North Point Press
A division of Farrar, Straus and Giroux
19 Union Square West, New York 10003

Distributed in Canada by Douglas & McIntyre Ltd.
Printed in China
First edition, 2002

Library of Congress Cataloging-in-Publication Data
McDonough, William.
Cradle to cradle : remaking the way we make things / William McDonough and Michael Braungart.
p. cm.
ISBN 0-86547-587-3 (hc. : alk. paper)
1. Recycling (Waste, etc.) 2. Industrial management—Environmental aspects. I. Braungart, Michael, 1958– II. Title.
TD794.5 .M395 2002
745.2—dc21
2001044245

Designed by Janine James / The Moderns

www.fsgbooks.com

1 3 5 7 9 10 8 6 4 2

Remaking the Way
We Make Things

cradle to cradle

William McDonough & Michael Braungart

North Point Press
A division of Farrar, Straus and Giroux
New York

›ducts and systems that celebrate an abundance of human ›ativity, culture, and productivity? That are so intelligent and fe, our species leaves an ecological footprint to delight in, not ment?

Consider this: all the ants on the planet, taken together, have a biomass greater than that of humans. Ants have been incredibly industrious for millions of years. Yet their productiveness nourishes plants, animals, and soil. Human industry has been in full swing for little over a century, yet it has brought about a decline in almost every ecosystem on the planet. Nature doesn't have a design problem. People do.

Chapter One

A Question of Design

In the spring of 1912, one of the largest moving objects ever created by human beings left Southampton, England, and began gliding toward New York. It appeared to be the epitome of its industrial age—a potent representation of technology, prosperity, luxury, and progress. It weighed 66,000 tons. Its steel hull stretched the length of four city blocks. Each of its steam engines was the size of a town house. And it was headed for a disastrous encounter with the natural world.

This vessel, of course, was the *Titanic*, a brute of a ship, seemingly impervious to the forces of the natural world. In the minds of the captain, the crew, and many of the passengers, nothing could sink it.

One might say that the *Titanic* was not only a product of the Industrial Revolution but remains an apt metaphor for the industrial infrastructure that revolution created. Like that famous ship, this infrastructure is powered by brutish and artificial sources of energy that are environmentally depleting. It pours waste into the water and smoke into the sky. It attempts to work by its own rules, which are contrary to those of nature. And although it may seem invincible, the fundamental flaws in its design presage tragedy and disaster.

A Brief History of the Industrial Revolution

Imagine that you have been given the assignment of designing the Industrial Revolution—retrospectively. With respect to its negative consequences, the assignment would have to read something like this:

Design a system of production that

- puts billions of pounds of toxic material into the air, water, and soil every year
- produces some materials so dangerous they will require constant vigilance by future generations
- results in gigantic amounts of waste
- puts valuable materials in holes all over the planet, where they can never be retrieved
- requires thousands of complex regulations—not to keep people and natural systems safe, but rather to keep them from being poisoned too quickly
- measures productivity by how few people are working
- creates prosperity by digging up or cutting down natural resources and then burying or burning them
- erodes the diversity of species and cultural practices.

Of course, the industrialists, engineers, inventors, and other minds behind the Industrial Revolution never intended such consequences. In fact, the Industrial Revolution as a whole was not really designed. It took shape gradually, as industrialists, engineers, and designers tried to solve problems and to take immediate advantage of what they considered to be opportunities in an unprecedented period of massive and rapid change.

It began with textiles in England, where agriculture had been the main occupation for centuries. Peasants farmed, the manor and town guilds provided food and goods, and industry consisted of craftspeople working individually as a side venture to farming. Within a few decades, this cottage industry, dependent on the craft of individual laborers for the production of small quantities of woolen cloth, was transformed into a mechanized factory system that churned out fabric—much of it now cotton instead of wool—by the mile.

This change was spurred by a quick succession of new technologies. In the mid-1700s cottage workers spun thread on spinning wheels in their homes, working the pedals with their hands and feet to make one thread at a time. The spinning jenny, patented in 1770, increased the number of threads from one to eight, then sixteen, then more. Later models would spin as many as eighty threads simultaneously. Other mechanized equipment, such as the water frame and the spinning mule, increased production levels at such a pace, it must have seemed something like Moore's Law (named for Gordon Moore, a founder of Intel), in which the processing speed of computer chips roughly doubles every eighteen months.

