POPs Culture

by Anne Platt McGinn
Between 1962 and 1970, U.S. soldiers and their South Vietnamese allies sprayed nearly 12 million gallons of herbicide over vast tracts of Southeast Asian forest and more than half of South Vietnam’s arable land. The program was designed to eliminate any cover that might conceal North Vietnamese Army units or Viet Cong guerrillas. The crews on the planes that did the spraying devised a slogan for themselves—a variation on a famous “Smokey the Bear” public service message back in the United States. They said, “only you can prevent forests.”

The herbicide came in orange-striped drums, so it was called “agent orange.” It was a mixture of two chemicals: 2,4,5-T and 2,4-D, both of them commonly used herbicides at the time. As with complex synthetic chemicals in general, these herbicides contained trace amounts of various unwanted substances that arose as byproducts of production. Among the byproducts were some of the chemicals called dioxins. A 1985 report by the U.S. Environmental Protection Agency called dioxins “the most potent carcinogen ever tested in laboratory animals.” More recent laboratory work has linked dioxins with birth defects, spontaneous abortion, and injury to the immune system. When those two herbicides were sold in the United States, they typically contained dioxin concentrations of about 0.05 parts per million. But agent orange had dioxin concentrations up to 1,000 times as high.

At the time, the spraying of agent orange seemed a relatively minor part of the conflict. The dioxins, however, will linger in Vietnam’s soil long after the war has vanished from living memory. Yet no one is really sure how much damage has been done. Medical doctors in Vietnam do not, by and large, have the resources to carry out longterm public health studies, but some doctors report that in sprayed areas, certain birth defects have become more common: anencephaly (absence of all or part of the brain), spina bifida (a malformation of the vertebral column), and hydrocephaly (overproduction of cerebrospinal fluid, causing a “swelling” of the skull). Immune deficiency diseases and learning disabilities may also be higher in sprayed areas. And if the human damage is uncertain, the broader ecological impact is a complete mystery.

In part because it is so vague, the agent orange legacy illustrates some of the worst aspects of dealing with dangerous synthetic chemicals like dioxins. For purposes of environmental analysis, dioxins are grouped in a loose class of potent toxins known as POPs, short for “persistent organic pollutants.” The full definition of a POP, however, is somewhat more complex than the acronym implies. In addition to being persistent (that is, not liable to break down rapidly), organic (having a carbon-based molecular structure), and polluting (in the sense of being significantly toxic), POPs have two other properties. They

**If there’s one form of industrial innovation that we can definitely do without, it’s the kind that is continually producing new Persistent Organic Pollutants—toxins so potent and durable that current emissions may still be causing cancer and birth defects 1,000 years from now.**

_by Anne Platt McGinn_
are fat soluble and therefore liable to accumulate in living tissue; and they occur in the environment in forms that allow them to travel great distances.

If you put all five of these properties together, you can begin to see the potential for “agent orange scenarios” in many places. We know that POPs are very dangerous, but we can never be sure exactly who will be injured by them. In the 1970s, for example, a group of children developed leukemia (a usually fatal blood disorder involving uncontrolled production of white blood cells) in Woburn, a small town in Massachusetts. The leukemia had apparently been caused by solvents in the tap water. But why did the disease emerge only in certain children and not in many others who also presumably ingested the solvents? It often takes sophisticated statistical analysis to find any connection at all between contamination and injury—that’s one of the reasons it’s so difficult to assess the public health risks from POPs. But of course statistics can’t capture the experience of contamination: such a threat can seem like an evil lottery.

The apparent randomness of the threat is exacerbated by the fact that injury is often delayed or indirect. Extremely toxic chemicals can bide their time, then poison their victims in ways that are very hard to see. Benzene, for example, is a common solvent. It’s an ingredient in some paints, degreasing products, gasoline, and various other shop and industrial compounds. If you’re heavily exposed to it, you stand a heightened chance of developing cancer—and so may any children that you have after your exposure. That’s true even if you’re a man, since fetal exposure isn’t the only way benzene may poison children: it can reach right into your chromosomes and injure the genes your child will inherit. Benzene may do its damage without ever touching the child directly at all.

