufficient and/or biased, is not supported by the safety records of foods and consumer products.

Myth #6: If there is any evidence that a chemical might cause harm, it should be taken off the market.

As stated previously, all chemicals, both natural and synthetic, are toxic at some exposure level so applying this principle would lead to the removal of all chemicals, whether beneficial or not. This approach would deny people the benefits of drugs that cure serious diseases, disinfectants that protect citizens against microorganisms, pesticides that protect us against insect-borne diseases and a host of lifesaving medical devices.

Those who believe that chemicals should be removed from the market whenever there is the slightest evidence that they may cause harm base this view on the "better safe than sorry" precautionary principle. However reasonable this principle may seem on the surface, this approach is unlikely to make you safer and, instead, could very well increase risk.

Why is this? For one, devoting resources to taking a chemical—and products containing it—off the market and replacing it means that these

same resources will not be available to assess other risks. If there is little evidence that this product causes serious harm, then it is unlikely there will be any reduction in risk from removing it. On the contrary, since this action would divert resources from known risks to public health, it is more likely that there would be a net decrease in safety.

In addition, the replacement of a product in common use has environmental consequences since it would require the use of significant amounts of energy to collect and dispose of the banned substance and to develop, produce, market and distribute a replacement. Generating the energy needed for these steps would be associated with pollution and the potential for adverse effects in people exposed to these pollutants. Thus, the replacement process itself entails risks that must be considered.

It is often the case that at least some of the benefits of the product being replaced are lost. This happens because many products, such as plastics in medical devices, are in use because of unique properties that cannot be exactly duplicated. So, in addition to a significant possibility of increased risk from banning a chemical of unproven harm, there is also the likelihood of a loss of benefits.

Because all chemicals are toxic, it is quite likely that there will be some toxicity associated with the replacement. It is often not clear until a product has been in use for a long time what this toxicity is and how many people it may affect. It is quite possible that the replacement chemical, and products containing it, will be associated with at least as much risk as the original chemical. The application of the principle of "better safe than sorry" can result in the replacement of an unsubstantiated risk with an unknown one.

The seemingly prudent step of taking chemicals off the market when there is the slightest suggestion of toxicity in unlikely to accomplish what is intended. Because there is no solid evidence of harm, it is not clear that any reduction in risk will occur. It is much more likely that there will be an overall increase in risk, because the substitution process incurs other risks, as well as a loss of benefits if the chemical and products containing this chemical are taken off the market. The really prudent step is to make

the best scientific evaluation of the risk from the product as compared to the risks and loss of benefits associated with removing it from the market before any actions are taken.

Conclusion

Throughout history, scientific innovations and discoveries have been subject to criticism and resistance. It is primarily the fear of the unknown that fuels this sentiment. This is not to say that reasonable concerns regarding scientific innovations should be ignored. Appropriate safeguards should be implemented while adopting the latest technology. But we have to recognize that most activities involving technology will have undesired effects as well as desirable ones. Had it not been for a stream of scientific innovations throughout history, the world today would not be able to support seven billion people living in dynamic and complex community systems. Science and technology have improved our lives in more ways than we can imagine, and chemicals have played a key role. Let's hope that continues.

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