In preindustrial times, exported fabrics would travel by canal or sailing ships, which were slow and unreliable in poor weather, weighted with high duties and strict laws, and vulnerable to piracy. In fact, it was a wonder the cargo got to its destination at all. The railroad and the steamship allowed products to be moved more quickly and farther. By 1840 factories that had once made a thousand articles a week had the means and motivation to produce a thousand articles a day. Fabric workers grew too busy to farm and moved into towns to be closer to factories, where they and their families might work twelve or more hours a day. Urban areas spread, goods proliferated, and city populations increased. More, more, more—jobs, people, products, factories, businesses, markets—seemed to be the rule of the day.

Like all paradigm shifts, this one encountered resistance. Cottage workers afraid of losing work and Luddites (followers of Ned Ludd)—experienced cloth makers angry about the new machines and the unapprenticed workers who operated them—smashed labor-saving equipment and made life difficult for inventors, some of whom died outcast and penniless before they could profit from their new machines. Resistance touched not simply on technology but on spiritual and imaginative life. The Romantic poets articulated the growing difference between the rural, natural landscape and that of the city—often in despairing terms: "Citys . . . are nothing less than over grown prisons that shut out the world and all its beauties," wrote the poet John Clare. Artists and aesthetes like John Ruskin and William Morris feared for a civilization whose aesthetic sensibility and physical structures were being reshaped by materialistic designs.

There were other, more lasting problems. Victorian London was notorious for having been "the great and dirty city," as Charles Dickens called it, and its unhealthy environment and suffering underclasses became hallmarks of the burgeoning industrial city. London air was so grimy from airborne pollutants, especially emissions from burning coal, that people would

change their cuffs and collars at the end of the day (behavior that would be repeated in Chattanooga during the 1960s, and even today in Beijing or Manila). In early factories and other industrial operations, such as mining, materials were considered expensive, but people were often considered cheap. Children as well as adults worked for long hours in deplorable conditions.

But the general spirit of early industrialists—and of many others at the time—was one of great optimism and faith in the progress of humankind. As industrialization boomed, other institutions emerged that assisted its rise: commercial banks, stock exchanges, and the commercial press all opened further employment opportunities for the new middle class and tightened the social network around economic growth. Cheaper products, public transportation, water distribution and sanitation, waste collection, laundries, safe housing, and other conveniences gave people, both rich and poor, what appeared to be a more equitable standard of living. No longer did the leisure classes alone have access to all the comforts.

The Industrial Revolution was not planned, but it was not without a motive. At bottom it was an economic revolution, driven by the desire for the acquisition of capital. Industrialists wanted to make products as efficiently as possible and to get the greatest volume of goods to the largest number of people. In most industries, this meant shifting from a system of manual labor to one of efficient mechanization.

Consider cars. In the early 1890s the automobile (of European origin) was made to meet a customer's specifications by craftspeople who were usually independent contractors. For example, a machine-tool company in Paris, which happened to be the leading manufacturer of cars at the time, produced only several hundred a year. They were luxury items, built slowly and carefully by hand. There was no standard system of measuring and gauging parts, and no way to cut hard steel, so parts were created by different contractors, hardened under heat (which often altered dimensions), and individually filed down to fit the hundreds of other parts in the car. No two were alike, nor could they be.

Henry Ford worked as an engineer, a machinist, and a builder of race cars (which he himself raced) before founding the Ford Motor Company in 1903. After producing a number of early vehicles, Ford realized that to make cars for the modern American worker—not just for the wealthy—he would need to manufacture vehicles cheaply and in great quantities. In 1908 his company began producing the legendary Model T, the "car for the great multitude" that Ford had dreamed of, "constructed of the best materials, by the best men to be hired, after the simplest designs that modern engineering can devise . . . so low in price that no man making a good salary will be unable to own one."

In the following years, several aspects of manufacturing meshed to achieve this goal, revolutionizing car production and rapidly increasing levels of efficiency. First, centralization: in 1909 Ford announced that the company would produce only Model T's and in 1910 moved to a much larger factory that would use electricity for its power and gather a number of production processes under one roof. The most famous of Ford's

innovations is the moving assembly line. In early production, the engines, frames, and bodies of the cars were assembled separately, then brought together for final assembly by a group of workmen. Ford's innovation was to bring "the materials to the man," instead of "the man to the materials." He and his engineers developed a moving assembly line based on the ones used in the Chicago beef industry: it carried materials to workers and, at its most efficient, enabled each of them to repeat a single operation as the vehicle moved down the line, reducing overall labor time dramatically.