POPs are potent ecological poisons as well. And just as in the human body, their ecological effects often exhibit a kind of weird indirection. In the United States in the 1960s, for example, biologists began to find strong field evidence that the pesticide DDT (dichlorodiphenyltrichloroethane) and similar chemicals were dangerous. But the evidence didn’t come from the organisms that had absorbed the pesticides directly. It came from birds of prey—eagles and falcons—who were suffering widespread reproductive failure. Too few eggs and egg shells so thin they cracked soon after laying: these were the results of a type of indirect poisoning known as bioaccumulation. The fat solubility of the pesticides allowed them to concentrate in the tissues of their hosts as they moved up the food chain, from insects to rodents to raptors. Even today, the North American Great Lakes basin is showing the effects of certain POPs, like DDT, which have not been used in the region for decades. Eagle populations are still depressed; tumors continue to appear in fish, birds, and mammals.

But there is one way in which the agent orange scenario deviates from the norm. Most POPs owe their presence in the environment not to the horrible exigencies of war, but to ordinary industrial processes—plastic and pesticide manufacturing, leaky transformers, waste incineration, and so forth. POPs are an inevitable byproduct of business as usual. By design and by accident, we are continually introducing new chemicals into the environment without any clear notion of what they will eventually do—or whether we may one day find ourselves in a desperate scramble to remove them. And among the tens of thousands of chemicals that have been in circulation for decades, relatively few have been studied for their health and environmental effects. Consequently, no one knows exactly how many POPs there are, but it’s likely that many thousands of chemicals could qualify for the term.

And beyond their number is the question of their effect: while POPs are toxic by definition, their longterm health...
and environmental impacts are still largely unknown. Even more complex than evaluating individual POPs is the looming need to understand what kinds of synergistic interactions could be triggered by overlapping exposure—to multiple POPs or to POPs combined with other chemicals. Multiple contamination is the rule, rather than the exception, but virtually nothing is known about it. What we do know is that most of the world’s living things are now steeping in a diffuse bath of POPs. And that almost certainly includes you. No matter where you live, you’re likely to be contaminated by trace amounts of POPs. They’re in your food and water; they may be in the air you breathe; they’re probably on your skin from time to time—if, for instance, you handle paints, solvents, or fuels.

Currently, 140 nations are negotiating a treaty to phase out 12 specific POPs (see table, page 32). This so-called “dirty dozen” includes nine pesticides, one group of industrial compounds known as polychlorinated biphenyls (PCBs), and two types of industrial byproducts, the dioxins and their
chemical cousins, the furans. The treaty is called the “International Legally Binding Instrument for Implementing International Action on Certain Persistent Organic Pollutants” and as its name suggests, it is a laudable but rather timid effort. Its supporters hope that it will eventually serve as a mechanism to phase out dozens of other POPs. But at least in its present form, it doesn’t address the fundamental problem. If we want to reduce the risks from the vast and growing number of synthetic chemicals that are being released into the environment, we will have to rethink some of our basic notions of industrial development.

**Every Twenty Seven Seconds**

There are now over 20 million synthetic chemicals, and that number is increasing by more than 1 million a year. As a rough global average, a new chemical is synthesized every 27 seconds of the day. Very few of these substances ever go into commercial production—something like 99.5 percent remain academic curiosities, or rapidly forgotten attempts to produce a new pesticide, or solvent, or whatever. But every year another 1,000 or so new compounds enter the chemical economy, either as ingredients in finished products, or as “intermediates”—chemicals used to make other chemicals. The total number of

**DISPERAL**

Over the decades, transformers deteriorated or were destroyed—some by lightning, others by demolition. The PCBs leaked into the ground and were dispersed by runoff into streams or slow seepage into aquifers. Some lodged in soil that baked in the sun, turned to dust, and blew away, eventually settling throughout the global environment.
synthetics in commerce is probably now somewhere between 50,000 and 100,000. But the total number of synthetics in the environment is probably far greater than that, because of the byproducts (like dioxins) unintentionally generated during production, and because of the breakdown products that result from the decay of commercial substances.

Chemical innovation on this scale creates an enormous biological risk, despite the fact that many synthetic chemicals are probably harmless, and many naturally-occurring chemicals are extremely dangerous. To understand the risk, it’s useful to have a general sense for what usually happens with natural toxins. Most really potent natural toxins break down far more readily than POPs. Powerful natural toxins also tend to be geographically isolated—they aren’t usually dispersed throughout the environment. And while it’s true that there are some natural forms of “mass poisoning,” such events are generally episodic rather than continual—think of “red tide” algal blooms along ocean shorelines, for example. Finally, apart from such mass poisonings, any really powerful poison produced by a living thing is likely to be “trophically isolated”—that is, it will tend to affect only organisms that play certain ecological roles. To be poisoned by a toxic frog, for example, you almost have to be a frog predator. Don’t mess with the frog and you’ll be fine. The toxic frog paradigm does not, however, apply to our current chemical economy, which is causing broadscale, chronic exposure to powerful toxins at virtually every ecological level.

Not all manufactured chemicals are organic (that is, carbon-containing); inorganic chemicals play key industrial roles as well. Sulfuric acid (H₂SO₄), for example, is a key feedstock for much chemical production, especially fertilizer. But most

**ACCUMULATION**

PCB-containing dust that settled in lakes or rivers became a nutrient for algae. Water fleas ate the algae. Small shrimp ate the fleas—each shrimp eating many fleas and bioaccumulating the PCBs that lodged in its fat. Small fish called smelt ate the shrimp, and trout ate many of the smelt—each stage increasing the concentration of the toxin.
commercially important inorganics, like sulfuric acid, aren’t synthetic in the sense of being completely artificial—they occur in nature. And synthetic or not, only around 100,000 inorganic chemicals are known. Contrast that with the many millions of organic compounds now known—most of them wholly artificial—and you can begin to get an idea of the stupifying variety in molecular structure that carbon permits.

Large-scale industrial production of organic chemicals was well underway by the middle of the 19th century. Refineries in both Europe and the United States were using coal to produce kerosene—or “coal oil,” as it was then called. In 1859, western Pennsylvania became the site of the world’s first oil well. As other oil fields opened in the United States, Europe, and east Asia, those coal refineries became oil refineries, and industry acquired a vast and extremely versatile supply of lubricants and fuels. Synthesis of completely novel compounds began in European laboratories at about the same time. DDT, for example, dates from 1874, when it was synthesized by a German chemistry student, although its pesticidal properties were not appreciated until the 1930s. The first plastics were synthesized from cellulose (the primary constituent of wood) in the 1890s. By the end of the century, organic chemistry had revolutionized a major industry—the production of dyes.

The key to that development was the realization that synthetics could be produced in abundance directly from oil, instead of from living plant products. With a cheap source of raw material at hand, synthetics offered an answer to war-time shortages of often much more expensive natural products. Vinyl,
for instance, was developed in the 1920s as a rubber substitute; during World War II, it helped ease the demand for this essential plant product—tires still had to be made of rubber, but vinyl worked well as a wire insulator.

In the years following the war, synthetics flooded one manufacturing process after another, since they were often much cheaper than such traditional materials as rubber, wood, metal, glass, and plant fiber. In some cases the synthetic displaced a traditional material outright, but arguably just as important has been the interest in combining old and new—the metal that has a specialty coating to make it more durable, the flooring laminate composed of resin and wood fiber, and so forth. In ways large and small, synthetics have transformed our built environments—and not simply by replacing things that were made before out of some other material, but by allowing for the creation of products that probably wouldn’t otherwise have existed, at least on a mass scale. Plastic, for instance, is as fundamental in electronics manufacturing as microchips. Today, synthetic organic chemicals flow through just about every pipe in the chemical economy (see table, page 35).

Not surprisingly, the volume of synthetic organic chemical production has moved continually upwards ever since large-scale manufacturing began in the 1930s. Global production escalated from near zero in 1930 to an estimated 300 million tons by the late 1980s. In the United States alone, production has soared from about 150,000 tons in 1935 to nearly 150 million tons by 1995—almost a thousandfold increase. Cinema fans may recall the one word of advice given to the confused young man played by Dustin Hoffman in the 1968 film, “The Graduate”: “Plastics.” The trend was as clear then as it is now: U.S. production of plastics has increased 6-fold since 1960.