This and other advances made possible the mass production of the universal car, the Model T, from a centralized location, where many vehicles were assembled at once. Increasing efficiency pushed costs of the Model T down (from $850 in 1908 to $290 in 1925), and sales skyrocketed. By 1911, before the introduction of the assembly line, sales of the Model T had totaled 39,640. By 1927, total sales reached fifteen million.

The advantages of standardized, centralized production were manifold. Obviously, it could bring greater, quicker affluence to industrialists. On another front, manufacturing was viewed as what Winston Churchill referred to as "the arsenal of democracy," because the productive capacity was so huge, it could (as in the two world wars) produce an undeniably potent response to war conditions. Mass production had another democratizing aspect: as the Model T demonstrated, when prices of a previously unattainable item or service plummeted, more people had access to it. New work opportunities in factories improved standards of living, as did wage increases. Ford himself assisted in this shift. In 1914, when the prevailing salary for factory workers was $2.34 a day, he hiked it to $5, pointing out that cars cannot buy cars. (He also reduced the hours of the workday from nine to eight.) In one fell swoop, he actually created his own market, and raised the bar for the entire world of industry.

Viewed from a design perspective, the Model T epitomized the general goal of the first industrialists: to make a product that was desirable, affordable, and operable by anyone, just about anywhere; that lasted a certain amount of time (until it was time to buy a new one); and that could be produced cheaply and quickly. Along these lines, technical developments centered on increasing "power, accuracy, economy, system, continuity, speed," to use the Ford manufacturing checklist for mass production.

For obvious reasons, the design goals of early industrialists were quite specific, limited to the practical, profitable, efficient, and linear. Many industrialists, designers, and engineers did not see their designs as part of a larger system, outside of an economic one. But they did share some general assumptions about the world.

"Those Essences Unchanged by Man"

Early industries relied on a seemingly endless supply of natural "capital." Ore, timber, water, grain, cattle, coal, land—these were the raw materials for the production systems that made goods for the masses, and they still are today. Ford's River

Rouge plant epitomized the flow of production on a massive scale: huge quantities of iron, coal, sand, and other raw materials entered one side of the facility and, once inside, were transformed into new cars. Industries fattened as they transformed resources into products. The prairies were overtaken for agriculture, and the great forests were cut down for wood and fuel. Factories situated themselves near natural resources for easy access (today a prominent window company is located in a place that was originally surrounded by giant pines, used for the window frames) and beside bodies of water, which they used both for manufacturing processes and to dispose of wastes.

In the nineteenth century, when these practices began, the subtle qualities of the environment were not a widespread concern. Resources seemed immeasurably vast. Nature itself was perceived as a "mother earth" who, perpetually regenerative, would absorb all things and continue to grow. Even Ralph Waldo Emerson, a prescient philosopher and poet with a careful eye for nature, reflected a common belief when, in the early 1830s, he described nature as "essences unchanged by man; space, the air, the river, the leaf." Many people believed there would always be an expanse that remained unspoiled and innocent. The popular fiction of Rudyard Kipling and others evoked wild parts of the world that still existed and, it seemed, always would.

At the same time, the Western view saw nature as a dangerous, brutish force to be civilized and subdued. Humans perceived natural forces as hostile, so they attacked back to exert control. In the United States, taming the frontier took on the power of a defining myth, and "conquering" wild, natural places was recognized as a cultural—even spiritual—imperative.

Today our understanding of nature has dramatically changed. New studies indicate that the oceans, the air, the mountains, and the plants and animals that inhabit them are more vulnerable than early innovators ever imagined. But modern industries still operate according to paradigms that developed when humans had a very different sense of the world. Neither the health of natural systems, nor an awareness of their delicacy, complexity, and interconnectedness, have been part of the industrial design agenda. At its deepest foundation, the industrial infrastructure we have today is linear: it is focused on making a product and getting it to a customer quickly and cheaply without considering much else.

To be sure, the Industrial Revolution brought a number of positive social changes. With higher standards of living, life expectancy greatly increased. Medical care and education greatly improved and became more widely available. Electricity, telecommunications, and other advances raised comfort and convenience to a new level. Technological advances brought the so-called developing nations enormous benefits, including increased productivity of agricultural land and vastly increased harvests and food storage for growing populations.

But there were fundamental flaws in the Industrial Revolution's design. They resulted in some crucial omissions, and devastating consequences have been handed down to us, along with the dominant assumptions of the era in which the transformation took shape.

From Cradle to Grave

Imagine what you would come upon today at a typical landfill: old furniture, upholstery, carpets, televisions, clothing, shoes, telephones, computers, complex products, and plastic packaging, as well as organic materials like diapers, paper, wood, and food wastes. Most of these products were made from valuable materials that required effort and expense to extract and make, billions of dollars' worth of material assets. The biodegradable materials such as food matter and paper actually have value too—they could decompose and return biological nutrients to the soil. Unfortunately, all of these things are heaped in a landfill, where their value is wasted. They are the ultimate products of an industrial system that is designed on a linear, one-way *cradle-to-grave* model. Resources are extracted, shaped into products, sold, and eventually disposed of in a "grave" of some kind, usually a landfill or incinerator. You are probably familiar with the end of this process because you, the customer, are responsible for dealing with its detritus. Think about it: you may be referred to as a consumer, but there is very little that you actually consume—some food, some liquids. Everything else is designed for you to throw away when you are finished with it. But where is "away"? Of course, "away" does not really exist. "Away" has gone away.

Cradle-to-grave designs dominate modern manufacturing. According to some accounts more than 90 percent of materials extracted to make durable goods in the United States become waste almost immediately. Sometimes the product itself scarcely lasts longer. It is often cheaper to buy a new version of even the most expensive appliance than to track down someone to repair the original item. In fact, many products are designed with "built-in obsolescence," to last only for a certain period of time, to allow—to encourage—the customer to get rid of the thing and buy a new model. Also, what most people see in their garbage cans is just the tip of a material iceberg; the product itself contains on average only 5 percent of the raw materials involved in the process of making and delivering it.

One Size Fits All

Because the cradle-to-grave model underlying the design assumptions of the Industrial Revolution was not called into question, even movements that were formed ostensibly in opposition to that era manifested its flaws. One example has been the push to achieve universal design solutions, which emerged as a leading design strategy in the last century. In the field of architecture, this strategy took the form of the International Style movement, advanced during the early decades of the twentieth century by figures such as Ludwig Mies van der Rohe, Walter Gropius, and Le Corbusier, who were reacting against Victorian-era styles. (Gothic cathedrals were still being proposed and built.) Their goals were social as well as aesthetic. They wanted to globally replace unsanitary and inequitable housing—fancy, ornate places for the rich; ugly, unhealthy places for the poor—with clean, minimalist, affordable buildings unencumbered by distinctions of wealth or class. Large sheets of glass, steel, and concrete, and cheap

transportation powered by fossil fuels, gave engineers and architects the tools for realizing this style anywhere in the world.

Today the International Style has evolved into something less ambitious: a bland, uniform structure isolated from the particulars of place—from local culture, nature, energy, and material flows. Such buildings reflect little if any of a region's distinctness or style. They often stand out like sore thumbs from the surrounding landscape, if they leave any of it intact around their "office parks" of asphalt and concrete. The interiors are equally uninspiring. With their sealed windows, constantly humming air conditioners, heating systems, lack of daylight and fresh air, and uniform fluorescent lighting, they might as well have been designed to house machines, not humans.

The originators of the International Style intended to convey hope in the "brotherhood" of humankind. Those who use the style today do so because it is easy and cheap and makes architecture uniform in many settings. Buildings can look and work the same anywhere, in Reykjavík or Rangoon.

In product design, a classic example of the universal design solution is mass-produced detergent. Major soap manufacturers design one detergent for all parts of the United States or Europe, even though water qualities and community needs differ. For example, customers in places with soft water, like the Northwest, need only small amounts of detergent. Those where the water is hard, like the Southwest, need more. But detergents are designed so they will lather up, remove dirt, and kill germs efficiently the same way anywhere in the world—in hard, soft, urban, or spring water, in water that flows into fish-filled streams and water channeled to sewage treatment plants. Manufacturers just add more chemical force to wipe out the conditions of circumstance. Imagine the strength a detergent must have to strip day-old grease from a greasy pan. Now imagine what happens when that detergent comes into contact with the slippery skin of a fish or the waxy coating of a plant. Treated and untreated effluents as well as runoff are released into lakes, rivers, and oceans. Combinations of chemicals, from household detergents, cleansers, and medicines along with industrial wastes, end up in sewage effluents, where they have been shown to harm aquatic life, in some cases causing mutations and infertility.

To achieve their universal design solutions, manufacturers design for a *worst-case scenario*; they design a product for the worst possible circumstance, so that it will always operate with the same efficacy. This aim guarantees the largest possible market for a product. It also reveals human industry's peculiar relationship to the natural world, since designing for the worst case at all times reflects the assumption that nature is the enemy.