The chemical structure of synthetic organics

### Production and Use of the “Dirty Dozen” POPs

<table>
<thead>
<tr>
<th>Material</th>
<th>Date of Introduction</th>
<th>Cumulative World Production (tons)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Aldrin (insecticide)</td>
<td>1949</td>
<td>240,000</td>
</tr>
<tr>
<td>Chlordane (insecticide)</td>
<td>1945</td>
<td>70,000</td>
</tr>
<tr>
<td>DDT (insecticide)</td>
<td>1942</td>
<td>2.8–3 million</td>
</tr>
<tr>
<td>Dieldrin (insecticide)</td>
<td>1948</td>
<td>240,000</td>
</tr>
<tr>
<td>Endrin (insecticide and rodenticide)</td>
<td>1951</td>
<td>(3,119 tons in 1977)</td>
</tr>
<tr>
<td>Heptachlor (insecticide)</td>
<td>1948</td>
<td>(900 tons used in 1974 in the U.S.)</td>
</tr>
<tr>
<td>Hexachlorobenzene (fungicide and byproduct of pesticide production)</td>
<td>1945</td>
<td>1–2 million</td>
</tr>
<tr>
<td>Mirex™ (insecticide and flame retardant)</td>
<td>1959</td>
<td>no data</td>
</tr>
<tr>
<td>Toxaphene™ (insecticide)</td>
<td>1948</td>
<td>1.33 million</td>
</tr>
<tr>
<td>PCBs (liquid insulators in transformers, hydraulic fluids; ingredients in some paints, adhesives, and resins. No longer generally produced in industrialized countries.)</td>
<td>1929</td>
<td>1–2 million</td>
</tr>
<tr>
<td>Dioxins (byproducts of organochlorine production and incineration, and of wood pulp bleaching)</td>
<td>1920s</td>
<td>(10.5 tons International Toxic Equivalency of dioxins and furans combined in 1995)</td>
</tr>
<tr>
<td>Furans (same as with dioxins)</td>
<td>1920s</td>
<td></td>
</tr>
</tbody>
</table>

varies enormously, of course, but when it comes to assessing the potential of any particular chemical to cause trouble, either in the human body or in the environment, one question is of overriding importance: does it contain chlorine? Chlorine is highly reactive—that is, it combines very readily with certain other elements and it tends to bind to them very tightly. (The big exception to this rule involves a looser association called an ionic bond. For example, sodium chloride, or table salt, is the product of an ionic bond between a chlorine and a sodium atom. Such a bond is weak enough to allow the two atoms to separate from each other in solution.) Carbon is one of the elements that chlorine will bond to, although in nature such combinations, known as organochlorines, are rarely abundant. (There are a few exceptions, such as salt marsh emissions of methyl chloride.) But chemists have found that by adding chlorine to carbon-based compounds, an even greater molecular variety becomes possible. Chlorine’s ability to snap firmly into place—and to anchor all sorts of chemical structures—has made it, in the words of W. Joseph Stearns, Director of Chlorine Issues for the Dow Chemical Company, “the single most important ingredient in modern [industrial] chemistry.”

Take a sophisticated chemical sector, like that of the United States, and consider the importance of chlorine in it. Chlorine is used to make thousands of chemicals—solvents, pesticides, pharmaceuticals, bleaches, and so on. Around 11,000 organochlorines are in production. The biggest readily identifiable category of these is plastic. Of the more than 10 million tons of chlorine that the U.S. industry consumes each year, about one-third goes to produce 14 different types of plastic. The most common of those is polyvinyl chloride (PVC), which is light, strong, and easy to mold. PVC is used to make plastic wrap, shoe soles, automobile components, siding, pipes, and medical products, among other things. In less than a decade, from 1988 to 1996 (the most recent year for which figures were available), global production of PVC expanded by more than 70 percent, from 12.8 million tons to 22 million tons. In the use of products like PVC, you can see how thoroughly we’ve enveloped ourselves in organochlorines.

Although many organochlorines are not known to be dangerous, a substantial number of them do create major risks. In large measure, those risks are the result of three common characteristics. Organochlorines are very stable—that’s obviously part of their manufacturing appeal, but it also means that they don’t go away. They tend to be fat soluble, which means that they can bioaccumulate. And many of them have substantial chronic toxicity—that is, while exposure over the short term may not be dangerous, long-term exposure frequently is. (The reasons for toxicity vary. Some organochlorines can “mimic” naturally-occurring chemicals such as hormones, thereby upsetting the body’s chemical processes; some weaken the immune system; some affect organ development, some promote cancer, and so on.) Stability, fat solubility, and chronic toxicity: does that begin to sound like a POP? Chlorine certainly isn’t required to make a POP. Among the nonchlorinated POPs are various organometals (used, for example, in marine paints) and organobromines (used as pesticides and as liquid insulators in electrical equipment). But most known POPs—including all of the “dirty dozen”—are organochlorines.