Brute Force

If the first Industrial Revolution had a motto, we like to joke, it would be "If brute force doesn't work, you're not using enough of it." The attempt to impose universal design solutions on an infinite number of local conditions and customs is one manifestation of this principle and its underlying assumption, that nature should be overwhelmed; so is the application of the chemical brute force and fossil fuel energy necessary to make such solutions "fit."

All of nature's industry relies on energy from the sun, which can be viewed as a form of current, constantly renewing income. Humans, by contrast, extract and burn fossil fuels such as coal and petrochemicals that have been deposited deep below the Earth's surface, supplementing them with energy produced through waste-incineration processes and nuclear reactors that create additional problems. They do this with little or no attention to harnessing and maximizing local natural energy flows. The standard operating instruction seems to be "If too hot or too cold, just add more fossil fuels."

You are probably familiar with the threat of global warming brought about by the buildup of heat-trapping gases (such as carbon dioxide) in the atmosphere due to human activities. Increasing global temperatures result in global climate change and shifts of existing climates. Most models predict more severe weather—hotter hots, cooler colds*—and more intense storms, as global thermal contrasts grow more extreme. A warmer atmosphere draws more water from oceans, resulting in bigger, wetter, more frequent storms, rises in sea level, shifts in seasons, and a chain of other climatic events.

The reality of global warming has gained currency not only among environmentalists but among industry leaders. But global warming is not the sole reason to rethink our reliance on the "brute force" approach to energy. Incinerating fossil fuels contributes particulates—microscopic particles of soot—to the environment, where they are known to cause respiratory and

* Actually models predict warmer colds and barely unchanged hots.

other health problems. Regulations for airborne pollutants known to threaten health are growing more severe. As new regulations, based on mounting research about the health threats of airborne toxins resulting from incinerating fossil fuels, are implemented, industries invested solely in continuing the current system will be at a serious disadvantage.

Even beyond these important issues, brute force energy doesn't make good sense as a dominant strategy over the long term. You wouldn't want to depend on savings for all of your daily expenditures, so why rely on savings to meet all of humanity's energy needs? Clearly, over the years petrochemicals will become harder (and more expensive) to get, and drilling in pristine places for a few million more drums of oil isn't going to solve that problem. In a sense, finite sources of energy, such as petrochemicals derived from fossil fuels, can be seen as a nest egg, something to be preserved for emergencies, then used sparingly—in certain medical situations, for example. For the majority of our simple energy needs, humans could be accruing a great deal of current solar income, of which there is plenty: thousands of times the amount of energy needed to fuel human activities hits the surface of the planet every day in the form of sunlight.

A Culture of Monoculture

Under the existing paradigm of manufacturing and development, diversity—an integral element of the natural world—is typically treated as a hostile force and a threat to design goals.

Brute force and universal design approaches to typical development tend to overwhelm (and ignore) natural and cultural diversity, resulting in less variety and greater homogeneity.

Consider the process of building a typical universal house. First builders scrape away everything on the site until they reach a bed of clay or undisturbed soil. Several machines then come in and shape the clay to a level surface. Trees are felled, natural flora and fauna are destroyed or frightened away, and the generic mini McMansion or modular home rises with little regard for the natural environment around it—ways the sun might come in to heat the house during the winter, which trees might protect it from wind, heat, and cold, and how soil and water health can be preserved now and in the future. A two-inch carpet of a foreign species of grass is placed over the rest of the lot.

The average lawn is an interesting beast: people plant it, then douse it with artificial fertilizers and dangerous pesticides to make it grow and to keep it uniform—all so that they can hack and mow what they encouraged to grow. And woe to the small yellow flower that rears its head!

Rather than being designed around a natural and cultural landscape, most modern urban areas simply grow, as has often been said, like a cancer, spreading more and more of themselves, eradicating the living environment in the process, blanketing the natural landscape with layers of asphalt and concrete.

Conventional agriculture tends to work along these same lines. The goal of a midwestern commercial corn operation is to produce as much corn as possible with the least amount of trouble, time, and expense—the Industrial Revolution's first design goal of maximum efficiency. Most conventional operations today focus on highly specialized, hybridized, and perhaps genetically modified species of corn. They develop a monocultural landscape that appears to support only one particular crop that's likely not even a true species but some over-hybridized cultivar. Planters remove other species of plant life using tillage, which leads to massive soil erosion from wind and water, or no-till farming, which requires massive applications of herbicide. Ancient strains of corn are lost because their output does not meet the demands of modern commerce.

On the surface, these strategies seem reasonable to modern industry and even to "consumers," but they harbor both underlying and overlying problems. Elements that are removed from the ecosystem to make the operation yield more grain more quickly (that is, to make it more efficient) would otherwise actually provide benefits to farming. The plants removed by tillage, for example, could have helped to prevent erosion and flooding and to stabilize and rebuild soil. They would have provided habitat for insects and birds, some of them natural enemies of crop pests. Now, as pests grow resistant to pesticide, their numbers increase because their natural enemies have been wiped out.

Pesticides, as typically designed, are a perennial cost both to farmers and to the environment and represent a less than mindful use of chemical brute force. Although chemical companies warn farmers to be careful with pesticides, they benefit when more of them are sold. In other words, the companies are unintentionally invested in profligacy with—even the mishan-

dling of—their products, which can result in contamination of the soil, water, and air.

In such an artificially maintained system, where the natural enemies of pests and some of the nutrient-cycling plants and organisms have been eliminated, more chemical brute force (pesticides, fertilizers) must be applied to keep the system commercially stable. Soil is depleted of nutrients and saturated with chemicals. People may not want to live too close to the operation because they fear chemical runoff. Rather than being an aesthetic and cultural delight, modern agriculture becomes a terror and a fright to local residents who want to live and raise families in a healthy setting. While the economic payoff immediately rises, *the overall quality of every aspect of this system is actually in decline.*

The problem here is not agriculture per se but the narrowly focused goals of the operation. The single-minded cultivation of one species drastically reduces the rich network of "services" and side effects in which the entire ecosystem originally engaged. To this day, conventional agriculture is still, as scientists Paul and Anne Ehrlich and John Holdren said several decades ago, "a simplifier of ecosystems, replacing relatively complex natural biological communities with relatively simple manmade ones based on a few strains of crops." These simple systems cannot survive on their own. Ironically, simplification necessitates even more brute force for the system to achieve its design goals. Take away the chemicals and the modern modes of agricultural control, and the crops would languish (until, that is, diverse species gradually crept back, returning complexity to the ecosystem).

Activity Equals Prosperity

An interesting fact: the 1991 Exxon *Valdez* oil spill actually increased Alaska's gross domestic product. The Prince William Sound area was registered as economically more prosperous because so many people were trying to clean up the spill. Restaurants, hotels, shops, gas stations, and stores all experienced an upward blip in economic exchange.

The GDP takes only one measure of progress into account: activity. Economic activity. But what sensible person would call the effects of an oil spill progress? By some accounts, the *Valdez* accident led to the death of more wildlife than any other human-engineered environmental disaster in U.S. history. According to a 1999 government report, only two of the twenty-three animal species affected by the spill recovered. Its impact on fish and wildlife continues today with tumors, genetic damage, and other effects. The spill led to losses of cultural wealth, including five state parks, four state critical-habitat areas, and a state game sanctuary. Important habitats for fish spawning and rearing were damaged, which may have led to the 1993 decimation of the Prince William Sound's Pacific herring population (perhaps because of a viral infection due to oil exposure). The spill took a significant toll on fishermen's income, not to mention the less measurable effects on morale and emotional health.

The GDP as a measure of progress emerged during an era when natural resources still seemed unlimited and "quality of life" meant high economic standards of living. But if prosperity is judged only by increased economic activity, then car accidents, hospital visits, illnesses (such as cancer), and toxic spills are all signs of prosperity. Loss of resources, cultural depletion, negative social and environmental effects, reduction of quality of life—these ills can all be taking place, an entire region can be in decline, yet they are negated by a simplistic economic figure that says economic life is good. Countries all over the world are trying to boost their level of economic activity so they, too, can grab a share of the "progress" that measurements like the GDP propound. But in the race for economic progress, social activity, ecological impact, cultural activity, and long-term effects can be overlooked.

Crude Products

The design intention behind the current industrial infrastructure is to make an attractive product that is affordable, meets regulations, performs well enough, and lasts long enough to meet market expectations. Such a product fulfills the manufacturer's desires and some of the customers' expectations as well. But from our perspective, products that are not designed particularly for human and ecological health are unintelligent and inelegant—what we call *crude products.*

For example, the average mass-produced piece of polyester clothing and a typical water bottle both contain antimony, a toxic heavy metal known to cause cancer under certain circumstances. Let's put aside for the moment the issues of whether this substance represents a specific danger to the user. The question we would pose as designers is: Why is it there? Is it necessary? Actually, it is not necessary: antimony is a current catalyst in the polymerization process and is not necessary for polyester production. What happens when this discarded product is "recycled" (that is, downcycled) and mixed with other materials? What about when it is burned along with other trash as cooking fuel, a common practice in developing countries? Incineration makes the antimony bioavailable—that is, available for breathing. If polyester might be used for fuel, we need polyesters that can be safely burned.