Organochlorine pesticides are the class of products that has produced what are probably the most notorious POPs (see the table on page 32 for some examples). It’s hardly surprising that pesticides are a major ingredient in our stew of dangerous chemicals—after all, pesticides are designed to be toxic and they are produced in enormous quantities. Since 1945, global production of pesticides has increased an estimated 26-fold, from 0.1 million tons to 2.7 million tons, although growth has slowed in the last 15 years, as health and environmental concerns have inspired an increasing number of bans, primarily in industrialized countries. These restrictions have reduced the total quantity of pesticides used in the industrialized countries, but the toxicity of particular pesticides has continued to grow. Current pesticide formulations are 10 to 100 times as toxic as they were in 1975.

Today, pesticide manufacturers usually want their products to have a high acute toxicity and low chronic toxicity. They’re looking for compounds that will kill quickly but that don’t haunt the field indefinitely, so organochlorines, with their substantial chronic toxicities, no longer have the universal appeal they once did. Newer pesticides are less likely to contain chlorine. That’s obviously good, but not good enough, for two reasons: non-organochlorine pesticides also sometimes turn out to be POPs, and nearly all the old products are still with us anyway. They persist in the environment and most are still used in developing countries.

A more obscure array of POPs involves a family of organochlorines that have been used as liquid insulators in electrical equipment, as hydraulic fluids, and as trace additives to plastics, paints, even carbonless copy paper. These are the polychlorinated biphenyls, or PCBs. For decades, the extreme stability, low flammability, and low conductivity of POPs made them the standard liquid insulation in transformers—and since transformers are a near-ubiquitous part of every electrical grid, PCB contamination is now a standard form of landscape poisoning. In industrialized countries, PCBs were manufactured mostly between the 1920s and the late 1970s; they are still manufactured in Russia and are still in use in many developing
countries. Scientists estimate that up to 70 percent of all PCBs ever manufactured are still in use or in the environment, often in landfills where they are gradually seeping into water tables. The United Nations Environment Programme (UNEP) recently published guidelines for helping officials in developing countries identify PCBs. But given their multiple uses and more than 90 trade names, simply finding them is going to be a mind-boggling task—let alone cleaning them up.

But the overwhelming majority of POPs are not intentionally produced—they’re by-products, like dioxins and furans, two classes of POPs that result primarily from organochlorine production, the bleaching of wood pulp, and the incineration of municipal waste. A 1995 UNEP emissions inventory of 15 countries traced some 7,000 kilograms of dioxin and furan releases to incinerator emissions—that’s 69 percent of the total releases of those substances in these countries. (Seven thousand kilograms may not sound like all that much—but bear in mind that these are extremely toxic substances usually produced in trace quantities.) There are 210 known dioxins and furans. And among the byproducts of organochlorine production and use, it’s almost certain that many more thousands of POPs remain to be discovered.

**Do we really need it?**

Over the past three decades or so, attempts to regulate the chemical industry in the industrialized world have grown to a phenomenal degree. In the United States, for example, the effort now involves four federal agencies on a regular basis, and at least seven major pieces of federal legislation, which address pesticides, pollution, and attempt to promote cleaner industries. Any new synthetic produced in Europe or the United States is now subject to some degree of toxicity testing before it can be injected into commerce.

But despite this gargantuan bureaucratic effort, the current regulatory approach is no match for the threat. In the first place, most of the toxicity testing is done by the companies themselves—a practice that invites obvious conflicts of interest. Nor do current efforts offer a realistic possibility of dealing with the testing backlog. Tens of thousands of chemicals entered commerce in the decades before testing was required—and we still have no clear notion of the risks most of them pose. Fewer than 20 percent of the chemicals in commerce have been adequately evaluated for toxicity, according to a 1984 National Academy of Sciences report. (It’s perhaps a reflection of the magnitude of the problem that this 16-year-old report should still be widely cited.)

And then there is our uncertainty over what we ought to be testing for. The toxicology of synthetic organics is in a near constant state of flux, and the difficulty of establishing a causal link between exposure and injury opens the science up to all sorts of tendentious reinterpretation. Anyone familiar with the smoking and health debates will recognize this problem. Take dioxins, for example. Chloracne—the severe skin deformity that is the hallmark of dioxin poisoning—was identified more than a century ago, in 1899. In 1998, the UN World Health Organization (WHO) reduced its standard for tolerable daily intake of dioxin-like substances from 10 picograms per kilogram of body weight per day to 1-4 picograms. So a person who weighs 68 kilograms (about 150 pounds) shouldn’t be exposed to more than 4 trillionths of a gram per day. For infants, the safe levels are even more minuscule. Yet just a couple of years ago, a consultant to the Chemical Manufacturers Association reported that “dioxin has not been shown to pose any health threat to the general public.”

Even where obtfuscation is not an issue, advances in toxicology tend to create a second testing backlog, since thousands of previously-screened chemicals may need to be re-evaluated. In 1996, for example, the United States launched a major pesticide re-evaluation program, in the light of new research on how these chemicals can affect children, whose high metabolism and rapid rate of physical development make them more vulnerable to certain kinds of toxins. Thus far, screening has been completed on less than a quarter of U.S. pesticide “registrations.” (The United States regulates pesticides by designating specific uses permitted for each chemical; each such use is known as a registration.)

The shifting horizon of toxicology can call into question even widely accepted synthetics. The plasticizers known as phthalates, for example, are believed to be among the most common industrial compounds in the environment. Yet recent laboratory research in animals has linked phthalates to damage to the liver, kidney, and testicles, as well as to miscarriage, birth defects, and reduced fertility. Incineration of phthalates produces dioxins. Phthalates occur in everything from construction materials to children’s teething rings. And among the 1,000 new chemicals that will enter the economy this year, who knows how many more such discoveries will eventually be made?

In its current form, the chemical sector is clearly at odds with our collective obligation to maintain human and environmental health. What is needed is fundamental reform—a change that goes far deeper than conventional regulation. That reform could start with a very simple but revolutionary idea: it’s wise to avoid unnecessary risk. This is the kernel of one of the environmental movement’s core concepts: the precautionary principle. The principle states that when any action is contemplated that could affect the environment, those who advocate the action should...
show that the risks are either negligible, or that they are decisively outweighed by the benefits.

The principle reverses the usual burden of proof. In most environmental controversies today, that burden effectively rests with those who argue against an action: they must usually persuade the public or policy makers that the benefits are outweighed by the risks. But of course, we rarely understand the risks until after the fact—and maybe not even then. That’s the problem the principle is meant to address; it’s a kind of insurance policy against our own ignorance.

In terms of our chemical use, a reasonable application of the precautionary principle would require us to assume that in certain chemical classes—organochlorines, for example—any new compound is dangerous. The next step would be to ask: do we really need it? This kind of inquiry would tend to foster a different kind of inventiveness, both within the chemical industry and within society as a whole. The emphasis would tend to shift from inventing new chemicals, to inventing new uses for chemicals thought to be reasonably safe, and to inventing new procedures that may not be dependent on chemicals at all. Fewer new chemicals would come into commerce; a growing number of established ones would come out.

There is already a strong precedent for this kind of chemical “stand down” in the impending ban of chlorofluorocarbons (CFCs), the now-notorious class of chemicals once almost universally used as refrigerants and spray-can propellents. CFCs were found to be weakening the stratospheric ozone layer, which shields the Earth’s surface from harmful ultraviolet radiation. Under the Montreal Protocol of 1987, CFCs are being phased out in favor of other compounds that are less harmful to the ozone layer. In many parts of the chemical economy, you can see the potential for similar developments. Consider three examples.

**Pesticides:** the phase-out may already have begun

Pesticides are the mainstay of monoculture farming. They are the mechanism that allows for vast expanses of pure corn, cotton, or soybeans—a highly unnatural condition that is very vulnerable to infestation. But pesticides are also expensive and dangerous, and these liabilities underlie the growing boom in organic agriculture. In the industrialized countries, organic production (which uses no synthetic pesticides) is the strongest market within the agricultural sector. In the United States, the organic market has been growing at a rate of 20 percent per year since 1989. Some 35 percent of U.S. consumers look for the organic label at least part of the time. In Europe, one-third of the continent’s farmland is expected to be in organic production by the end of this decade. Organic and other forms of low-pesticide farming usually involve more careful stewardship of the soil and more diverse plantings, which tend to have fewer pest problems than conventional monocultures. Even though the yield of a particular crop may be lower than in conventional agriculture, an organic farm can do just as well in terms of total productivity (that is, in terms of all the crops coming off a unit of land) and in terms of financial return—and that’s before you factor in the environmental benefits.