That polyester shirt and that water bottle are both examples of what we call *products plus*: as a buyer you got the item or service you wanted, *plus* additives that you didn't ask for and didn't know were included and that may be harmful to you and your loved ones. (Maybe shirt labels should read: *Product contains toxic dyes and catalysts. Don't work up a sweat or they will leach onto your skin.*) Moreover, these extra ingredients may not be necessary to the product itself.

Since 1987 we have been studying various products from major manufacturers, ordinary things such as a computer mouse, an electric shaver, a popular handheld video game, a hair dryer, and a portable CD player. We found that during use they all off-gassed teratogenic and/or carcinogenic compounds—substances known to have a role in causing birth defects and cancer. An electric hand mixer emitted chemical gases that got trapped in the oily butter molecules of the cake batter and ended up in the cake. So be careful—you might unintentionally be eating your appliances.

Why does this happen? The reason is that high-tech products are usually composed of low-quality materials—that is,

cheap plastics and dyes—globally sourced from the lowest-cost provider, which may be halfway around the world. This means that even substances banned for use in the United States and Europe can reach this country via products and parts made elsewhere. So, for example, the carcinogen benzene, banned for use as a solvent in American factories, can be shipped here in rubber parts that were manufactured in developing countries that have not banned it. They can be assembled into, say, your treadmill, which will then emit the "banned" substance as you exercise.

The problem intensifies when parts from numerous countries are assembled into one product, as is often the case with high-tech items such as electronic equipment and appliances. Manufacturers do not necessarily keep track of—nor are they required to know—what exactly is in all of these parts. An exercise machine assembled in the United States may contain rubber belts from Malaysia, chemicals from Korea, motors from China, adhesives from Taiwan, and wood from Brazil.

How do these crude products affect you? They produce poor indoor air quality, for one thing. Combined in the workplace or home, crude products—whether appliances, carpets, wallpaper adhesives, paints, building materials, insulation, or anything else—make the average indoor air more contaminated than outdoor air. One study of household contaminants found that more than half of the households showed concentrations of seven toxic chemicals that are known to cause cancer in animals and are suspected to cause cancer in humans at levels higher than those that would "trigger a formal risk assessment for residential soil at a Superfund site." Allergies, asthma, and "sick building syndrome" are on the rise. Yet legislation establishing mandatory standards for indoor air quality is practically nonexistent.

Even products ostensibly designed for children can be crude products. An analysis of a child's swim wings, made from polyvinyl chloride (PVC), showed that they off-gassed potentially harmful substances—including, under heat, hydrochloric acid. Other harmful substances, like the plasticizing phthalates, may be ingested through contact. This scenario is particularly alarming in a swimming pool, since a child's skin, ten times thinner than the skin of an adult, gets wrinkled when wet—the ideal condition for absorbing toxins. Once again, in purchasing swim wings, you've inadvertently purchased a "product plus": you got the flotation device you wanted for your child *plus* unasked-for toxins—not a great bargain, and surely not what the manufacturers had in mind when they created this child-safety device.

You may be saying to yourself, "I certainly don't know any children who have gotten sick from a plastic float or pool!" But rather than a readily identifiable illness, some people develop an allergy, or multiple chemical sensitivity syndrome, or asthma, or they just do not feel well, without knowing exactly why. Even if we experience no immediate ill effects, coming into constant contact with carcinogens like benzene and vinyl chloride may be unwise.

Think of it this way. Everyone's body is subjected to stress, from both internal and external sources. These stresses may take the form of cancer cells that are naturally produced by the body—by some accounts, as many as twelve cells a day—exposure to heavy metals and other pathogens, and so on. The immune system is capable of handling a certain amount of stress. Simplistically speaking, you could picture those stressors as balls your immune system is juggling. Ordinarily, the juggler is skillful enough to keep those balls in the air. That is, the immune system catches and destroys those ten or twelve cells. But the more balls in the air—the more the body is besieged by all kinds of environmental toxins, for example—the greater the probability that it will drop the ball, that a replicating cell will make a mistake. It would be very hard to say which molecule or factor was the one that pushed a person's system over the edge. But why not remove negative stressors, especially since people don't want or need them?