A thornier set of pesticide problems involves public health. DDT may be eliminated by the new treaty as an agricultural pesticide, but it’s still key to malar-
nia control in many parts of the tropics. Malaria kills 2.7 million people every year—a death toll greater than that of AIDS. In much of sub-Saharan Africa and tropical Asia, control of the mosquitoes that carry the disease is a life-and-death issue, and that has frequently involved the broadscale spraying of DDT. But even here, more careful targeting of the mosquitoes would permit enormous reductions in pesticide use—and might even improve malaria control. Researchers in Africa, for example, have demonstrated that bednets soaked in alternative, less-toxic insecticides can reduce malaria transmission by 30 to 60 percent and childhood mortality by up to 30 percent. And bednets are relatively cheap: a net plus a year’s supply of insecticide costs about $11. In 1993, WHO dropped its blanket spraying recommendation for DDT, in favor of targeted spraying of the insecticide indoors only.

**PVC:** taking the POPs out of the products

The incineration of solid waste is a primary generator of dioxins and furans. While better incineration procedures can greatly reduce this kind of contamination, the single most effective way to lower dioxin output is to get as much chlorine as possible out of the waste stream. PVC is the source of an estimated 80 percent of the chlorine that flows into municipal waste incinerators and nearly all the chlorine in medical waste incinerators (these are among the most important second-rank dioxin emitters, after the municipal incinerators). A top priority for the new chemical economy should therefore be the elimination of PVC, which is 45 percent chlorine by weight, in favor of low-chlorine or chlorine-free materials. Initially, the substitutes are liable to be more expensive than PVC, but even incipient demand could rapidly generate an economy of scale. The market prospects have already led the Exxon Corporation, one of the world’s largest PVC producers, to begin planning a shift from PVC to chlorine-free polyolefin plastics.

**Bleaching and benzene:** removing POPs from industrial processes

POP’s often haunt industrial processes to a far greater degree than they contaminate the products themselves. Thus, for example, paper is not ordinarily a source of organochlorine contamination while it’s being used. But paper production certainly is, and paper disposal can be as well, because the huge volume of paper converging on an incinerator may allow trace contaminants to concentrate. Both forms of contamination are caused by the use of chlorine bleaches to whiten woodpulp. Bleaching can produce up to 35 tons of organochlorines per day per mill. Yet this type of pollution is now almost wholly unnecessary—and the paper you’re looking at right now proves it. (WORLD WATCH is printed on paper that is bleached without any chlorine or chlorine-based compounds, although unfortunately, that is not yet true of our cover stock.) Thus far, only 6 percent of global bleached pulp production is “totally chlorine free,” but that includes more than a quarter of Scandinavian production, so the economic viability of the process is not in question. Some 54 percent of global bleached pulp production is now “elementally chlorine free”—meaning that a chlorine bleach was used, but at least it wasn’t raw chlorine. (Our cover stock falls in this category.) It’s true that converting a mill to chlorine-free production is expensive, but the picture is very different when you start from scratch. It’s actually cheaper to build a chlorine-free mill than a conventional one.

At least some of the more dangerous “intermediates” within the industry are probably susceptible to replacement as well. Benzene, for example, is a major feedstock chemical in the production of a wide range of materials—for example, dyes, film developing agents, solvents, and nylon. For some applications, however, it may be possible to replace benzene with the simple blood sugar, glucose. That may sound like a bizarre substitution, but it’s the ring structure of both molecules that allows for a degree of interchangeability. Glucose is cheaper to make than benzene (6 versus 13 cents per pound) and for all practical purposes, it’s harmless. As a feedstock, however, the processes for handling glucose are more expensive than the better-established processes for benzene, but these costs don’t take into account emissions control costs for benzene. In any case, the costs would presumably decline if the use of glucose as a feedstock became more common. Such adjustments deep within the industrial machinery may seem rather obscure, but they could be major news: the possibility of substituting an innocuous substance for an extremely dangerous one suggests that there may be all sorts of hidden opportunities for re-engineering the chemical sector.

If such re-engineering is to succeed, it will have to proceed from a much broader understanding of what we’re doing when we make and use synthetic chemicals. Whether we intend it this way or not, chemical manufacturing is as much an ecological process as it is an economic or industrial one. Any industry executive knows that a chemical plant has to make some sort of economic sense. The POPs legacy is telling us that it had better make environmental sense as well.

Anne Platt McGinn is a senior researcher at the Worldwatch Institute.