Some industrial chemicals produce a second effect, more insidious than causing stress: they weaken the immune system. This is like tying one of the juggler's hands behind his back, which makes it much harder for him to catch the cancer cells before they cause problems. The deadliest chemicals both destroy the immune system *and* damage cells. Now you have a one-handed juggler struggling to keep an increasing number of balls in the air. Will he continue to perform with accuracy and grace? Why take the risk that he won't? Why not look for opportunities to strengthen the immune system, not challenge it?

We've focused on cancer here, but these compounds may have other effects that science has yet to discover. Consider endocrine disrupters, which were unheard of a decade ago but are now known to be among the most damaging chemical compounds for living organisms. Of the approximately eighty thousand defined chemical substances and technical mixes that are produced and used by industries today (each of which has five or more by-products), only about three thousand so far have been studied for their effects on living systems.

It may be tempting to try to turn back the clock. Yet the next industrial revolution will not be about returning to some idealized, preindustrial state in which, for example, all textiles are made from natural fibers. Certainly at one time fabrics were biodegradable and unwanted pieces could be tossed on the ground to decompose or even be safely burned as fuel. But the natural materials to meet the needs of our current population do not and cannot exist. If several billion people want natural-fiber blue jeans dyed with natural dyes, humanity will have to dedicate millions of acres to the cultivation of indigo and cotton plants just to satisfy the demand—acres that are needed to produce food. In addition, even "natural" products are not necessarily healthy for humans and the environment. Indigo contains mutagens and, as typically grown in monocultural practices, depletes genetic diversity. You want to change your jeans, not your genes. Substances created by nature can be extremely toxic; they were not specifically designed by evolution for our use. Even something as benign and necessary as clean drinking water can be lethal if you are submerged in it for more than a couple of minutes.

A Strategy of Tragedy, or a Strategy of Change?

Today's industrial infrastructure is designed to chase economic growth. It does so at the expense of other vital concerns, particularly human and ecological health, cultural and natural richness, and even enjoyment and delight. Except for a few generally known positive side effects, most industrial methods and materials are unintentionally depletive.

Yet just as industrialists, engineers, designers, and developers of the past did not intend to bring about such devastating effects, those who perpetuate these paradigms today surely do not intend to damage the world. The waste, pollution, crude products, and other negative effects that we have described are not the result of corporations doing something morally wrong. They are the consequence of outdated and unintelligent design.

Nevertheless, the damage is certain and severe. Modern industries are chipping away at some of the basic achievements that industrialization brought about. Food stocks, for example, have increased so that more children are fed, but more children go to bed hungry as well. But even if well-fed children are regularly exposed to substances that can lead to genetic mutations, cancer, asthma, allergies, and other complications from industrial contamination and waste, then what has been achieved? Poor design on such a scale reaches far beyond our own life span. It perpetrates what we call *intergenerational remote tyranny*—our tyranny over future generations through the effects of our actions today.

At some point a manufacturer or designer decides, "We can't keep doing this. We can't keep supporting and maintaining this system." At some point they will decide that they would prefer to leave behind a positive design legacy. But when is that point?

We say that point is today, and negligence starts tomorrow.

Once you understand the destruction taking place, unless you do something to change it, even if you never intended to cause such destruction, you become involved in a strategy of tragedy. You can continue to be engaged in that strategy of tragedy, or you can design and implement a *strategy of change.*

Perhaps you imagine that a viable strategy for change already exists. Aren't a number of "green," "environmental," and "eco-efficient" movements already afoot? The next chapter takes a closer look at these movements and the solutions they offer.

Chapter Two

Why Being "Less Bad" Is No Good

The drive to make industry less destructive goes back to the earliest stages of the Industrial Revolution, when factories were so destructive and polluting that they had to be controlled in order to prevent immediate sickness and death. Since then the typical response to industrial destruction has been to find a less bad approach. This approach has its own vocabulary, with which most of us are familiar: *reduce, avoid, minimize, sustain, limit, halt.* These terms have long been central to environmental agendas, and they have become central to most of the environmental agendas taken up by industry today.

One early dark messenger was Thomas Malthus, who warned at the end of the eighteenth century that humans would reproduce exponentially, with devastating consequences for humankind. Malthus's position was unpopular during the explosive excitement of early industry, when much was made of humanity's potential for good, when its increasing ability to mold the earth to its own purposes was seen as largely constructive; and when even population growth was viewed as a boon. Malthus envisioned not great, gleaming advancement but darkness, scarcity, poverty, and famine. His *Population: The First Essay*, published in 1798, was framed as a response to essayist and utopian William Godwin, who often espoused man's "perfectibility." "I have read some of the speculations on the perfectibility of man and of society with great pleasure," Malthus wrote. "I have been warmed and delighted with the en-